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Date: October 14, 2008
Refer To: ENV-RCRA-08-0204
LA-UR: 08-06542

Mr. John Kieling
Permits Management Program
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6303

OCT 2008

Dear Mr. Kieling:

SUBJECT: RESPONSE TO "NOTICE OF DEFICIENCY TECHNICAL REVIEW OF THE SEPTEMBER 7, 2007 LOS ALAMOS NATIONAL LABORATORY TECHNICAL AREA 16 BURN GROUND AIR PATHWAY ASSESSMENT REPORT, REVISION 0"

The purpose of this letter is to provide the National Nuclear Security Administration (NNSA) and the Los Alamos National Security, LLC (LANS) response to the Notice of Deficiency (NOD) issued by the New Mexico Environment Department Hazardous Waste Bureau (NMED-HWB) on July 22, 2008. The NOD required additional explanation and specific changes to the air pathway assessment report that was transmitted to the NMED-HWB on September 7, 2007. The enclosed documents contain responses to each of the 37 comments contained within the NOD (Attachment A), a revised report (Appendix A), Digital Elevation Model data as requested by the NOD (Appendix B), and a copy of a memorandum referenced within the report (Appendix C).

Some of the comments within the NOD were discussed and clarified during a conference call on August 5, 2008 between Rebecca Kay and David Cobrain of your staff, Michael Smith of TechLaw Inc., and Jack Ellvinger, Luciana Vigil-Holterman, Bruce Letellier and Gene Turner representing NNSA/LANS. In the revised report (Appendix A), NNSA/LANS has further explained some technical issues for the air pathway analysis, discussed general operations at the Technical Area 16 Burn Ground, and made changes to the report as specified within the NOD. Additional changes have been made to the revised report to address any typographical errors, clarification issues, and inaccuracies found during the revision of the document.

The NOD requires that a response to the NOD be submitted by October 14, 2008 along with any results of any new model applications and input parameters. This letter transmits the response to the comments in the NOD, and the revised report including changes requested by the NMED-HWB.

Three hard copies and one electronic copy are provided. The electronic copy contains a wordprocessing file with editing marks that illustrate the changes made to the Revision 0 of the report.

If you should have any questions or concerns regarding this submittal, please feel free to contact Gene Turner, LASO-EO, at (505) 667-5794 or Jack Ellvinger, of the Water Quality and RCRA Group (ENV-RCRA), at (505) 667-0633.

Sincerely,

A R Grieggs

Anthony R. Grieggs
Group Leader
Water Quality & RCRA Group (ENV-RCRA)

ARG:LRVH/lm

Enclosures: a/s

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ENV-RCRA, File, w/enc., K490
IRM-RMMSO, (U0802049), w/enc., A150

Attachment A

Response to "Notice of Deficiency Technical Review of the September 7, 2007 Los Alamos National Laboratory Technical Area 16 Burn Ground Air Pathway Assessment Report, Revision 0"

LA-UR-08-06542

Response to Notice of Deficiency;
LANL TA-16 Burn Ground Pathway Assessment Report, Revision 0

INTRODUCTION

The following document provides the response by Los Alamos National Laboratory (LANL) to a Notice of Deficiency (NOD) sent by the New Mexico Environment Department (NMED) on July 22, 2008. The full title of the NOD is "Notice of Deficiency Technical Review of the September 7, 2007 Los Alamos National Laboratory Technical Area 16 Burn Ground Air Pathway Assessment Report, Revision 0, HWB-LANL-01-006." This document responds to the 37 comments contained in the NOD and includes appendices with information to supplement the individual responses to the numbered comments. The original comments from NMED are included as italicized text for ease of review.

NOD COMMENTS AND RESPONSES

General Comments:

1. *The August 2007 Report lacks the necessary detail needed to demonstrate that treatment operations at the TA-16 Burn Ground are protective of human health and the environment. The text of the Report must be expanded to include:*

    a. *additional information supporting deviations from LANL's air pathway assessment protocols (LANL, 2007a and LANL, 2007c) (see comment #'s 4,6, 7, 8, 9, and 13);*

    b. *additional information on the location of the receptors listed in Table 2-3 (Unit/Waste Scenarios Creating Maximum Impacts by Averaging Period), Table 3-1 (Deposition Fluxes), and Table 3-2 (Soil Input Concentrations) relative to the locations of the modeled emission sources (i.e., the UTM coordinates and elevations of the identified receptors) (see comment #'s 21,22,24, 28, 29,32 and 34);*

    c. *information on the points of maximum on-site and maximum off-site impacts and deposition fluxes listed in Tables 2-3 and 3-1 (see comment #'s 24 and 32); and*

    d. *typical open burning operations at TA-16-388 and TA-16-399 compared to the worst-case scenarios addressed in the Report (see comment # 3).*

Response: The Los Alamos National Laboratory (LANL) Technical Area 16 (TA-16) Burn Ground Air Pathway Assessment Report, Revision 0 has been revised and is included with this submittal as Appendix A, titled "LANL TA-16 Burn Ground Air Pathway Assessment Report, Revision 1.0". Please see specific comments as referenced within general comment #1 for responses to requests for additional information and the location of that information within the revised Report (Appendix A).

2. *The Report does not include an assessment of the uncertainties embedded in the air pathway assessment. Any assessment of the air pathway for an open burning unit is subject to uncertainty stemming from the tools and methodologies employed. Identification and discussion of the sources of uncertainty is essential to the interpretation and effective application of the*

assessment results by all stakeholders. The Report must include such a discussion to characterize the results of the air pathway assessment. Uncertainties typically associated with screening level risk based air pathway assessments for open burn units include, but are not limited to:

a. use of surrogate emission factors to represent actual process emissions;

b. use of air dispersion and deposition models to estimate air quality impacts; and

c. application of risk-based screening levels to assess potential impacts to human health and the environment.

Further, the assumptions made in applying the emission factors, air model, and screening levels introduce uncertainty into the assessment. Comments related to such assumptions are detailed herein (see comment #'s 3, 11, 14, 15, 19, 20, 30, 31, 36, and 37). Revise the Report to identify and discuss the sources of uncertainty associated with the air pathway assessment for the TA-16 Burn Ground. This discussion must address the three items listed above and the assumptions referenced above. The Permittees should identify and discuss additional sources of uncertainty as necessary to adequately characterize the results of the air pathway assessment.

Response: Please see specific comments as referenced within general comment #2 for responses to requests for uncertainty discussions and the location of that information within the revised Report (Appendix A).

3. *Section 1.0 (Introduction) should be expanded to provide additional information on the open burning operations conducted at the TA-16 Burn Ground. Because the Report does not model typical operations (the analysis is intended to illustrate that worst-case operations are protective of human health and the environment), the Report must provide an expanded discussion of:*

a. typical open burning operations at TA-16-388 and TA-16-399. This could be accomplished by augmenting the revised Report with a technical comparison of the similarities and differences between typical open burn parameter values (from descriptions of typical operations at the Burn Ground found in other LANL documents, (e.g., LANL, 2003, Attachment G) and the parameter values used in the air pathway assessment. The Permittees must provide a text discussion and a comparative table; and

b. changes in magnitude and location of the maximum air quality impacts as the amount of waste treated per event is decreased. The Permittees must demonstrate that treatment of smaller quantities than those addressed in the Report will not generate emissions that exceed levels that are protective of human health and the environment. If magnitudes and locations of maximum off-site and maximum on-site impacts change as the volume of waste treated decreases, and the Permittees are not able to demonstrate that treatment of smaller quantities will not be harmful, they must indicate what procedures and controls will be used to prevent exposures to human and ecological receptors that exceed protective levels.

Revise Section 1.0 of the Report to address these issues.

Response: Description of typical operations has been added to Section 1.1 of the revised Report (Appendix A) and Section 6.0 has been added to discuss the results of the air pathway assessment and the conclusion that operations at the TA-16 Burn Ground are protective of human health and the environment. As contained in the responses to specific comment #s 4, 8 and 9, additional discussion of the factors affecting dispersion of potential air contaminants has been added to Sections 2.4 and 2.5 of the revised Report (Appendix A). As part of that discussion, the effects of varying several of the conditions for burn events at the treatment units were examined. These included ambient temperatures, effluent temperatures, burn times, burn amount limits, and burn areas. The revised language includes a discussion of how the effects of two burn factors (high explosives mass to area and burn time) remain relatively constant and thus support the trend that larger burns of given high explosives (HE) types release pollutants at a faster rate than smaller burns, which increases downwind air concentrations. Therefore, the discussion supports the demonstration that the treatment of smaller quantities of waste material will not exceed the values computed for the worst-case higher burn quantities used for the air modeling report.

Comment # 3b refers to the possible competition between the greater emissions released from a large burn and the possible enhanced dilution that one intuitively expects from a "larger" fire. For a burn of a given intensity, higher emissions increase impacts in a linear manner. For example, 1000 pounds (lb) of HE burned over the course of 1 hour will yield 4 times the cumulative exposure as 250 lb of HE burned over the same 1 hour. But if the larger burn had substantially different plume characteristics that enhance dilution by more than a factor of 4, then an apparent paradox would be faced where the "smaller" batch leads to higher impacts. These conditions are not likely to occur at the TA-16 Burn Ground, and even if larger burns do exhibit more dilution, no credit was taken for this complex effect in the scenarios that were simulated.

One key safety practice at the TA-16 Burn Ground assures that larger burns always maximize downwind impacts: solid HE pieces are never stacked; they are arranged across the tray with several inches of separation to avoid confinement of combustion gases that may initiate a detonation. This practice implies that the energy released per unit of area on the burn tray is approximately constant for a given type and configuration of HE, because each piece burns independently from the others. An operational commitment was made to always burn chips and pellets with propane assist. For propane assisted burns, any additional buoyancy provided by the waste material was neglected to artificially suppress plume rise, but this assumption also avoids the difficulties involved with describing the areal energy density of variable waste mass. Available data describe burn rates for several HE types that were disposed of as solid, single parts, and this time and temperature information was used to describe the updraft characteristics of several burn scenarios, regardless of the maximum total mass that might actually be present.

Section 2.4 now illustrates the calculations used to estimate updraft velocity. All calculations assume that the ratio of HE mass to effective burn tray area is approximately constant and that the maximum permitted loading at each site will be spread over the full area of the respective tray. For smaller loadings that do not approach the mass limits, roughly the same characteristic spacing will be preserved between solid pieces because the flame must propagate between the pieces to consume all of the waste. The actual thermal column from a large burn may constrict to a roughly circular cross section that is smaller than the burn tray and induce additional lofting through a higher cross sectional

energy density, but this phenomena was ignored in favor of conservative plume suppression based on combustion of single billets. Essentially, the analysis assumptions impose realistic plume characteristics observed for isolated pieces on every postulated release regardless of the total mass loading.

Comment # 3b references the question of whether the magnitude and location of maximum off-site and maximum on-site impacts will change as the mass of waste treated decreases. As explained above, the magnitude of projected impacts will always decrease as the mass of waste decreases from the site-specific maximum loadings. Within the present assumptions of the case studies, the locations of the maxima will also remain the same as the mass of waste decreases. All CALPUFF dispersion studies assume a unit emission rate per second. Plume rise characteristics are specific to each case study and are based on data that describe the behavior of isolated HE pieces that are relatively small compared to the full tray area and total mass limits. The specific mass (large or small) that is used to estimate impacts is simply a linear scaling applied to the dispersion factors; the chosen mass does not change the assumed conditions of the burn in any way, and therefore, will not change the locations of the observed maxima.

While considering the location of the projected maximum impacts, it is worth noting that CALPUFF predictions of time-averaged impacts were generated at all points on a uniform grid with 100-m spacing. The specific point that experiences a maximum is a complex function of the meteorology set that was sampled, the assumed plume rise conditions, and the post-processing averaging time. Important initial conditions that affect plume rise include size, location, temperature, velocity and the point at which temperature and velocity assumptions are applied within the plume. Any changes in the meteorology set, the initial conditions, or the post processing may affect the specific location of the observed maxima. In particular, it is important to note that real burn events will almost certainly not produce maximum exposures at the same predicted locations because of the concerted effort made to suppress predicted plume rise. However, real burn events will always produce lower magnitude maximum impacts than the simulated case studies.

4. *Section 1.1 (Protocol Variances) states, "...the TA-16 Burn Ground Units are too small an area for CALPUFF to model as an area source, so they were modeled as point sources." Based on discussions with the Permittees in addressing NMED's comments on the Permittees' initial Burn Ground Air Pathway Assessment Protocol (Protocol) (LANL, 2007a), NMED expected the Permittees to model the open burning processes at TA-16 as area sources (NMED, 2007 and LANL, 2007b). Assuming that the processes are analogous to a point source represents a significant change in methodology and will require additional explanation and justification by the Permittees.*

   It is not clear if the size issue the Permittees refer to is the result of a data resolution problem, a size constraint built into the version of CALPUFF used by the Permittees, or some other origin. The Permittees must provide an expanded discussion of the problem encountered with CALPUFF's area source algorithm. The Permittees shall also:

   a. *state the size limitations of the area source algorithm;*

   b. *indicate if all available versions of CALPUFF are subject to these size limitations; and,*

c. *identify and discuss the criteria considered in deciding to use the point source algorithm.*

While it is possible to adequately model processes such as the open burning of bulk high explosives (HE) and HE-contaminated wastes using CALPUFF's point source algorithm, its application requires that the expected buoyant rise is adequately represented. As indicated in Section 2.4.6, Area Source Plume Rise, of the CALPUFF User's Guide, CALPUFF computes the plume rise for area sources by solving the mass, momentum, and energy equations free of the Boussinesq Approximation [1](Scire et al., 2000). The plume rise calculation for area sources accounts for the difference in density between the plume and the ambient air and the effects of radiative heat loss. These processes are not considered by the point source algorithm (Scire et. al., 2000). Due to the importance of adequately modeling the source in regulatory air dispersion modeling, the Permittees must demonstrate that the application of the CALPUFF point source algorithm that was used to model the open burning operations at the TA-16 Burn Ground adequately represents the buoyant rise of the open burns that would be predicted by CALPUFF's area source algorithm (Strimaitis, 2007b).

Within Section 2.1 (Unit/Waste-Specific Modeling Scenarios) of the Report, the Permittees present an equation for vertical velocity, w_s (see LANL, 2007c, Section 4.3, Source-Specific Information). However, w_s is never related to the buoyant plume rise predicted by CALPUFF for an area source. Further, it appears that the derivation of w_s presented in the Protocol (LANL, 2007c) does not account for radiative heat loss from the rising plume.

Equation 2-143, Section 2.4.6, Area Source Plume Rise, of the CALPUFF User's Guide (Scire et al., 2000) presents an energy balance for an area source as a function of the change in plume height. Based on the information provided by the Permittees, it is not clear how the expression for w_s in Section 1.1 of the Report is related to Equation 2-143.

In order to ensure appropriate application of CALPUFF in modeling the open burn processes at the TA-16 Burn Ground, the Permittees must demonstrate that the plume rise predicted by the point source algorithm is analogous to that predicted by the area source algorithm. If such a demonstration cannot be made mathematically, the Permittees must perform sensitivity modeling runs using the CALPUFF point source algorithm to determine the change in estimated plume rise due to variations in stack exit temperature, stack exit velocity, and stack cross-sectional area.

The plume rise produced by the actual open burn operations must then be modeled by the CALPUFF area source algorithm using a version of the model not subject to the size constraint encountered by the Permittees (if available) or by a source model with demonstrated capability for modeling the plume rise from an open burn operation (e.g., OBODM, POLU). The results of the two modeling efforts must then be compared to identify a set of input parameter values that will ensure that CALPUFF's point source algorithm mimics the buoyant plume rise obtained from the actual open burning operations (Strimaitis, 2007b).

[1] The Bousinesq Approximation, used in calculating plume rise in the CALPUFF point source algorithm, neglects the density difference between the ambient air and the rising plume except in the buoyancy equation.

If such a set of input parameter values for CALPUFF's point source algorithm cannot be identified, the Permittees' air dispersion and deposition modeling analysis must be repeated using a suitable source model (e.g., OBODM, POLU). Note that CALPUFF provides "plug in" capabilities, allowing the plume rise to be modeled by another source model (e.g., OBODM, POLU) and the result used as ail input to the CALPUFF dispersion and deposition routines (Strimaitis, 2007a). This type of "hybrid" application may offer an approach that reflects the inherent strengths of a dedicated source model and the air dispersion and deposition algorithms in CALPUFF.

Revise the Report to demonstrate that the input parameter values used in the air pathway assessment based on the CALPUFF point source algorithm produce the same buoyant plume rise as the CALPUFF area source algorithm when actual process parameter values are used as model inputs. If such a demonstration cannot be provided, the Permittees must repeat the air dispersion and deposition modeling using source models and/or techniques that constitute a scientifically defensible representation of the open burns performed at the TA-16 open burn ground.

Response: The TA-16 Burn Ground units are not too small to be modeled as a CALPUFF area source, rather they are small enough to be considered as a point source. The statement about this variance in the "Protocol Variance" section of the revised Report (Section 1.2 of Appendix A) has been changed to reflect this. From a practical modeling perspective, in addition to the location and duration of the emissions, the CALPUFF area source requires the following as input: the effective height of the emissions above ground, the elevation of the ground, the effluent temperature, the effective rise velocity, the effective radius for rise calculation, the initial vertical spread, and the emission rate. The point source requires the same information, except the initial vertical spread is not required. Section 2.4 of the revised Report (Appendix A) contains a detailed discussion of the buoyant plume rise formulation contained in CALPUFF and a how the TA-16 source term was approximated using a point source.

5. *According to the Protocol (LANL, 2007c) and the TA-16 General Part B Application (LANL, 2003), the Permittees state that the treatment of three different types of wastes (Bulk HE at TA-16-399, Wet and Bulk HE at TA-16-388, and HE-contaminated waste at TA-16-388) will occur at the Burn Ground. In conversations with the Permittees, it is understood that the Permittees are requesting an allowance to treat a maximum of 20,000 pounds cumulatively (with maximum single treatment events of 1000 lb/treatment of Bulk HE at TA-16-399, a maximum of 250 lb/treatment of Wet or Bulk HE at TA-16-388, and a maximum of 250 lb/treatment of HE-contaminated waste at TA-16-388) of HE annually at the two permitted units with a maximum use of 15,000 gallons/year of propane for treatments at TA-16-388. The Permittees' application (LANL, 2003), however, does not explicitly state these limits (see Attachment G in LANL, 2003). The Permittees must ensure that these quantities are the values for which a permit is sought. If the air pathway assessment successfully demonstrates that these quantities can be treated without negatively impacting human health and the environment, NMED will consider them in setting permit limits (e.g., annual treatment amounts) for the TA-16 Burn Ground in the Permittees' draft renewal permit. Revise the Report to explicitly state that these are the actual treatment volumes for which the Permittees are seeking allowance to treat at the Burn Ground.*

Response: The Report has been revised with a new Section 1.1 to address this comment and the revision is included herein as Appendix A. Although LANL does not oppose the maximum waste

treatment quantities as described in the comment above, these are not consistent with quantities described in the LANL Part A (LANL, 2006) and TA-16 permit application (LANL, 2003). The revised Report explains these quantity differences and the reasoning behind the choice to model these quantities.

Specific Comments:

6. ***Section 1.1, Protocol Variances, Page 1 of 41***

The Permittees indicate that the air pathway assessment for the TA-16 Burn Ground was performed using a meteorological data set that differed from that proposed in the Protocol (LANL, 2007c):

> *"The 1995 meteorological data were not available in a format that could be processed by CALMET, the meteorological model associated with CALPUFF. Meteorological data from 1999 were available in a CALMET-processed file and were used."*

The Report must include the following information related to the meteorological data file from 1999:

a. *the identity of the raw data sets used;*

b. *the identity of any meteorological data preprocessors (e.g., CALMET) used to generate the model-ready meteorological data file for the air pathway assessment; and*

c. *a brief summary of the procedures followed in converting the raw data into a model-ready file. The summary should include references to documents that provided detailed descriptions of the methods used to generate the model-ready meteorological data file (e.g., CALMET User's Guide).*

The Permittees submitted to NMED "Meteorological Input to the CALPUFF Modeling System" (referenced by SWRC: 02-028) dated April 15,2002. However, the Permittees have not cited the document in Section 1.1 or included it in the Report's reference section. If the meteorological data described in the above-referenced document is in fact the data used by the Permittees in the air pathway assessment, the Permittees must revise the Report to accurately cite the document and ensure it is listed in Section 5.0 (References). Revise the Report to address this issue.

Response: The statement "The 1995 meteorological data for LANL has already been approved by NMAQB," within Section 4.3 of the Protocol (LANL, 2007c) was based on an incorrect assumption. The project intention was to use the same meteorological data for the 2007 modeling as was used in the deposition analysis conducted in 2002. The 2002 deposition analysis was conducted as part of the February 2002 "Response to Notice of Deficiency; TA-16 Part B Application Revision 3.0, January 31, 2000" (LANL, 2002a) and was included within the TA-16 permit application (LANL, 2003). The meteorological data for the 2002 analysis were transmitted to the NMED on April 15, 2002 (LANL, 2002b). The data can clearly be identified as data for the calendar year 1999, not 1995. The text within

the "Protocol Variances" section of the Report (Appendix A, Section 1.2) has been revised to reflect this information.

7. ***Section 2.1, Unit/Waste-Specific Modeling Scenarios, Page 2 of 41***

The first paragraph of Section 2.1 describes the modeling of bulk HE that burns rapidly at a relatively high temperature and the modeling of bulk HE that burns slower at a lower temperature so that upper and lower bound values for vertical plume velocity could be addressed in the Report. The two cases were referred to as the maximum and the minimum lofting scenario, respectively. While Section 2.1 (Unit/Waste-Specific Modeling Scenarios) indicates that these scenarios were "referred to in the protocol," no such reference could be found in either LANL, 2007a or LANL, 2007c (see references in Attachment A). For completeness and a transparent description of the modeling analysis, the Permittees must revise Section 1.1 of the Report to indicate that although not proposed in the Protocols, modeling of a maximum and a minimum lofting scenario was performed for the open burning of bulk HE at the TA-16 Burn Ground.

Response: The text within the Report (Appendix A, Section 2.1) has been revised to delete this reference nd clearly explain the scenarios modeled.

8. ***Section 2.1, Unit/Waste-Specific Modeling Scenarios, Page 2 of 41***

With the vertical velocity serving as a key line of evidence in the justification for using the point source algorithm to model the open burning processes at the TA-16 Burn Ground, the Permittees must provide information on the range of vertical velocities expected from the bulk HE burned at the TA-16 Burn Ground in the Report. Revise Section 2.1 to discuss whether or not the vertical velocities derived for use in the air pathway assessment effectively bracket the range of vertical velocities (i.e., represent the maximum and minimum vertical velocities) expected for the bulk HE treated at the TA-16 Burn Ground.

Response: Plume rise is a dominant factor affecting ground-level air concentrations. Plume rise occurs because of buoyancy induced by the temperature difference between the effluent and the ambient air and because of momentum driven by the updraft velocity (see Section 2.4 of the revised Report in Appendix A for details of the plume rise formulation). Together, these phenomena will be referred to as lofting. Generally, increased lofting will decrease ground-level air concentrations. However, lofting can also transport material farther downrange and affect additional receptors, so it is important to investigate a range of possible plume heights that might be associated with HE burn activities. Several key aspects of buoyant plume specification are discussed in the following section before making quantitative recommendations needed for CALPUFF case studies in the remaining section.

9. ***Section 2.1, Unit/Waste-Specific Modeling Scenarios, Page 2 of 41***

With the vertical velocity serving as a key line of evidence in the justification for using the point source algorithm to model the open burning processes at the TA-16 Burn Ground, the Permittees must provide additional information on the calculation of this parameter. Revise the Report to include a summary of the calculation performed in determining the vertical velocities presented in Table 2-1 (Vertical Velocities for Unit/Waste Scenarios). Provide this information for Composition B (COMPB), PBX 9501, propane, and any other constituent for which a vertical velocity was needed.

Response: Section 2.4 has been added within the attached revised Report (Appendix A) to address the calculation of vertical velocity with respect to the input parameters used in CALPUFF. Additional information on other input parameters is also included in Section 2 of the revised Report.

10. ***Section 2.1, Unit/Waste-Specific Modeling Scenarios, Page 3 of 41***

The third bullet on page 3 states that receptor elevations were taken from Digital Elevation Model (DEM) data. Section 1.0 of the Protocol (LANL, 2007c), however, referenced the coordinates of the open burn pads to NAD27 projections. It is unclear whether the same datum was used for source locations and modeled receptor locations when the coordinates were entered into the CALPUFF input files. For clarification and transparency in the description of the air pathway assessment, confirm that the same datum was used. As part of the revised Report, provide an electronic copy of the DEM data utilized in the air pathway assessment.

Response: Current site boundary and road data were obtained from the LANL engineering services division (KSL-UMAP) in New Mexico State Plane coordinates (Central Zone #3002) based on the NAD-83 datum. Approximate easting and northing coordinates for the discrete receptors were visually selected from plots of this data based on relative locations to familiar roads and geographic features. Site boundary and receptor coordinates were then converted to UTM Zone #13 coordinates based on the NAD-27 datum using a free-ware program called GEO_CON available from the United States Geological Survey (USGS). Plots of the converted data overlaid on the DEM-file terrain data confirmed the consistency of the common reference system. CALPUFF accepts lateral coordinates of discrete receptors and then automatically interpolates the terrain data to compute the elevations used for dose assessment. Receptor elevations were never entered manually. Relevant terrain files are provided as Appendix B in an archive named "BurnPermitTerrain.zip" containing data for 6 quadrangles that span the 10-kilometer by 10-kilometer CALMET/CALPUFF dispersion domain. No specific changes have been made to the revised Report (Appendix A) associated with this comment.

11. ***Section 2.1, Unit/Waste-Specific Modeling Scenarios, Page 4 of 41***

The first bullet at the top of page 4 lists burn times for calculating the vertical velocities of COMPB, PBX 9501, and propane. Section 4.2 (Meteorology and Source Specific Input) of the Protocol (LANL, 2007a) indicates that air dispersion and deposition modeling of open burning processes at the Burn Ground would simulate a 1-hour burn time. Revise Section 2.1 of the Report to include the burn time simulated in the CALPUFF dispersion and deposition modeling for open burns conducted at the Burn Ground. If the time differs from the burn times used to calculate the vertical velocities employed in the analysis, revise the Report to include a

discussion of the impact of using different burn times to calculate vertical velocities and to simulate the open burning processes on the output of the CALPUFF model.

Response: Measured characteristic burn times for the predominant bulk HE types of PBX 9501 and COMPB were used to define the combustion rate that drives buoyant plume rise. Actual burn times are controlled largely by the chemical properties and by physical form of the fuel (solid or chips). The combustion rate per unit of tray area determines the physical characteristics of the thermal column including updraft velocity, which in turn has a nonlinear influence on downwind air quality impacts. It is important that the physical behavior of the plume be described realistically to capture these effects, because during a CALPUFF simulated burn, all aspects of the plume are held constant. Supplementary material in Section 2.4 explains how experimental data were combined with parameter variations to describe a realistic range of updraft velocities.

Simulated burn time is a separate issue that does not affect the behavior of the plume and does not contribute uncertainty to the impact assessment. The explanation for this statement is that CALPUFF accumulates over time the total impacts experienced at each receptor. Simulated burn time does control the contaminant emission rate for a given HE mass, but then all emissions are added up (integrated) over the total exposure time. Consistent with the protocol, all simulations were specified to last for exactly 1 hour because this is the shortest time interval in which CALMET computes changing wind fields. Actual burns of solid HE are typically much faster, but the cumulative impact of releasing in a period of 8 to 10 minutes the emissions associated with 250 lbs of PBX 9501 is the same as the cumulative impact of releasing the same emissions over 1 hour.

12. ***Section 2.1, Unit/Waste-Specific Modeling Scenarios, Page 4 of 41***

The Permittees reference author Hatler (1982) in the text but do not include the entire reference in the Report's reference page. Revise the Report including the full reference.

Response: The references within the revised Report (Appendix A) have been changed to address this issue and the memorandum referenced has been included as Appendix C.

13. ***Section 2.1, Unit/Waste-Specific Modeling Scenarios, Page 4 of 41***

The discussion on page 4 notes that a burn rate of one (1) gallon per minute (gpm) was assumed for the propane-only scenario at TA-16-388. This differs from the 25 gallons per hour (gph) per propane burner proposed in Section 3.2.5 (Emission Factors for Open Burning of Propane) of the Protocol (LANL, 2007a). For two burners, the total burn rate for propane in the Protocol was 50 gph compared to the 60 gph (60 min/hr x 1 gal/min) used in the air pathway assessment. Information provided to NMED by the Permittees indicate that calculations performed for estimating 1-hour impacts from burning propane would use a burn rate of 100 gph (LANL, 2007c). It does not appear that a burn rate of 100 gph was used in the 1-hour impact calculations. Revise Section 1.1 in the Report to indicate that the burn rate for propane used in the air pathway assessment differed from that proposed in the Protocol. In addition, explain why a 1 gpm burn rate was used in the air pathway assessment instead of the Protocol value of 50 gph.

Response: The text within the "Protocol Variances" section of the revised Report (Appendix A, Section 1.2) now addresses that the burn rate for propane used in the air pathway assessment differed from that proposed in the Protocol (LANL, 2007c). However, in the comment above, NMED cites statements in both Revision 0 (LANL, 2007a) and Revision 1.0 (LANL, 2007c) of the protocol document. The transmittal letter for the document "Response to Notice of Deficiency Technical Review of the March 29, 2007 Protocol for Air Dispersion Modeling at TA-16", dated April 18, 2007 states that the air impact analysis will be conducted based on Revision 1.0 of the TA-16 Burn Ground Air Pathway Assessment Protocol, not Revision 0. Therefore, Section 1.2 of the revised Report (Appendix A) does not address the variance from Revision 0 of the protocol document, only Revision 1.0.

14. ***Section 2.1, Unit/Waste-Specific Modeling Scenarios, Page 4 of 41***

According to the text on page 4, COMPB chip burn time and temperature data were adjusted based on the differences observed in the data for chip and solid PBX 9501 and PBX 9502. The basis for making such an adjustment must be established within the Report. Revise Section 2.1 of the Report to establish the similarity between COMPB, PBX 9501, and PBX 9502. The Permittees must demonstrate that adjusting COMPB chip burn time and temperature data based on similar data for PBX 9501 and PBX 9502 is a technically sound and acceptable approach. The Permittees must identify this approach as a source of uncertainty in the analysis and discuss the impact of its use on the results of the air pathway assessment. Revise the Report to address this issue.

Response: Available HE burn data were used as described in the revised Report (Appendix A, Section 2.3) to estimate burn times and temperatures for HE types and configurations that did not appear in the data table. This approach is in fact an investigation of uncertainty and is not based on any similarity between the HE types. Rather, the estimates are based on systematic comparisons between burn geometry (solids vs. chips) and measurement techniques (thermocouple vs. pyrometer). Reported data were propagated as needed and were not "adjusted" or "modified" in any way. Estimation of burn times and temperatures in the manner described forms a wider parameter space from which to identify the minimum and maximum lofting case studies that bound uncertainties in emission impacts.

15. ***Section 2.1, Unit/Waste-Specific Modeling Scenarios, Page 4 of 41***

The information on T_s values presented in the fifth bullet on page 4 includes a short discussion on the modification of COMPB chip temperature data based on PBX 9501 and PBX 9502 solid HE temperature measurements. While the discussion indicates that the COMPB data were modified similarly to burn time data for chips, the modifier(s) are not specifically stated. Revise this discussion in the Report to include additional information on how the chip data were modified. The information should be analogous to information provided under the first bullet on page 4 for modification of chip burn times based on burn times for solid HE (e.g., "...solids burn 2 to 4 times longer than the same HE burned as chips. The COMPB burn time was adjusted accordingly.").

Response: Please see response to specific comment #14 above.

16. ***Section 2.1, Unit/Waste-Specific Modeling Scenarios, Page 5 of 41***

The discussion at the top of page 5 indicates that the release height for the burn tray at TA-16-399 is 2.38 meters (m) based on a tray base height of one (1) m. Section G.1.2 (page G-5) in Attachment G (LANL, 2003) lists the leg height of the TA-16-399 burn tray as 1.5 feet (0.46 m). The discussion also states that the TA-16-399 burn tray is lined with firebrick. However, insufficient information was provided to determine the actual height of the tray base. Revise Section 2.1 to include additional information that establishes the appropriate tray base height for TA-16-399.

Response: Section 2.5 of the revised Report (Appendix A) has been changed to no longer mention this within the text, however, Table 2-4 establishes the actual tray base height for TA-16-399.

17. ***Section 2.2, Air Quality Impacts Calculations, Page 5 of 41***

The discussion in Section 2.2 states, "[t]he annual averaging period assumes that 20,000 lb of waste and 15,000 gal of propane are burned at the most conservative unit and the burn size is not considered in calculating impacts." It is not clear how an impact presented in Section 2.2 with units of micrograms of pollutant per cubic meter of air ($\mu g/m^3$) can be obtained from the air modeling results (in units of $\mu g/m^3$ per gram of pollutant emitted per second) without consideration of the amount of waste treated, (i.e., burn size). Revise the Report clarifying this statement and provide a numerical example illustrating the calculation of the annual average impacts presented in Table 2-3.

Response: The Report has been revised in Section 3.0 (formerly Section 2.2) to address this comment and the revision is included as Appendix A. An example calculation of the annual impacts presented in Tables 3-7 and 3-8 along with supplementary explanation of the maximum annual waste treatment quantity have been provided in the modified text.

18. ***Section 2.2, Air Quality Impacts Calculations, Page 5 of 41***

The text does not clearly explain why the TA-16-399 conversion factors were multiplied by four. The discussion in Section 2.2 states, "[b]ecause the fuel amount burned at TA-16-399 is four times higher than at TA-16-388, the TA-16-399 conversion factors were multiplied by four and compared to the TA-16-388 conversion factors." Revise Section 2.2 to include a numerical example clearly illustrating the impact calculation for TA-16-399. Within the calculation, show that the term 1000 lb_{waste}/hr can be represented as four times 250 lb_{waste}/hr. The revision must illustrate that when comparing calculated impacts, the comparison is made between four times the correction factors for TA-16-399 and TA-16-388.

Response: After modeling was completed for the five scenarios outlined in Section 2.1 of the revised Report (Appendix A), all of the conversion factors generated were assessed to determine the highest impact receptor for each averaging period. This process was initially conducted by choosing the

highest on-site and off-site conversion factor/scenario combinations for each of the averaging periods. These conversion factors were selected based solely on their maximum value. However, this process was revised because it was determined that the short-term impacts for TA-16-399 could have the potential to result in higher impacts than those for TA-16-388 because 1,000 pounds of waste can be treated at one time at TA-16-399 and only 250 pounds of waste can be treated at one time at TA-16-388. This would not affect the annual averaging period because the waste volume (20,000 pounds) assessed in this analysis was a total annual maximum for both units combined.

To account for the greater quantity of waste during short-term averaging periods, the conversion factors for TA-16-399 were temporarily multiplied by four in order to determine the true highest impact receptor and conversion factor for each short-term averaging time value. The conversion factors (in their original form) and scenario combinations that resulted from this evaluation were compiled into Table 3-1 (formerly Table 2-3) of the revised Report. The conversion factors that are included in Table 3-1 and that are used in the calculations of emissions and impacts are the actual conversion factors generated by the model, not any of the higher conversion factors used to determine the highest impact conversion factor/scenario combinations. Added text in Section 3 of revised Report (Appendix A) details that the conversion factor/scenario combinations chosen and included in Table 3-1 are the combinations that were determined to have the highest calculated receptor impact rather than the highest conversion factor. A numerical example has not been included as part of the revision because adding a calculation would require the inclusion of all the conversion factors generated by the model to explain the equation, increasing confusion.

19. ***Section 2.2, Air Quality Impacts Calculations, Page 6 of 41***

The discussion at the top of page 6 indicates that in calculating impacts for 3-, 8-, and 24-hour averaging periods, "...the equation doesn't change because the amount of fuel doubles... in the numerator and the number of seconds...doubles in the denominator... " The meaning of this statement is not clear. In determining the impacts for the 3-, 8-, and 24-hour averaging periods, the total mass emitted over the time period considered should be divided by the total time period considered. For example, to calculate an 8-hour average impact, two one-hour burns would occur and the following equation would be applied:

$$EF\ g_{pollutant}/g_{waste} \times 454\ g_{waste}/lb_{waste} \times 250\ lb_{waste}/hr \times 2\ hr \times (1\ hr/3600\ sec) \times (1/8\ hr) \times [CF\ \mu g/(m^3 \cdot g/sec)]_{8\text{-}hr} = [I\ \mu g/m^3]_{8\text{-}hour}$$

Revise the text at the top of page 6 to address the average impacts as stated above as well as the entries in the columns labeled "Waste Burned and Calculated Contaminant Emissions" presented in Tables 2-4 and 2-5 where appropriate. Provide a numerical example illustrating the impact calculation for the columns entitled 3-, 8-, and 24-hour averaging periods listed in Table 2-3. Further, identify and discuss the implemented approach as a source of uncertainty in the air pathway assessment.

Response: The scaling equation suggested in comment #19 for predicting air impacts is not appropriate for this air pathway assessment and would decrease the conservative nature of the analysis. The following, attempts to clarify any confusion that lies in the definition of the time-averaged dispersion factors (called conversion factors within the Report) provided by CALPUFF, which already

implicitly include the averaging period, thus, it is not appropriate to divide the scaling equation by the averaging period a second time.

Given an annual operational sequence that disperses material according to a specified time history, CALPUFF monitors every receptor point of interest, including the uniform 100-meter grid, and accumulates the time-integrated exposure over every averaging period of interest. For the annual average, there will only be one period within a year, for the 24-hour average, there will be 365 periods, etc. Finally, the cumulative exposures are divided by their respective averaging times and the maxima from each group of averaging periods are reported. Mathematically speaking, this process generates a time-weighted average air concentration $\bar{C}_{avg}$ in units of grams per cubic meter {g/m^3} given by

$$\bar{C}_{avg} = \frac{1}{T_{avg}} \int C(t) dt$$

where $C(t)$ is the time-dependent local air concentration {g/m^3}, dt is a small unit of time in seconds {s}, T_{avg} is the averaging time {s} of interest, and the symbol $\int$ indicates summation over small continuous time intervals. The same process is used for cumulative ground deposition except that an additional factor of deposition velocity in meters per second {m/s} is applied to each concentration profile giving a time-averaged deposition flux $\bar{D}_{avg}$ in units of grams per square meter per second {g/m^2/s}.

The above formula for time-weighted air concentration includes all of the time periods when the burn ground is not operating. During these hours, the local air concentrations are 0 g/m^3. For the maximum 1-hour impacts, the zero-level contributions do not affect the averaging. For all other averaging times, zero-level contributions suppress the time-weighted average. The important point is that the averaging time is already inherent to the definition of the CALPUFF dispersion factors.

CALPUFF accepts any possible operational history that can be described in 1-hour increments. For the burn-ground simulations, two operational hours per weekday were sampled at random with the constraints that at least 1 hour of preparation time be provided between the two burns and that the wind speed not exceed 15 miles per hour (6.7 meters per second) at the time of the burn. Twelve random hours exceeded the wind speed limit and 508 simulated burns were executed. For each case study, the plume lofting conditions were held constant for all simulated burns. This operational sequence is a faithful representation of maximum burn-ground activities, but in retrospect, the details are almost irrelevant for the purposes of scaling time-averaged unit-emission-rate dispersion factors, because the simulations serve only to sample variability in the meteorology file. Equally valid results could be obtained by running every hour of (qualifying) meteorology or by randomly sampling an arbitrary number like 1000 hours of (qualifying) meteorology. The important point is that each proposed sampling strategy has an inherent basis given by the number of burn events that contribute to the simulated time-averaged impact.

The level of simulated exposure during an averaging period may or may not match the maximum level of operational exposure during the same averaging period, and this leads to a statistical scaling factor defined as n/N where N is the number of simulations within the period of interest and n is the number

of operations within the period of interest. For the 1-hour, 3-hour, 8-hour, and 24-hour averaging periods, the simulation matches operations exactly, $n/N = 1$, and no correction is needed. For the annual averaging period at TA-16-399, there can only be a maximum of $n = 20$ 1000-lb burn events, and yet, the simulations included $N = 508$ exposure events in the annual averaging period. These examples explain why no changes were required in the formula for 1-, 3-, 8-, and 24-hour average impacts and why the factor of 508 appears in the denominator of the annual-average impacts. An example calculation for the 3-, 8-, and 24- hour averaging periods was added to Section 3 in the revised Report (Appendix A) to clarify the approach used in the analysis.

20. ***Section 2.2, Air Quality Impacts Calculations, Page 6 of 41***

At the end of the first paragraph on page 6, the discussion states, "[a]nnual emissions were averaged over 508 hours, the number of meteorological hours modeled..." The meaning of this statement is not clear. To determine actual annual averages (as would be experienced by receptors at the modeled locations), the total mass of pollutant emitted over a calendar year should be averaged over the total number of hours in a calendar year. Review the information presented at the end of the first paragraph on page 6 and revise as necessary. Provide a numerical example illustrating the calculation of annual average impacts. If the calculation does not show the correct parameter values for calculating the total mass emitted during a year averaged over the total hours in a calendar year, identify and discuss the approach used as a source of uncertainty in the air pathway assessment.

Response: Please see the LANL response to specific comment # 19 above for a detailed explanation of averaging periods. Section 2.2 of the revised Report (Appendix A) includes an additional statement to explain the use of 508 hours resulted from the potential burn times being restricted to hours within the year of meteorology data that were during the daylight hours and winds were $\leq$ 15 miles per hour. Section 3 (formerly Section 2.2) was also revised to include an example calculation for annual air quality impacts.

21. ***Section 2.2, Air Quality Impacts Calculations, Page 6 of 41***

The third paragraph on page 6 discusses the worst-case on-site and worst-case off-site impact receptors and indicates that other receptors have lower impacts than the worst-case impact receptors. This implies that the worst-case on- and off-site impact receptors represent those locations where the maximum on-site CALPUFF modeling result and the maximum off-site CALPUFF modeling result, respectively, occurred. However, the text does not explain how the worst-case on- and off-site locations were determined and the figures in the Report do not explicitly identify which points represent these locations. Revise Section 2.2 to describe how the worst-case on-site and off-site receptor locations were identified and indicate these locations on the figures (see also comment #22).

Response: Dispersion simulations were performed for all combinations of the 5 release scenarios (described in Section 2.1 of the revised Report) and 3 surrogate species (particulate matter, toluene, and nitrogen dioxide). Time-averaged air concentration impacts for toluene were identical to those for

nitrogen dioxide and both were higher than for particulate matter, so only the toluene air impacts were compiled. For ground concentration impacts, the maximum deposition flux observed between the 3 species was recorded at each receptor location of interest.

For each calculation, CALPUFF generated a file of potential receptor impacts based on a uniform 100-meter grid across the entire domain. A digital site boundary map was overlaid and those points "on-site" and "off-site" were sorted in two separate groups to determine the locations and magnitudes of the corresponding maximal impacts. On-site maxima for Figures 3-1 through 3-4 occurred within 200 meters of site TA-16-388 and cannot be discriminated on the map. (The same is true for on-site annual deposition maxima). Locations of maximum off-site impacts on revised Figures 3-1, 3-2, 3-3, 3-4, 4-1, and 4-2 (formerly Figures 2-1, 2-2, 2-3, 2-4, 3-1, and 3-2) in Appendix A are marked on each figure with a red dot. All "off-site" maxima occur at the site boundary. Sections 3 and 4 of the revised Report (Appendix A) have been modified to include a description of how worst case on-site and off-site conversion factors and deposition flux values were chosen. Please see LANL responses to specific comments 18, 28, and 29 for additional information. Maximum calculated atmospheric dispersion factors (or conversion factors) for all receptors are summarized in Table 3-1 of the revised Report (Appendix A). Maximum deposition flux values are summarized in Table 4-1.

22. ***Section 2.2, Air Quality Impacts Calculations, Page 6 of 41***

As indicated in comment #21, little information is provided on the worst case on-site and off-site impacts (identified as HE Max On Site and HE Max Off Site, respectively, in Table 2-3). As such, it is not clear that the worst case on-site and off-site impacts listed in Table 2-3 represent the overall maximum impacts among all on-site receptor locations and among all off-site receptor locations. If they do, this should be clearly stated in the text. If not, on-site and off-site modeled receptor locations with higher predicted impacts than those listed in Table 2-3 must be identified in the text. For any modeled location exhibiting an impact higher than the impacts listed for HE Max On Site and Max Off Site in Table 2-3, identify and discuss in the revised Report the procedures and/or controls used to prevent exposure to human and ecological receptors.

Response: Please see LANL responses to specific comment #s 18 and 21.

23. ***Section 2.2, Air Quality Impacts Calculations, Page 7 of 41***

The first full sentence on page 7 is confusing; off-site impacts should be compared to 0.1 times Environmental Protection Agency's (EPA's) Preliminary Remediation Goals (PRGs). Revise the sentence to read, "[t]he annual off-site impacts are compared with 0.1 times the EPA's PRGs and long-term Ambient Air Quality Standards (AAQSs) in Table 2-10."

Response: The change has been made within the revised Report included herein as Appendix A in Section 3 (formerly Section 2.2).

24. ***Table 2-3, Unit/Waste Scenarios Creating Maximum Impacts by Averaging Periods, Page 9 of 41***

The far left column of Table 2-3 lists the "Receptors" considered in the presentation of maximum impacts by averaging period. While identified by a text descriptor, (e.g., Sombrillo Nursing Care), the modeled location (described by its UTM coordinates and elevation) is not provided. Revise Table 2-3 to include the modeled location for the receptors listed in the far left column (see also comment #32). The Permittees must also revise Figures 2-1, 2-2, 2-3, 2-4, 3-1, and 3-2 in the Report labeling these receptors appropriately.

Response: The former Table 2-2, *Location Specific Information* has been revised to include the locations of special receptors considered in the dispersion analyses as Table 2-5 of the revised Report (Appendix A). Sequential numbering of these receptors is used to identify plotted points in all subsequent figures.

25. ***Table 2-3, Unit/Waste Scenarios Creating Maximum Impacts by Averaging Periods, Page 9 of 41***

The footnote to Table 2-3 states, "TA-16-388 propane was never the most conservative weighted conversion factor." The parameter TA-16-388 propane is not defined. Revise the Report to define this parameter.

Response: The text within Section 2-1 of the revised Report (Appendix A) have been revised to allow for all of the Unit/Waste-Specific Scenarios that were modeled. The footnote to former Table 2-3 (in Appendix A this is now Table 3-1) has been revised to explain the reference to the TA-16-388 propane only scenario more completely in that context.

26. ***Table 2-9, Annual On-Site Impacts, Pages 21 and 22 of 41***

The far right column of Table 2-9 lists and identifies the EPA Region 9 PRGs as the screening level for assessing annual on-site impacts. According to Section 4.1.2 (Step 2-Identify Criteria) (USEPA Region 3, 2002) annual impacts should be screened against 0.1 times the EPA Region 9 PRGs. Revise Table 2-9 in the Report to list and identify 0.1 times the EPA Region 9 PRGs as the screening criteria for annual on-site impacts.

Response: The change has been made within the revised Report (Appendix A) in Table 3-7 (formerly Table 2-9).

27. ***Table 2-10, Annual On-Site Impacts, Pages 23 and 24 of 41***

The far right column of Table 2-10 lists and identifies the EPA Region 9 PRGs as the screening level for assessing annual off-site impacts. According to Section 4.1.2 (Step 2- Identify Criteria) (USEPA Region 3, 2002), annual impacts should be screened against 0.1 times the EPA

Region 9 PRGs. Revise Table 2-10 to list and identify 0.1 times the EPA Region 9 PRGs as the screening criteria for annual off-site impacts.

Response: The change has been made within the revised Report (Appendix A) in Table 3-8 (formerly Table 2-10).

28. ***Section 3.0, Deposition Modeling Results, Page 29 of 41***

The first sentence in Section 3.0 indicates that deposition modeling was performed for the same worst-case unit/waste scenarios addressed in Section 2.0. The third paragraph of Section 3.0 notes that the worst-case unit deposition factors are shown in Table 3-1 (Deposition Fluxes). Neither the text nor Table 3-1 explains how the unit deposition factors listed in the table were selected from among the CALPUFF output to represent the worst-case on-site and worst-case off-site deposition fluxes. Revise Section 3.0 of the Report to describe how the worst-case on- and off-site deposition rates listed in Table 3-1 were chosen.

Response: Section 4.0 (formerly Section 3.0) of the revised Report (Appendix A) includes discussion on how the worst-case deposition flux values were chosen.

29. ***Section 3.0, Deposition Modeling Results, Page 29 of 41***

As indicated in comment #28, little information is provided on the worst case on-site and off-site deposition fluxes listed in Table 3-1. As such, it is not clear that the worst case on-site and off-site fluxes listed in Table 3-1 represent the overall maximum deposition fluxes among all on-site receptor locations and among all off-site receptor locations. If they do, this should be clearly stated in the text. If not, on-site and off-site modeled receptor locations with higher predicted fluxes than those listed in Table 3-1 must be identified in the text. For any modeled location exhibiting a deposition flux higher than the fluxes listed in Table 3-1, identify and discuss the procedures and/or controls used to prevent exposure to human and ecological receptors.

Response: Section 4.0 (formerly Section 3.0) of the revised Report (Appendix A) includes a statement that the deposition flux values chosen were the largest calculated by the model and were determined to result in the highest depositional impact.

30. ***Section 3.0, Deposition Modeling Results, Page 29 of 41***

The discussion at the end of the first paragraph of Section 3.0 states that CALPUFF default parameters for particulate matter, oxides of nitrogen, and toluene were used as surrogates for the constituents considered in the deposition analysis. Specifically, the text indicated:

a. *particulate matter would represent total suspended particulate and PM_{10};*

b. *oxides of nitrogen would represent inorganic gaseous pollutants such as carbon monoxide and nitrogen dioxide; and*

c. toluene would represent emissions of gaseous hydrocarbons.

No information supporting these assumptions was provided. Revise Section 3.0 of the Report to include information supporting the use of CALPUFF default parameter values as surrogates for those constituents addressed in the deposition analysis. The information provided should:

d. demonstrate that the use of the identified surrogates is a technically sound approach and will lead to conservative results for the constituents that they represent; and

e. characterize the uncertainty related to the use of surrogate data so that its impact on the results of the deposition analysis is clear.

Further, identify and discuss in the revised Report this approach as a source of uncertainty in the air pathway assessment. Revise the Report to address these issues.

Response: The use of default parameters for particulate matter, oxides of nitrogen, and toluene to represent the constituents in the deposition analysis table within the Report (Table 4-3, formerly Table 3-3), was consistent with previous deposition modeling analysis conducted for the TA-16 Burn Ground. Supplement H-1 of the TA-16 General Part B Permit Renewal Application, Revision 4.0 (LANL, 2003) states:

> "Pollutant emissions can occur as particles, vapors, and gases. The CALPUFF model, in addition to containing species-specific data for the primary air pollutants (particulate matter, oxides of nitrogen, oxides of sulfur, and carbon monoxide), includes some toxic pollutants in the species library such as toluene and xylene. However, it does not contain data for many of the constituents of concern from the TA-16 Burn Ground. Therefore, LANL used particulate matter with a diameter of less than ten microns to represent particulate emissions (e.g., metals), oxides of nitrogen to represent nonmetallic inorganics (e.g., acids and bases that would be volatilized during treatment), and toluene to represent emissions from the burning of organic compounds (e.g., vapors emitted from the burning of solvents)."

Explanatory text similar to the quoted text is present in the February 2002 "Response to Notice of Deficiency; TA-16 Part B Application Revision 3.0, January 31, 2000" (LANL, 2002a) response to comment 6.d and within Appendix G of the response. Similar text has been added to the revised Report (Appendix A, Section 4) along with a discussion of the uncertainty associated with these assumptions.

31. ***Section 3.0, Deposition Modeling Results, Page 29 of 41***

While the discussion at the end of the first paragraph of Section 3.0 indicates that the CALPUFF default parameters for particulate matter were used to represent total suspended particulate and PM_{10} in the deposition analysis, a surrogate for the metals addressed in the analysis was not identified. Based on information contained in Table 3-3, it appears that the CALPUFF default parameters for particulate matter were used. Revise Section 3.0 of the Report to identify the surrogate used for the metals addressed in the deposition analysis. Further, identify and discuss the use of a surrogate as a source of uncertainty in the air pathway assessment.

Response: As stated in the response to comment #30, the application of particulate matter (PM-10), toluene and nitrogen dioxide as dispersion/deposition surrogates for the many specific pollutants emitted from burning HE was included in past permitting actions (see Supplement H-1 2003-Aug-22 (LANL, 2003)). The following rationale for the use of surrogate species is paraphrased from Supplement H-1 and is supplemented by a discussion of physical parameters that affect deposition behavior.

It is important to note that the three selected species provide only their representative dispersion behavior to describe a plausible range of behavior that includes both significant deposition to estimate maximum ground concentrations and negligible deposition to estimate maximum air concentrations. Species-specific emission factors are still used to compare estimated chemical concentrations to the relevant guidelines. Furthermore, the maximum impact observed among the three candidates was applied to all emissions, so no claim is being made that a given surrogate accurately predicts any specific chemical group.

In the interest of uncertainty assessment, the intent here is to examine a range of plausible behavior and to select the most conservative outcome. This appears to be a practical and common approach, given the paucity of species specific parameters in the CALPUFF library (see below) that is routinely used for air quality assessment. Refined treatment of specific species is generally only warranted when conservative concentration estimates challenge established action levels.

Pollutant emissions can occur as particles, vapors, and gases. The CALPUFF model, in addition to containing species-specific data for the primary air pollutants (particulate matter, oxides of nitrogen, oxides of sulfur, and carbon monoxide), also includes some toxic pollutants in the species library such as toluene and xylene. It does not, however, contain data for many of the constituents of concern from the TA-16 Burn Ground.

Therefore, LANL used particulate matter with a diameter of less than ten microns to represent particulate emissions (e.g., metals), oxides of nitrogen to represent non-metallic inorganics (e.g., acids and bases that would be volatilized during treatment), and toluene to represent emissions from the burning of organic compounds (e.g., vapors emitted from the burning of solvents). Both air concentration and dry deposition rates were modeled with CALPUFF.

The CALPUFF model has a built-in species library that is used to select appropriate chemicals for the air concentration and deposition calculations. The CALPUFF species library is presented in its entirety in Table 1.

Table 1. CALPUFF Species Library

Gas							
Species	Liq. Scav.	Froz. Scav.	D	α^*	React.	Meso. R	H
SO_2	0.00003	0	0.1509	1000	8	0	0.04
NO_X	0	0	0.1656	1	8	5	3.5
HNO_3	0.00006	0	0.1628	1	12	0	8e-8
NO	0	0	0.1345	1	2	25	18
NO_2	0	0	0.1656	1	8	5	3.5
ODOR	0	0	0.1509	1	8	0	0.04
TOLUENE	0	0	0.1509	1	8	0	0.04
XYLENE	0	0	0.1509	1	8	0	0.04
B-PINENE	0	0	0.1509	1	8	0	0.04
A-PINENE	0	0	0.1509	1	8	0	0.04
Particle							
Species	Liquid Scav.	Froz. Scav.	GMMD	GSD			
SO_4	0.0001	0.00003	0.48	2			
NO_3	0.0001	0.00003	0.48	2			
PM10	0.0001	0.00003	0.48	2			
SOA	0.0001	0.00003	0.48	2			
H_2O	0	0	0.001	0			
TXS	0	0	0.001	0			

Note: For gases, Liq. Scav. is the scavenging coefficient (1/s) for liquid precipitation, Froz. Scav. is the scavenging coefficient for frozen precipitation (1/s), D is the Diffusivity (cm^2/s), α^* is a coefficient, React. is the Reactivity, Meso. R. is the Mesophyllial Resistance (s/cm), and H the Henry's Law coefficient. For particles, GMMD is the geometric mass median diameter (μm), and GSD is the geometric standard deviation (μm).

The PM-10 material was used to simulate particulate dispersion and surface deposition. As was used in previous analyses (LANL, 2003), a polydisperse (lognormal) particulate size distribution was simulated using a geometric mass-median diameter of 2 microns, and a geometric standard deviation of 2 microns. For estimating the deposition of non-metallic inorganics, dispersion and gas-phase deposition were simulated for oxides of nitrogen (NO_2). It should be noted that the NO_2 and NO_x species in CALPUFF have identical deposition coefficients (see Table 1). To represent burning of organic compounds, the dispersion and gas-phase deposition of toluene was simulated. Each of these materials, PM-10, NO_2 and toluene, has different diffusivity, reactivity, etc. that affect the amount of material deposited to the surface; however, informal comparisons of annual-averaged air concentrations for NO_2 and toluene were identical for each case study, indicating a weak dependence on the Henry's Law coefficient, H, in Table 1. What follows is a presentation of the CALPUFF deposition flux approximations, and a discussion of how the selection of the NO_2 and toluene species represent nearly the entire range of possible deposition fluxes for all constituents listed in the CALPUFF species library.

In the CALPUFF model (Scire et. al., 2000), the deposition flux is computed by

$$F = v_d \chi_s$$

where v_d is the deposition velocity and χ_s the pollutant concentration at the top of the surface layer. The deposition velocity for gases is computed using a resistance model

$$v_d = \left(r_a + r_d + r_c\right)^{-1}$$

where r_a is the atmospheric resistance (s/m) through the surface layer, r_d is the deposition layer resistance (s/m), and r_c is the canopy (vegetation layer) resistance (s/m). The particulate (PM-10) deposition velocity includes the same resistances terms in addition to the settling velocity of the particulate. Note that precipitation deposition (scavenging) mechanisms were not included because of operational constraints; the burn units are not operated during precipitating meteorological conditions. The selection of the particular pollutant species affects r_d and r_c, and the meteorological conditions simulated affect r_a.

The deposition layer resistance, r_d, is calculated by

$$r_d = d_1 S_c^{d_2} / \left(\kappa u^*\right)$$

where d_1 and d_2 are empirical constants, κ is Von Karman's constant, and u^* is the surface layer friction velocity. The deposition layer resistance is a function of the Schmidt number of the pollutant, $\left(Sc = \nu / D\right)$ where ν is the kinematic viscosity and D is the molecular diffusivity. The surface layer friction velocity, u^*, is a function of meteorological and land use conditions, specifically the mean wind speed and surface roughness.

For a given meteorological condition and the range of diffusivities shown in Table 1, the r_a term may be considered relatively constant for all pollutants in the library. The Henry's Law coefficient (H) shown in Table 1 has the largest range and thus might be expected to have the largest effect on the pollutant surface deposition. The canopy resistance term is calculated as

$$r_c = \left[LAI / r_f + LAI / r_{cut} + 1 / r_g \right]^{-1}$$

where LAI is the Leaf Area Index, r_f is the internal foliage resistance, r_{cut} is the cutile resistance, and r_g is the ground resistance. The LAI and the foliage resistance are solely functions of the meteorological conditions and the land use (imported from the USGS terrain database), and are not

functions of the pollutant species. The cutile resistance, r_{cut}, is a function of the Resistance, R, in Table 1. The ground resistance term, r_g, is computed by

$$r_g = H / \left(\alpha_* d_3 u_*\right)$$

where H is the Henry's law constant, which is the ratio of gas to liquid phase concentration of the pollutant, α_* is the solubility enhancement factor, and d_3 is a constant (equal to 4.8e-4). This term is primarily responsible for the amount of material deposited on the ground surface due to the chemical properties of the pollutant. Table 1 shows that for the gaseous pollutants selected in the modeling effort, NO_2 and toluene, most of the variation in the values of these parameters affecting the deposition velocity are included in the in the NO_2 and toluene species.

32. ***Table 3-1, Deposition Fluxes, Page 31 of 41***

Table 3-1 lists the pollutant type and the worst-case on-site and worst-case off-site deposition rates obtained from the CALPUFF deposition modeling. The locations corresponding to the listed deposition rates are not provided. Revise Table 3-1 to include the modeled location, described by its UTM coordinates and elevation, for each deposition rate listed in Table 3-1. If a text descriptor is associated with the modeled location, the descriptor should be provided as well.

Response: All maximum, emission-specific, annual deposition fluxes reported in Table 4-1 (formerly Table 3-1) are traceable to the minimum lofting scenario at TA-16-388. The table has been revised and included in Appendix A to incorporate the x and y coordinates where these maxima were found. However, it is not practical to report corresponding elevations, because this information is embedded in the terrain files that CALMET and CALPUFF use to develop wind fields and transport material. Contour plots of air-quality impacts provided automatically by CALPOST that were processed independently to locate on-site and off-site points from a uniform grid of postulated receptors do not include the corresponding elevation data. Soil input concentrations reported in Table 4-2 (formerly Table 3-2) occur at exactly the same locations. Deposition fluxes from Table 4-1 have been scaled to account for additional soil concentration factors, but they have not been shifted spatially.

33. ***Table 3-1, Deposition Fluxes, Page 31 of 41***

Table 3-1 does not identify the scenario corresponding to the worst-case on-site and worst-case off-site deposition rates listed in the table. Revise Table 3-1 to include the modeled scenario (e.g., TA-16-388 HE Min) that generated each listed deposition rate.

Response: The revised Report (Appendix A) has been modified to address this concern, please see responses to specific comment #s 29 and 32.

34. ***Table 3-2, Soil Input Concentrations, Page 31 of 41***

Similarly to Table 3-1, Table 3-2 lists the worst-case on-site and worst-case off-site soil input concentrations by pollutant type but does not identify the corresponding modeled locations. Revise Table 3-2 to include information that identifies the modeled locations associated with the listed soil concentrations (see also comment #32 above).

Response: The revised Report (Appendix A) has been modified to address this concern, please see responses to specific comment #s 29 and 32.

35. ***Section 4.0, Regulated Solvent Impacts Analysis, Page 37 of 41***

The second paragraph of Section 4.0 indicates that no bulk solvents have been treated at the TA-16 Burn Ground in several years. The meaning of bulk solvents as related to open burning operations at the TA-16 Burn Ground is not clear. Revise Section 4.0 to define the term bulk solvent. Provide in the revision a comparison of a bulk solvent to an HE-contaminated solvent as they relate to open burning operations at the TA-16 Burn Ground. Also, specify when the last treatment of bulk solvents occurred at the burn ground as well as their composition and volume.

Response: All references to "bulk solvent" in the LANL TA-16 Burn Ground Air Pathway Assessment Report, Revision 0.0 (LANL, 2007b) were used to refer to a waste stream listed in the Waste Analysis Plan (Appendix B) of the 2003 LANL General Part B Permit Renewal Application, Revision 2.0 (LANL, 2003). This waste stream is described as: "HE-Contaminated Solvent Waste - This waste stream consists of HE-contaminated solvents. It is generated primarily by laboratory analysis; research and development, environmental restoration, and decontamination and decommissioning activities; HE production; spills; and the dissolving of HE and polymers." Solvents that are not HE-contaminated are not treated at the TA-16 Burn Ground. Specifically, Section 5.0 (formerly Section 4.0) of the Report attempts to give a conservative estimate of air impacts associated with any HE-contaminated solvents that carry a listed Environmental Protection Agency (EPA) Hazardous Waste Number. One half gallon of an HE-contaminated oil/solvent/water mixture was treated in April 2004. This was the last time that an F-listed solvent was treated at the TA-16 Burn Ground in liquid form (i.e. not as part of contaminated solid waste). Since then, only solids contaminated with trace amounts of regulated solvents have been treated through open burning. Revision 1.0 of the Report (Appendix A) has been edited to remove the term "bulk solvent" to resolve the confusion.

36. ***Section 4.0, Regulated Solvent Impacts Analysis, Page 37 of 41***

The fourth paragraph of Section 4.0 indicates a destruction efficiency of 95% was assumed in the regulated solvent impacts analysis. No information was furnished in support of this value. Revise Section 4.0 of the Report to include information supporting the use of a destruction efficiency of 95% in the regulated solvent impacts analysis. The information provided should include a technically defensible argument supporting a 95% (or higher) destruction efficiency for the open burning of HE contaminated solvents at the TA-16 Burn Ground. Numerical and/or observational data from the Permittees' process or other similar processes (e.g., open burning of solvents where the burn is assisted by an auxiliary fuel source) should be presented and/or referenced as needed. Further, the uncertainty of estimating solvent emissions from the Permittees' process should be discussed to place the regulated solvent impacts analysis in the

proper context. As part of the uncertainty discussion, specifically address the assumed value for destruction efficiency.

Response: The February 2002 "Response to Notice of Deficiency; TA-16 Part B Application Revision 3.0, January 31, 2000" (LANL, 2002a), response to comment 1.a incorporates the initial use of the method described and utilized within the Report. In part, the response states, "There are no data on the efficiency of burning oils and solvents at TA-16-388. However, opacity (visible emissions) during burning is so low based upon the operator's observation during burn events that it is likely that combustion efficiency is high. For air emissions of solvents, it was assumed that the burners would have 95% combustion efficiency, with the other 5% being emitted as the parent chemical." Assumptions used for the Air Pathway Assessment Report were consistent with the 2002 emissions estimations. Text has been added to Section 5.0 (formerly Section 4.0) of the revised Report (Appendix A) to discuss this assumption and the associated uncertainty.

37. ***Section 4.0, Regulated Solvent Impacts Analysis, Page 37 of 41***

Examination of Table 4-1 (Short-Term and Annual Solvents Impacts Estimation) revealed several aspects of the analysis that were not discussed in the text. These include:

a. EPA Region 9 PRGs were used as the chronic screening level rather than 0.1 times the PRGs;

b. deposition was not considered in the calculation of annual solvent limits; and

c. the calculated annual solvent limits assume open burning of solvents during 508 hours per year.

Revise the text in Section 4.0 to include a description and numerical example of the calculation of annual solvent limits and identify and characterize the uncertainties associated with the methodology employed in the analysis so that the results of the regulated solvent impacts analysis are placed in the proper context.

Response: The text within Section 5.0 (formerly 4.0) of the revised Report (Appendix A) has been changed to address these concerns. The chronic screening level was changed to 0.1 times the PRGs and the items addressed in specific comment #s 37b & 37c have been added to the text.

ATTACHMENT A
REFERENCES

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Appendix A

Los Alamos National Laboratory Technical Area 16 Burn Ground Air Pathway Assessment Report, Revision 1.0

LA-UR-08-06542

1.0 Introduction

The Technical Area 16 (TA-16) Burn Ground consists of two units operating under Resource Conservation and Recovery Act (RCRA) interim status:

- the TA-16-399 Burn Tray, which is used to treat bulk dry high explosives (HE) and
- the TA-16-388 Flash Pad, which is used primarily to treat wet HE, combustibles, or other HE-contaminated materials using an external heat source (propane) but can also be used to treat HE.

When Revision 4.0 of the Los Alamos National Laboratory (LANL) TA-16 Part B Permit Renewal Application (LANL, 2003) was submitted to the New Mexico Environment Department (NMED), open burning impacts from the treatment of RCRA wastes were subject to an air permit issued under the NMED's Open Burning Regulation within New Mexico Administrative Code, Title 20, Chapter 2, Part 60 (20.2.60 NMAC). The TA-16 RCRA application referenced the air permit as the means of assessing and regulating air emissions impacts. In 2003, the Open Burning regulation changed to exclude all burning activities covered under RCRA and the Open Burning permit for the TA-16 Burn Ground was withdrawn. This air quality impacts analysis has been developed to support the Technical Area 16 Part B Permit Renewal Application (LANL, 2003) in the absence of an air permit. Model input parameters and assumptions are discussed in Section 2. To provide conservative impacts estimates, this analysis assumes higher quantities of waste treated and more frequent burns than actually occur, and worst-case emission factors. The assumed waste quantities are approximately ten times the amount of waste that is currently burned. These higher levels will not be treated, but provide a conservative analysis. The air quality impacts analysis based on ultra-conservative parameters is presented in Section 3.

LANL previously submitted a deposition modeling analysis based on an actual year's burn activity as part of the TA-16 Part B Permit Renewal Application (LANL, 2003). The deposition modeling has been rerun with the same worst-case assumptions used for the air dispersion modeling, to provide an equally conservative deposition impacts analysis. The deposition modeling analysis is described in Section 4. An analysis of potential solvent releases, as requested by NMED and described in the TA-16 Air Pathway Assessment Protocol, Revision 1.0 (LANL, 2007), is contained in Section 5. Section 6 includes a discussion of the results and conclusions of this report.

Both the air quality impacts and deposition analyses were conducted using the CALPUFF (Scire et. al., 2000) modeling package. The rationale for choosing CALPUFF is described in the protocol document (LANL, 2007), submitted to NMED on May 31, 2007.

1.1 Capacities and Typical Open Burning Treatment Operations

The most recent LANL Part A Permit Application (LANL, 2006) and Attachment G of the LANL TA-16 Part B Permit Renewal Application (LANL, 2003), list capacities for the units at the TA-16 Burn Ground: TA-16-388, 100 gallons or 40,000 pounds per burn (lbs/burn); and TA-16-399, 1,000 lbs/burn. The 40,000 lbs/burn limit at TA-16-388 takes into consideration all solids that may be placed on the pad. This includes the weight of large machine tools, other equipment, and soil that do not burn and should not necessarily be counted as part of the waste treated. Annual burn limits for the TA-16 Burn Ground are not listed in the permit application documents.

The air dispersion and deposition modeling conducted for the TA-16 Burn Ground as detailed in this report, assumes that a maximum amount of 250 lbs/burn of HE or HE-contaminated combustible material can be treated at TA-16-388 at any one time. This weight does not take into account other non-combustible solids that may be present during a burn at TA-16-388 so that a representation of the maximum amount of waste that can be treated at one time could be analyzed for air impacts. Additionally, this air impact analysis report assumes that the maximum amount of HE and HE-contaminated combustible waste that can be treated at both units annually is 20,000 lbs. This approach allowed for the calculation of annual air impacts for a potential maximum volume of waste per year and the calculation of the cumulative effects associated with that potential maximum. Past analysis derived the potential volume of waste from a single year's data. This air impact assessment was designed to give a worst-case analysis, therefore, a maximum waste volume was chosen.

The maximum waste quantities modeled for the TA-16 Burn Ground are: 250 lb/burn HE or HE-contaminated waste at TA-16-388, 1,000 lb/burn HE waste at TA-16-399, and a maximum quantity of 20,000 lb/year at both units combined. Actual operations at the TA-16 Burn Ground are generally much reduced from the quantities of waste modeled in this analysis. In fact, since 2003, the annual quantity of waste treated at the TA-16 Burn Ground has not been over 5000 lbs. Accurate quantities for the waste treated prior to 2003 are not available for direct comparison because the weights of equipment pieces and soil were included in the total waste quantity sums. Current practices record the estimated quantity of HE on the equipment piece or within the soil as the treated volume of waste and the weight of the equipment or soil are kept separately.

Additionally and as explained in the protocol (LANL, 2007), the waste streams that are actually treated at the TA-16 Burn Ground are different from and in general less hazardous to human health and the environment than the waste streams that the emissions factors used in this analysis are based upon. No attempt was made to eliminate non-characteristic emissions from the analysis, which increases the conservative nature of the analysis. Waste stream emissions factors that have been chosen for this analysis estimate a higher air impact than would actually be released from day-to-day operations at the TA-16 Burn Ground.

1.2 Protocol Variances

The air and deposition impacts analyses were conducted in accordance with the protocol (LANL, 2007) except for some minor changes. The 1995 meteorological data were not available in a format that could be processed by CALMET, the meteorological model associated with CALPUFF. Meteorological data from 1999 were available in a CALMET-processed file and were used in the development of past deposition modeling for the TA-16 Burn Ground (LANL, 2003). These data were transmitted to NMED in 2002 (LANL, 2002) and were confirmed to be 1999 meteorological data files. When the modeling protocol (LANL, 2007) was drafted, it was incorrectly assumed that 1995 data were used in the development of the previous deposition modeling rather than 1999 data. It was intended that the data used be the same as the previous data; therefore, the 1999 data were used in the present analysis. Also, the TA-16 Burn Ground Units are very small areas compared to the resolution of the wind field for CALPUFF to model realistically as an area source, so they were modeled using point source rather than area source options. Point source options allow for definition of finite initial volumes, updraft velocities and temperatures in much the same manner as the area source options.

The modeling protocol (LANL, 2007) states in Section 5.1 that when propane-assisted burning creates the highest estimated impact, the impact would be calculated by adding the calculated impact for the pollutant of interest to the calculated impact of propane for the pollutant of interest. Model runs did not indicate that the propane burning at TA-16-388 (discussed in Section 2.1) was ever the worst-case scenario, so propane emissions were calculated but not added to the impact analysis calculations for off-site impacts. Therefore, Section 5.1 of the modeling protocol (LANL, 2007) shows an example of a situation that did not occur during the analysis. Propane emissions were added to the annual off-site impacts outlined in Table 3-8 only. A maximum of 15,000 gal/yr propane use estimation was used for those calculations. These calculations do not take into account individual waste treatment sizes, but are designed to give an idea of an overall annual maximum emissions impact.

Additionally, the model run used to estimate emissions from propane-assisted burning as outlined in Section 2.5 utilized a burn rate of 1 gal/min to describe the updraft characteristics rather than calculating how much propane would be used per burn if 15,000 gallons of propane were used in one year. The value of 1 gal/min is derived from operational experience that indicates that the propane fuel reserves are depleted at that rate when both of the burners that are used at TA-16-388 are operating. The TA-16-388 flash pad was designed with a third propane burner at the back side of the pad, but it was found to create an asymmetric flame pattern that was not centered on the combustion tray. Therefore, only the two opposing burners are used for routine waste treatment at TA-16-388.

2.0 Air Quality Modeling Scenarios and Parameters

The first step in performing the air quality modeling was to determine which unit/waste combinations had the worst case impacts. These results are discussed in the first paragraph of Section 3.0. The second step was to use the worst-case unit/waste conditions to calculate air quality impacts, discussed throughout the remainder of Section 3.0. Parameters not specifically addressed within this report are discussed in the modeling protocol (LANL, 2007), submitted March 31, 2007.

2.1 Unit/Waste-Specific Modeling Scenarios

The two units, TA-16-388 and TA-16-399, treat different amounts and types of waste which affect the amount of pollutants emitted as well as the plume rise and dispersion from each unit. The first step in the modeling was to determine which units/wastes created the worst case on-site and off-site impacts for each averaging period. The modeling protocol (LANL, 2007) proposed to evaluate the impacts of burning 1000 pounds (lb) of HE at TA-16-399, 250 lb of HE at TA-16-388, and propane-assisted burning of less energetic HE-contaminated materials at TA-16-388. The first two scenarios were refined by evaluating both an HE that burned rapidly and an HE that burned less rapidly in combination with variable burn temperature, variable ambient temperature and variable burn-tray area to provide an upper and lower bound for vertical plume velocity. These are referred to in this report as "maximum lofting" and "minimum lofting" scenarios. To summarize, the following scenarios were modeled:

- TA-16-388 with maximum lofting,
- TA-16-388 with minimum lofting,
- TA-16-388 with propane only,
- TA-16-399 with maximum lofting, and
- TA-16-399 with minimum lofting.

The description TA-16-388 with propane only" refers to the assumption that only the energy of the propane burners was used to drive buoyancy; additional energy from the burning waste was neglected to suppress plume rise. However, emissions for this case *were* based on the maximum quantity of waste expected at TA-16-388. The modeling runs confirmed that the minimum lofting HE had the highest impacts on-site and at some nearby off-site locations but that overall the maximum lofting HE had the highest impacts at more distant off-site receptors. Figures 3-1 through 3-4 show the effect of maximum and minimum lofting on air concentrations.

2.2 General Burn Parameters/Assumptions

All modeling runs assumed the following:

- Each burn occurs in < 1 hour (hr) to provide the most conservative short-term impacts.
- Burns are separated by at least 1 hour of preparation time.
- Two burns a day would be conducted 5 days a week. In fact, TA-16 Burn Ground typically burns waste once or twice a week.
- Specific burn times were randomly sampled from an annual set of hourly meteorology data to begin during daytime hours and allow at least 1 hr of preparation time between burns. Burn times were restricted to hours with winds $\leq$ 15 miles per hr, similar to actual

conditions when burning occurs. This resulted in 508 hours of meteorological data used in the analysis rather than the 520 hours that one might expect from 2 burns per weekday throughout the year.

- A 20 kilometer (km) by 20 km receptor grid was centered on the Burn Ground, with receptors spaced at 100 meter (m) intervals. Additional discrete receptors at public areas such as residential areas, hospitals, and Bandelier National Monument were included.
- Receptor elevations were determined from Digital Elevation Model (DEM) data imported into the model.
- A standard 1 gram per second (g/s) emission rate was used to obtain the conversion factor that is applied to pollutant-specific emission rates in Section 3.

2.3 Burn Rate

For the HE-only burns, Composition B (COMPB), which is 60 percent by weight (wt. %) cyclonite (RDX) and 40 wt. % trinitrotoluene (TNT), was used to represent a high energy release (high heat of combustion and burn rate) waste. PBX 9501 (95 wt% Cyclotetramethylenetetranitramine (HMX) and 5 wt. % inert binder) was used as a lower energy release waste. These explosives were selected because experimental data on their burning characteristics was available to calculate vertical velocity. Similar data is not available for the pure explosives such as TNT. For the propane-assisted scenario with less energetic wastes (e.g., HE-contaminated materials, PBX 9502), the energy releases were calculated assuming that the heat released was only from the propane used at TA-16-388 to improve burning; it does not take credit for the energy and additional plume rise caused by the burning waste material.

Burn rate and temperature are important parameters that affect plume rise, and they vary based on the type of HE and on the physical configuration of the waste (solid billets versus chips and pellets, for example). Handbook references for HE properties focus on idealized configurations and highly controlled calorimetry measurements, so it is desirable to use data representative of burn-ground operations wherever possible. Table 2-1 summarizes burn-time and temperature data reported in Hatler 1982 for several types of HE and two physical configurations including solid pieces and collections of machining chips and casting pellets.

Table 2-1 entries in parentheses have been estimated by observing trends in the available measurements. For example, the burn time of a HE type varies by a factor of 2 to 4 depending on its geometry (56 minutes/23 minutes ≈ 2 for PBX 9502 and 8 minutes/2 minutes = 4 for PBX 9501). Burn time is greatly affected by the surface area exposed to combustion, which explains why chips and pellets burn faster than large solid pieces. The range of 2 to 4 in burn time captures typical variability caused by geometry, independent of chemical combustion properties, so it is reasonable to assume that solid COMPB might burn 2 to 4 times longer than the observed measurement of 0.75 minutes for machining chips. This is the basis for the 1.5-3 minutes burn time for solid COMPB shown in blue in Table 2-1.

When considering HE burn times it is important to understand that waste materials are never stacked in piles within a given tray area, because confinement of combustion gases can initiate an unplanned detonation. Solid pieces are separated by several inches of space and chips/pellets are spread uniformly across the tray. This means that burn times for a batch are determined more by the type of HE and the geometry than by the total mass, because the pieces burn almost independently. Doubling the mass does not double the required burn time. In fact, the burn time

is roughly constant regardless of the total mass on the tray, as illustrated in the table by two batches of PBX 9501 chips of size 226 kilograms (kg) and 408 kg that both burned in approximately 2 minutes. This operational safety practice of distributing pieces across the tray also implies that (for a given HE type) the energy release rate per unit of loaded tray area is roughly constant.

Plume rise and dispersion from burning HE are driven by (1) the size of the column, (2) the velocity of the updraft, (3) the temperature of the gas, and (4) the height at which the first three parameters are known. The particular location where this information is obtained does not matter as much as the fact that all parameters are determined in a self-consistent manner; however, simple models will be more successful if data are taken in a gaseous region away from the heart of the flame where rapid temperature gradients caused by air mixing and radiative heat transfer are not as severe.

With these objectives in mind, the thermocouple data from Hatler 1982 were judged to be the most relevant temperature estimates for driving buoyant plume rise. Theoretical temperatures are based on chemical equilibrium equations with no heat transfer, but they provide an upper-bound check on the validity of the other direct measurement techniques. Pyrometer measurements provide a direct line of sight to the combustion surface, but at this location in the burn no significant air mixing or radiative losses have occurred. Although, the thermocouples in the subject tests were placed on the initial surface of the HE, they did experience convective and conductive heat transfer processes. The reported temperatures are still probably higher than the ideal measurement described above, but this overestimate conservatively suppresses updraft velocities calculated by Equation 1 below and compensates for the lack of a formal treatment of radiative heat losses in the CALPUFF point-source plume-rise model.

Table 2-1 includes thermocouple measurements for solid PBX 9501 that can be used directly in the analysis, but thermocouple temperatures for COMPB were estimated in a two-step process:

1. A systematic relationship exists between the thermocouple and pyrometer measurements of a single test. Burn tests of solid PBX 9501 and PBX 9502 included both measurement types, and the ratio of thermocouple temperature divided by pyrometer temperature for these tests ranges from 0.865 to 0.961. These ratios were applied respectively to available PBX 9501 and PBX 9502 chip pyrometer measurements to obtain estimated thermocouple temperatures for those tests. Both ratios were applied to the reported COMPB chip pyrometer temperature to obtain a range of estimated thermocouple temperatures for COMPB chips.
2. The ratio of chip burn temperature divided by solid burn temperature was found to vary between 0.922 and 1.000 for PBX 9501 and PBX 9502, respectively. These ratios were applied to the range of estimated COMPB chip thermocouple temperatures to obtain a range of estimated burn temperatures for solid COMPB. Note that in all comparisons, minimum and maximum estimates were combined as needed to extend the estimation range as widely as possible. It is also important to note that absolute temperatures reported in Kelvin (K) should be used when forming ratios of temperatures.

2.4 Buoyancy Driven Dispersion

Plume rise formulas used by the CALPUFF model are first presented in a review of theoretical considerations. This discussion below is extracted verbatim from the CALPUFF Users Guide (Scire et. al., 2000), with slight changes in the nomenclature. Inherent to all CALPUFF source

descriptions is the specification of initial updraft velocity, so a practical formulation of this parameter is discussed next. Finally, a parametric investigation of plume height and ground-level air concentrations is developed for exercising CALPUFF over a range of HE burn rates, burn area, and atmospheric stability conditions. The assumptions used to calculate vertical velocity and the values for each variable follow.

Briggs Plume Rise Formulas

The basic point-source plume rise formulation for buoyant emissions that is employed by CALPUFF (and many other plume rise simulations) was developed by Briggs (1975). For neutral or unstable atmospheric conditions, the plume rise is given as (Scire et. al., 2000, Section 2.4.1)

$$\Delta h = \left(\frac{3F_m x}{\beta_j^2 u_s^2} + \frac{3Fx^2}{2\beta_1^2 u_s^3} \right)^{1/3}$$

(Equation 1)

Where:

$F_m = (T_a/T_s) w_s^2 r_s^2$ is the momentum flux in meters to the fourth per squared second (m^4/s^2),

$F = (g/T_s) w_s r_s^2 (T_s - T_a)$ is the buoyancy flux in meters to the fourth per cubed second (m^4/s^3),

u_s is the stack-height wind speed in meters per second (m/s),

x is the downwind distance meters (m),

β_1 is the neutral entrainment parameter (≈ 0.6),

$\beta_j = 1/3 + u_s/w_s$ is the jet entrainment coefficient,

w_s is the effluent gas exit speed (m/s),

T_a is the ambient air temperature in Kelvin (K),

T_s is the exit gas temperature (K),

g is the acceleration of gravity in meters per squared second (9.812 m/s^2), and

r_s is the effective radius of the burn area (m).

During stable conditions, the final plume rise is determined by

$$\Delta h_s = \left(\frac{3F_m}{\beta_j^2 u_s S^{1/2}} + \frac{6F}{\beta_2^2 u_s S} \right)^{1/3}$$

(Equation 2)

Where:

β_2 is the stable entrainment parameter (≈0.36),

$S = (g/T_a)(d\theta/dz)$ is the static stability parameter, and

$d\theta/dz$ is the potential temperature lapse rate (≈0.1 K/m for stable conditions).

Transitional plume rise during stable conditions is computed by Equation 1 up to the point at which $\Delta h = \Delta h_s$. For low wind speed and calm conditions during neutral or unstable conditions, a minimum wind speed of $u_s = 1$ m/s is imposed. During stable conditions, the following equation is used to compute the plume centerline rise for buoyant plumes:

$$\Delta h_s = 4F^{1/4}/S^{3/8} \qquad \text{(Equation 3)}$$

Momentum rise during stable conditions is computed with a minimum wind speed of $u_s = 1$ m/s, but this is not allowed to exceed the momentum rise for neutral conditions.

For HE burn conditions, the updraft velocity w_s needed to evaluate the momentum and buoyancy flux terms is determined by a balance between energy released from the fuel, energy absorbed by the entrained air, and energy radiated to the surroundings. If H_C is the heat of combustion for a given HE type in Joules per kilogram {J/kg} and R is the bulk-averaged burn rate in kilograms per second {kg/s}, then the rate of energy released by combustion $H_C R$ {W} must equal the rate of energy absorbed by the air plus any radiative losses that occur *prior to the point of effluent-temperature measurement,* i.e.,

$$H_C R = \dot{m} c_P \Delta T + \varepsilon \sigma A \left(T_c^4 - T_s^4\right) \qquad \text{(Equation 4)}$$

where c_P is the constant-pressure heat capacity of air {J/kg-K}, $\dot{m}$ is the mass flow rate of air {kg/s}, $\Delta T = T_s - T_a$ is the temperature increase {K} between ambient air and the exhaust products leaving the burn, ε is the emissivity of the combustion gas volume, $\sigma = 5.670 \times 10^{-8}$ {W/m^2-K^4} is the Stefan-Boltzmann constant, T_c is the temperature of combustion {K}, and A is the cross sectional area {m^2} of the burn. Assuming a constant nominal air density ρ_a {kg/m^3}, the mass flow rate can be expressed as $\dot{m} = \rho_a A w_s$. Substituting $\dot{m}$ into Eq. (26) and rearranging gives a formula for the updraft velocity

$$w_s = \frac{H_C R}{\rho_a c_P A \left(T_s - T_a\right)} - \frac{\varepsilon \sigma \left(T_c^4 - T_s^4\right)}{\rho_a c_P \left(T_s - T_a\right)} \qquad \text{(Equation 5)}$$

that can be specified in terms of known or parameterized properties of a burn scenario.

The first term of Equation 5 can be interpreted as updraft generated by heat absorbed in entrained air. The second term can be interpreted as updraft suppression resulting from immediate radiative losses to the ambient atmosphere. Inconsistencies can appear in a simple formula like Equation 5 depending on where temperature measurements are taken and how they are interpreted. For example, when estimates of the gas temperature T_s are too high, radiative suppression will exceed the buoyant updraft and w_s will be less than zero. Given uncertainties noted below and the desire to rely on actual measurements of burn temperature to identify a wide range of plausible updraft conditions, the radiative correction term will not be carried forward.

Estimated updraft velocities are appropriately minimized by assigning all of the heat generation to gas temperature increase and neglecting the radiative correction term of Equation 5 whenever the estimated gas temperature is sufficiently high. Using pyrometer measurements of solid PBX 9501 burns as the estimated combustion temperature and corresponding thermocouple measurements as an estimated gas temperature leads to a radiative updraft suppression (second term) estimate for PBX 9501 of -2.44 m/s. Later tables show that the largest updraft (first term) estimated for PBX 9501 burns is only 0.89 m/s. This example confirms that available thermocouple measurements are conservatively high because they were taken at a point in the flame before full air mixing and initial radiative losses could occur. The same conservatism is inherent to all of the burn data, so a refined radiative loss correction is not warranted.

Several attributes of Equation 5 (first term only) should be emphasized. The updraft velocity is generally assumed to be constant during a burn; so all factors are specified based on nominal values. Of all the factors, burn rate is perhaps the most variable during a real scenario. Air properties ρ_a and c_p are generally specified at ambient conditions and slightly more plume suppression is provided by using the larger values associated with ambient-temperature air. The cross sectional area is intended to describe the size of the column rising from the pad, so if the fuel is widely distributed across a tray, the effective column area may be smaller than the footprint of the fuel. The exhaust temperature may be difficult to specify because it is intended to describe the initial temperature of the exhaust gases entering the buoyant column. These gases include both combustion products and the entrained air. Theoretical burn temperatures computed by CHEETAH (Fried et. al., 1998) do not include an estimate of thermal equilibrium between the combustion products and the air, neither do they include direct radiative losses of energy to the surroundings; therefore, they are probably too high to be used without compensation for these effects. Similarly, pyrometry measurements reported in Table 2-1 give a more direct measurement of flame temperatures in the combustion zone, but do not account for mixing. Given these considerations, thermocouple data are perhaps most representative of the desired gas temperatures.

Ground-level air-quality impacts are generally maximized by selecting parameter values that suppress the plume rise. Examination of Equations 1 and 4 show that plume rise is directly proportional to both the momentum and buoyancy flux, which are both directly proportional to the updraft velocity. Therefore, minimizing w_s will minimize the effective plume height. While it is natural to think that a "hotter" fire will drive higher plumes, Equation 5 (first term only) shows that a higher gas temperature actually *decreases* the updraft velocity for a given area and heat generation rate because ΔT is in the denominator. This apparent contradiction is resolved by remembering that volumetric airflow is driving the velocity. If the air can efficiently absorb the released energy and incur a larger temperature increase, then less flow is required across a given area.

Selection of Case-Study Conditions

Plume rise is a dominant factor affecting ground-level air concentrations. Plume rise occurs because of buoyancy induced by the temperature difference between the effluent and the ambient air and because of momentum driven by the updraft velocity. Together, these phenomena will be referred to as lofting. Generally, increased lofting will decrease ground-level air concentrations. However, lofting can also transport material farther downrange and affect additional receptors,

so it is important to investigate a range of possible plume heights that might be associated with HE burn activities. Several key aspects of buoyant plume specification are discussed below before making quantitative recommendations needed for CALPUFF case studies in the remaining section.

Key Aspects of Buoyant Plume Specification

Input parameters needed to fully specify a buoyant plume in the CALPUFF dispersion model include: the area A_s $\{\mathrm{m}^2\}$, the effective radius r_{eff} $\{\mathrm{m}\}$, the vertical velocity w_s $\{\mathrm{m/s}\}$, the effluent temperature T_s $\{\mathrm{K}\}$, the release height z_s $\{\mathrm{m}\}$, and the initial vertical spread $\sigma_{z_0}\{m\}$. In the case of a point source, A_s and σ_{z_0} are obtained from r_{eff} by assuming a spherical release volume. Together, these attributes define the initial conditions of a packet or "bubble" of hot gas that will expand while rising and mixing with ambient air to dilute and disperse entrained pollutants. As explained earlier in this section, vertical updraft velocity can be derived by balancing the amount of ambient air that must be entrained to absorb the combustion energy and attain a given exhaust temperature while rising across the area of the burn. The formula obtained by this argument neglects the volume of combustion gases, and it assumes perfect heat transfer to the air without radiative losses. Despite these simplifications, the simple energy balance provides a framework for visualizing a spatial volume in which temperature, velocity, and size must be specified in a self-consistent manner.

There is no absolutely correct choice for the combination of size and temperature that is used to define an initial source puff. A rational choice will homogenize, or average, complex physical phenomena like combustion chemistry and turbulent mixing into a volume that is suitable for the level of complexity (or lack of complexity) offered by the plume rise formulation. In many buoyant dispersion applications, it is common to initialize the height approximately equal to the diameter so that the unit puff is spherical. This is the approach followed in this analysis; the characteristic height is conceptualized as being equal to twice the effective circular radius, which can range from 1.0 to 1.4 m on the trays at the burn ground. Thus, for the largest burn scenarios, temperatures must be selected that represent spatial averages over a 2 to 3-m diameter sphere. Note from Equation 5 (first term only) that higher source temperatures in the denominator will suppress the updraft velocity, because a smaller volumetric flow of air is required to attain the presumed temperature.

Temperature data for burning HE is available from three sources: thermocouples placed on the surface of solid HE, optical pyrometers, and point kinetics thermochemistry models Table 2-1. Combustion chemistry predictions generally represent an idealization of maximum energy release through sequential oxidation steps and adiabatic equalization of combustion gas temperatures without any ambient mixing. Temperatures predicted under these assumptions are quite high and they are relevant only to the thin combustion boundary at the surface of the burning HE. Pyrometer measurements can suffer from a similar specificity to the combustion boundary unless they are focused over the appropriate-sized volume. Thermocouple measurements can suffer from nonuniform heat transfer conditions caused by relocation during the burn, but the available measurements were taken near the surface of the HE and still represent conservatively high estimates of the gas temperature when presumed to be homogeneous over the desired volume. Recall that using higher estimates of temperature than are actually expected to occur will suppress plume lofting and generally increase ground-level air

concentrations. Proper temperature measurements for initializing plume rise calculations might best be obtained by suspending thermocouples 5 to 10 feet above the burning material.

In classical Gaussian dispersion models, of which CALPUFF is a discretized numerical variant, the spatial dispersion coefficients σ_x, σ_y and σ_z literally specify the standard deviations of the spatial concentration field in the x, y, and z dimensions. Thus, in the cross-wind direction, the concentration field varies according to a normal distribution, or bell-shaped profile, with the peak on the centerline and the width characterized by the standard deviation σ_y. The rapidly moving vertical exhaust column can be represented by a stream of discrete puffs that are widely spread vertically and completely overlapped at their edges to create an initially uniform concentration within the rising column. In order to initialize the vertical spread of a unit puff while spreading the mass across the span of successive puffs, only a reasonably dominant percentage of the aerosol mass distribution should be packed within the characteristic vertical dimension $2r_{eff}$. From introductory statistics, it is commonly known that 68% of the normal probability distribution is contained within ±1 standard deviations, 95.4% is contained within ±2 standard deviations and 99.75% of the probability distribution is contained within ±3 standard deviations, etc. To achieve the desired overlap with only 68% of the puff mass located within the characteristic height, the initial vertical spread could be set according to the formula $2\sigma_{z_0} = 2r_{eff}$, or $\sigma_{z_0} = r_{eff}$.

This is a very subjective selection process for a parameter that can have dramatic effects on the initial release concentration, and no definitive guidance exists on proper specification of σ_{z_0} for rapidly rising buoyant columns. However, the CALPUFF point-source option, which was used exclusively for the analysis computations, does not require an explicit specification of the initial dispersion parameters. It is presumed that σ_x, σ_y and σ_z are set equal to effect a spherical release, and it is most likely that $\sigma_{i_0} = r_{eff}$ as illustrated above for the initial vertical spread; however, no confirmation of these assumptions could be found in the theory manual or users guides.

Increased lofting tends to suppress ground-level air concentrations through increased dilution, but increased lofting may also be a characteristic of large burns that release more pollutants. The competition between increasing source-term mass and increased dilution was explored through a limited set of parametric studies using elevated Gaussian plume results in moderately stable atmospheric conditions. These studies suggest that increasing the source term mass always dominates the potential effect of enhanced dilution at the point of maximum downwind air concentration, so it is appropriate for case studies to use maximum desired permit quantities. (A contradictory result could be conceived where a smaller HE mass results in a higher concentration to a given receptor because of less dilution).

Perhaps the easiest way to explain this finding is to examine the formula given for updraft velocity, Equation 5 first term only, which expresses the vertical velocity in terms of key burn-scenario attributes. If the burn rate is written as $R = M_b/t_b$ for burn mass M_b and burn time t_b, then the formula for vertical velocity can be factored into terms that depend on the HE type and terms that depend on the location of the burn, i.e.,

$$w_s = \frac{H_C}{\rho_a c_p t_b (T_s - T_a)} \cdot \frac{M_b}{A_s} \quad \text{(Equation 6)}$$

The first factor has units of $\{m^3/s/kg\}$ and can be interpreted as the volumetric flow rate of air per unit mass of HE that is burned. This factor is a unique attribute of the dominant HE type that is present. The second factor has units of $\{kg/m^2\}$ and can be interpreted as the initial area-averaged mass density, or surface concentration, of HE that is loaded on a tray.

Pieces of solid HE are loaded on a burn tray with sufficient separation distance to avoid confinement of combustion gases that might lead to detonation. Stacking of pieces is strictly avoided. Therefore, the ratio M_b/A_s is approximately constant, because, as the mass of HE increases, so does the area required for the burn. Isolation of pieces on the tray also means that each piece burns somewhat independently after ignition. This implies that the time required to burn 10 pieces is roughly the same as the time required to burn 1 piece of the same type and size of HE. Of course, somewhat disparate times are required to consume pieces that vary in size, but the important observation is that the burn time *does not* scale with total mass in a linear manner. Experimental burn times were reported in Table 2-3 for relatively large billets of pressed HE, so the characteristic times are relatively long compared to that expected for smaller pieces with higher surface area. Using these longer periods to estimate burn times for large loadings tends to suppress the vertical velocity.

The two observations that (1) the HE mass-to-area ratio is approximately constant and (2) the burn time is relatively constant regardless of total mass explain why large burns of solid material always produce higher air concentrations – the vertical velocity, and hence, the lofting is approximately the same for a given HE type regardless of the quantity that is burned. For the same amount of lofting, larger burns release pollutants at a faster rate than smaller burns, which increases downwind air concentrations.

2.5 Recommended Case Study Parameters

A broad selection of representative burn conditions was reviewed to select case-study parameters that both maximize and minimize vertical lofting from each burn site. In addition, a case was constructed for a propane-driven burn at TA-16-388. For this case, only the heat released from propane was used to loft the plume; all other energy from HE or mixed waste was ignored in order to suppress the plume. Thus, five cases were defined for evaluation using the CALPUFF dispersion model. All of the factors in Equation 6 with known variation or substantial uncertainty were examined for their potential effect on updraft velocity. These factors include: (1) ambient temperature (35 °F and 85 °F), (2) effluent temperatures T_s (ranges defined in Table 2-1), (3) burn time (ranges defined in Table 2-1), (4) site burn limit (250 lb for TA-16-388 and 1000 lb for TA-16-399), and (5) site burn area (4 ft × 8 ft at TA-16-388 and 4 ft × 16 ft at TA-16-399). All combinations of parameters were examined to both minimize and maximize the estimated updraft velocity at each site.

From Section 2.4 it can be determined that both the buoyancy flux and the momentum flux are directly proportional to the updraft velocity and that the effective release height is proportional to both the buoyancy and the momentum. Thus, the potential for lofting is adequately captured by

an examination of w_s. The following information regarding physical parameters of burn activities was compiled to help choose conditions that represent high and low lofting potential at each of the burn sites.

Table 2-2 summarizes selected burn times and temperatures for various HE types from the experimental data reported in Table 2-1. Some entries (noted in parentheses) were estimated by taking ratios between available data for the two HE configurations. (See additional explanation provided in Section 2.3). Where two or more comparisons were available, all combinations of the factors were evaluated to identify the widest possible variation in the estimate. Note that thermocouple readings were selected as the most representative temperatures for describing the large initial release volumes. Only the data highlighted in blue in Table 2-2 were carried forward into the burn-ground case studies. All chip and fragment configurations are presumed to be burned in small-batches of wet material that require propane assist at TA-16-388. Likewise, PBX 9502 has such poor burn characteristics that an operational decision was made to burn it under propane assist as well. PBX 9404 and Baratol are legacy materials that will not be disposed of in large quantities; they are typically only present as contamination in wastes with blended explosives content or as small fragments that will also employ propane assisted combustion. This screening leaves only PBX 9501 and COMPB as realistic candidates for large-volume HE disposal events. Typically, burns approaching the site-specific permit limits will be conducted at TA-16-399, but maximum-quantity pure HE burns at TA-16-388 were also examined to maintain operating flexibility under the permit.

Heats of combustion were calculated using molecular weighting of $-\Delta H_c^\circ$ reported for pure HE and the assumption of zero energy release from minor constituents. Secondary comparisons were made with values reported in an informal memo on HE properties (Patterson, 1992) but primary references for the data were not provided. Compared to Table 2-1 the memo reported values that were 5% higher for PBX 9501 and 3.6% lower for COMPB. These margins are considered adequate independent validation of the computed estimates for the purposes of this study. A calculation using the CHEETAH code, which defines thermodynamically preferred combustion paths and products, would provide another independent validation, but the degree of uncertainty in burn conditions would introduce a similar degree of error.

HE properties from Table 2-1 were combined with standard air properties and two different air temperatures (35 °F and 85 °F) to evaluate the minimum and maximum volumetric flow rate per unit HE mass burned (leading factor of Equation 6 that can be generated by solid forms of the various HE types. Table 2-3 summarizes these calculations for several common HE types. Between the two types of interest, PBX 9501 generates the lowest flow rate and COMPB generates the highest flow rate (blue cells within Table 2-3). These values of flow rate happen to correspond to application of the lowest and highest ambient temperatures, respectively. The highest and lowest values from Table 2-1 were combined with the highest and lowest HE loading densities reported in Table 2-3 for each burn site to evaluate Equation 6 and obtain the high and low estimates of vertical updraft velocity that are also reported in Table 2-3 as parameters of the respective case studies. Table 2-4 summarizes the CALPUFF inputs for the propane-only and minimum and maximum lofting conditions. Data specific to the unit location are also required: UTM Zone 13 coordinates and the ground elevation in m above mean sea level (m MSL), which are shown in Table 2-5. As requested by NMED, LANL is providing an electronic copy of model run input and output along with the program files as part of this report. Source-specific

information is described above and the model runs provide model flag settings and other general information.

Table 2-1. Operational descriptions of actual HE burns.

HE Type	Physical Condition[a]	Mass (kg)	Burn Time (min)	Thermocouple Temp[b] (K)	Pyrometer Temp[b] (K)	Theoretical Temp[c] (K)
PBX 9404	1	19	6.5	2013	--	--
PBX 9501	1	26	8.0	1993	2303	2904
PBX 9502	1	26	56.0	1343	1398	1661
COMPB	1	--	(1.5 – 3)	(1837 – 2212)	--	--
Baratol	2	295	5	--	2023	--
Baratol	2	386	5	--	2023	--
COMPB	2	27	0.75	(1837 – 2040)	2123	2672
PBX 9501	2	226	2	(1837)	2123	2904
PBX 9501	2	408	2	(1993)	2303	2904
PBX 9502	2	77	23	(1343)	1398	1661

[a] Condition 1 denotes a pressed cylinder, Condition 2 denotes molding powder and casting chips.
[b] Parentheses denote estimates based on absolute-temperature ratios of other available measurements.
[c] Obtained from the Cheetah point-kinetics thermochemistry code at 1-atm pressure of air.
Note: Pink cells mark measured data used in ratio-based estimates. Blue cells mark estimates that were propagated as uncertainties in the dispersion analysis.

Table 2-2. High-Explosive and Propane Combustion Properties.

	Burn Period[a] (min)		Burn Temp (K)		Heat of Combustion[b] (MJ/kg)
Explosive	Solids	Chips	Solids	Chips	
PBX 9404	6.5	(1.6 - 3.25)	2013	(1856 - 2013)	8.78
PBX 9501	8.0	2.0	1993	(1837 - 1993)	8.87
PBX 9502	56.0	23	1343	(1343)	11.34
Baratol	(10 - 20)	5.0	(1751 - 1900)	(1751 - 1943)	---[c]
COMPB	(1.5 - 3)	0.75	(1837 - 2212)	(1837 - 2039)	11.58
	Burn Rate (gal/min)		Energy Content (MBtu/gal)		Heat Rate (MW)
Propane	1.0		15.7 (at 70% efficiency)		1.12

[a] Parentheses denote ranges estimated from available measurements between solids and chips.
[b] Obtained from Gibbs and Popolato (Gibbs and Popolato, A., 1980) $-\Delta H_c^\circ$ for pure HE weighted by inert constituents.
[c] No immediate information could be found on the primary constituent barium nitrate.
NOTE: Data from blue cells were carried forward into the burn-ground case studies.

Table 2-3. Ranges of volumetric flow rate for common high explosives.

Explosive	Volumetric Flow Rate (m^3/s) per kg burned	
	min	max
PBX 9404	1.41×10^{-2}	1.44×10^{-2}
PBX 9501	1.17×10^{-2}	1.19×10^{-2}
PBX 9502	3.45×10^{-3}	3.53×10^{-3}
Baratol	---	---
COMPB	3.62×10^{-2}	9.14×10^{-2}

NOTE: Blue cells indicate minimum and maximum flow rates.

Table 2-4. Additional information that defines burn-area case studies.

Site TA-16-388 Solid HE	
Max burn area (full tray)	4-ft × 8-ft = 32 ft^2 (2.97 m^2)
Effective radius	$r_{eff} = \sqrt{A/\pi} = 0.97$ m
Release height	0.5 m + r_{eff} = 1.47 m
Max solid HE	250 lb (113.4 kg)
HE loading concentration	113.4 kg / 2.97 m^2 = 38.18 kg/m^2
Max Lofting	
Max vertical velocity	3.49 m/s
Corresponding temp	1837 K
Corresponding burn time	1.5 min
Corresponding ambient temp	85 °F
Corresponding HE type	COMPB
Plume height (stable met)	73 m
Min Lofting	
Min vertical velocity	0.45 m/s
Corresponding temp	1993 K
Corresponding burn time	8 min
Corresponding ambient temp	35 °F
Corresponding HE type	PBX 9501
Plume height (stable met)	36 m
TA-16-388 Mixed Waste w/Propane	
Typical mixed-waste mass	50 lb (22.68 kg)
Corresponding burn time	~20 min
Mixed-waste burn area	4-ft × 8-ft = 32 ft^2 (2.97 m^2)
Effective radius	$r_{eff} = \sqrt{A/\pi} = 0.97$ m
Release height	0.5 m + r_{eff} = 1.47 m
Propane burn rate	1 gal/min = 1.12 MW
Nominal vertical velocity	1.2 m/s
Corresponding ambient temp	85 °F
Propane temp	1300 °F (977.6 K)
Plume height (stable met)	48 m

Table 2-4. Additional information that defines burn-area case studies. (continued)

Site TA-16-399	
Max burn area (full tray)	4-ft × 16-ft = 64 ft^2 (5.95 m^2)
Effective radius	$r_{eff} = \sqrt{A/\pi} = 1.38$ m
Release Height	1.0 m + r_{eff} = 2.38 m [a]
Max solid HE	1000 lb (453.6 kg)
HE loading concentration	453.6 kg / 5.95 m^2 = 76.24 kg/m^2
Max Lofting	
Max vertical velocity	7.0 m/s
Corresponding temp	1837 K
Corresponding burn time	1.5 min
Corresponding ambient temp	85 °F
Corresponding HE type	COMPB
Plume height (stable met)	116 m
Min Lofting	
Min vertical velocity	0.89 m/s
Corresponding temp	1993 K
Corresponding burn time	8 min
Corresponding ambient temp	35 °F
Corresponding HE type	PBX 9501
Plume height (stable met)	57 m
General	
Minimum air temp	35 °F (275 K)
Maximum air temp	85 °F (303 K)
Nominal air temp	72 °F (295.5 K)
Nominal local air pressure	77460 Pa (LANL weather machine)
Dry air density at 7200 ft	0.913 kg/m^3 (ideal gas law $P = \rho RT$)
Air const. press. specific heat	1004.67 J/kg/K (Stull, 1988)
Gas const. for dry air	287.04 J/K/kg (Stull, 1988)

[a] Actual height to the bottom of the tray is approximately 0.381 m and height to the rim of the tray is approximately 0.58 m.

Note: Blue cells denote required CALPUFF input parameters.

Table 2-5. Location-Specific Information

Map Ref.	Site	UTM X-Coordinate	UTM Y-Coordinate	Ground Elevation (m MSL)
	TA-16-388 Flash Pad	379720	3967617	2286.3
	TA-16-399 Burn Tray	379783	3967736	2275.03
1	Sombrillo Nursing Care	383951	3971488	2202
2	Los Alamos Middle School	383072	3972775	2254
3	Tsankawi Ruins	389596	3968917	1999
4	Bandelier Visitor Center	385279	3959714	1893
5	San Ildefonso Pueblo	384709	3968497	2154
6	Los Alamos County Hospital	381009	3971563	2226
7	Royal Crest Trailer Park	382152	3970450	2237
8	Ponderosa Campground	379159	3966056	2267

Map Ref. = References location of this receptor site on Figures 3-1, 3-2, 3-3, 3-4, 4-1, and 4-2.
UTM = Universal Transverse Mercator (UTM)
m MSL = meters above mean sea level
Note: Air impacts computed at 1.5 m above ground elevation.

3.0 Air Quality Impacts Calculations

CALPUFF estimates air quality impacts in micrograms per cubic meter ($\mu g/m^3$) for a 1 g/s emission rate. From these estimates, a conversion factor (CF) in $\mu g/m^3$ per g/s of a pollutant emitted is calculated for each screening level averaging period. However, to determine which unit has the highest impacts at various locations for the short-term averaging periods, the CF must be weighted by the maximum amount of waste that can be burned at each unit: 250 lb at TA-16-388 and 1000 lb at TA-16-399. The annual averaging period assumes that 20,000 lb of waste and 15,000 gal of propane are burned at the most conservative unit and the burn size is not considered in calculating impacts. Because the maximum fuel amount burned at TA-16-399 is four times higher than at TA-16-388, the TA-16-399 conversion factors were multiplied by 4 and compared to the TA-16-388 conversion factors so that the highest calculated impacts could be estimated. Rather than base the worst-case scenario solely on the highest conversion factor value, the conversion factors were temporarily weighted in order to determine the conversion factor/scenario combinations that would result in the highest calculated air impacts. Based on this weighting, the highest impact receptor locations were chosen and included in Table 3-1. The table shows the averaging period and location for the worst-case CFs. Ambient air impacts were calculated using the unit-specific amount of fuel burned, and the emission factors described in the modeling protocol (LANL, 2007). In accordance with the protocol, the calculated impacts have been compared to the following screening levels in Tables 3-5 through 3-8:

- The NMED and the Environmental Protection Agency's (EPA's) ambient air quality standards (AAQS). (Tables 3-6 and 3-8)
- The EPA Region 9 Preliminary Remediation Goals (PRGs) (EPA, 2004). (Tables 3-7 and 3-8)
- The acute (1 hr) inhalation exposures (AIEC) for toxic air pollutants from the Companion Database to EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA, 2005). (Tables 3-5 and 3-6)

Contaminant-specific emissions for 1-hr, 3-hr, 8-hr and 24-hr averaging periods are presented in Tables 3-2 and 3-3. Emissions were calculated for each of the contaminants listed in Table 3-6 of the modeling protocol (LANL, 2007). The CF for the appropriate scenario located in Table 3-1 was then multiplied by the calculated emissions and included in Tables 3-5 and 3-6 for short-term averaging periods. For example, the highest hourly on-site impacts resulted from burning HE at TA-16-388 were calculated as follows:

$$\frac{EF \text{ g pollutant}}{\text{g waste}} \times \frac{n}{N} \times \frac{454 \text{ g waste}}{\text{lb waste}} \times \frac{250 \text{ lb waste}}{1 \text{ hr}} \times \frac{1 \text{ hr}}{3600 \text{ s}} \times \frac{CF \ \mu g \text{ pollutant}/m^3}{\text{g pollutant/s}} = \frac{I \ \mu g \text{ pollutant}}{m^3}$$

where:

EF = emission factors from Table 3-6 in the modeling protocol (LANL, 2007)
CF = conversion factors from g/s of pollutant emitted to $\mu g/m^3$ concentrations of the pollutant in air for a 1-hr averaging period
I = calculated air pollutant concentration in $\mu g/m^3$
n = maximum number of burns conducted within averaging period ($n=1$ for 1-hr avg.)
N = Number of simulations during the averaging period ($N=1$ for 1-hr avg.)

When the averaging periods for the screening levels span 3-hrs, 8-hrs and 24-hrs, two burns are assumed because that would be the maximum amount of waste that could be burned during these time periods. However, the equation doesn't change because the modeled operations schedule also included two simulations during these averaging periods, thereby cancelling each other.

An example of an impact calculation for 3-, 8-, and 24- hour averaging periods for TA-16-388 is:

$$\frac{EF\ \text{g pollutant}}{\text{g waste}} \times \frac{n}{N} \times \frac{454\ \text{g waste}}{\text{lb waste}} \times \frac{250\ \text{lb waste}}{1\ \text{hr}} \times \frac{1\ \text{hr}}{3600\ \text{s}} \times \frac{CF\ \mu\text{g pollutant/m}^3}{\text{g pollutant/s}} = \frac{I\ \mu\text{g pollutant}}{\text{m}^3}$$

where:

- EF = emission factors from Table 3-6 in the modeling protocol
- CF = conversion factors from g/s of pollutant emitted to $\mu g/m^3$ concentrations of the pollutant in air for the specific averaging period (3-, 8-, or 24- hours)
- I = calculated air pollutant concentration in $\mu g/m^3$
- n = maximum number of burns conducted within averaging period ($n=1$ for 1-hr avg.)
- N = Number of simulations during the averaging period ($N=1$ for 1-hr avg.)

Contaminant-specific emissions for the annual averaging period are presented in Table 3-4. Annual impacts assessments assume that 15,000 gal of propane are used and 20,000 lb of burnable waste (HE and combustible wastes) are treated annually. Thus, annual emissions estimations represent a maximum amount of waste burned per year rather than taking into account individual burn sizes. Also, annual emissions were averaged over 508 hours, the number of meteorological hours modeled, to compensate for oversampling the meteorology beyond the number of hours needed to process the maximum projected annual inventory.

The annual on-site impacts resulted from burning HE at TA-16-388 were calculated as follows:

$$\frac{EF\ \text{g pollutant}}{\text{g waste}} \times \frac{20{,}000\ \text{lb waste}}{\text{yr}} \times \frac{454\ \text{g waste}}{\text{lb waste}} \times \frac{1\ \text{yr}}{508\ \text{hr}} \times \frac{1\ \text{hr}}{3600\ \text{s}} = \text{Annual Emissions (g/s)}$$

then:

$$\text{Annual Emission (g/s)} \times \frac{CF\ \mu\text{g pollutant/m}^3}{\text{g/s}} = \frac{I\ \mu\text{g pollutant}}{\text{m}^3}$$

where:

- EF = emission factors from Table 3-6 in the modeling protocol
- CF = conversion factors from g/s of pollutant emitted to $\mu g/m^3$ concentrations of the pollutant in air for an annual averaging period
- I = calculated air pollutant concentration in $\mu g/m^3$

Because the types and quantities of wastes treated vary from year-to-year, the impacts analysis used only the worst-case emissions factors (EFs) from Table 3-6 of the modeling protocol (LANL, 2007) for all wastes. This avoids the need to estimate the quantities of each type of waste stream for the next 10 years and results in a conservative air impacts analysis. The EFs from Table 3-5 of the modeling protocol (LANL, 2007) were used for propane. Tables 3-2 and 3-3 calculate the short-term emissions for TA-16-388 and TA-16-399, respectively. Table 3-4 provides the calculated emissions for the annual averaging period. In addition, propane emissions were not added to impacts analysis tables for any scenarios where burning of HE alone caused the highest impacts (e.g. off-site cases). Accordingly, the propane emissions that are calculated in Table 3-4 have been added to the annual off-site impacts in Table 3-8 only.

Tables 3-5 through 3-8 compare the calculated worst-case on- and off-site impacts to the applicable screening levels. Note that not all of the tables have the same contaminants. Some contaminants with AIECs do not have PRGs, and vice versa. The AAQS are evaluated only for off-site impacts, in accordance with the EPA's Draft Final Open Burning/Open Detonation Permitting Guidelines (EPA, 2002) and NMED's air quality requirements. Receptors other than the worst-case on- and off-site impact receptors have lower CFs (see Table 3-1) than the worst-case CFs; therefore, the impacts to these other receptors are lower than the worst-case impacts. Other receptor impacts are lower than the worst-case impact in a ratio of the other receptor's CF divided by the worst-case impact CF for each averaging period.

Table 3-5 compares the calculated worst-case on-site emissions impacts to EPA's AIECs. No screening levels are exceeded and only acrolein approaches the short-term level. The acrolein emission factor was derived from the open burning of fuel oil (e.g., a fuel spill), which was used as a very conservative representative of burning oils and solvents. Oils and solvents are a small waste stream treated rarely at the TA-16 Burn Ground and none of the other waste streams at the Burn Ground have acrolein emission factors. Therefore, acrolein is not an environmental concern.

The short-term off-site impacts are compared to EPA's AIECs and short-term AAQS in Table 3-6. All impacts are below the screening levels. To obtain the final impacts, background values from the New Mexico Air Quality Bureau Air Dispersion Modeling Guidelines (NMED, 2007) were added, as appropriate, to the calculated impacts from the TA-16 Burn Ground.

Table 3-7 compares the annual on-site impacts with EPA's PRGs. As described in the modeling protocol (LANL, 2007), a risk assessment is required if the impacts exceed 0.1 times the PRGs. This conservative analysis shows no exceedences of 0.1 times the PRGs and no risk assessment is required. The annual off-site impacts are compared with 0.1 times the EPA's PRGs and long-term AAQS in Table 3-8. No screening levels are exceeded and the impacts are less than the screening levels, with the exception of Particulate Matter. The estimated impact for Particulate Matter is 26.6 $\mu g/m^3$ and the standard is 60 $\mu g/m^3$. The calculated impact from the TA-16 Burn Ground activities is 5.72 E-03 $\mu g/m^3$. The remaining 26.6 $\mu g/m^3$ is the assumed background level in accordance with the NMED's 2007 Modeling Guidelines (NMED, 2007). Therefore, the TA-16 Burn Ground had negligible additive impacts. Based on this analysis, screening levels were not exceeded at any receptor, including the maximum on- and off-site receptors. Therefore, additional analyses are not warranted.

Table 3-1. Unit/Waste Scenarios Creating Maximum Impacts by Averaging Periods

	Air Impacts Conversion Factors (μg/m³ per g/s)									
Receptor	**1 hr**	**Scenario[1]**	**3 hr**	**Scenario**	**8 hr**	**Scenario**	**24 hr**	**Scenario**	**Annual**	**Scenario**
Sombrillo Nursing Care	1.09E-01	TA-16-399 HE Max	3.62E-02	TA-16-399 HE Max	1.36E-02	TA-16-399 HE Max	5.03E-03	TA-16-399 HE Min	3.05E-04	TA-16-388 HE Min
Los Alamos Middle School	2.24E-01	TA-16-399 HE Min	8.50E-02	TA-16-399 HE Max	4.80E-02	TA-16-399 HE Min	1.60E-02	TA-16-399 HE Min	5.24E-04	TA-16-399 HE Min
Tsankawi Ruins	4.31E-02	TA-16-399 HE Max	1.54E-02	TA-16-399 HE Max	6.33E-03	TA-16-399 HE Min	2.11E-03	TA-16-399 HE Min	6.70E-05	TA-16-388 HE Min
Bandelier Visitor Center	7.56E-02	TA-16-399 HE Max	2.99E-02	TA-16-399 HE Max	1.41E-02	TA-16-399 HE Max	4.68E-03	TA-16-399 HE Max	7.69E-05	TA-16-388 HE Min
San Ildefonso Pueblo	2.37E-01	TA-16-399 HE Max	1.42E-01	TA-16-399 HE Max	5.36E-02	TA-16-399 HE Max	1.79E-02	TA-16-399 HE Max	3.66E-04	TA-16-388 HE Min
Los Alamos County Hospital	9.90E-01	TA-16-399 HE Min	3.55E-01	TA-16-399 HE Min	1.33E-01	TA-16-399 HE Min	4.49E-02	TA-16-399 HE Min	1.86E-03	TA-16-399 HE Min
Royal Crest Trailer Park	2.80E-01	TA-16-399 HE Max	1.17E-01	TA-16-399 HE Max	4.38E-02	TA-16-399 HE Max	1.46E-02	TA-16-399 HE Max	7.49E-04	TA-16-388 HE Min
Ponderosa Campground	1.92E+00	TA-16-399 HE Min	6.93E-01	TA-16-399 HE Min	2.60E-01	TA-16-399 HE Min	8.76E-02	TA-16-399 HE Min	1.94E-03	TA-16-388 HE Min
HE Max On-Site	1.49E+02	TA-16-388 HE Min	4.95E+01	TA-16-388 HE Min	3.41E+01	TA-16-388 HE Min	1.14E+01	TA-16-388 HE Min	1.48E+00	TA-16-388 HE Min
Max Off-Site	2.87E+00	TA-16-399 HE Min	9.57E-01	TA-16-399 HE Min	4.19E-01	TA-16-399 HE Min	1.40E-01	TA-16-399 HE Min	5.76E-03	TA-16-388 HE Min

[1] TA-16-388 or TA-16-399 HE Max is based on the explosives Maximum Lofting scenarios. TA-16-388 or TA-16-399 HE Min is based on the Minimum Lofting scenarios. For the short-term impacts, if TA-16-388 is the maximum scenario, impact calculations use 250 lb of waste per burn. If TA-16-399 is the maximum scenario, impact calculations use 1000 lb of waste per burn. TA-16-388 propane only scenario (as discussed in Section 2.1) was never the most conservative weighted conversion factor and is not included in this table. For the annual impacts, 20,000 pounds of wastes and 15,000 pounds of HE were assumed to be burned at the most conservative impact unit.

Table 3-2. Contaminant-Specific Emissions for Short-Term Averaging Times at TA-16-388

Contaminant	Total Waste Burned Over Averaging Period (lb) [1]	Waste Burned (g/s)	Calculated Contaminant Emissions (g/s) [2]
Acenaphthene	250	3.15E+01	3.15E-04
Acetaldehyde	250	3.15E+01	1.99E-03
Acetone	250	3.15E+01	1.10E-03
Acetophenone	250	3.15E+01	5.49E-06
Acrolein	250	3.15E+01	1.23E-03
Aluminum	250	3.15E+01	2.25E-05
Anthracene	250	3.15E+01	4.73E-04
Barium	250	3.15E+01	1.32E-05
Benzaldehyde	250	3.15E+01	3.28E-03
Benzene	250	3.15E+01	3.22E-02
Benzo(a)anthracene	250	3.15E+01	1.58E-04
Benzo(a)pyrene	250	3.15E+01	1.58E-04
Benzo(b,k)fluoranthene	250	3.15E+01	2.21E-04
Benzyl alcohol	250	3.15E+01	1.25E-03
Butadiene [1-3-]	250	3.15E+01	4.22E-05
Butyl benzyl phthalate	250	3.15E+01	3.85E-06
Carbon monoxide - 1 hr	250	3.15E+01	2.84E+00
Carbon monoxide - 8 hr	500	3.15E+01	2.84E+00
Carbon tetrachloride	250	3.15E+01	2.17E-06
Chloromethane (methyl chloride)	250	3.15E+01	8.95E-06
Chromium (total)	250	3.15E+01	1.25E-05
Chrysene	250	3.15E+01	2.84E-04
Crotonaldehyde	250	3.15E+01	1.89E-04
Cyclohexane	250	3.15E+01	8.42E-04
Dibenzo(a,h)anthracene	250	3.15E+01	6.31E-06
Dibutyl phthalate	250	3.15E+01	1.04E-05
Dichloroethylene [1,1-]	250	3.15E+01	6.78E-06
Diethyl phthalate	250	3.15E+01	2.21E-06
Dimethyl phthalate	250	3.15E+01	5.93E-06
Dioctyl phthalate	250	3.15E+01	2.90E-05
Dioxin (2,3,7,8-TCDD)	250	3.15E+01	4.70E-11
Ethylbenzene	250	3.15E+01	1.73E-03
Ethyl chloride	250	3.15E+01	2.17E-06
Fluoranthene	250	3.15E+01	6.31E-04
Fluorene	250	3.15E+01	3.15E-05
Formaldehyde	250	3.15E+01	9.55E-03
Furan	250	3.15E+01	4.73E-06
Hexane	250	3.15E+01	5.04E-04
Hydrogen chloride	250	3.15E+01	3.14E-02
Indeno[1,2,3-cd]pyrene	250	3.15E+01	1.58E-04
Methylcyclohexane	250	3.15E+01	4.92E-03
Methylene chloride	250	3.15E+01	2.35E-05
Methyl ethyl ketone (2-Butanone)	250	3.15E+01	4.10E-04

Table 3-2. Contaminant-Specific Emissions for Short-Term Averaging Times at TA-16-388 (continued)

Contaminant	Total Waste Burned Over Averaging Period (lb) [1]	Waste Burned (g/s)	Calculated Contaminant Emissions (g/s) [2]
Methyl isobutyl ketone	250	3.15E+01	3.47E-04
Naphthalene	250	3.15E+01	5.11E-03
Nitrogen dioxide - 24 hr	500	3.15E+01	2.36E+00
Particulate matter (PM-10) - 24 hr	500	3.15E+01	6.31E+00
Particulate matter (TSP) - 24 hr	500	3.15E+01	6.31E+00
Phenanthrene	250	3.15E+01	2.26E-04
Phenol	250	3.15E+01	4.92E-04
Pyrene	250	3.15E+01	6.31E-05
Styrene	250	3.15E+01	1.57E-03
Sulfur dioxide - 3 hr	500	3.15E+01	7.88E-02
Sulfur dioxide - 24 hr	500	3.15E+01	7.88E-02
Toluene	250	3.15E+01	3.85E-03
Trichloroethane [1,1,1-]	250	3.15E+01	1.08E-06
Trimethylbenzene [1,2,4-]	250	3.15E+01	7.66E-03
Trimethylbenzene [1,3,5-]	250	3.15E+01	1.76E-02
Vinyl chloride	250	3.15E+01	7.03E-06
Xylene (Total)	250	3.15E+01	1.82E-02
Zinc	250	3.15E+01	1.97E-03

[1] Unless noted in the contaminant column, averaging times are 1 hour (hr) and include only one burn at the unit. In the case of the 3-hr, 8-hr, and 24-hr averaging times, two burns are included in the emissions analysis.

[2] Emissions factors used to calculate these emissions can be found in the modeling protocol (LANL, 2007).

hr = hour
g/s = grams per second
lb = pounds
PM-10 = particulate matter less than 10 micrometers
TSP= total suspended particulate

Table 3-3. Contaminant-Specific Emissions for Short-Term Averaging Times at TA-16-399

Contaminant	Total Waste Burned Over Averaging Period (lb) [1]	Waste Burned (g/s)	Calculated Contaminant Emissions (g/s) [2]
Acenaphthene	1.00E+03	1.26E+02	1.26E-03
Acetaldehyde	1.00E+03	1.26E+02	7.95E-03
Acetone	1.00E+03	1.26E+02	4.41E-03
Acetophenone	1.00E+03	1.26E+02	2.19E-05
Acrolein	1.00E+03	1.26E+02	4.92E-03
Aluminum	1.00E+03	1.26E+02	8.99E-05
Anthracene	1.00E+03	1.26E+02	1.89E-03
Barium	1.00E+03	1.26E+02	5.30E-05
Benzaldehyde	1.00E+03	1.26E+02	1.31E-02
Benzene-	1.00E+03	1.26E+02	1.29E-01
Benzo(a)anthracene	1.00E+03	1.26E+02	6.31E-04
Benzo(a)pyrene	1.00E+03	1.26E+02	6.31E-04
Benzo(b,k)fluoranthene	1.00E+03	1.26E+02	8.83E-04
Benzyl alcohol	1.00E+03	1.26E+02	4.99E-03
Butadiene [1-3-]	1.00E+03	1.26E+02	1.69E-04
Butyl benzyl phthalate	1.00E+03	1.26E+02	1.54E-05
Carbon monoxide - 1 hr	1.00E+03	1.26E+02	1.14E+01
Carbon monoxide - 8 hr	2.00E+03	1.26E+02	1.14E+01
Carbon tetrachloride	1.00E+03	1.26E+02	8.69E-06
Chloromethane (methyl chloride)	1.00E+03	1.26E+02	3.58E-05
Chromium (total)	1.00E+03	1.26E+02	5.01E-05
Chrysene	1.00E+03	1.26E+02	1.14E-03
Crotonaldehyde	1.00E+03	1.26E+02	7.57E-04
Cyclohexane	1.00E+03	1.26E+02	3.37E-03
Dibenzo(a,h)anthracene	1.00E+03	1.26E+02	2.52E-05
Dibutyl phthalate	1.00E+03	1.26E+02	4.16E-05
Dichloroethylene [1,1-]	1.00E+03	1.26E+02	2.71E-05
Diethyl phthalate	1.00E+03	1.26E+02	8.83E-06
Dimethyl phthalate	1.00E+03	1.26E+02	2.37E-05
Dioctyl phthalate	1.00E+03	1.26E+02	1.16E-04
Dioxin (2,3,7,8-TCDD)	1.00E+03	1.26E+02	1.88E-10
Ethylbenzene	1.00E+03	1.26E+02	6.92E-03
Ethyl chloride	1.00E+03	1.26E+02	8.69E-06
Fluoranthene	1.00E+03	1.26E+02	2.52E-03
Fluorene	1.00E+03	1.26E+02	1.26E-04
Formaldehyde	1.00E+03	1.26E+02	3.82E-02
Furan	1.00E+03	1.26E+02	1.89E-05
Hexane	1.00E+03	1.26E+02	2.02E-03
Hydrogen chloride	1.00E+03	1.26E+02	1.26E-01
Indeno[1,2,3-cd]pyrene	1.00E+03	1.26E+02	6.31E-04
Methylcyclohexane	1.00E+03	1.26E+02	1.97E-02
Methylene chloride	1.00E+03	1.26E+02	9.41E-05
Methyl ethyl ketone (2-Butanone)	1.00E+03	1.26E+02	1.64E-03
Methyl isobutyl ketone	1.00E+03	1.26E+02	1.39E-03

Table 3-3. Contaminant-Specific Emissions for Short-Term Averaging Times at TA-16-399 (continued)

Contaminant	Total Waste Burned Over Averaging Period (lb) [1]	Waste Burned (g/s)	Calculated Contaminant Emissions (g/s) [2]
Naphthalene	1.00E+03	1.26E+02	2.04E-02
Nitrogen dioxide - 24 hr	2.00E+03	1.26E+02	9.46E+00
Particulate matter (PM-10) - 24 hr	2.00E+03	1.26E+02	2.52E+01
Particulate matter (TSP) - 24 hr	2.00E+03	1.26E+02	2.52E+01
Phenanthrene	1.00E+03	1.26E+02	9.04E-04
Phenol	1.00E+03	1.26E+02	1.97E-03
Pyrene	1.00E+03	1.26E+02	2.52E-04
Styrene	1.00E+03	1.26E+02	6.29E-03
Sulfur dioxide - 3 hr	2.00E+03	1.26E+02	3.15E-01
Sulfur dioxide - 24 hr	2.00E+03	1.26E+02	3.15E-01
Toluene	1.00E+03	1.26E+02	1.54E-02
Trichloroethane [1,1,1-]	1.00E+03	1.26E+02	4.34E-06
Trimethylbenzene [1,2,4-]	1.00E+03	1.26E+02	3.06E-02
Trimethylbenzene [1,3,5-]	1.00E+03	1.26E+02	7.02E-02
Vinyl chloride	1.00E+03	1.26E+02	2.81E-05
Xylene (Total)	1.00E+03	1.26E+02	7.28E-02
Zinc	1.00E+03	1.26E+02	7.89E-03

[1] Unless noted in the contaminant column, averaging times are 1 hour (hr) and include only one burn at the unit. In the case of the 3-hr, 8-hr, and 24-hr averaging times, two burns are included in the emissions analysis.

[2] Emissions factors used to calculate these emissions can be found in the modeling protocol (LANL, 2007).

hr = hour
g/s = grams per second
lb = pounds
PM-10 = particulate matter less than 10 micrometers
TSP= total suspended particulate

Table 3-4. Contaminant-Specific Emissions for the Annual Averaging Period [1]

Contaminant	Amount Waste Burned (lb/yr)	Amount Waste Burned (g/s)	Calculated Waste Emissions [2] (g/s)	Amount Propane Burned [3] (gal/yr)	Calculated Propane Emissions (lb/yr)	Propane Emissions (g/s)	Total Calculated Emissions [2,3] (g/s)
Acenaphthene	2.00E+04	4.97E+00	4.97E-05				4.97E-05
Acetaldehyde	2.00E+04	4.97E+00	3.13E-04				3.13E-04
Acetone	2.00E+04	4.97E+00	1.74E-04				1.74E-04
Acetophenone	2.00E+04	4.97E+00	8.64E-07				8.64E-07
Acrolein	2.00E+04	4.97E+00	1.94E-04				1.94E-04
Aluminum	2.00E+04	4.97E+00	3.54E-06				3.54E-06
Anthracene	2.00E+04	4.97E+00	7.45E-05				7.45E-05
Barium	2.00E+04	4.97E+00	2.09E-06				2.09E-06
Benzaldehyde	2.00E+04	4.97E+00	5.16E-04				5.16E-04
Benzene	2.00E+04	4.97E+00	5.07E-03				5.07E-03
Benzo(a)anthracene	2.00E+04	4.97E+00	2.48E-05				2.48E-05
Benzo(a)pyrene	2.00E+04	4.97E+00	2.48E-05				2.48E-05
Benzo(b,k)fluoranthene	2.00E+04	4.97E+00	3.48E-05				3.48E-05
Benzyl alcohol	2.00E+04	4.97E+00	1.97E-04				1.97E-04
Butadiene [1-3-]	2.00E+04	4.97E+00	6.65E-06				6.65E-06
Butyl benzyl phthalate	2.00E+04	4.97E+00	6.06E-07				6.06E-07
Carbon monoxide	2.00E+04	4.97E+00	4.47E-01	1.50E+04	2.85E+01	3.33E-02	4.80E-01
Carbon tetrachloride	2.00E+04	4.97E+00	3.42E-07				3.42E-07
Chloromethane (methyl chloride)	2.00E+04	4.97E+00	1.41E-06				1.41E-06
Chromium (total)	2.00E+04	4.97E+00	1.97E-06				1.97E-06
Chrysene	2.00E+04	4.97E+00	4.47E-05				4.47E-05
Crotonaldehyde	2.00E+04	4.97E+00	2.98E-05				2.98E-05
Cyclohexane	2.00E+04	4.97E+00	1.33E-04				1.33E-04
Dibenzo(a,h)anthracene	2.00E+04	4.97E+00	9.93E-07				9.93E-07
Dibutyl phthalate	2.00E+04	4.97E+00	1.64E-06				1.64E-06
Dichloroethylene [1,1-]	2.00E+04	4.97E+00	1.07E-06				1.07E-06
Diethyl phthalate	2.00E+04	4.97E+00	3.48E-07				3.48E-07
Dimethyl phthalate	2.00E+04	4.97E+00	9.33E-07				9.33E-07
Dioctyl phthalate	2.00E+04	4.97E+00	4.56E-06				4.56E-06
Dioxin (2,3,7,8-TCDD)	2.00E+04	4.97E+00	7.40E-12				7.40E-12

Table 3-4. Contaminant-Specific Emissions for the Annual Averaging Period [1] (continued)

Contaminant	Amount Waste Burned (lb/yr)	Amount Waste Burned (g/s)	Calculated Waste Emissions [2] (g/s)	Amount Propane Burned [3] (gal/yr)	Calculated Propane Emissions (lb/yr)	Propane Emissions (g/s)	Total Calculated Emissions [2,3] (g/s)
Ethylbenzene	2.00E+04	4.97E+00	2.73E-04				2.73E-04
Ethyl chloride	2.00E+04	4.97E+00	3.42E-07				3.42E-07
Fluoranthene	2.00E+04	4.97E+00	9.93E-05				9.93E-05
Fluorene	2.00E+04	4.97E+00	4.97E-06				4.97E-06
Formaldehyde	2.00E+04	4.97E+00	1.50E-03				1.50E-03
Furan	2.00E+04	4.97E+00	7.45E-07				7.45E-07
Hexane	2.00E+04	4.97E+00	7.94E-05				7.94E-05
Hydrogen chloride	2.00E+04	4.97E+00	4.95E-03				4.95E-03
Indeno[1,2,3-cd]pyrene	2.00E+04	4.97E+00	2.48E-05				2.48E-05
Methylcyclohexane	2.00E+04	4.97E+00	7.75E-04				7.75E-04
Methylene chloride	2.00E+04	4.97E+00	3.70E-06				3.70E-06
Methyl ethyl ketone (2-Butanone)	2.00E+04	4.97E+00	6.45E-05				6.45E-05
Methyl isobutyl ketone	2.00E+04	4.97E+00	5.46E-05				5.46E-05
Naphthalene	2.00E+04	4.97E+00	8.04E-04				8.04E-04
Nitrogen dioxide	2.00E+04	4.97E+00	3.72E-01	1.50E+04	2.10E+02	2.55E-02	3.98E-01
Particulate matter (TSP)	2.00E+04	4.97E+00	9.93E-01	1.50E+04	6.00E+00	1.49E-03	9.94E-01
Phenanthrene	2.00E+04	4.97E+00	3.56E-05				3.56E-05
Phenol	2.00E+04	4.97E+00	7.75E-05				7.75E-05
Pyrene	2.00E+04	4.97E+00	9.93E-06				9.93E-06
Styrene	2.00E+04	4.97E+00	2.48E-04				2.48E-04
Sulfur dioxide	2.00E+04	4.97E+00	1.24E-02	1.50E+04	2.70E-01	6.70E-05	1.25E-02
Toluene	2.00E+04	4.97E+00	6.06E-04				6.06E-04
Trichloroethane [1,1,1-]	2.00E+04	4.97E+00	1.71E-07				1.71E-07
Trimethylbenzene [1,2,4-]	2.00E+04	4.97E+00	1.21E-03				1.21E-03
Trimethylbenzene [1,3,5-]	2.00E+04	4.97E+00	2.77E-03				2.77E-03
Vinyl chloride	2.00E+04	4.97E+00	1.11E-06				1.11E-06
Xylene (Total)	2.00E+04	4.97E+00	2.86E-03				2.86E-03
Zinc	2.00E+04	4.97E+00	3.11E-04				3.11E-04

1 Annual averaging period assumes that 15,000 gallons of propane are burned a year and 20,000 pounds of burnable waste (high explosives and combustible wastes).
2 Emissions factors used to calculate these emissions can be found in the modeling protocol (LANL, 2007).
3 Propane emissions were not added for scenarios where burning of high explosives alone caused the highest impacts.

Table 3-4. Contaminant-Specific Emissions for the Annual Averaging Period [1] (continued)

lb/yr = pounds per year
g/s = grams per second
gal/yr = gallons per year
PM-10 =particulate matter less than 10 micrometers
TSP = total suspended particulate

Table 3-5. Short-Term On-Site Impacts [1]

Contaminant	Calculated Emissions[2] (g/s)	On-site Conversion Factor ($\mu g/m^3$ per g/s)	On-Site Impacts [3] ($\mu g/m^3$)	Acute Limits [4] ($\mu g/m^3$)
Acenaphthene	3.15E-04	1.5E+02	4.70E-02	1.3E+03
Acetaldehyde	1.99E-03	1.5E+02	2.96E-01	8.1E+04
Acetone	1.10E-03	1.5E+02	1.64E-01	4.8E+05
Acetophenone	5.49E-06	1.5E+02	8.17E-04	3.0E+04
Acrolein	1.23E-03	1.5E+02	1.83E-01	1.9E-01
Anthracene	4.73E-04	1.5E+02	7.05E-02	6.0E+03
Barium	1.32E-05	1.5E+02	1.97E-03	1.5E+03
Benzaldehyde	3.28E-03	1.5E+02	4.89E-01	1.5E+04
Benzene	3.22E-02	1.5E+02	4.80E+00	1.3E+03
Benzo[a]anthracene	1.58E-04	1.5E+02	2.35E-02	3.0E+02
Benzo[a]pyrene	1.58E-04	1.5E+02	2.35E-02	6.0E+02
Benzo[b&k]fluoanthene	2.21E-04	1.5E+02	3.29E-02	6.0E+02
Benzyl alcohol	1.25E-03	1.5E+02	1.86E-01	6.0E+04
Butyl benzyl phthalate	3.85E-06	1.5E+02	5.73E-04	1.5E+04
Carbon tetrachloride	2.17E-06	1.5E+02	3.24E-04	1.9E+03
Chloromethane (methyl chloride)	8.95E-06	1.5E+02	1.33E-03	2.0E+05
Chromium	1.25E-05	1.5E+02	1.86E-03	1.5E+03
Chrysene	2.84E-04	1.5E+02	4.23E-02	6.0E+02
Dibenzo[ah]anthracene	6.31E-06	1.5E+02	9.40E-04	3.0E+04
Dibutyl phthalate	1.04E-05	1.5E+02	1.55E-03	1.5E+04
Dichloroethylene [1,1-]	6.78E-06	1.5E+02	1.01E-03	7.5E+04
Diethyl phthalate	2.21E-06	1.5E+02	3.29E-04	1.5E+04
Dimethyl phthalate	5.93E-06	1.5E+02	8.83E-04	1.5E+04
Dioctyl phthalate	2.90E-05	1.5E+02	4.32E-03	5.0E+04
Dioxin	4.70E-11	1.5E+02	7.00E-09	1.3E+00
Ethylbenzene	1.73E-03	1.5E+02	2.58E-01	5.0E+05
Fluoranthene	6.31E-04	1.5E+02	9.40E-02	1.5E+01
Fluorene	3.15E-05	1.5E+02	4.70E-03	1.2E+04
Formaldehyde	9.55E-03	1.5E+02	1.42E+00	9.4E+01
Furan	4.73E-06	1.5E+02	7.05E-04	8.0E-02
Hydrogen chloride	3.14E-02	1.5E+02	4.68E+00	2.1E+03
Indeno[1,2,3-cd]pyrene	1.58E-04	1.5E+02	2.35E-02	5.0E+02
Methylene chloride	2.35E-05	1.5E+02	3.50E-03	1.4E+04
Methyl ethyl ketone	4.10E-04	1.5E+02	6.11E-02	1.3E+04
Methyl isobutyl ketone	3.47E-04	1.5E+02	5.17E-02	3.0E+05
Naphthalene	5.11E-03	1.5E+02	7.61E-01	7.5E+04
Phenanthrene	2.26E-04	1.5E+02	3.37E-02	1.0E+03
Phenol	4.92E-04	1.5E+02	7.33E-02	5.8E+03
Pyrene	6.31E-05	1.5E+02	9.40E-03	1.5E+04
Styrene	1.57E-03	1.5E+02	2.34E-01	2.1E+04

Table 3-5. Short-Term On-Site Impacts (continued)

Contaminant	Calculated Emissions[2] (g/s)	On-site Conversion Factor ($\mu g/m^3$ per g/s)	On-Site Impacts [3] ($\mu g/m^3$)	Acute Limits [4] ($\mu g/m^3$)
Toluene	3.85E-03	1.5E+02	5.73E-01	3.7E+04
Trichloroethane [1,1,1-]	1.08E-06	1.5E+02	1.62E-04	6.8E+04
Trimethylbenzene [1,3,5-]	1.76E-02	1.5E+02	2.62E+00	1.3E+05
Vinyl chloride	7.03E-06	1.5E+02	1.05E-03	1.8E+05
Xylenes	1.82E-02	1.5E+02	2.71E+00	2.2E+04
Zinc	1.97E-03	1.5E+02	2.94E-01	3.0E+04

1 Assumes 250 pounds per hour burned, converted to grams per second (31.5 g/s)
2 See Table 3-2 for the method of calculating these emissions
3 Background included, as appropriate (NMED, 2007)
4 Screening limits are from acute limits (1 hr) inhalation exposures (AIEC) for toxic air pollutants (EPA, 2005)
g/s = grams per second
$\mu g/m^3$ = micrograms per cubic meter

Table 3-6. Short-Term Off-Site Impacts

Contaminant	Calculated Emissions [1] (g/s)	Off-site Conversion Factor ($\mu g/m^3$ per g/s)	Off-Site Impacts [2] ($\mu g/m^3$)	Acute Limits [3] ($\mu g/m^3$)
Acenaphthene	1.26E-03	2.87E+00	3.62E-03	1.3E+03
Acetaldehyde	7.95E-03	2.87E+00	2.28E-02	8.1E+04
Acetone	4.41E-03	2.87E+00	1.27E-02	4.8E+05
Acetophenone	2.19E-05	2.87E+00	6.30E-05	3.0E+04
Acrolein	4.92E-03	2.87E+00	1.41E-02	1.9E-01
Anthracene	1.89E-03	2.87E+00	5.43E-03	6.0E+03
Barium	5.30E-05	2.87E+00	1.52E-04	1.5E+03
Benzaldehyde	1.31E-02	2.87E+00	3.76E-02	1.5E+04
Benzene	1.29E-01	2.87E+00	3.70E-01	1.3E+03
Benzo[a]anthracene	6.31E-04	2.87E+00	1.81E-03	3.0E+02
Benzo[a]pyrene	6.31E-04	2.87E+00	1.81E-03	6.0E+02
Benzo[b&k]fluoanthene	8.83E-04	2.87E+00	2.53E-03	6.0E+02
Benzyl alcohol	4.99E-03	2.87E+00	1.43E-02	6.0E+04
Butyl benzyl phthalate	1.54E-05	2.87E+00	4.42E-05	1.5E+04
Carbon Monoxide 1-hr	1.14E+01	4.19E-01	4.76E+00	7.9E+03 [4]
Carbon Monoxide 8-hr	1.14E+01	2.87E+00	3.26E+01	1.2E+04 [5]
Carbon tetrachloride	8.69E-06	2.87E+00	2.49E-05	1.9E+03
Chloromethane	3.58E-05	2.87E+00	1.03E-04	2.0E+05
Chromium	5.01E-05	2.87E+00	1.44E-04	1.5E+03
Chrysene	1.14E-03	2.87E+00	3.26E-03	6.0E+02
Dibenzo[ah]anthracene	2.52E-05	2.87E+00	7.24E-05	3.0E+04
Dibutyl phthalate	4.16E-05	2.87E+00	1.19E-04	1.5E+04
Dichloroethylene [1,1-]	2.71E-05	2.87E+00	7.78E-05	7.5E+04
Diethyl phthalate	8.83E-06	2.87E+00	2.53E-05	1.5E+04
Dimethyl phthalate	2.37E-05	2.87E+00	6.80E-05	1.5E+04
Dioctyl phthalate	1.16E-04	2.87E+00	3.33E-04	5.0E+04
Dioxin	1.88E-10	2.87E+00	5.39E-10	1.3E+00
Ethylbenzene	6.92E-03	2.87E+00	1.99E-02	5.0E+05
Fluoranthene	2.52E-03	2.87E+00	7.24E-03	1.5E+01
Fluorene	1.26E-04	2.87E+00	3.62E-04	1.2E+04
Formaldehyde	3.82E-02	2.87E+00	1.10E-01	9.4E+01
Furan	1.89E-05	2.87E+00	5.43E-05	7.5E-02
Hydrogen chloride	1.26E-01	2.87E+00	3.61E-01	2.1E+03
Indeno[1,2,3-cd]pyrene	6.31E-04	2.87E+00	1.81E-03	5.0E+02
Methylene chloride	9.41E-05	2.87E+00	2.70E-04	1.4E+04
Methyl ethyl ketone	1.64E-03	2.87E+00	4.71E-03	1.3E+04
Methyl isobutyl ketone	1.39E-03	2.87E+00	3.98E-03	3.0E+05
Naphthalene	2.04E-02	2.87E+00	5.86E-02	7.5E+04
Nitrogen dioxide 24-hr	9.46E+00	1.40E-01	1.32E+00	1.5E+02 [6]
Particulate matter (PM-10) 24-hr	2.52E+01	1.40E-01	2.35E+01	1.5E+02 [6]
Particulate matter (TSP) 24-hr	2.52E+01	1.40E-01	3.01E+01	1.5E+02 [6]
Phenanthrene	9.04E-04	2.87E+00	2.60E-03	1.0E+03

Table 3-6. Short-Term Off-Site Impacts (continued)

Contaminant	Calculated Emissions [1] (g/s)	Off-site Conversion Factor ($\mu g/m^3$ per g/s)	Off-Site Impacts [2] ($\mu g/m^3$)	Acute Limits [3] ($\mu g/m^3$)
Phenol	1.97E-03	2.87E+00	5.65E-03	5.8E+03
Pyrene	2.52E-04	2.87E+00	7.24E-04	1.5E+04
Styrene	6.29E-03	2.87E+00	1.81E-02	2.1E+04
Sulfur Dioxide 3-hr	3.15E-01	9.57E-01	3.02E-01	1.1E+03 [7]
Sulfur Dioxide 24-hr	3.15E-01	1.40E-01	4.41E-02	2.1E+02 [6]
Toluene	1.54E-02	2.87E+00	4.42E-02	3.7E+04
Trichloroethane [1,1,1-]	4.34E-06	2.87E+00	1.25E-05	6.8E+04
Trimethylbenzene [1,3,5-]	7.02E-02	2.87E+00	2.02E-01	1.3E+05
Vinyl chloride	2.81E-05	2.87E+00	8.07E-05	1.8E+05
Xylenes	7.28E-02	2.87E+00	2.09E-01	2.2E+04
Zinc	7.89E-03	2.87E+00	2.27E-02	3.0E+04

1 Calculated using 1000 pounds per hour of waste burned, converted to 126 grams/second (g/s). See Table 3-3 for the method of calculating emissions
2 Background included, as appropriate (NMED, 2007)
3 Except where noted, screening limits are from acute limits (1 hr) inhalation exposures (AIEC) for toxic air pollutants (EPA, 2005).
4 Acute limits for these contaminants are from the Environmental Protection Agency's (EPA's) Ambient Air Quality Standards (AAQS) for a 8 hour averaging period.
5 Acute limit for this contaminant is from the EPA's AAQS for a 1 hour averaging period.
6 Acute limit for this contaminant is from the EPA's AAQS for a 24 hour averaging period.
7 Acute limit for this contaminant is from the EPA's AAQS for a 3 hour averaging period.

g/s = grams per second
$\mu g/m^3$ = micrograms per cubic meter
PM-10 = particulate matter less than 10 micrometers
TSP= total suspended particulate

Table 3-7. Annual On-Site Impacts

Contaminant	Calculated Emissions [1] (g/s)	On-site Conversion Factor ($\mu g/m^3$ per g/s)	Annual Impact [2] ($\mu g/m^3$)	Screening Level [3] ($\mu g/m^3$)
Acenaphthene	4.97E-05	1.48E+00	7.35E-05	2.2E+01
Acetaldehyde	3.13E-04	1.48E+00	4.63E-04	8.7E-02
Acetone	1.74E-04	1.48E+00	2.57E-04	3.3E+02
Acrolein	1.94E-04	1.48E+00	2.87E-04	2.1E-03
Aluminum	3.54E-06	1.48E+00	5.24E-06	5.1E-01
Anthracene	7.45E-05	1.48E+00	1.10E-04	1.1E+02
Barium	2.09E-06	1.48E+00	3.09E-06	5.2E-02
Benzaldehyde	5.16E-04	1.48E+00	7.64E-04	3.7E+01
Benzene	5.07E-03	1.48E+00	7.51E-03	2.5E-02
Benzo(a)anthracene	2.48E-05	1.48E+00	3.67E-05	9.2E-04
Benzo(a)pyrene	2.48E-05	1.48E+00	3.67E-05	9.2E-05
Benzo(b,k)fluoranthene	3.48E-05	1.48E+00	5.14E-05	2.6E-03
Benzyl alcohol	1.97E-04	1.48E+00	2.91E-04	1.1E+02
Butadiene [1-3-]	6.65E-06	1.48E+00	9.85E-06	1.1E-03
Butyl benzyl phthalate	6.06E-07	1.48E+00	8.96E-07	7.3E+01
Carbon tetrachloride	3.42E-07	1.48E+00	5.06E-07	1.3E-02
Chloromethane (methyl chloride)	1.41E-06	1.48E+00	2.09E-06	9.5E+00
Chromium (total)	1.97E-06	1.48E+00	2.92E-06	1.6E-05
Chrysene	4.47E-05	1.48E+00	6.61E-05	1.7E-02
Crotonaldehyde	2.98E-05	1.48E+00	4.41E-05	3.5E-04
Cyclohexane	1.33E-04	1.48E+00	1.96E-04	6.2E+02
Dibenzo(a,h)anthracene	9.93E-07	1.48E+00	1.47E-06	9.2E-05
Dibutyl phthalate	1.64E-06	1.48E+00	2.42E-06	3.7E+01
Dichloroethylene [1,1-]	1.07E-06	1.48E+00	1.58E-06	2.1E+01
Diethyl phthalate	3.48E-07	1.48E+00	5.14E-07	2.9E+02
Dimethyl phthalate	9.33E-07	1.48E+00	1.38E-06	3.7E+03
Dioctyl phthalate	4.56E-06	1.48E+00	6.75E-06	1.5E+01
Dioxin (2,3,7,8-TCDD)	7.40E-12	1.48E+00	1.09E-11	4.5E-09
Ethylbenzene	2.73E-04	1.48E+00	4.03E-04	1.1E+02
Ethyl chloride	3.42E-07	1.48E+00	5.06E-07	2.3E-01
Fluoranthene	9.93E-05	1.48E+00	1.47E-04	1.5E+01
Fluorene	4.97E-06	1.48E+00	7.35E-06	1.5E+01
Formaldehyde	1.50E-03	1.48E+00	2.23E-03	1.5E-02
Furan	7.45E-07	1.48E+00	1.10E-06	3.7E-01
Hexane	7.94E-05	1.48E+00	1.18E-04	2.1E+01
Hydrogen chloride	4.95E-03	1.48E+00	7.33E-03	2.1E+00
Indeno[1,2,3-cd]pyrene	2.48E-05	1.48E+00	3.67E-05	9.2E-04
Methylcyclohexane	7.75E-04	1.48E+00	1.15E-03	3.1E+02
Methylene chloride	3.70E-06	1.48E+00	5.48E-06	4.1E-01
Methyl ethyl ketone (2-Butanone)	6.45E-05	1.48E+00	9.55E-05	5.1E+02
Methyl isobutyl ketone	5.46E-05	1.48E+00	8.08E-05	3.1E+02
Naphthalene	8.04E-04	1.48E+00	1.19E-03	5.6E-03
Phenol	7.75E-05	1.48E+00	1.15E-04	1.1E+02
Pyrene	9.93E-06	1.48E+00	1.47E-05	1.1E+01

Table 3-7. Annual On-Site Impacts (continued)

Contaminant	Calculated Emissions [1] (g/s)	On-site Conversion Factor ($\mu g/m^3$ per g/s)	Annual Impact [2] ($\mu g/m^3$)	Screening Level [3] ($\mu g/m^3$)
Styrene	2.48E-04	1.48E+00	3.67E-04	1.1E+02
Toluene	6.10E-04	1.48E+00	9.03E-04	4.0E+01
Trichloroethane [1,1,1-]	1.72E-07	1.48E+00	2.55E-07	2.3E+02
Trimethylbenzene [1,2,4-]	1.22E-03	1.48E+00	1.80E-03	6.2E-01
Trimethylbenzene [1,3,5-]	2.79E-03	1.48E+00	4.12E-03	6.2E-01
Vinyl chloride	1.12E-06	1.48E+00	1.65E-06	1.1E-02
Xylene (Total)	2.89E-03	1.48E+00	4.27E-03	1.1E+01

1 Calculated assuming the amount of waste burned is 20,000 lb and 15,000 gal of propane. See Table 3-4 for the method of calculating emissions
2 Background included, as appropriate (NMED, 2007)
3 Source for annual screening levels are from Environmental Protection Agency's Region 9 Preliminary Remediation Goals (PRGs), (EPA, 2004). The levels are multiplied by 0.1 as described in the modeling protocol (LANL, 2007).
g/s = grams per second
$\mu g/m^3$ = micrograms per cubic meter

Table 3-8. Annual Off-Site Impacts

Contaminant	Calculated Emissions [1] (g/s)	Off-site Conversion Factor (µg/m³ per g/s)	Annual Impact [2] (µg/m³)	Screening Level [3] (µg/m³)
Acenaphthene	4.97E-05	5.76E-03	2.86E-07	2.2E+01
Acetaldehyde	3.13E-04	5.76E-03	1.80E-06	8.7E-02
Acetone	1.74E-04	5.76E-03	1.00E-06	3.3E+02
Acrolein	1.94E-04	5.76E-03	1.12E-06	2.1E-03
Aluminum	3.54E-06	5.76E-03	2.04E-08	5.1E-01
Anthracene	7.45E-05	5.76E-03	4.29E-07	1.1E+02
Barium	2.09E-06	5.76E-03	1.20E-08	5.2E-02
Benzaldehyde	5.16E-04	5.76E-03	2.97E-06	3.7E+01
Benzene	5.07E-03	5.76E-03	2.92E-05	2.5E-02
Benzo(a)anthracene	2.48E-05	5.76E-03	1.43E-07	9.2E-04
Benzo(a)pyrene	2.48E-05	5.76E-03	1.43E-07	9.2E-05
Benzo(b,k)fluoranthene	3.48E-05	5.76E-03	2.00E-07	2.6E-03
Benzyl alcohol	1.97E-04	5.76E-03	1.13E-06	1.1E+02
Butadiene [1-3-]	6.65E-06	5.76E-03	3.83E-08	1.1E-03
Butyl benzyl phthalate	6.06E-07	5.76E-03	3.49E-09	7.3E+01
Carbon tetrachloride	3.42E-07	5.76E-03	1.97E-09	1.3E-02
Chloromethane (methyl chloride)	1.41E-06	5.76E-03	8.12E-09	9.5E+00
Chromium (total)	1.97E-06	5.76E-03	1.14E-08	1.6E-05
Chrysene	4.47E-05	5.76E-03	2.57E-07	1.7E-02
Crotonaldehyde	2.98E-05	5.76E-03	1.72E-07	3.5E-04
Cyclohexane	1.33E-04	5.76E-03	7.64E-07	6.2E+02
Dibenzo(a,h)anthracene	9.93E-07	5.76E-03	5.72E-09	9.2E-05
Dibutyl phthalate	1.64E-06	5.76E-03	9.44E-09	3.7E+01
Dichloroethylene [1,1-]	1.07E-06	5.76E-03	6.15E-09	2.1E+01
Diethyl phthalate	3.48E-07	5.76E-03	2.00E-09	2.9E+02
Dimethyl phthalate	9.33E-07	5.76E-03	5.38E-09	3.7E+03
Dioctyl phthalate	4.56E-06	5.76E-03	2.63E-08	1.5E+01
Dioxin (2,3,7,8-TCDD)	7.40E-12	5.76E-03	4.26E-14	4.5E-09
Ethylbenzene	2.73E-04	5.76E-03	1.57E-06	1.1E+02
Ethyl chloride	3.42E-07	5.76E-03	1.97E-09	2.3E-01
Fluoranthene	9.93E-05	5.76E-03	5.72E-07	1.5E+01
Fluorene	4.97E-06	5.76E-03	2.86E-08	1.5E+01
Formaldehyde	1.50E-03	5.76E-03	8.67E-06	1.5E-02
Furan	7.45E-07	5.76E-03	4.29E-09	3.7E-01
Hexane	7.94E-05	5.76E-03	4.58E-07	2.1E+01
Hydrogen chloride	4.95E-03	5.76E-03	2.85E-05	2.1E+00
Indeno[1,2,3-cd]pyrene	2.48E-05	5.76E-03	1.43E-07	9.2E-04
Methylcyclohexane	7.75E-04	5.76E-03	4.46E-06	3.1E+02
Methylene chloride	3.70E-06	5.76E-03	2.13E-08	4.1E-01
Methyl ethyl ketone (2-Butanone)	6.45E-05	5.76E-03	3.72E-07	5.1E+02
Methyl isobutyl ketone	5.46E-05	5.76E-03	3.15E-07	3.1E+02
Naphthalene	8.04E-04	5.76E-03	4.63E-06	5.6E-03

Table 3-8. Annual Off-Site Impacts (continued)

Contaminant	Calculated Emissions [1] (g/s)	Off-site Conversion Factor ($\mu g/m^3$ per g/s)	Annual Impact [2] ($\mu g/m^3$)	Screening Level [3] ($\mu g/m^3$)
Nitrogen dioxide	3.98E-01 [5]	5.76E-03	2.29E-03	7.5E+01 [4]
Particulate matter (TSP)	9.94E-01 [5]	5.76E-03	2.66E+01	6.0E+01 [4]
Phenol	7.75E-05	5.76E-03	4.46E-07	1.1E+02
Pyrene	9.93E-06	5.76E-03	5.72E-08	1.1E+01
Styrene	2.48E-04	5.76E-03	1.43E-06	1.1E+02
Sulfur dioxide	1.25E-02 [5]	5.76E-03	7.22E-05	4.2E+01 [4]
Toluene	6.10E-04	5.76E-03	3.51E-06	4.0E+01
Trichloroethane [1,1,1-]	1.72E-07	5.76E-03	9.91E-10	2.3E+02
Trimethylbenzene [1,2,4-]	1.22E-03	5.76E-03	7.00E-06	6.2E-01
Trimethylbenzene [1,3,5-]	2.79E-03	5.76E-03	1.60E-05	6.2E-01
Vinyl chloride	1.12E-06	5.76E-03	6.42E-09	1.1E-02
Xylene (Total)	2.89E-03	5.76E-03	1.66E-05	1.1E+01

1 Calculated assuming the amount of waste burned is 20,000 lb and 15,000 gallons of propane. See Table 3-4 for the method of calculating emissions
2 Background included, as appropriate (NMED, 2007)
3 Except as noted, source for annual screening levels are from Environmental Protection Agency's Region 9 Preliminary Remediation Goals (PRGs), (EPA, 2004). The levels are multiplied by 0.1 as described in the modeling protocol (LANL, 2007).
4 Source for this annual screening level is the Environmental Protection Agency's (EPA's) Ambient Air Quality Standards (AAQS).
5 Calculated emissions include the addition of propane emissions, see Table 3-4.

g/s = grams per second
$\mu g/m^3$ = micrograms per cubic meter
TSP= total suspended particulate

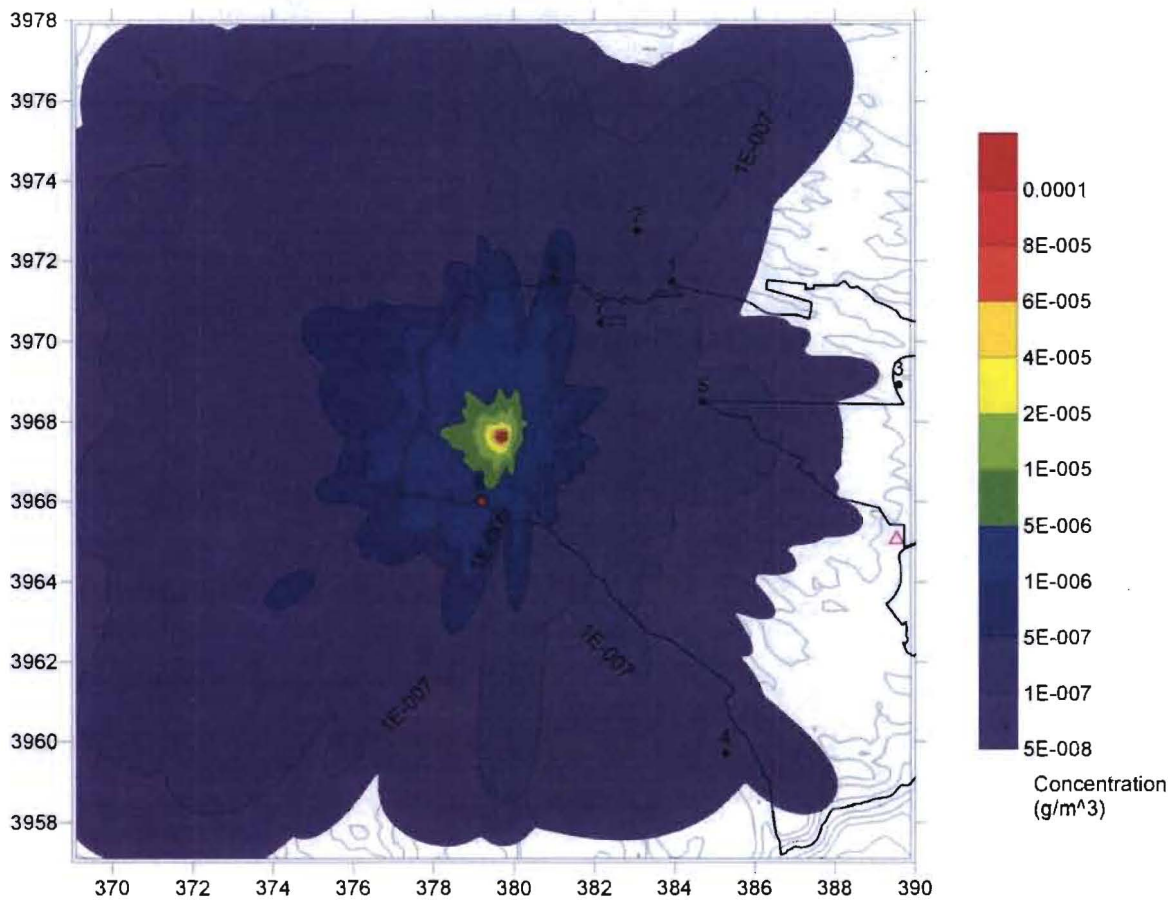

Figure 3-1. Peak 1-hour average air concentrations for the TA-16-388 minimum lofting case study for a 1 gram per second release rate.

Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^3 = grams per cubic meter

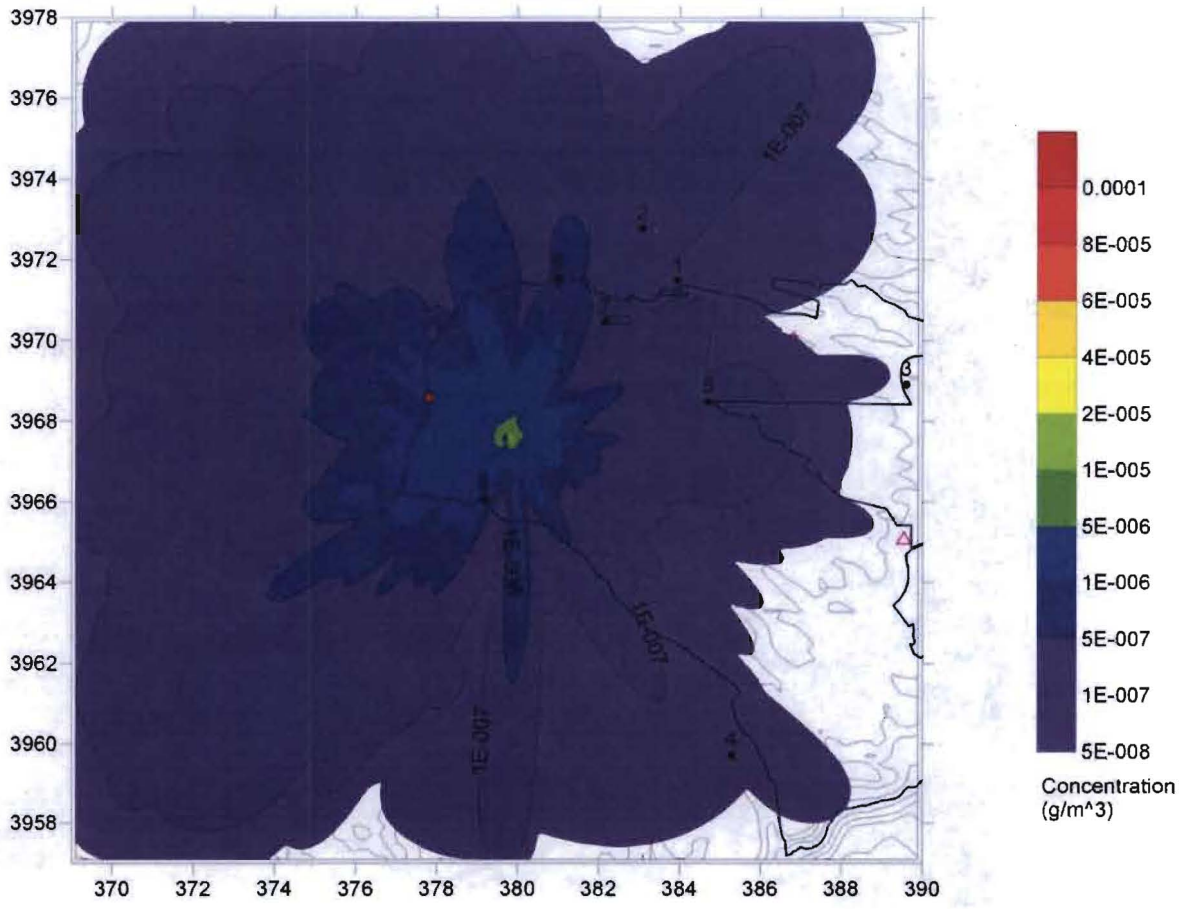

Figure 3-2. Peak 1-hour average air concentrations for the TA-16-388 maximum lofting case study with a 1 gram per second release rate.

Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^3 = grams per cubic meter

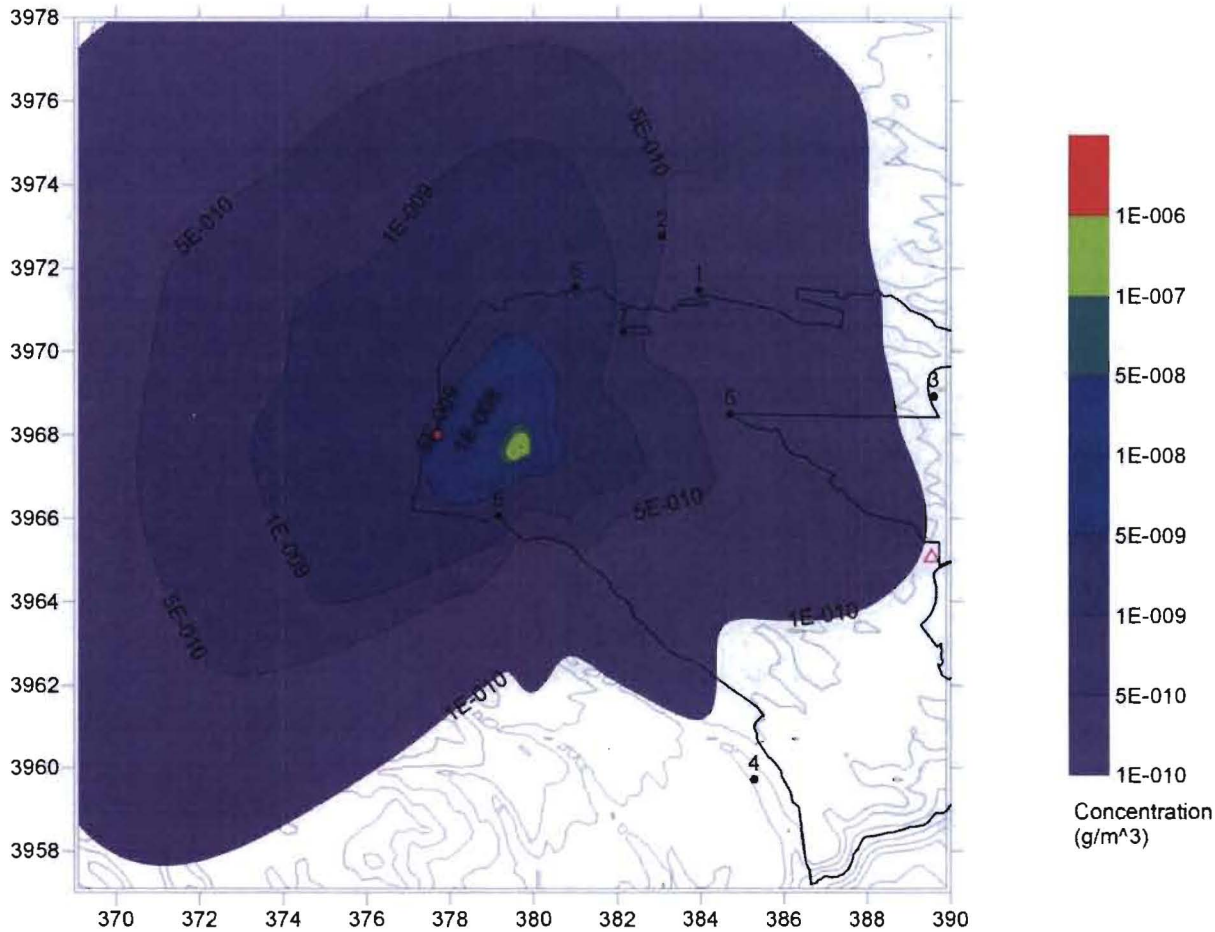

Figure 3-3. Peak annual average air concentration for the TA-16-388 minimum lofting case study with a 1 gram per second release rate.

Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^3 = grams per cubic meter

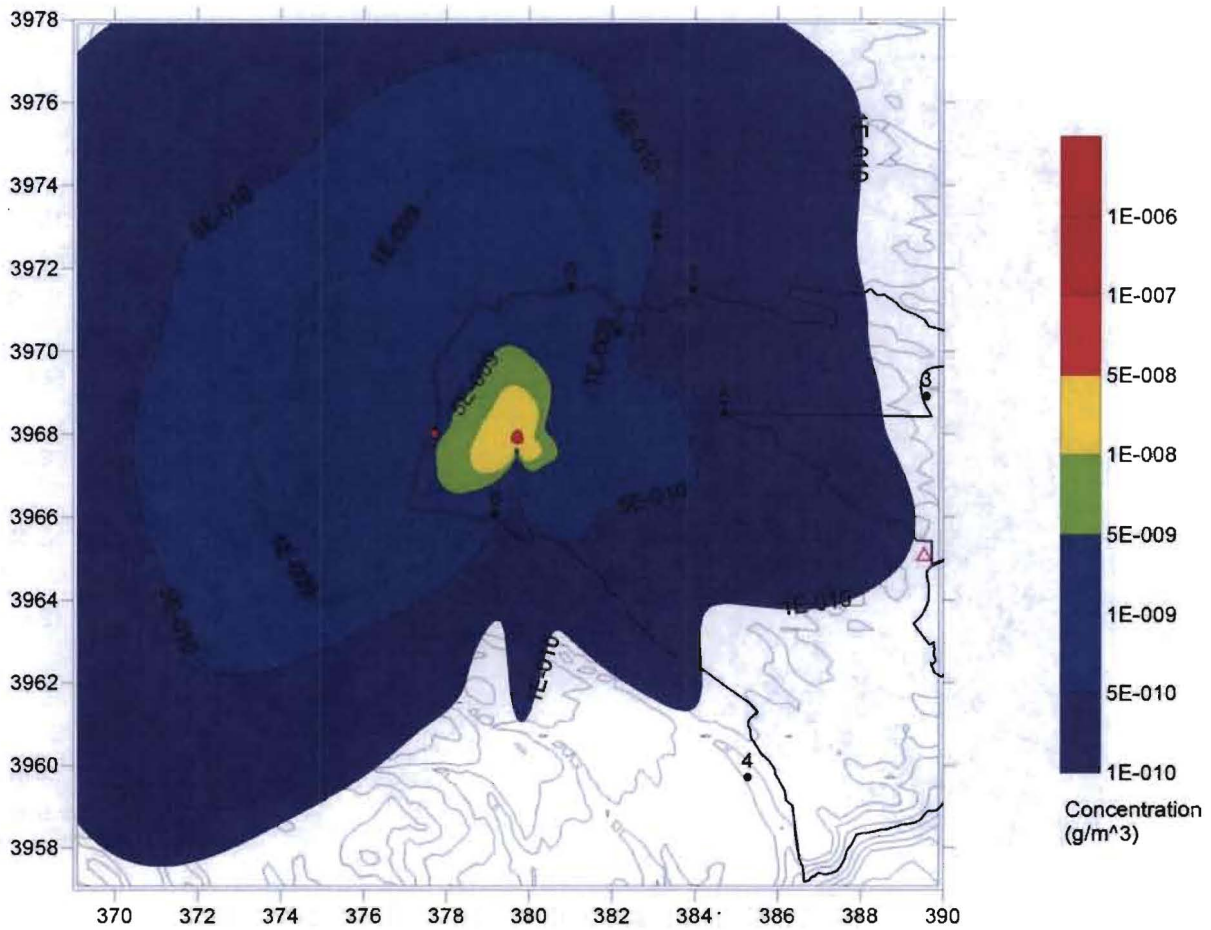

Figure 3-4. Peak annual-average air concentration for the TA-16-388 maximum lofting case study with a 1 gram per second release rate.

Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^3 = grams per cubic meter

4.0 Deposition Modeling Results

Deposition modeling was performed using the same worst-case unit/waste scenarios explained at the beginning of Section 3.0. CALPUFF's deposition option uses the same air concentrations calculated for air quality impacts then "deposits" the pollutants on surfaces using pollutant-specific deposition rates. The pollutant-specific deposition parameters are complex and, because LANL-specific information is not available, representative model parameter defaults were used. CALPUFF provides a library of information for particulate matter, sulfur dioxide, various oxides of nitrogen, nitric acid, odor, toluene, xylene, and pinenes. It does not, however, contain data for many of the contaminants from the worst-case waste scenario described in Section 3.3 of the modeling protocol (LANL, 2007). To best reflect the types of pollutants that may be emitted from the TA-16 Burn Ground, the CALPUFF parameters for particulate matter represented total suspended particulate and PM_{10}; oxides of nitrogen represented inorganic gaseous pollutants such as carbon monoxide and nitrogen dioxide; and toluene represented emissions of gaseous hydrocarbons. These assumptions introduce additional uncertainty to the deposition impact analysis because surrogates have been chosen that may not completely represent each constituent. However, the most similar surrogate for each worst-case scenario contaminant is used to represent that contaminant and the use of surrogates allows for the impact analysis to extend to all of the contaminants for which emissions factors have been identified rather than only those in the CALPUFF library.

CALPUFF derives annual deposition fluxes (DF) in g of pollutant deposited per m^2 of soil per second ($g/m^2 s$) for each g/s of pollutant released. Illustrations of the deposition fluxes are located in Figures 4-1 and 4-2 for the TA-16-388 minimum and maximum lofting scenarios. Table 4-1 shows the deposition fluxes for particulates and particulate matter, hydrocarbons, and inorganic gases for the worst-case on-site and off-site impacts scenarios. However, the screening levels used are in milligrams of pollutant deposited per kilogram of soil (mg/kg) so the deposition fluxes must be converted to unit soil input concentrations as follows:

$$\frac{DF\ (\text{g waste})}{(\text{m}^2\ \text{soil} * \text{s})(\text{g/s})} * \frac{1}{D\ (\text{m soil})} * \frac{(\text{m}^3\ \text{soil})}{BD\ (\text{kg soil})} = \frac{SC\ \text{g waste}}{\text{kg soil} * \text{s (g/s)}}$$

Where:

- SC = Soil input concentration rate (g pollutant/kg soil * s) per g/s pollutant emission rate
- DF = the annual deposition flux in g/m^2 s per g/s pollutant emission rate
- D = depth of the soil mixing layer = 2 cm = 0.02 m (EPA, 2005)
- BD = bulk soil density = 1.5 g/cm^3 = 1500 kg/m^3 (EPA, 2005)

Then soil deposition is calculated as follows:

$$\frac{EF\ \text{g pollutant}}{\text{g waste}} \times \frac{SC\ \text{g waste}}{\text{kg soil} * \text{s (g/s)}} \times \frac{20\ \text{burns/yr}}{508\ \text{sims/yr}} \times \frac{1{,}000\ \text{lb waste}}{1\ \text{hr}} \times \frac{1\text{hr}}{3600\ \text{s}} \times \frac{454\ \text{g waste}}{1\ \text{lb waste}} \times$$

$$\frac{1000\ \text{mg pollutant}}{\text{g pollutant}} \times \frac{8760\ \text{hr}}{\text{yr}} \times \frac{3600\ \text{s}}{\text{hr}} = \frac{AD\ \text{mg pollutant}}{\text{kg soil} * \text{yr}}$$

where:

EF = emission factors from Table 3-6 in the modeling protocol (LANL, 2007)
AD = calculated air pollutant deposition in mg/kg*yr

The worst-case depositions flux values listed in Table 4-1 were chosen because they were the highest model calculated DFs. Since deposition impact analysis is conducted based on a maximum annual waste quantity of 20,000 pounds, weighted DF values were not considered as weighted conversion factors as they were for the dispersion impact analysis. Both the maximum on-site and off-site worst-case DF values occurred with the TA-16-388 minimum lofting scenario. Table 4-1 shows the DFs that have been determined to result in the highest deposition concentrations and Table 4-2 shows the calculated SCs. The SC rates are multiplied by pollutant emissions rates to calculate deposition. The contaminant-specific annual emissions rates are the same as those used for the chronic air quality impacts analysis (Table 3-4). These emission rates assume that 20,000 lb/yr of burnable wastes (this does not include non-combustibles associated with the waste, such as scrap metal or soil) are treated annually and 15,000 gal of propane is used as supplemental fuel annually. Annual deposition was multiplied by 10 to estimate a 10-year impact, which provides an incremental change over the lifetime of the permit. The 10-year deposition quantities are then compared to deposition screening levels. In accordance with the modeling protocol (LANL, 2007), the screening levels used were:

- The NMED Human Health Industrial/Occupational Soil Screening Levels (SSLs) (NMED, 2006)
- The EPA Region 6 Human Health Medium-Specific Screening Levels (EPA, 2007), contaminants which are not on the NMED SSL table. EPA guidance uses a 10^{-6} cancer risk level and NMED uses a 10^{-5} cancer risk level for chemical carcinogens. To equalize the deposition pollutant assessment, EPA carcinogen screening levels are multiplied by 10 to reflect the 10^{-5} cancer risk.
- The LANL Ecological Screening Levels (ESLs).

Table 4-3 shows the worst-case pollutant-specific annual deposition and 10-yr deposition and the screening levels. Based on Table 4-3, screening levels would not be approached until orders of magnitude more material was burned than the maximum limit assessed. This confirms that the air pathway will not create unacceptable soil contamination.

Table 4-1. Deposition Fluxes[1]

	Worst-Case On-Site		
Pollutant Type	**x (UTM km)**	**y (UTM km)**	**Deposition Flux[1]**
Particulate matter	380	3968	9.68E-09
Volatile organic gases	380	3968	1.19E-08
Inorganic gases	380	3968	9.45E-09
	Worst-Case Off-Site		
Pollutant Type	**x (UTM km)**	**y (UTM km)**	**Deposition Flux[1]**
Particulate matter	380	3971	1.70E-11
Volatile organic gases	379	3971	2.55E-11
Inorganic gases	379	3971	2.10E-11

[1] All deposition maxima arise from the minimum lofting scenario at TA-16-388.
[2] Units are grams of pollutant deposited per square meter of soil per second for a standard gram per second pollutant emissions rate

Table 4-2. Soil Input Concentrations

Pollutant Type	Soil Input Concentration[1]	
	Worst-Case On-Site	**Worst- Case Off-Site**
Particulate matter	3.23E-10	5.66E-13
Volatile organic gases	3.97E-10	8.50E-13
Inorganic gases	3.15E-10	6.99E-13

[1] Units are grams of pollutant deposited per kilogram of soil per second for a standard gram per second pollutant emissions rate

Table 4-3. Worst-Case On-Site 10-year Deposition

Contaminant	Emissions Factor (g/g)	Conversion Factor Source [1]	Worst-Case On-site Conversion Factor [2]	Annual Deposition (mg/kg)	10-year Deposition (mg/kg)	ESL[3] (mg/kg)	SSL[4] (mg/kg)
Acenaphthene	1.00E-05	HC	3.97E-10	6.21E-04	6.21E-03	2.50E-01	3.35E+04
Acetaldehyde	6.30E-05	HC	3.97E-10	3.91E-03	3.91E-02		3.84 E+02
Acetone	3.50E-05	HC	3.97E-10	2.17E-03	2.17E-02	1.20E+00	1.00E+05
Acrolein	3.90E-05	HC	3.97E-10	2.42E-03	2.42E-02		7.52 E-01
Aluminum	7.13E-07	PM	3.23E-10	3.60E-05	3.60E-04		1.00E+05
Anthracene	1.50E-05	HC	3.97E-10	9.32E-04	9.32E-03	2.10E+02	1.00E+05
Barium	4.20E-07	PM	3.23E-10	2.12E-05	2.12E-04	1.10E+02	1.00E+05
Benzaldehyde	1.04E-04	HC	3.97E-10	6.46E-03	6.46E-02		6.80E+04
Benzene	1.02E-03	HC	3.97E-10	6.35E-02	6.35E-01	2.40E+01	2.58E+01
Benzo(a)anthracene	5.00E-06	HC	3.97E-10	3.11E-04	3.11E-03	3.00E+00	2.34E+01
Benzo(a)pyrene	5.00E-06	HC	3.97E-10	3.11E-04	3.11E-03	9.60E+00	2.34E+00
Benzo(b,k)fluoranthene	7.00E-06	HC	3.97E-10	4.35E-04	4.35E-03	1.80E+01	2.34E+01
Benzyl alcohol	3.96E-05	HC	3.97E-10	2.46E-03	2.46E-02		1.00E+05
Butadiene [1-3-]	1.34E-06	HC	3.97E-10	8.32E-05	8.32E-04		2.38E+00
Butyl benzyl phthalate	1.22E-07	HC	3.97E-10	7.58E-06	7.58E-05	9.00E+01	2.40E+02
Carbon tetrachloride	6.89E-08	HC	3.97E-10	4.28E-06	4.28E-05		8.64E+00
Chloromethane	2.84E-07	HC	3.97E-10	1.76E-05	1.76E-04		5.34E+01
Chromium (total)	3.97E-07	PM	3.23E-10	2.01E-05	2.01E-04	2.30E+00	5.00E+03
Chrysene	9.00E-06	HC	3.97E-10	5.59E-04	5.59E-03	2.40E+00	2.31E+03
Crotonaldehyde	6.00E-06	HC	3.97E-10	3.73E-04	3.73E-03		1.70E-01
Cyclohexane	2.67E-05	HC	3.97E-10	1.66E-03	1.66E-02		1.40E+02
Dibenzo(a,h)anthracene	2.00E-07	HC	3.97E-10	1.24E-05	1.24E-04	1.20E+01	2.34E+00
Dibutyl phthalate	3.30E-07	HC	3.97E-10	2.05E-05	2.05E-04	1.10E-02	6.84E+04
Dichloroethylene [1,1-]	2.15E-07	HC	3.97E-10	1.34E-05	1.34E-04	1.10E+01	7.77E+02
Diethyl phthalate	7.00E-08	HC	3.97E-10	4.35E-06	4.35E-05		1.00E+05

Table 4-3. Worst-Case On-Site 10-year Deposition (continued)

Contaminant	Emissions (g/s)	Conversion Factor Source [1]	Worst-Case On-site Conversion Factor [2]	Annual Deposition (mg/kg)	10-year Deposition (mg/kg)	ESL[3] (mg/kg)	SSL[4] (mg/kg)
Dimethyl phthalate	1.88E-07	HC	3.97E-10	1.17E-05	1.17E-04	1.17E-04	1.00E+05
Dioctyl phthalate	9.19E-07	HC	3.97E-10	5.71E-05	5.71E-04	5.71E-04	
Dioxin (2,3,7,8-TCDD)	1.49E-12	HC	3.97E-10	9.25E-11	9.25E-10	9.25E-10	1.80E-04
Ethylbenzene	5.49E-05	HC	3.97E-10	3.41E-03	3.41E-02	3.41E-02	1.28E+02
Ethyl chloride	6.89E-08	HC	3.97E-10	4.28E-06	4.28E-05	4.28E-05	1.54E+02
Fluoranthene	2.00E-05	HC	3.97E-10	1.24E-03	1.24E-02	1.24E-02	2.44E+04
Fluorene	1.00E-06	HC	3.97E-10	6.21E-05	6.21E-04	6.21E-04	2.65E+04
Formaldehyde	3.03E-04	HC	3.97E-10	1.88E-02	1.88E-01	1.88E-01	4.20E+02
Furan	1.50E-07	HC	3.97E-10	9.32E-06	9.32E-05	9.32E-05	2.12E+01
Hexane	1.60E-05	HC	3.97E-10	9.94E-04	9.94E-03	9.94E-03	3.80E+01
Hydrogen chloride	9.97E-04	INORG	3.15E-10	4.92E-02	4.92E-01	4.92E-01	1.00 E+05
Indeno[1,2,3-cd]pyrene	5.00E-06	HC	3.97E-10	3.11E-04	3.11E-03	3.11E-03	2.34E+01
Methylcyclohexane	1.56E-04	HC	3.97E-10	9.69E-03	9.69E-02	9.69E-02	7.89E+01
Methylene chloride	7.46E-07	HC	3.97E-10	4.63E-05	4.63E-04	4.63E-04	4.90E+02
Methyl ethyl ketone (2-Butanone)	1.30E-05	HC	3.97E-10	8.07E-04	8.07E-03	8.07E-03	4.87E+04
Methyl isobutyl ketone	1.10E-05	HC	3.97E-10	6.83E-04	6.83E-03	6.83E-03	7.01E+03
Naphthalene	1.62E-04	HC	3.97E-10	1.01E-02	1.01E-01	1.01E-01	3.00E+02
Nitrogen dioxide	7.50E-02	INORG	3.15E-10	3.70E+00	3.70E+01	3.70E+01	1.00E+05
Phenanthrene	7.17E-06	HC	3.97E-10	4.45E-04	4.45E-03	4.45E-03	2.05E+04
Phenol	1.56E-05	HC	3.97E-10	9.69E-04	9.69E-03	9.69E-03	1.00E+05
Pyrene	2.00E-06	HC	3.97E-10	1.24E-04	1.24E-03	1.24E-03	3.09E+04
Styrene	4.99E-05	HC	3.97E-10	3.10E-03	3.10E-02	3.10E-02	1.00E+02
Toluene	1.22E-04	HC	3.97E-10	7.58E-03	7.58E-02	7.58E-02	2.52E+02
Trichloroethane[1,1,1-]	3.44E-08	HC	3.97E-10	2.14E-06	2.14E-05	2.14E-05	5.63E+02
Trimethylbenzene [1,2,4-]	2.43E-04	HC	3.97E-10	1.51E-02	1.51E-01	1.51E-01	2.13E+02
1,3,5-Trimethylbenzene	5.57E-04	HC	3.97E-10	3.46E-02	3.46E-01	3.46E-01	6.92E+01
Vinyl chloride	2.23E-07	HC	3.97E-10	1.39E-05	1.39E-04	1.39E-04	1.40E+01

Table 4-3. Worst-Case On-Site 10-year Deposition (continued)

Contaminant	Emissions (g/s)	Conversion Factor Source [1]	Worst-Case On-site Conversion Factor [2]	Annual Deposition (mg/kg)	10-year Deposition (mg/kg)	ESL[3] (mg/kg)	SSL[4] (mg/kg)
Xylene (Total)	5.77E-04	HC	3.97E-10	3.58E-02	3.58E-01	1.40E+00	8.20E+01
Zinc	6.26E-05	PM	3.23E-10	3.16E-03	3.16E-02	1.00E+01	1.00E+05

[1] The source of the conversion factor (CF) is either the Table 4-2 particulate matter (PM) deposition rate, the inorganic gases (INORG) deposition rate, based on oxides of nitrogen, or the hydrocarbon (HC) deposition rate, based on toluene.
[2] The units of the CF are grams of pollutant deposited per kilogram of soil per second (mg/kg*s) per gram per second pollutant emission rate.
[3] ESL = The LANL Ecological Screening Levels
[4] SSL = The NMED Human Health Industrial/Occupational Soil Screening Levels (SSLs) (NMED, 2006) or the EPA Region 6 Human Health Medium-Specific Screening Levels (EPA, 2007), which are used for contaminants not appearing on the NMED SSL table

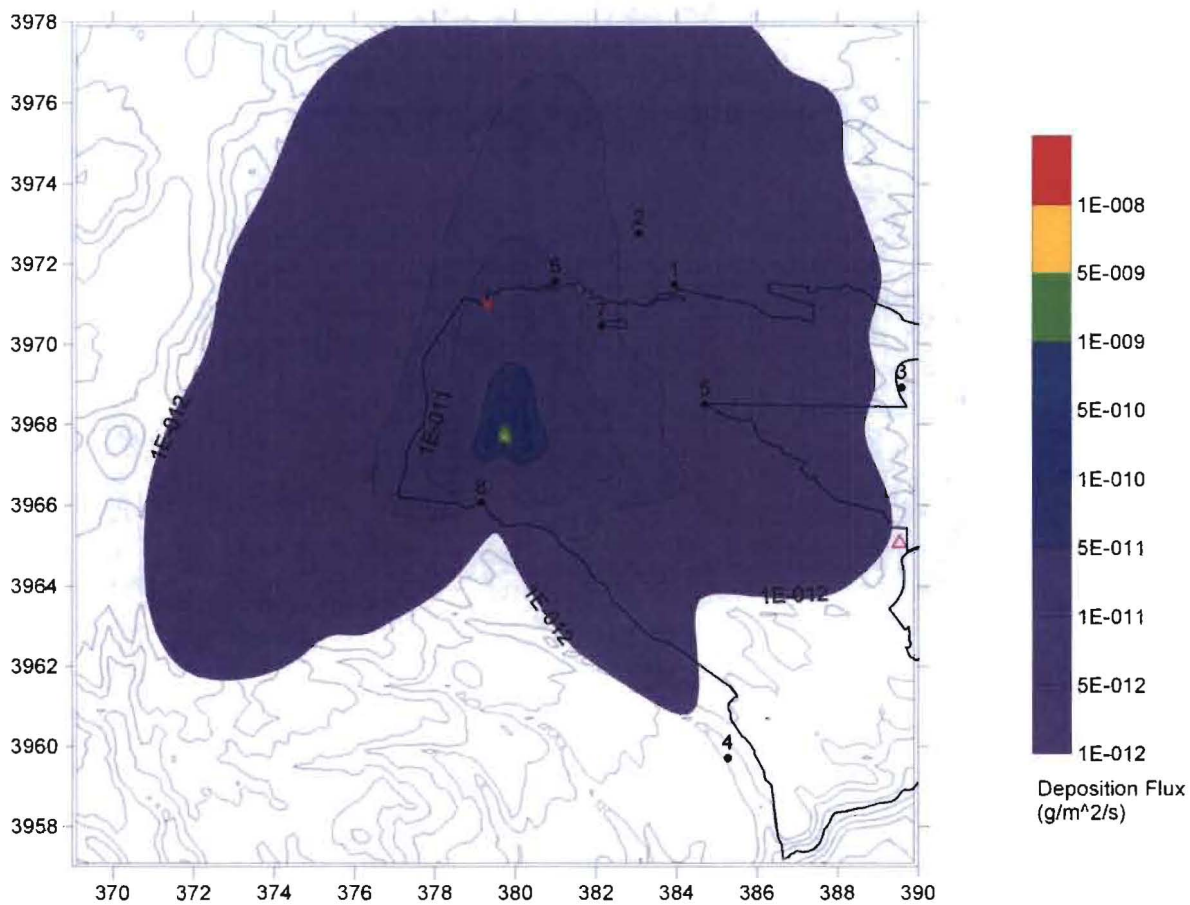

Figure 4-1. Peak annual average deposition flux for the TA-16-388 minimum lofting case with a 1 gram per second release rate.

Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^2-s = grams per square meter seconds

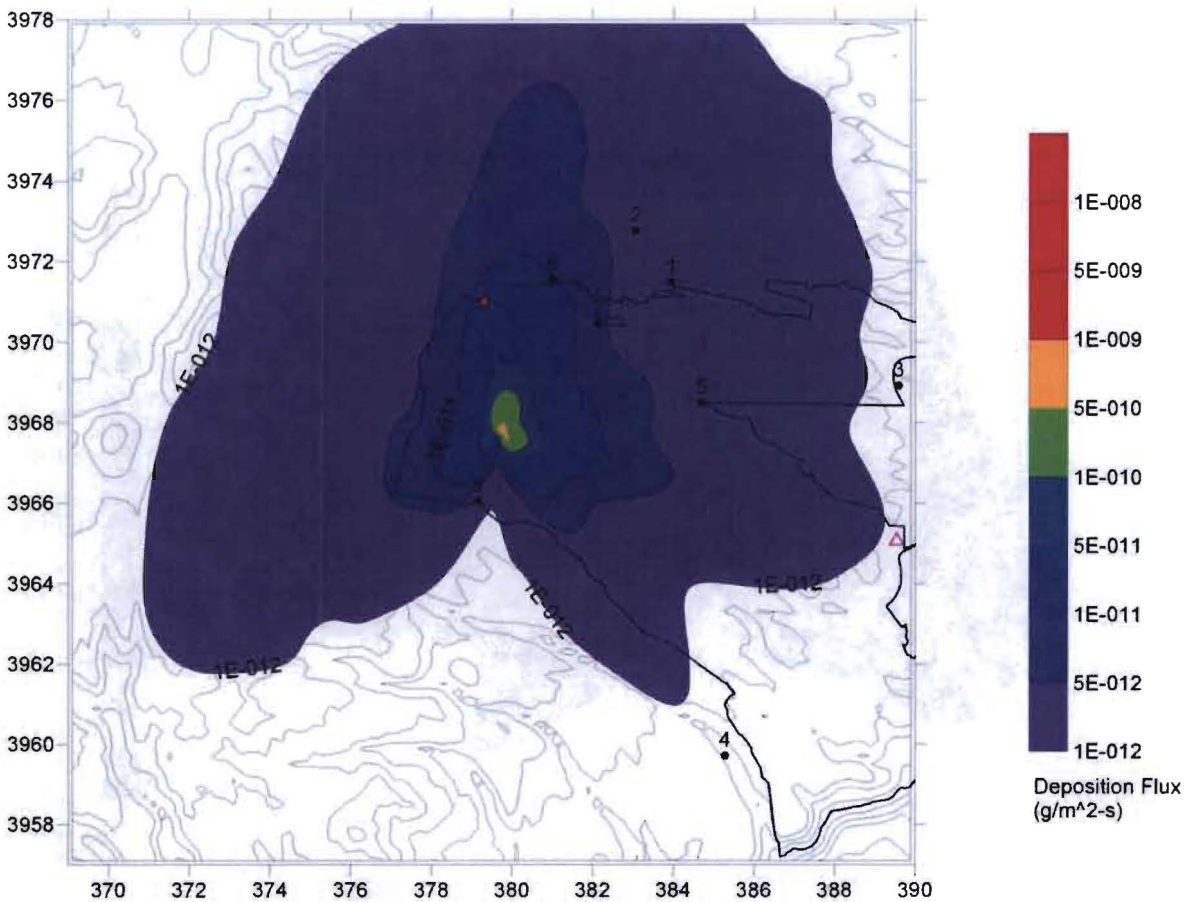

Figure 4-2. Peak annual average deposition flux for the TA-16-388 maximum lofting case with a 1 gram per second release rate.

Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^2-s = grams per square meter seconds

5.0 Regulated Solvent Impacts Analysis

Specific individual solvents burned at the TA-16 Burn Ground cannot be modeled as described in Sections 2 and 3 because there are no solvent-specific emission factors for open burning of solvents. Emission factors for the open burning of spilled fuel oil were used to conservatively estimate the products of combustion that result from burning solvents.

Solvents treated at TA-16 are produced mainly from research and development processes, which may change frequently. Therefore, the types and amounts of solvents cannot be estimated. Solvent emissions calculated in the past were snapshots of a single year's activities and cannot be extrapolated to other years with certainty. Over the past several years, alternatives have been implemented to reduce the amount of HE-contaminated solvents that require treatment. As a result, no RCRA regulated HE-contaminated solvents have been treated for several years and <300 gallons of HE-contaminated dimethylsulfoxide (DMSO) were treated in 2006. Small amounts of a few solvents are present at trace levels on combustibles treated at the TA-16 Burn Ground. Regulated solvents in liquid form were last treated at the TA-16 Burn Ground in April 2004 as part of a 0.5 gallon HE-contaminated oil/solvent/water mixture that carried the EPA Hazardous Waste Numbers D001, D003, F003, and F005.

To put into perspective the acceptable releases of regulated solvents that can be treated at the TA-16 Burn Ground, LANL used the worst-case hourly and annual CFs to back-calculate acceptable release impacts and compared the impacts to the air quality screening levels described in Section 3 of this document. The solvents analyzed were those listed in the most recent version of the LANL General Part A Permit Application (LANL, 2006). Many of these are F-listed and are not expected to be treated at the TA-16 Burn Ground, but are included to provide a worst-case analysis. The estimation process outlined below is designed to conservatively estimate how much of each solvent could be treated at the TA-16-388 before screening levels were approached. One of the largest assumptions in this process is that 95% of the solvent would be destroyed by the propane burners. For consistency with past estimations (LANL, 2002) and based upon the operator's observation during burn events, it is assumed that the burners would have 95% combustion efficiency, with the other 5% being emitted as the parent chemical for this impact analysis. There are no measured data on the efficiency of burning oils and solvents at TA-16-388 and from the operator's observation during burn events, it is likely that combustion efficiency is high based on opacity (visible emissions) during burning. Additionally, as discussed earlier, it is not likely that large amounts of any regulated solvents would be treated at TA-16-388 throughout the rest of its operating life.

The screening levels for acute (1-hr) and chronic (annual) exposures and the CFs calculated by CALPUFF can be used to estimate the amount of a pollutant that could be released from the TA-16 Burn Ground operations before the screening level is reached. Note that the amount released is not the same as the amount burned because burning destroys most of the material. Below is an example using benzene as the pollutant, with a screening level of 1300 $\mu g/m^3$, and the hourly worst-case on-site CF of 1.49 E+02 $\mu g/m^3$ of pollutant per g/s of solvent burned. Assuming a 95% destruction efficiency:

Hourly example:

$$\frac{1300\ \mu g/m^3}{} \times \frac{g/sec}{1.49E+02\ \mu g/m3} \times \frac{3600\ sec}{hr} \times \frac{1\ lb}{454\ g} \times \frac{100\ lb\ burned}{5\ lb\ released} = 1384\ lb/hr$$

Therefore, 1384 lb/hr of benzene could be burned before the acute screening level was exceeded. Since only 250 lb of waste can be burned per hour at TA-16-388, the screening level will not be exceeded.

Annual example:

$$0.025\ \mu g/m^3 \times \frac{g/sec}{1.48\ \mu g/m3} \times \frac{3600\ sec}{hr} \times \frac{508\ hr}{yr} \times \frac{1\ lb}{454\ g} \times \frac{100\ lb\ burned}{5\ lb\ released} = 1.79E{+}07\ lb/yr$$

Deposition to soil was not considered in the calculation of annual solvent limits. The chronic screening levels used for annual calculations are 0.1 times the PRGs because a risk assessment is required if the impacts exceed 0.1 times the PRGs. This conservative analysis shows that a very large amount of each of the solvents estimated would have to be burned each year to approach the screening levels. Additionally, calculated annual solvent limits assume open burning of solvent during 508 hours per year for consistency with the number of meteorological hours modeled, to provide a more conservative estimate than averaging over 520 hours.

Table 5-1 shows the hourly and annual contaminant-specific screening levels, the CFs, and the calculated quantities of bulk solvents that could be treated (assuming a 95 % destruction efficiency) before the screening levels were reached. These quantities were calculated using the on-site CFs. If calculated with the off-site CFs, the calculated quantities would be even larger.

Table 5-1. Short-Term and Annual Solvents Impacts Estimation [1]

Contaminant	Acute Screening Limit [2] ($\mu g/m^3$)	On-site 1 Hour Conversion Factor ($\mu g/m^3$ per g/s)	1-Hour Solvent Limits [3] (lb/hr)	Chronic Screening Level [4] ($\mu g/m^3$)	On-site Annual Conversion Factor ($\mu g/m^3$ per g/s)	Annual Solvent Limits (lb/yr)[5]
Acetone	4.75E+05	1.49E+02	5.06E+05	3.29E+02	1.48E+00	1.79E+07
Benzene	1.30E+03	1.49E+02	1.38E+03	2.50E-02	1.48E+00	1.36E+03
Carbon disulfide	6.20E+03	1.49E+02	6.60E+03	7.50E+01	1.48E+00	4.08E+06
Carbon tetrachloride	1.90E+03	1.49E+02	2.02E+03	1.30E-02	1.48E+00	7.08E+02
Chlorobenzene	1.25E+05	1.49E+02	1.33E+05	6.20E+00	1.48E+00	3.37E+04
Chloroform	1.50E+02	1.49E+02	1.60E+02	3.50E-02	1.48E+00	1.91E+03
Cresols	2.00E+04	1.49E+02	2.13E+04	NA[6]	NA	NA
Dichlorobenzene, o-	3.00E+05	1.49E+02	3.19E+05	2.10E+01	1.48E+00	1.14E+06
Dichloroethane [1,2-]	2.02E+05	1.49E+02	2.15E+05	5.10E-01	1.48E+00	2.78E+04
Dichloroethylene [1,1-]	7.50E+04	1.49E+02	7.98E+04	2.10E+01	1.48E+00	1.14E+06
Dichlorodifluoromethane	1.50E+07	1.49E+02	1.60E+07	NA	NA	NA
Ethyl benzene	5.00E+05	1.49E+02	5.32E+05	1.10E+02	1.48E+00	5.99E+06
Methanol	2.80E+04	1.49E+02	2.98E+04	NA	NA	NA
Methyl ethyl ketone	1.30E+04	1.49E+02	1.38E+04	5.10E-04	1.48E+00	2.78E+01
Methyl isobutyl ketone	3.00E+05	1.49E+02	3.19E+05	3.10E+02	1.48E+00	1.69E+07
Methylene chloride	1.40E+04	1.49E+02	1.49E+04	3.10E+02	1.48E+00	1.69E+07
Nitrobenzene	1.50E+04	1.49E+02	1.60E+04	2.10E-01	1.48E+00	1.14E+04
Pyridine	5.00E+04	1.49E+02	5.32E+04	3.70E-01	1.48E+00	2.01E+04
Tetrachloroethylene	2.00E+04	1.49E+02	2.13E+04	3.20E-02	1.48E+00	1.74E+03
Toluene	3.70E+04	1.49E+02	3.94E+04	4.00E+01	1.48E+00	2.18E+06
Trichloroethane, 1,1,1-	6.80E+04	1.49E+02	7.24E+04	2.30E+04	1.48E+00	1.25E+07
Trichloroethane, 1,1,2-	5.00E+04	1.49E+02	5.32E+04	1.50E+00	1.48E+00	8.17E+04
Trichloroethylene	6.98E+05	1.49E+02	7.43E+05	9.60E-02	1.48E+00	5.23E+03
Trichlorofluoromethane	2.50E+06	1.49E+02	2.66E+06	7.30E+01	1.48E+00	3.97E+06
Xylenes	2.20E+04	1.49E+02	2.34E+04	1.10E+01	1.48E+00	5.99E+05

1 Quantities calculated assume 95% destruction of the solvent while burning.
2 Screening limits are from acute limits (1 hour) inhalation exposure (AIEC) for toxic air pollutants (EPA, 2005)

[3] Calculated solvent limits illustrate the amount of solvent that could be burned before the respective screening limit was reached

[4] Annual screening limits are from the Environmental Protection Agency's Region 9 Preliminary Remediation Goals (PRGs), (EPA, 2004) and have been multiplied by 0.1 for comparison purposes as described in as described in the modeling protocol (LANL, 2007).

[5] Calculated solvent limits assume 508 hours of treatment occurring per year.

[6] NA indicates that there is no screening limit for the contaminant

g/s = grams per second
$\mu g/m^3$ = micrograms per cubic meter
lb/yr = pounds per year

6.0 Results and Conclusions

The following discusses the results of the on-site and off-site air dispersion impact analysis and the on-site deposition impact analysis as conducted for this report. The results show, in addition to the explanations included below, the operations at the TA-16 Burn Ground are protective of human health and the environment and pose no adverse effects due to migration of waste constituents in the air.

Short-term on-site air dispersion impacts were assessed for 46 contaminants with only two concerns—furan and acrolein. Impacts for all contaminants assessed were calculated to be below the AIECs, the majority by a factor of at least two orders of magnitude. Furan and acrolein were closer to the AIECs. The emissions factor for furan was taken from the Open Burn/Open Detonation Dispersion Model (OBODM) User's Guide (EPA, 1998a) emissions for Manufacturer's Waste which consisted of 65% aluminized ammonium perchlorate, 20% plastic material, 11% paper/wood/cloth and 4% diesel fuel. The emissions factor for acrolein is based on the burning of 500 gallons of No. 2 fuel oil (a petroleum product) in a 15-30 minute time span from Emissions of Organic Air Toxics from Open Burning (EPA, 2002a). The calculated 1-hour air quality impacts for furan were within two orders of magnitude of the acute inhalation exposure limit. Acrolein impacts were calculated to be just under the exposure limit. While these calculations put estimated impacts near the range of the AIEC limits, these contaminants are not an environmental concern at the TA-16 Burn Ground and will not have adverse effects on human health or the environment due to migration of waste constituents in the air. The contaminants do not pose unacceptable risk because of the following:

- The example waste streams that were used for this analysis are much "dirtier" wastes than the waste streams that are treated at TA-16-388.
  - The HE-contaminated combustible waste streams that are treated at TA-16-388 consist of pieces or powder HE, cloth, some cardboard, kim wipes, limited plastic bags, small amounts of solvent or oil on kim wipes or filters, small glass pieces, and small metal pieces. In most cases this waste stream does not contain a high percentage of plastics, wood, or paper as does the waste that the emissions factor was based on and would lead to the higher production of furan.
  - The HE-contaminated oils and solvents that are treated at TA-16-388 which are oils and solvents that contain high enough dissolved concentrations of HE (all pieces are filtered out and treated as part of a combustible waste stream) to be considered a detonation risk. Small amounts of kerosene or other petroleum products (which could lead to the production of acrolein) are also used to start bulk HE burns at both treatment units at the TA-16 Burn Ground. It is unlikely that bulk amount of fuel oil (or other petroleum product) ever has to be treated at TA-16-388. Most of the oils and solvents that may be used during HE manufacturing or within research and development activities are of a grade that is more refined than fuel oil and would generally contain less contaminants.
- The air impact calculations were conducted assuming that 250 lb of waste was treated per 1-hour long burn. This is larger than typical treatment activities at TA-16-388.
  - Routine treatment weights range from 30 to 160 lb and would have less air quality impact.

- Sources for these contaminants are not regularly burned at TA-16-388 and would never be treated in the volumes modeled; therefore, impacts from these contaminants would be less than those calculated.
  - Furan is generally produced through the burning of polychlorinated biphenyls or burning in barrels, pits, woodstoves, or outdoor boilers. Waste treatment of combustible waste streams at TA-16-388 is always conducted with the assistance of the propane burners to ensure the destruction of HE compounds. Therefore, the waste burns hotter and more completely than a simple fire alone and decreases the potential for the formation and release of furan.
  - Sources of acrolein in the air come mainly from cigarette smoke, forest fire emissions, and gasoline and diesel exhaust. Generally, acrolein does not seem to be a measured release associated with the burning of solvents. The small amounts of petroleum products that are treated at the TA-16 Burn Ground (or used for ignition) would not result in as high an impact as calculated for this analysis.
- During burning operations personnel are not allowed within the area where burning is occurring.
  - Since the highest calculated on-site impacts occur at the unit, this decreases the potential for human exposure to contaminants in the air during the treatment and directly after.

Both of these contaminants are produced during the combustion process rather than originally present within the waste stream, so the prohibition of their treatment at the TA-16 Burn Ground is not a feasible option. Additionally, analysis for these constituents within a waste stream would often require chemical analysis which cannot be conducted for all HE-contaminated waste streams because of reactivity concerns associated with safety.

Short-term off-site air dispersion impacts were assessed for 53 contaminant/averaging-period combinations, all of which are below screening levels. Calculated impacts for off-site receptors were generally at least and order of magnitude less than the air impacts calculated for on-site. Three of the calculations come within one order of magnitude of the screening level and one comes within two orders of magnitude. These contaminants are acrolein, the two calculations for particulate matter, and formaldehyde.

Acrolein is not an environmental concern at the burn units for the reasons outlined above. Furthermore, off-site impacts were assessed assuming a maximum waste quantity of 1,000 lb of waste treated per 1-hour burn, so the waste quantity estimate for this calculation is higher than the typical waste treatment occurring at the TA-16-388. Particulate matter calculations for PM_{10} and TSP include the background concentration within the air impacts analysis and it is that concentration that brings the off-site impact calculation within an order of magnitude of the AIECs. Actual TA-16 Burn Ground impact was calculated to be 2.94E-01 $\mu g/m^3$ for both, greater than three orders of magnitude below the AIEC. Therefore, the particulate matter contribution associated with open burning operations is not a concern.

The emissions factor for formaldehyde, like acrolein, is also taken from Emissions of Organic Air Toxics from Open Burning (EPA, 2002a) and is based on the burning of fuel oil. Calculated short-term off-site air impacts for formaldehyde come within two orders of magnitude of the AIEC, however, this is not an environmental concern because sources of formaldehyde in the air come from plywood, veneered or laminated furniture and cabinets, fuel combustion, and adhesives. Although some adhesive may be present within the HE-contaminated combustible

waste streams treated at the TA-16 Burn Ground, it is not a significant percentage of the waste stream. Additionally, as with acrolein, the small amounts of petroleum products that are treated at the TA-16 Burn Ground (or used for ignition) would not result in as high an impact as calculated for this analysis. Consequently, formaldehyde concentration in air due to TA-16 Burn Ground operations does not pose an unacceptable risk to human health and the environment. Plus, chemical analysis for this constituent within a waste stream would pose the same problem as mentioned above.

Annual on-site air impacts were assessed for 51 contaminants, all of which are below screening levels. Calculated annual off-site air impacts were all below one tenth the PRG screening limits so they will not be discussed further. The three the calculations for annual on-site air impacts that come within one order of magnitude of one tenth the EPA preliminary remediation goal (PRG) screening limits are associated with the contaminants acrolein, benzene, and indeno[1,2,3-cd]pyrene. Acrolein is discussed above and should not be considered a concern.

Benzene also does not pose an unacceptable risk to human health and the environment. The emissions factor used for benzene, like acrolein and formaldehyde, is also taken from Emissions of Organic Air Toxics from Open Burning (EPA, 2002a) and is based on the burning of fuel oil. Other emissions factors are available for benzene for the combustible solid waste and the HE waste that were chosen for assessment in the modeling protocol (LANL, 2007). The largest of the emissions factors (fuel oil) was used for this assessment as part of a very conservative analysis. The other two smaller emissions factors represent wastes that are generally more routinely treated at the TA-16 Burn Ground. Annual on-site air impact calculations conducted for the other two wastes result in lesser impacts: 5.76E-04 $\mu g/m^3$ for the combustible solid waste and 3.59E-05 $\mu g/m^3$ for the HE waste. These are both more than two orders of magnitude from 10% of the PRG screening limit. Sources of benzene include crude oil, gasoline, cigarette smoke, plastics, resins, nylon and synthetic fibers, lubricants, rubbers, dyes, detergents, drugs, and pesticides; therefore, it would not be practical to prohibit the treatment of waste streams that contain benzene. Chemical analysis for benzene within a waste stream poses the same problem in HE-contaminated waste streams due to reactivity concerns as mentioned above. Also, the quantity of benzene in the actual waste streams treated at the TA-16 Burn Ground is likely much less than for the wastes that the emissions factors are based upon. The maximum quantity of waste used in the calculation for annual air impacts is 20,000 lb/yr which is larger than the average quantity that is generally treated at the TA-16 Burn Ground (less than 5,000 lb/yr). This would further decrease the potential air impact of benzene at the TA-16 Burn Ground. It is also important to consider that this estimated impact is being compared to 0.1 times a screening limit, not the actual limit.

Comparisons similar to benzene can be made for indeno[1,2,3-cd]pyrene which also does not pose an unacceptable risk to human health and the environment. The emissions factor is also conservatively based on the burning of fuel oil and another lower emissions factor is available for the burning of combustible solid waste. Calculation of the annual on-site air impact using the other available emissions factor results in an estimated impact of 2.08E-06 $\mu g/m^3$, adding an another order of magnitude to the difference between the estimated impact and 0.1 screening limit. Indeno(1,2,3-cd)pyrene is formed in most combustion or elevated temperature processes that involve compounds containing carbon and hydrogen and known sources include coal, wood, and gasoline combustion, municipal waste incineration, coke ovens and cigarette smoke. Thus, the compound is a product of combustion rather than originally present within the waste stream,

so the prohibition of its treatment is not a viable option. The potential for this contaminant to have impacts associated with TA-16 Burn Ground operations is decreased by the actual quantity of waste treated at the TA-16 Burn Ground rather than the maximum quantities and the less impact-likely type of waste that is treated at the open burn treatment units.

Annual and 10-year deposition impacts were all calculated for 56 contaminants and all were estimated to be below the NMED Human Health Industrial/Occupational Soil Screening Levels (SSLs) (NMED, 2006) and the EPA Region 6 Human Health Medium-Specific Screening Levels (EPA, 2007). Two of the 10-year deposition impact calculations come within one order of magnitude of one of the screening levels assessed and one is within the same order of magnitude as the Medium-Specific Screening Level. These contaminants are acrolein and total xylene within two orders of magnitude and naphthalene within the same range as the Medium-Specific Screening Level. Acrolein is discussed above and should not be considered a concern.

Naphthalene and total xylene also do not pose unacceptable risk to human health and the environment. The emissions factor used for naphthalene, like acrolein, is also taken from Emissions of Organic Air Toxics from Open Burning (EPA, 2002a) and is based on the burning of fuel oil. Another emissions factors within the protocol document (LANL, 2007) is available for naphthalene for the combustible solid waste. This smaller emissions factor represents wastes that are generally more routinely treated at the TA-16 Burn Ground because liquids are rarely treated. 10-year depositional impact calculation conducted for this emissions factor results in lesser impacts: 5.20E-02 mg/kg. This is one order of magnitude from the EPA Region 6 Human Health Medium-Specific Screening Levels and four orders of magnitude from the SSLs. Naphthalene is produced when wood and tobacco are burned, and manufactured from coal tar distillation and petroleum refining. It is also used to make dyes, some plastics, leather tanning agents, and insecticide carcaryl. The emissions factor used for total xylene, like furan, was taken from the Open Burn/Open Detonation Dispersion Model (OBODM) User's Guide (EPA, 1998a) emissions for Manufacturer's Waste and is not as segregated and carefully assessed as the HE-contaminated combustible waste streams that are treated at TA-16-388. The 10-year deposition impact calculations conducted for the other two wastes result in lesser impacts: 1.04E-03 mg/kg for the HE waste and 1.55E-02 mg/kg for the He contaminated burning liquids. These are two or more orders of magnitude from the EPA Region 6 Human Health Medium-Specific Screening Levels and the SSLs. Additionally, sources of xylene range from petrol and automotive exhaust to aerosol paints, architectural coatings, caulks, hard surface cleaners, markers, and adhesives.

It would not be practical to prohibit the treatment of waste streams that contain naphthalene or total xylene because it is so widely used in production and naphthalene is also a product of combustion. Chemical analysis for naphthalene and xylene within a waste stream pose the same problems in HE-contaminated waste streams due to reactivity concerns as mentioned above. Also, the quantities of naphthalene and total xylene in the actual waste streams treated at the TA-16 Burn Ground are likely much less than for the wastes that the emissions factors are based upon. The maximum quantity of waste used in the calculation for annual deposition impacts is 20,000 lb/yr which is larger than the average quantity that is generally treated at the TA-16 Burn Ground (less than 5,000 lb/yr). Additionally, these levels are estimated impacts after 10 years of deposition and neither naphthalene and xylene have proven to persist in the environment.

The air pathway assessment conducted by LANL and detailed within this report was designed to provide a very conservative air dispersion and deposition impact analysis. CALPUFF input parameters were used as conservatively as deemed reasonable, and the unit/waste scenarios

modeled were chosen to represent the types of burning that occur at the TA-16 Burn Ground. The emissions factors used for the impacts calculations within this assessment were chosen from wastes that are generally not as refined as the research and development laboratory wastes or the manufacturing wastes that are treated through open burning at LANL. Also, the quantities of waste used within the assessment were the maximum amounts of waste that could possibly be treated at the TA-16 Burn Ground. Daily operations at LANL are less than a third of the quantity assessed. Due to the very conservative nature of this analysis and for the reasons outlined above, the operations at the TA-16 Burn Ground are protective of human health and the environment and pose no adverse effects due to migration of waste constituents in the air.

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Appendix B

Terrain .DEM Files Associated With Specific Comment #10
'BurnPermitTerrain.zip'

LA-UR-08-06542

TO VIEW THE FILES THAT ACCOMPANIES THIS DOCUMENT PLEASE CALL THE HAZARDOUS WASTE BUREAU AT 505-476-6000 TO MAKE AN APPOINMENT

Appendix C

Memorandum – "PBX Burn Temperatures and Times," L. E. Hatler

LA-UR-08-06542

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

memorandum

TO: C. Courtright, H-3, MS 935 DATE: July 27, 1982

THRU: H. L. Flaugh MAIL STOP/TELEPHONE: C920/7-6738

FROM: L. E. Hatler SYMBOL: M-1

SUBJECT: PBX BURN TEMPERATURES AND TIMES

The flame temperatures and burn times of pressed cylinders and hemispheres of PBX 9502, PBX 9501, and PBX 9404 have been measured. The burning temperatures and times for the bulk molding powders were also measured. The temperatures were determined using tungsten/rhenium thermocouples, an optical pyrometer, and in some cases, strips of high-purity metals with known melting points.

Cylinders of pressed PBX 9404, PBX 9501, and PBX 9502 were ignited using Caldweld welding powder. The configuration is shown in Figure 1. The thin strips of metals were only used in the PBX 9404 burn test. Table I lists the HE, weight, burn times, and temperatures.

TABLE I

RESULTS OF PBX 9404, PBX 9501, AND PBX 9502 BURN TESTS

HE	Weight (kg)	Burn Time (min)	Temperature[1] (°C)	Temperature[2] (°C)
PBX 9404	19	6.5	1740	---
PBX 9501	26	8.0	1720	2030
PBX 9502	26	56.0	1070	1125

[1]Maximum temperature measured with tungsten/rhenium thermocouples.
[2]Maximum temperature measured with optical pyrometer.

Thin strips of pure platinum, rhodium, and molybdenum were embedded in the PBX 9404 cylinder to cross check the thermocouple temperatures. The metal strips were recovered after the burn and inspected. The platinum strip was almost all melted and only a small piece recovered. The melting point of the platinum is 1769°C. The Mo strip, m.p. 2560°C, was recovered intact.

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The Rh, m.p. 1966°C, contained several small holes that looked like melting had started; however, after microscopic examination it appeared a eutectic reaction between the Rh and silica in the sand supporting the charges may have created the holes in the strip. In summary, we believe the burning temperature of the PBX 9404 is 1769 ± 30°C, which is good agreement with the thermocouple data.

A 22.7-kg hemispherical charge of PBX 9502 was burned at SNLA. The hemisphere was assembled into a weapon-like configuration shown in Figure 2. Thermocouples were placed in the potting layers between the HE and the aluminum shell and also inside the inner steel shell. Two aluminum screws were placed in the steel shell for temperature determination at that location. The melting point of the aluminum was determined to be 610°C.

A solid propellant torch was placed approximately 25 mm from the outer case and ignited. The torch cut a 50-mm-diam hole into the aluminum case and burned a hole approximately 125 mm into the PBX 9502 charge. The HE burned for approximately one minute and went out. Approximately two hours later a second torch was placed adjacent to the hole created by the first one and ignited. The PBX 9502 burned for one hour and 15 minutes and was totally consumed. The maximum temperature recorded by the thermocouples were No. 1 - 535°C, No. 2 - 561°C, No. 3 - no data, and No. 4 - 544°C. The aluminum screws showed no signs of melting indicating the temperature remained below 610°C.

A similar test (Figure 2) was run with the PBX 9502, without any thermocouples and the hemisphere burned for one hour and 55 minutes.

The flame temperature of burning PBX 9501 and PBX 9502 molding powder was measured with an optical pyrometer. The flame temperature of the castable HEs baratol and Composition B was also measured using the optical pyrometer. Table II summarizes these burn tests.

The PBX 9502 molding powder burned very quietly similar to a piece of wood or cardboard, in contrast to roaring flames that are characteristic of other burning HEs such as PBX 9501, baratol, and Comp B. A black residue that looks like molding powder agglomerates was observed after the PBX 9502 burn. Other HEs do not leave any residues after burning.

L. E. Hatler

L. E. Hatler

LEH:mmm

Cy: L. A. Gritzo/T. E. Gould, M-DO, P915
L. F. Luehring, WX-DO, P945
L. E. Hatler
H. L. Flaugh
M-1 File

TABLE II

MOLDING POWDER AND CASTING CHIPS BURN TESTS

HE	Amount (kg)	Temperature [1] (°C)	Burn Time (min)
Baratol	295	1750	5
Baratol	386	1750	5
Comp B	27	1850	0.75
PBX 9501	226	1850	2
PBX 9501	408	2030	2
PBX 9502	77	1125	23

[1]Measured with four Leeds and Northrup optical pyrometer.

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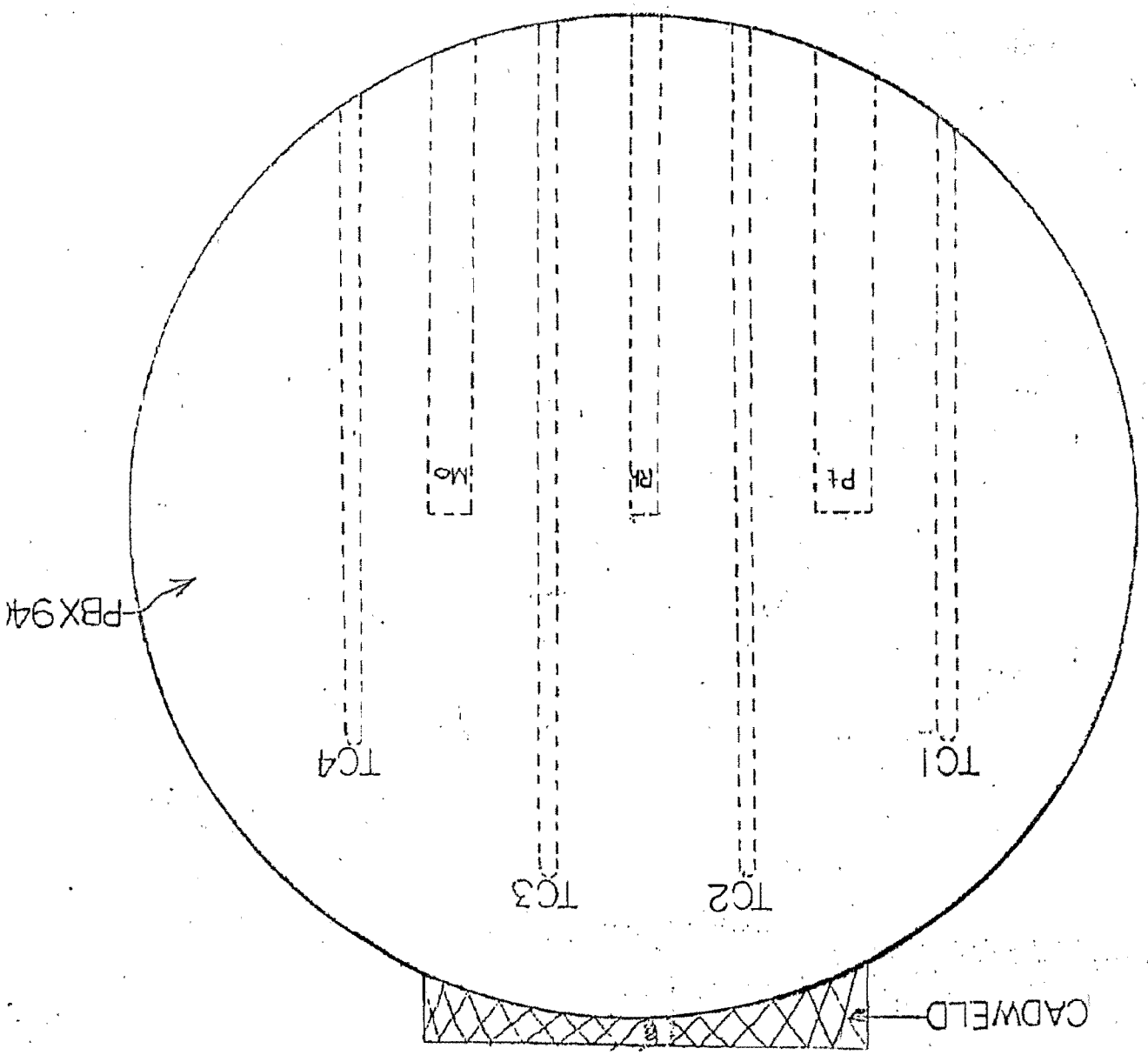


Fig. 1. PBX Cylinders for Burn Tests

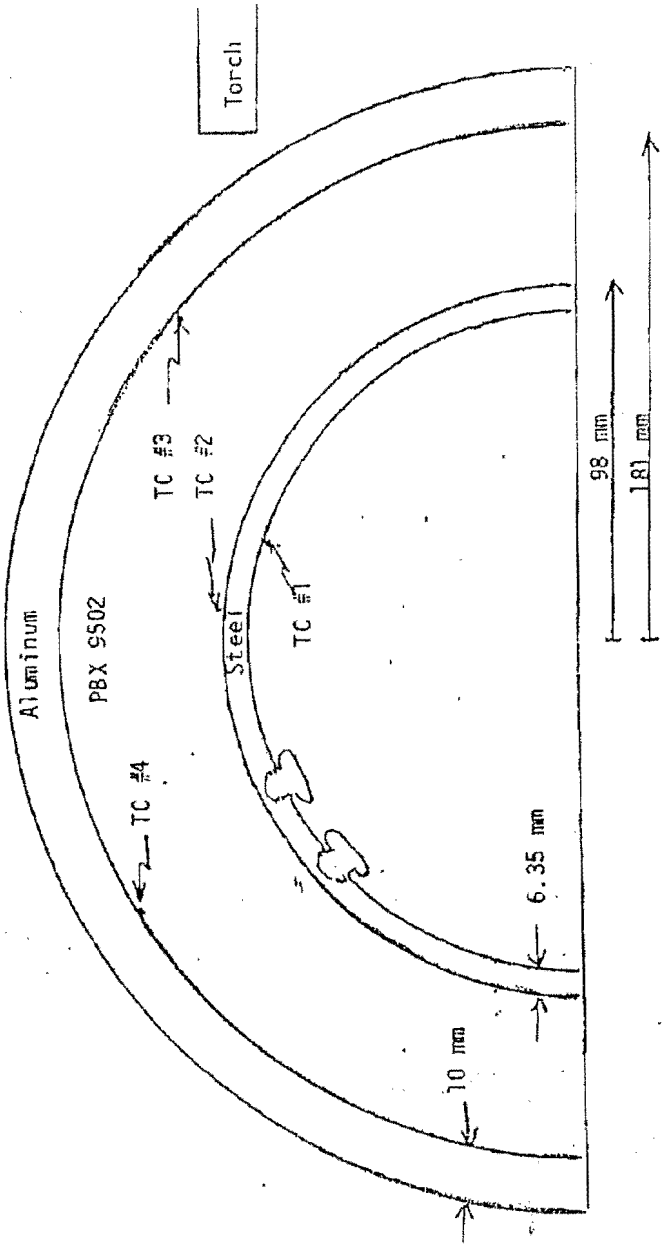
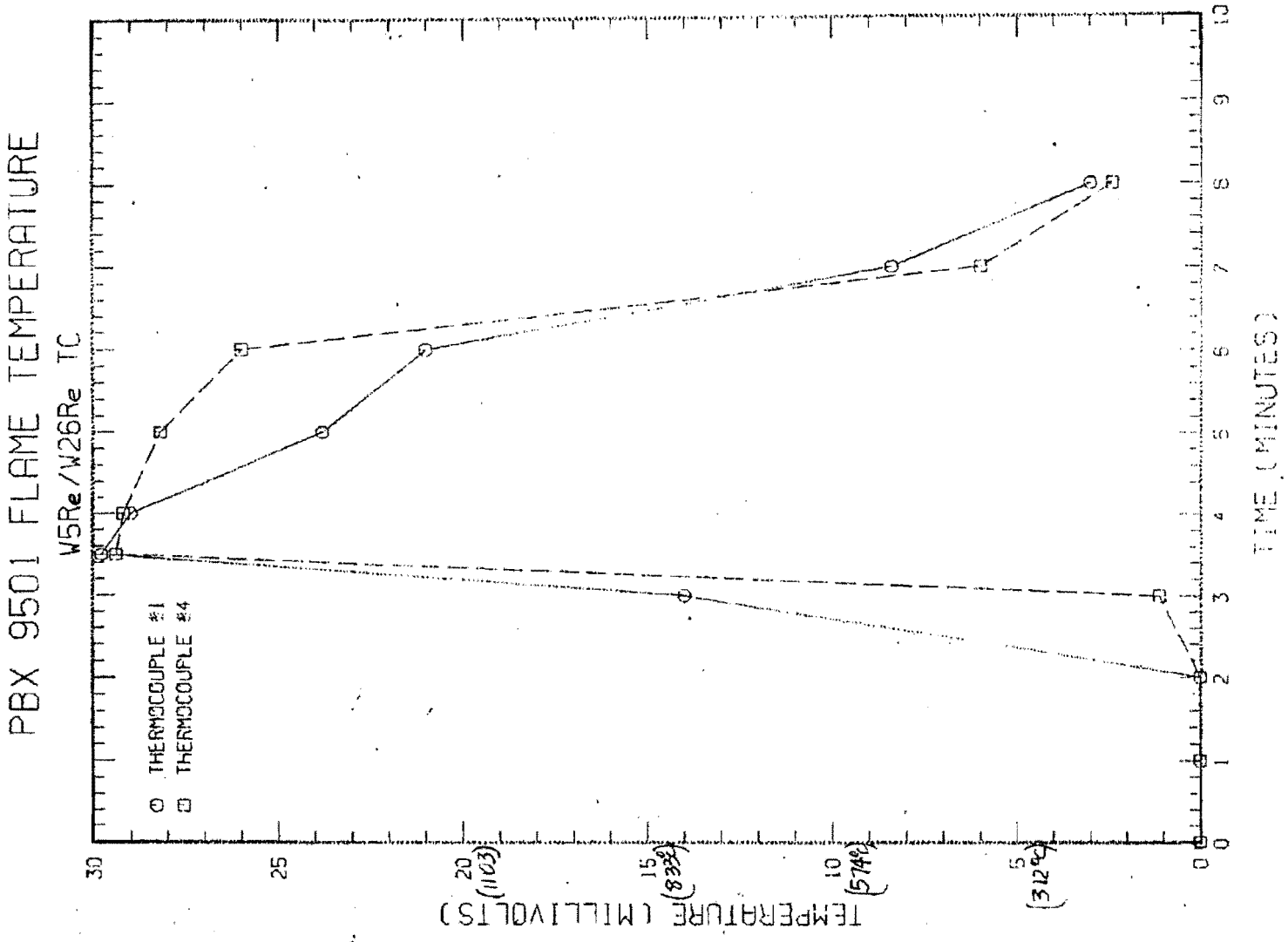
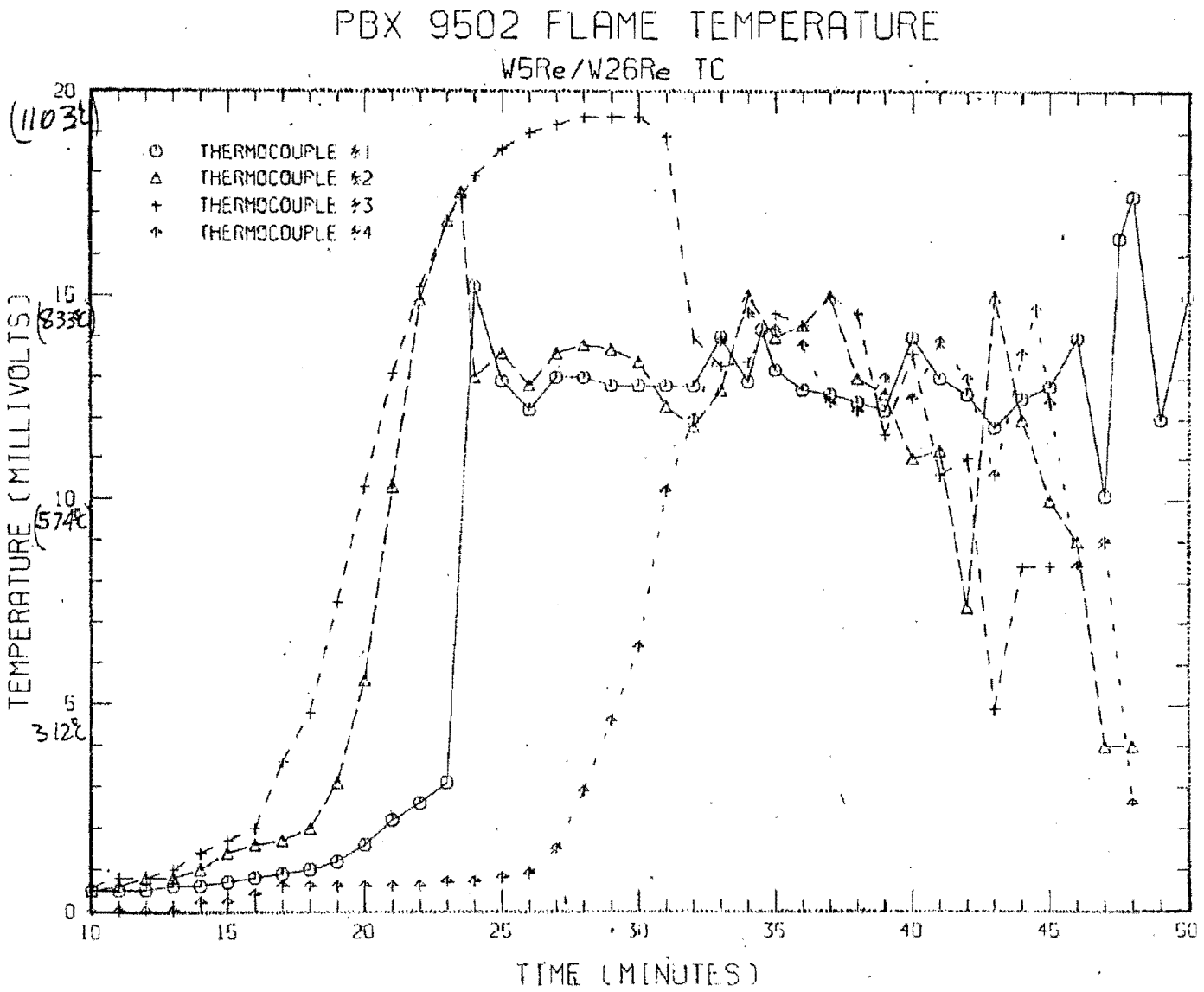


Fig. 2
PBX 9502 Burn Test Device


PBX 9501 FLAME TEMPERATURE
W5Re/W26Re TC
THERMOCOUPLE #1
THERMOCOUPLE #4
TEMPERATURE (MILLIVOLTS)
TIME (MINUTES)
30
25
20 (1103)
15 (832°C)
10 (574°C)
5 (312°C)
0
0
1
2
3
4
5
6
7
8
9
10


PBX 9502 FLAME TEMPERATURE
W5Re/W26Re TC
THERMOCOUPLE #1
THERMOCOUPLE #2
THERMOCOUPLE #3
THERMOCOUPLE #4
TEMPERATURE (MILLIVOLTS)
TIME (MINUTES)
20
15
10
5
0
10
15
20
25
30
35
40
45
50
(1103°C)
(833°C)
(574°C)
312°C

Larry Harker

5/1/07

Open Air

molding powder "rice crispies" (high area) max 3" thick

machine scrap (wet)

Solid pieces (low area)

measurements

flame temp

- pyrometers
- thermo couples
- melt strips

Can see solid core diminish

- PBX 9404 94% HMX 6% binder

Solid ~~powder~~ 19 kg ~~spread~~ ~~14.5" wide x 14.5" x 3" thick~~

cylinders ~~1 g/cm³ as spread~~

6.5 max 1.84 g/cc

1740°C thermo couple

- PBX 9501

26 kg ~~powder~~ solid 1.83 g/cc

8 max

1720°C – thermo

2030°C – pyrometer

Larry Harker

(2)

5/1/07

- 9502 95% TATB

26 kg ~~powder~~ solid

56 min 1.89 g/cc

1070°C thermocouple

- Powder A Bevitol 76% barium nitrate 24% TNT
+ casting chips B Comp B 60% RDX 40% TNT
irregular size

A. 295 kg (~500 lbs)
5 min burn 4-5' x 4-5' x 3"
$\rho = 1\ g/cm^3$ as spread

386 kg pyrometer 1750°C
5 min

B. 27 kg
.75 min 1850°C pyrometer

- 9501 226 kg powders
2 min pyro 1850°C

- 9501 408 kg powders
2 min pyro 1850°C

- 9502 77 kg
23 min
pyro 1100°C

Larry Hatler

(3.)

5/1/07

.9502 hemi ~50 lbs

thermocouples
Al case outside
steel inside
torch from outside to bre
1 min then stopped

1 hr 15 min all gone

.9501 hemi bare ~50 lbs

2 min temp up to 1925°C
6 min all gone
8 min total down to 300°C

- Warns about complications with wet scrap to boil off H_2O.

- Comp B maybe better and faster than TNT
- TNT comparable to Comp B (maybe longer)
- Baritol

Document: NOD Response TA-16 Burn Ground Air Pathway Assessment Report
Date: October 2008

CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Richard S Watkins

10/14/08

Richard S. Watkins
Associate Director
Environment, Safety, Health, & Quality
Los Alamos National Laboratory
Operator

Date Signed

10/14/08

for **Donald L. Winchell, Jr.**
Manager, Los Alamos Site Office
National Nuclear Security Administration
U.S. Department of Energy
Owner/Operator

Date Signed

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1.0 Introduction

The Technical Area 16 (TA-16) Burn Ground consists of two units operating under Resource Conservation and Recovery Act (RCRA) interim status:

- the TA-16-399 Burn Tray, which is used to treat bulk dry high explosives (HE) and
- the TA-16-388 Flash Pad, which is used primarily to treat wet HE, combustibles, or other HE-contaminated materials using an external heat source (propane) but can also be used to treat HE.

When Revision 4.0 of the Los Alamos National Laboratory (LANL) TA-16 Part B Permit Renewal Application (LANL, 2003) was submitted to the New Mexico Environment Department (NMED), open burning impacts from the treatment of RCRA wastes were subject to an air permit issued under the NMED's Open Burning Regulation within New Mexico Administrative Code, Title 20, Chapter 2, Part 60 (20.2.60 NMAC). The TA-16 RCRA application referenced the air permit as the means of assessing and regulating air emissions impacts. In 2003, the Open Burning regulation changed to exclude all burning activities covered under RCRA and the Open Burning permit for the TA-16 Burn Ground was withdrawn. This air quality impacts analysis has been developed to support the Technical Area 16 Part B Permit Renewal Application (LANL, 2003) in the absence of an air permit. Model input parameters and assumptions are discussed in Section 2. To provide conservative impacts estimates, this analysis assumes higher quantities of waste treated and more frequent burns than actually occur, and worst-case emission factors. The assumed waste quantities are approximately ten times the amount of waste that is currently burned. These higher levels will not be treated, but provide a conservative analysis. The air quality impacts analysis based on ultra-conservative parameters is presented in Section 3.

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LANL previously submitted a deposition modeling analysis based on an actual year's burn activity as part of the TA-16 Part B Permit Renewal Application (LANL, 2003). The deposition modeling has been rerun with the same worst-case assumptions used for the air dispersion modeling, to provide an equally conservative deposition impacts analysis. The deposition modeling analysis is described in Section 4. An analysis of potential solvent releases, as requested by NMED and described in the TA-16 Air Pathway Assessment Protocol, Revision 1.0 (LANL, 2007), is contained in Section 5. Section 6 includes a discussion of the results and conclusions of this report.

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Both the air quality impacts and deposition analyses were conducted using the CALPUFF (Scire et. al., 2000) modeling package. The rationale for choosing CALPUFF is described in the protocol document (LANL, 2007), submitted to NMED on May 31, 2007.

1.1 Capacities and Typical Open Burning Treatment Operations

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The most recent LANL Part A Permit Application (LANL, 2006) and Attachment G of the LANL TA-16 Part B Permit Renewal Application (LANL, 2003), list capacities for the units at the TA-16 Burn Ground: TA-16-388, 100 gallons or 40,000 pounds per burn (lbs/burn); and TA-16-399, 1,000 lbs/burn. The 40,000 lbs/burn limit at TA-16-388 takes into consideration all solids that may be placed on the pad. This includes the weight of large machine tools, other equipment, and soil that do not burn and should not necessarily be counted as part of the waste treated. Annual burn limits for the TA-16 Burn Ground are not listed in the permit application documents.

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The air dispersion and deposition modeling conducted for the TA-16 Burn Ground as detailed in this report, assumes that a maximum amount of 250 lbs/burn of HE or HE-contaminated combustible material can be treated at TA-16-388 at any one time. This weight does not take into account other non-combustible solids that may be present during a burn at TA-16-388 so that a representation of the maximum amount of waste that can be treated at one time could be analyzed for air impacts. Additionally, this air impact analysis report assumes that the maximum amount of HE and HE-contaminated combustible waste that can be treated at both units annually is 20,000 lbs. This approach allowed for the calculation of annual air impacts for a potential maximum volume of waste per year and the calculation of the cumulative effects associated with that potential maximum. Past analysis derived the potential volume of waste from a single year's data. This air impact assessment was designed to give a worst-case analysis, therefore, a maximum waste volume was chosen.

The maximum waste quantities modeled for the TA-16 Burn Ground are: 250 lb/burn HE or HE-contaminated waste at TA-16-388, 1,000 lb/burn HE waste at TA-16-399, and a maximum quantity of 20,000 lb/year at both units combined. Actual operations at the TA-16 Burn Ground are generally much reduced from the quantities of waste modeled in this analysis. In fact, since 2003, the annual quantity of waste treated at the TA-16 Burn Ground has not been over 5000 lbs. Accurate quantities for the waste treated prior to 2003 are not available for direct comparison because the weights of equipment pieces and soil were included in the total waste quantity sums. Current practices record the estimated quantity of HE on the equipment piece or within the soil as the treated volume of waste and the weight of the equipment or soil are kept separately.

Additionally and as explained in the protocol (LANL, 2007), the waste streams that are actually treated at the TA-16 Burn Ground are different from and in general less hazardous to human health and the environment than the waste streams that the emissions factors used in this analysis are based upon. No attempt was made to eliminate non-characteristic emissions from the analysis, which increases the conservative nature of the analysis. Waste stream emissions factors that have been chosen for this analysis estimate a higher air impact than would actually be released from day-to-day operations at the TA-16 Burn Ground.

1.2 Protocol Variances

The air and deposition impacts analyses were conducted in accordance with the protocol (LANL, 2007) except for some minor changes. The 1995 meteorological data were not available in a format that could be processed by CALMET, the meteorological model associated with CALPUFF. Meteorological data from 1999 were available in a CALMET-processed file and were used in the development of past deposition modeling for the TA-16 Burn Ground (LANL, 2003). These data were transmitted to NMED in 2002 (LANL, 2002) and were confirmed to be 1999 meteorological data files. When the modeling protocol (LANL, 2007) was drafted, it was incorrectly assumed that 1995 data were used in the development of the previous deposition modeling rather than 1999 data. It was intended that the data used be the same as the previous data; therefore, the 1999 data were used in the present analysis. Also, the TA-16 Burn Ground Units are very small areas compared to the resolution of the wind field for CALPUFF to model realistically as an area source, so they were modeled using point source rather than area source options. Point source options allow for definition of finite initial volumes, updraft velocities and temperatures in much the same manner as the area source options.

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The modeling protocol (LANL, 2007) states in Section 5.1 that when propane-assisted burning creates the highest estimated impact, the impact would be calculated by adding the calculated impact for the pollutant of interest to the calculated impact of propane for the pollutant of interest. Model runs did not indicate that the propane burning at TA-16-388 (discussed in Section 2.1) was ever the worst-case scenario, so propane emissions were calculated but not added to the impact analysis calculations for off-site impacts. Therefore, Section 5.1 of the modeling protocol (LANL, 2007) shows an example of a situation that did not occur during the analysis. Propane emissions were added to the annual off-site impacts outlined in Table 3-8 only. A maximum of 15,000 gal/yr propane use estimation was used for those calculations. These calculations do not take into account individual waste treatment sizes, but are designed to give an idea of an overall annual maximum emissions impact.

Additionally, the model run used to estimate emissions from propane-assisted burning as outlined in Section 2.5 utilized a burn rate of 1 gal/min to describe the updraft characteristics rather than calculating how much propane would be used per burn if 15,000 gallons of propane were used in one year. The value of 1 gal/min is derived from operational experience that indicates that the propane fuel reserves are depleted at that rate when both of the burners that are used at TA-16-388 are operating. The TA-16-388 flash pad was designed with a third propane burner at the back side of the pad, but it was found to create an asymmetric flame pattern that was not centered on the combustion tray. Therefore, only the two opposing burners are used for routine waste treatment at TA-16-388.

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2.0 Air Quality Modeling Scenarios and Parameters

The first step in performing the air quality modeling was to determine which unit/waste combinations had the worst case impacts. These results are discussed in the first paragraph of Section 3.0. The second step was to use the worst-case unit/waste conditions to calculate air quality impacts, discussed throughout the remainder of Section 3.0. Parameters not specifically addressed within this report are discussed in the modeling protocol (LANL, 2007), submitted March 31, 2007.

2.1 Unit/Waste-Specific Modeling Scenarios

The two units, TA-16-388 and TA-16-399, treat different amounts and types of waste which affect the amount of pollutants emitted as well as the plume rise and dispersion from each unit. The first step in the modeling was to determine which units/wastes created the worst case on-site and off-site impacts for each averaging period. The modeling protocol (LANL, 2007) proposed to evaluate the impacts of burning 1000 pounds (lb) of HE at TA-16-399, 250 lb of HE at TA-16-388, and propane-assisted burning of less energetic HE-contaminated materials at TA-16-388. The first two scenarios were refined by evaluating both an HE that burned rapidly and an HE that burned less rapidly in combination with variable burn temperature, variable ambient temperature and variable burn-tray area to provide an upper and lower bound for vertical plume velocity. These are referred to in this report as "maximum lofting" and "minimum lofting" scenarios. To summarize, the following scenarios were modeled:

- TA-16-388 with maximum lofting,
- TA-16-388 with minimum lofting,
- TA-16-388 with propane only,
- TA-16-399 with maximum lofting, and
- TA-16-399 with minimum lofting.

The description TA-16-388 with propane only" refers to the assumption that only the energy of the propane burners was used to drive buoyancy; additional energy from the burning waste was neglected to suppress plume rise. However, emissions for this case *were* based on the maximum quantity of waste expected at TA-16-388. The modeling runs confirmed that the minimum lofting HE had the highest impacts on-site and at some nearby off-site locations but that overall the maximum lofting HE had the highest impacts at more distant off-site receptors. Figures 3-1 through 3-4 show the effect of maximum and minimum lofting on air concentrations.

2.2 General Burn Parameters/Assumptions

All modeling runs assumed the following:

- Each burn occurs in < 1 hour (hr) to provide the most conservative short-term impacts.
- Burns are separated by at least 1 hour of preparation time.
- Two burns a day would be conducted 5 days a week. In fact, TA-16 Burn Ground typically burns waste once or twice a week.
- Specific burn times were randomly sampled from an annual set of hourly meteorology data to begin during daytime hours and allow at least 1 hr of preparation time between burns. Burn times were restricted to hours with winds ≤ 15 miles per hr, similar to actual

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conditions when burning occurs. This resulted in 508 hours of meteorological data used in the analysis rather than the 520 hours that one might expect from 2 burns per weekday throughout the year.

- A 20 kilometer (km) by 20 km receptor grid was centered on the Burn Ground, with receptors spaced at 100 meter (m) intervals. Additional discrete receptors at public areas such as residential areas, hospitals, and Bandelier National Monument were included.
- Receptor elevations were determined from Digital Elevation Model (DEM) data imported into the model.
- A standard 1 gram per second (g/s) emission rate was used to obtain the conversion factor that is applied to pollutant-specific emission rates in Section 3.

2.3 Burn Rate

For the HE-only burns, Composition B (COMPB), which is 60 percent by weight (wt. %) cyclonite (RDX) and 40 wt. % trinitrotoluene (TNT), was used to represent a high energy release (high heat of combustion and burn rate) waste. PBX 9501 (95 wt% Cyclotetramethylenetetranitramine (HMX) and 5 wt. % inert binder) was used as a lower energy release waste. These explosives were selected because experimental data on their burning characteristics was available to calculate vertical velocity. Similar data is not available for the pure explosives such as TNT. For the propane-assisted scenario with less energetic wastes (e.g., HE-contaminated materials, PBX 9502), the energy releases were calculated assuming that the heat released was only from the propane used at TA-16-388 to improve burning; it does not take credit for the energy and additional plume rise caused by the burning waste material.

Burn rate and temperature are important parameters that affect plume rise, and they vary based on the type of HE and on the physical configuration of the waste (solid billets versus chips and pellets, for example). Handbook references for HE properties focus on idealized configurations and highly controlled calorimetry measurements, so it is desirable to use data representative of burn-ground operations wherever possible. Table 2-1 summarizes burn-time and temperature data reported in Hatler 1982 for several types of HE and two physical configurations including solid pieces and collections of machining chips and casting pellets.

Table 2-1 entries in parentheses have been estimated by observing trends in the available measurements. For example, the burn time of a HE type varies by a factor of 2 to 4 depending on its geometry (56 minutes/23 minutes ≈ 2 for PBX 9502 and 8 minutes/2 minutes = 4 for PBX 9501). Burn time is greatly affected by the surface area exposed to combustion, which explains why chips and pellets burn faster than large solid pieces. The range of 2 to 4 in burn time captures typical variability caused by geometry, independent of chemical combustion properties, so it is reasonable to assume that solid COMPB might burn 2 to 4 times longer than the observed measurement of 0.75 minutes for machining chips. This is the basis for the 1.5-3 minutes burn time for solid COMPB shown in blue in Table 2-1.

When considering HE burn times it is important to understand that waste materials are never stacked in piles within a given tray area, because confinement of combustion gases can initiate an unplanned detonation. Solid pieces are separated by several inches of space and chips/pellets are spread uniformly across the tray. This means that burn times for a batch are determined more by the type of HE and the geometry than by the total mass, because the pieces burn almost independently. Doubling the mass does not double the required burn time. In fact, the burn time

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Deleted: Section 4.3 of the modeling protocol (LANL, 2007) describes the source-specific information required to calculate vertical velocity:¶
¶
$w_s = \frac{H_c R}{P_a c_p A_s (T_s - T_a)}$ ¶
¶
where ¶
w_s is the vertical velocity (m/s),¶
H_c is the heat of combustion for a given material (HE or propane) type in Joules per kilogram (J/kg)¶
R is the burn rate (kg/s)¶
P_a is the density of ambient air in kilograms per cubic meter (kg/m^3)¶
c_p is the constant-pressure heat capacity of air in Joules per kilogram-Kelvin (J/kg-K)¶
A_s is the source area in square meters (m^2)¶
T_s is the exit gas temperature in Kelvin (K) ¶
T_a is the ambient air temperature in (K)
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is roughly constant regardless of the total mass on the tray, as illustrated in the table by two batches of PBX 9501 chips of size 226 kilograms (kg) and 408 kg that both burned in approximately 2 minutes. This operational safety practice of distributing pieces across the tray also implies that (for a given HE type) the energy release rate per unit of loaded tray area is roughly constant.

Plume rise and dispersion from burning HE are driven by (1) the size of the column, (2) the velocity of the updraft, (3) the temperature of the gas, and (4) the height at which the first three parameters are known. The particular location where this information is obtained does not matter as much as the fact that all parameters are determined in a self-consistent manner; however, simple models will be more successful if data are taken in a gaseous region away from the heart of the flame where rapid temperature gradients caused by air mixing and radiative heat transfer are not as severe.

With these objectives in mind, the thermocouple data from Hatler 1982 were judged to be the most relevant temperature estimates for driving buoyant plume rise. Theoretical temperatures are based on chemical equilibrium equations with no heat transfer, but they provide an upper-bound check on the validity of the other direct measurement techniques. Pyrometer measurements provide a direct line of sight to the combustion surface, but at this location in the burn no significant air mixing or radiative losses have occurred. Although, the thermocouples in the subject tests were placed on the initial surface of the HE, they did experience convective and conductive heat transfer processes. The reported temperatures are still probably higher than the ideal measurement described above, but this overestimate conservatively suppresses updraft velocities calculated by Equation 1 below and compensates for the lack of a formal treatment of radiative heat losses in the CALPUFF point-source plume-rise model.

Table 2-1 includes thermocouple measurements for solid PBX 9501 that can be used directly in the analysis, but thermocouple temperatures for COMPB were estimated in a two-step process:

1. A systematic relationship exists between the thermocouple and pyrometer measurements of a single test. Burn tests of solid PBX 9501 and PBX 9502 included both measurement types, and the ratio of thermocouple temperature divided by pyrometer temperature for these tests ranges from 0.865 to 0.961. These ratios were applied respectively to available PBX 9501 and PBX 9502 chip pyrometer measurements to obtain estimated thermocouple temperatures for those tests. Both ratios were applied to the reported COMPB chip pyrometer temperature to obtain a range of estimated thermocouple temperatures for COMPB chips.
2. The ratio of chip burn temperature divided by solid burn temperature was found to vary between 0.922 and 1.000 for PBX 9501 and PBX 9502, respectively. These ratios were applied to the range of estimated COMPB chip thermocouple temperatures to obtain a range of estimated burn temperatures for solid COMPB. Note that in all comparisons, minimum and maximum estimates were combined as needed to extend the estimation range as widely as possible. It is also important to note that absolute temperatures reported in Kelvin (K) should be used when forming ratios of temperatures.

2.4 Buoyancy Driven Dispersion

Plume rise formulas used by the CALPUFF model are first presented in a review of theoretical considerations. This discussion below is extracted verbatim from the CALPUFF Users Guide (Scire et. al., 2000), with slight changes in the nomenclature. Inherent to all CALPUFF source

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descriptions is the specification of initial updraft velocity, so a practical formulation of this parameter is discussed next. Finally, a parametric investigation of plume height and ground-level air concentrations is developed for exercising CALPUFF over a range of HE burn rates, burn area, and atmospheric stability conditions. The assumptions used to calculate vertical velocity and the values for each variable follow.

Briggs Plume Rise Formulas

The basic point-source plume rise formulation for buoyant emissions that is employed by CALPUFF (and many other plume rise simulations) was developed by Briggs (1975). For neutral or unstable atmospheric conditions, the plume rise is given as (Scire et. al., 2000, Section 2.4.1)

$$\Delta h = \left(\frac{3F_m x}{\beta_j^2 u_s^2} + \frac{3Fx^2}{2\beta_1^2 u_s^3} \right)^{1/3}$$

(Equation 1)

Where:

$F_m = (T_a/T_s) w_s^2 r_s^2$ is the momentum flux in meters to the fourth per squared second (m^4/s^2),

$F = (g/T_s) w_s r_s^2 (T_s - T_a)$ is the buoyancy flux in meters to the fourth per cubed second (m^4/s^3),

u_s is the stack-height wind speed in meters per second (m/s),

x is the downwind distance meters (m),

β_1 is the neutral entrainment parameter (≈ 0.6),

$\beta_j = 1/3 + u_s/w_s$ is the jet entrainment coefficient,

w_s is the effluent gas exit speed (m/s),

T_a is the ambient air temperature in Kelvin (K),

T_s is the exit gas temperature (K),

g is the acceleration of gravity in meters per squared second (9.812 m/s^2), and

r_s is the effective radius of the burn area (m).

During stable conditions, the final plume rise is determined by

$$\Delta h_s = \left(\frac{3F_m}{\beta_j^2 u_s S^{1/2}} + \frac{6F}{\beta_2^2 u_s S} \right)^{1/3}$$

(Equation 2)

Where:

β_2 is the stable entrainment parameter (≈0.36),

$S = (g/T_a)(d\theta/dz)$ is the static stability parameter, and

$d\theta/dz$ is the potential temperature lapse rate (≈0.1 K/m for stable conditions).

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Deleted: The vertical velocities calculated using these variables are shown in Table 2-1.
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Transitional plume rise during stable conditions is computed by Equation 1 up to the point at which $\Delta h = \Delta h_s$. For low wind speed and calm conditions during neutral or unstable conditions, a minimum wind speed of $u_s = 1\ \text{m/s}$ is imposed. During stable conditions, the following equation is used to compute the plume centerline rise for buoyant plumes:

$$\Delta h_s = 4F^{1/4} / S^{3/8} \qquad \text{(Equation 3)}$$

Momentum rise during stable conditions is computed with a minimum wind speed of $u_s = 1\ \text{m/s}$, but this is not allowed to exceed the momentum rise for neutral conditions.

For HE burn conditions, the updraft velocity w_s needed to evaluate the momentum and buoyancy flux terms is determined by a balance between energy released from the fuel, energy absorbed by the entrained air, and energy radiated to the surroundings. If H_C is the heat of combustion for a given HE type in Joules per kilogram {J/kg} and R is the bulk-averaged burn rate in kilograms per second {kg/s}, then the rate of energy released by combustion $H_C R$ {W} must equal the rate of energy absorbed by the air plus any radiative losses that occur *prior to the point of effluent-temperature measurement*, i.e.,

$$H_C R = \dot{m} c_P \Delta T + \varepsilon \sigma A \left(T_c^4 - T_s^4 \right) \qquad \text{(Equation 4)}$$

where c_P is the constant-pressure heat capacity of air {J/kg-K}, $\dot{m}$ is the mass flow rate of air {kg/s}, $\Delta T = T_s - T_a$ is the temperature increase {K} between ambient air and the exhaust products leaving the burn, ε is the emissivity of the combustion gas volume, $\sigma = 5.670 \times 10^{-8}$ {W/m^2-K^4} is the Stefan-Boltzmann constant, T_c is the temperature of combustion {K}, and A is the cross sectional area {m^2} of the burn. Assuming a constant nominal air density ρ_a {kg/m^3}, the mass flow rate can be expressed as $\dot{m} = \rho_a A w_s$. Substituting $\dot{m}$ into Eq. (26) and rearranging gives a formula for the updraft velocity

$$w_s = \frac{H_C R}{\rho_a c_P A \left(T_s - T_a \right)} - \frac{\varepsilon \sigma \left(T_c^4 - T_s^4 \right)}{\rho_a c_P \left(T_s - T_a \right)} \qquad \text{(Equation 5)}$$

that can be specified in terms of known or parameterized properties of a burn scenario.

The first term of Equation 5 can be interpreted as updraft generated by heat absorbed in entrained air. The second term can be interpreted as updraft suppression resulting from immediate radiative losses to the ambient atmosphere. Inconsistencies can appear in a simple formula like Equation 5 depending on where temperature measurements are taken and how they are interpreted. For example, when estimates of the gas temperature T_s are too high, radiative suppression will exceed the buoyant updraft and w_s will be less than zero. Given uncertainties noted below and the desire to rely on actual measurements of burn temperature to identify a wide range of plausible updraft conditions, the radiative correction term will not be carried forward.

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Estimated updraft velocities are appropriately minimized by assigning all of the heat generation to gas temperature increase and neglecting the radiative correction term of Equation 5 whenever the estimated gas temperature is sufficiently high. Using pyrometer measurements of solid PBX 9501 burns as the estimated combustion temperature and corresponding thermocouple measurements as an estimated gas temperature leads to a radiative updraft suppression (second term) estimate for PBX 9501 of -2.44 m/s. Later tables show that the largest updraft (first term) estimated for PBX 9501 burns is only 0.89 m/s. This example confirms that available thermocouple measurements are conservatively high because they were taken at a point in the flame before full air mixing and initial radiative losses could occur. The same conservatism is inherent to all of the burn data, so a refined radiative loss correction is not warranted.

Several attributes of Equation 5 (first term only) should be emphasized. The updraft velocity is generally assumed to be constant during a burn; so all factors are specified based on nominal values. Of all the factors, burn rate is perhaps the most variable during a real scenario. Air properties ρ_a and c_P are generally specified at ambient conditions and slightly more plume suppression is provided by using the larger values associated with ambient-temperature air. The cross sectional area is intended to describe the size of the column rising from the pad, so if the fuel is widely distributed across a tray, the effective column area may be smaller than the footprint of the fuel. The exhaust temperature may be difficult to specify because it is intended to describe the initial temperature of the exhaust gases entering the buoyant column. These gases include both combustion products and the entrained air. Theoretical burn temperatures computed by CHEETAH (Fried et. al., 1998) do not include an estimate of thermal equilibrium between the combustion products and the air, neither do they include direct radiative losses of energy to the surroundings; therefore, they are probably too high to be used without compensation for these effects. Similarly, pyrometry measurements reported in Table 2-1 give a more direct measurement of flame temperatures in the combustion zone, but do not account for mixing. Given these considerations, thermocouple data are perhaps most representative of the desired gas temperatures.

Ground-level air-quality impacts are generally maximized by selecting parameter values that suppress the plume rise. Examination of Equations 1 and 4 show that plume rise is directly proportional to both the momentum and buoyancy flux, which are both directly proportional to the updraft velocity. Therefore, minimizing w_s will minimize the effective plume height. While it is natural to think that a "hotter" fire will drive higher plumes, Equation 5 (first term only) shows that a higher gas temperature actually *decreases* the updraft velocity for a given area and heat generation rate because ΔT is in the denominator. This apparent contradiction is resolved by remembering that volumetric airflow is driving the velocity. If the air can efficiently absorb the released energy and incur a larger temperature increase, then less flow is required across a given area.

Selection of Case-Study Conditions

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Plume rise is a dominant factor affecting ground-level air concentrations. Plume rise occurs because of buoyancy induced by the temperature difference between the effluent and the ambient air and because of momentum driven by the updraft velocity. Together, these phenomena will be referred to as lofting. Generally, increased lofting will decrease ground-level air concentrations. However, lofting can also transport material farther downrange and affect additional receptors,

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so it is important to investigate a range of possible plume heights that might be associated with HE burn activities. Several key aspects of buoyant plume specification are discussed below before making quantitative recommendations needed for CALPUFF case studies in the remaining section.

Key Aspects of Buoyant Plume Specification

Input parameters needed to fully specify a buoyant plume in the CALPUFF dispersion model include: the area A_s $\{\mathrm{m}^2\}$, the effective radius r_{eff} $\{\mathrm{m}\}$, the vertical velocity w_s $\{\mathrm{m/s}\}$, the effluent temperature T_s $\{\mathrm{K}\}$, the release height z_s $\{\mathrm{m}\}$, and the initial vertical spread σ_{z_0} $\{m\}$. In the case of a point source, A_s and σ_{z_0} are obtained from r_{eff} by assuming a spherical release volume. Together, these attributes define the initial conditions of a packet or "bubble" of hot gas that will expand while rising and mixing with ambient air to dilute and disperse entrained pollutants. As explained earlier in this section, vertical updraft velocity can be derived by balancing the amount of ambient air that must be entrained to absorb the combustion energy and attain a given exhaust temperature while rising across the area of the burn. The formula obtained by this argument neglects the volume of combustion gases, and it assumes perfect heat transfer to the air without radiative losses. Despite these simplifications, the simple energy balance provides a framework for visualizing a spatial volume in which temperature, velocity, and size must be specified in a self-consistent manner.

There is no absolutely correct choice for the combination of size and temperature that is used to define an initial source puff. A rational choice will homogenize, or average, complex physical phenomena like combustion chemistry and turbulent mixing into a volume that is suitable for the level of complexity (or lack of complexity) offered by the plume rise formulation. In many buoyant dispersion applications, it is common to initialize the height approximately equal to the diameter so that the unit puff is spherical. This is the approach followed in this analysis; the characteristic height is conceptualized as being equal to twice the effective circular radius, which can range from 1.0 to 1.4 m on the trays at the burn ground. Thus, for the largest burn scenarios, temperatures must be selected that represent spatial averages over a 2 to 3-m diameter sphere. Note from Equation 5 (first term only) that higher source temperatures in the denominator will suppress the updraft velocity, because a smaller volumetric flow of air is required to attain the presumed temperature.

Temperature data for burning HE is available from three sources: thermocouples placed on the surface of solid HE, optical pyrometers, and point kinetics thermochemistry models Table 2-1. Combustion chemistry predictions generally represent an idealization of maximum energy release through sequential oxidation steps and adiabatic equalization of combustion gas temperatures without any ambient mixing. Temperatures predicted under these assumptions are quite high and they are relevant only to the thin combustion boundary at the surface of the burning HE. Pyrometer measurements can suffer from a similar specificity to the combustion boundary unless they are focused over the appropriate-sized volume. Thermocouple measurements can suffer from nonuniform heat transfer conditions caused by relocation during the burn, but the available measurements were taken near the surface of the HE and still represent conservatively high estimates of the gas temperature when presumed to be homogeneous over the desired volume. Recall that using higher estimates of temperature than are actually expected to occur will suppress plume lofting and generally increase ground-level air

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concentrations. Proper temperature measurements for initializing plume rise calculations might best be obtained by suspending thermocouples 5 to 10 feet above the burning material.

In classical Gaussian dispersion models, of which CALPUFF is a discretized numerical variant, the spatial dispersion coefficients σ_x, σ_y and σ_z literally specify the standard deviations of the spatial concentration field in the *x*, *y*, and *z* dimensions. Thus, in the cross-wind direction, the concentration field varies according to a normal distribution, or bell-shaped profile, with the peak on the centerline and the width characterized by the standard deviation σ_y. The rapidly moving vertical exhaust column can be represented by a stream of discrete puffs that are widely spread vertically and completely overlapped at their edges to create an initially uniform concentration within the rising column. In order to initialize the vertical spread of a unit puff while spreading the mass across the span of successive puffs, only a reasonably dominant percentage of the aerosol mass distribution should be packed within the characteristic vertical dimension $2r_{eff}$. From introductory statistics, it is commonly known that 68% of the normal probability distribution is contained within ±1 standard deviations, 95.4% is contained within ±2 standard deviations and 99.75% of the probability distribution is contained within ±3 standard deviations, etc. To achieve the desired overlap with only 68% of the puff mass located within the characteristic height, the initial vertical spread could be set according to the formula $2\sigma_{z_0} = 2r_{eff}$, or $\sigma_{z_0} = r_{eff}$.

This is a very subjective selection process for a parameter that can have dramatic effects on the initial release concentration, and no definitive guidance exists on proper specification of σ_{z_0} for rapidly rising buoyant columns. However, the CALPUFF point-source option, which was used exclusively for the analysis computations, does not require an explicit specification of the initial dispersion parameters. It is presumed that σ_x, σ_y and σ_z are set equal to effect a spherical release, and it is most likely that $\sigma_{i_0} = r_{eff}$ as illustrated above for the initial vertical spread; however, no confirmation of these assumptions could be found in the theory manual or users guides.

Increased lofting tends to suppress ground-level air concentrations through increased dilution, but increased lofting may also be a characteristic of large burns that release more pollutants. The competition between increasing source-term mass and increased dilution was explored through a limited set of parametric studies using elevated Gaussian plume results in moderately stable atmospheric conditions. These studies suggest that increasing the source term mass always dominates the potential effect of enhanced dilution at the point of maximum downwind air concentration, so it is appropriate for case studies to use maximum desired permit quantities. (A contradictory result could be conceived where a smaller HE mass results in a higher concentration to a given receptor because of less dilution).

Perhaps the easiest way to explain this finding is to examine the formula given for updraft velocity, Equation 5 first term only, which expresses the vertical velocity in terms of key burn-scenario attributes. If the burn rate is written as $R = M_b / t_b$ for burn mass M_b and burn time t_b, then the formula for vertical velocity can be factored into terms that depend on the HE type and terms that depend on the location of the burn, i.e.,

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$$w_s = \frac{H_C}{\rho_a c_P t_b \left(T_s - T_a\right)} \cdot \frac{M_b}{A_s} \quad \text{(Equation 6)}$$

The first factor has units of $\{\mathrm{m}^3/\mathrm{s}/\mathrm{kg}\}$ and can be interpreted as the volumetric flow rate of air per unit mass of HE that is burned. This factor is a unique attribute of the dominant HE type that is present. The second factor has units of $\{\mathrm{kg}/\mathrm{m}^2\}$ and can be interpreted as the initial area-averaged mass density, or surface concentration, of HE that is loaded on a tray.

Pieces of solid HE are loaded on a burn tray with sufficient separation distance to avoid confinement of combustion gases that might lead to detonation. Stacking of pieces is strictly avoided. Therefore, the ratio M_b/A_s is approximately constant, because, as the mass of HE increases, so does the area required for the burn. Isolation of pieces on the tray also means that each piece burns somewhat independently after ignition. This implies that the time required to burn 10 pieces is roughly the same as the time required to burn 1 piece of the same type and size of HE. Of course, somewhat disparate times are required to consume pieces that vary in size, but the important observation is that the burn time *does not* scale with total mass in a linear manner. Experimental burn times were reported in Table 2-3 for relatively large billets of pressed HE, so the characteristic times are relatively long compared to that expected for smaller pieces with higher surface area. Using these longer periods to estimate burn times for large loadings tends to suppress the vertical velocity.

The two observations that (1) the HE mass-to-area ratio is approximately constant and (2) the burn time is relatively constant regardless of total mass explain why large burns of solid material always produce higher air concentrations – the vertical velocity, and hence, the lofting is approximately the same for a given HE type regardless of the quantity that is burned. For the same amount of lofting, larger burns release pollutants at a faster rate than smaller burns, which increases downwind air concentrations.

2.5 Recommended Case Study Parameters

A broad selection of representative burn conditions was reviewed to select case-study parameters that both maximize and minimize vertical lofting from each burn site. In addition, a case was constructed for a propane-driven burn at TA-16-388. For this case, only the heat released from propane was used to loft the plume; all other energy from HE or mixed waste was ignored in order to suppress the plume. Thus, five cases were defined for evaluation using the CALPUFF dispersion model. All of the factors in Equation 6 with known variation or substantial uncertainty were examined for their potential effect on updraft velocity. These factors include: (1) ambient temperature (35 ºF and 85 ºF), (2) effluent temperatures T_s (ranges defined in Table 2-1), (3) burn time (ranges defined in Table 2-1), (4) site burn limit (250 lb for TA-16-388 and 1000 lb for TA-16-399), and (5) site burn area (4 ft × 8 ft at TA-16-388 and 4 ft × 16 ft at TA-16-399). All combinations of parameters were examined to both minimize and maximize the estimated updraft velocity at each site.

From Section 2.4 it can be determined that both the buoyancy flux and the momentum flux are directly proportional to the updraft velocity and that the effective release height is proportional to both the buoyancy and the momentum. Thus, the potential for lofting is adequately captured by

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an examination of w_s. The following information regarding physical parameters of burn activities was compiled to help choose conditions that represent high and low lofting potential at each of the burn sites.

Table 2-2 summarizes selected burn times and temperatures for various HE types from the experimental data reported in Table 2-1. Some entries (noted in parentheses) were estimated by taking ratios between available data for the two HE configurations. (See additional explanation provided in Section 2.3). Where two or more comparisons were available, all combinations of the factors were evaluated to identify the widest possible variation in the estimate. Note that thermocouple readings were selected as the most representative temperatures for describing the large initial release volumes. Only the data highlighted in blue in Table 2-2 were carried forward into the burn-ground case studies. All chip and fragment configurations are presumed to be burned in small-batches of wet material that require propane assist at TA-16-388. Likewise, PBX 9502 has such poor burn characteristics that an operational decision was made to burn it under propane assist as well. PBX 9404 and Baratol are legacy materials that will not be disposed of in large quantities; they are typically only present as contamination in wastes with blended explosives content or as small fragments that will also employ propane assisted combustion. This screening leaves only PBX 9501 and COMPB as realistic candidates for large-volume HE disposal events. Typically, burns approaching the site-specific permit limits will be conducted at TA-16-399, but maximum-quantity pure HE burns at TA-16-388 were also examined to maintain operating flexibility under the permit.

Heats of combustion were calculated using molecular weighting of $-\Delta H_c^{\circ}$ reported for pure HE and the assumption of zero energy release from minor constituents. Secondary comparisons were made with values reported in an informal memo on HE properties (Patterson, 1992) but primary references for the data were not provided. Compared to Table 2-1 the memo reported values that were 5% higher for PBX 9501 and 3.6% lower for COMPB. These margins are considered adequate independent validation of the computed estimates for the purposes of this study. A calculation using the CHEETAH code, which defines thermodynamically preferred combustion paths and products, would provide another independent validation, but the degree of uncertainty in burn conditions would introduce a similar degree of error.

HE properties from Table 2-1 were combined with standard air properties and two different air temperatures (35 ºF and 85 ºF) to evaluate the minimum and maximum volumetric flow rate per unit HE mass burned (leading factor of Equation 6 that can be generated by solid forms of the various HE types. Table 2-3 summarizes these calculations for several common HE types. Between the two types of interest, PBX 9501 generates the lowest flow rate and COMPB generates the highest flow rate (blue cells within Table 2-3). These values of flow rate happen to correspond to application of the lowest and highest ambient temperatures, respectively. The highest and lowest values from Table 2-1 were combined with the highest and lowest HE loading densities reported in Table 2-3 for each burn site to evaluate Equation 6 and obtain the high and low estimates of vertical updraft velocity that are also reported in Table 2-3 as parameters of the respective case studies. Table 2-4 summarizes the CALPUFF inputs for the propane-only and minimum and maximum lofting conditions. Data specific to the unit location are also required: UTM Zone 13 coordinates and the ground elevation in m above mean sea level (m MSL), which are shown in Table 2-5. As requested by NMED, LANL is providing an electronic copy of model run input and output along with the program files as part of this report. Source-specific

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information is described above and the model runs provide model flag settings and other general information.

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¶
<#>H_c is unique to the type of material burned. The heats of combustion for the HE used in this analysis were obtained from Gibbs and Popolato (1980) for pure HE and adjusted for inert constituents. ¶
<#>8.87 million J/kg (MJ/kg) was used for PBX 9501¶
<#>11.58 MJ/kg was used for COMPB¶
<#>The heat content of propane was assumed to be 1 million British Thermal Units (MBtu) per 15.7 gallons (gal) (Glover, 1998). ¶
¶
<#>R can be expressed as M_b/t_b, where M_b is the amount of material burned in a given time period and t_b is the burn time for specific materials determined from the referenced literature. ¶
<#>For the HE burning scenarios, the maximum allowable HE unit limits were used for M_b: ¶
<#>1000 lb (453.6 kg) per burn for TA-16-399¶
<#>250 lb (113.4 kg) per burn for TA-16-388¶
<#>The values for t_b vary by the type of material being burned. ¶
<#>For PBX 9501, used in the minimum lofting HE scenarios for both units the burn time used was 8 minutes (28,800 s) (Hatler, 1982) based on measurements for burning solids. ¶
<#>For COMPB, the HE used for the maximum lofting HE scenarios for both units, the burn time used was estimated to be 1.5 minutes (5400 s). This was based on data for chips of COMPB (Hatler, 1982) adjusted to reflect the slower burn time for a solid composition. Other data in this reference for PBX 9501 or PBX 9502 show that solids burn 2 to 4 times longer than the same HE burned as chips. The COMPB burn time was adjusted accordingly. ¶
<#>Specific M_b and t_s were not necessary for propane because the propane-only scenario for TA-16-388 assumed a burn rate of 1 gal per minute (gal/min) based on operational observations.¶
¶
<#>Dry air density at 7200 feet (ft) (P_a = 0.913 kg/m^3) was calculated using the ideal gas law to adjust air density at standard conditions (Stull, 1988) to 7200 ft (T_a).¶
¶
<#>The heat capacity of air (c_p = 1004.67 J/kg/K) was obtained from Stull (1988).¶ ... [1]

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Table 2-1. Operational descriptions of actual HE burns.

HE Type	Physical Condition[a]	Mass (kg)	Burn Time (min)	Thermocouple Temp[b] (K)	Pyrometer Temp[b] (K)	Theoretical Temp[c] (K)
PBX 9404	1	19	6.5	2013	--	--
PBX 9501	1	26	8.0	1993	2303	2904
PBX 9502	1	26	56.0	1343	1398	1661
COMPB	1	--	(1.5 – 3)	(1837 – 2212)	--	--
Baratol	2	295	5	--	2023	--
Baratol	2	386	5	--	2023	--
COMPB	2	27	0.75	(1837 – 2040)	2123	2672
PBX 9501	2	226	2	(1837)	2123	2904
PBX 9501	2	408	2	(1993)	2303	2904
PBX 9502	2	77	23	(1343)	1398	1661

[a] Condition 1 denotes a pressed cylinder, Condition 2 denotes molding powder and casting chips.
[b] Parentheses denote estimates based on absolute-temperature ratios of other available measurements.
[c] Obtained from the Cheetah point-kinetics thermochemistry code at 1-atm pressure of air.
Note: Pink cells mark measured data used in ratio-based estimates. Blue cells mark estimates that were propagated as uncertainties in the dispersion analysis.

Table 2-2. High-Explosive and Propane Combustion Properties.

Explosive	Burn Period[a] (min)		Burn Temp (K)		Heat of Combustion[b] (MJ/kg)
	Solids	Chips	Solids	Chips	
PBX 9404	6.5	(1.6 - 3.25)	2013	(1856 - 2013)	8.78
PBX 9501	8.0	2.0	1993	(1837 - 1993)	8.87
PBX 9502	56.0	23	1343	(1343)	11.34
Baratol	(10 - 20)	5.0	(1751 - 1900)	(1751 - 1943)	---[c]
COMPB	(1.5 - 3)	0.75	(1837 - 2212)	(1837 - 2039)	11.58
	Burn Rate (gal/min)		Energy Content (MBtu/gal)		Heat Rate (MW)
Propane	1.0		15.7 (at 70% efficiency)		1.12

[a] Parentheses denote ranges estimated from available measurements between solids and chips.
[b] Obtained from Gibbs and Popolato (Gibbs and Popolato, A., 1980) $-\Delta H_c^{\circ}$ for pure HE weighted by inert constituents.
[c] No immediate information could be found on the primary constituent barium nitrate.
NOTE: Data from blue cells were carried forward into the burn-ground case studies.

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Table 2-3. Ranges of volumetric flow rate for common high explosives.

Explosive	Volumetric Flow Rate (m^3/s) per kg burned	
	min	max
PBX 9404	1.41×10^{-2}	1.44×10^{-2}
PBX 9501	1.17×10^{-2}	1.19×10^{-2}
PBX 9502	3.45×10^{-3}	3.53×10^{-3}
Baratol	---	---
COMPB	3.62×10^{-2}	9.14×10^{-2}

NOTE: Blue cells indicate minimum and maximum flow rates.

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Table 2-4. Additional information that defines burn-area case studies.

Site TA-16-388 Solid HE	
Max burn area (full tray)	4-ft × 8-ft = 32 ft^2 (2.97 m^2)
Effective radius	$r_{eff} = \sqrt{A/\pi} =$ 0.97 m
Release height	0.5 m + r_{eff} = 1.47 m
Max solid HE	250 lb (113.4 kg)
HE loading concentration	113.4 kg / 2.97 m^2 = 38.18 kg/m^2
Max Lofting	
Max vertical velocity	3.49 m/s
Corresponding temp	1837 K
Corresponding burn time	1.5 min
Corresponding ambient temp	85 ºF
Corresponding HE type	COMPB
Plume height (stable met)	73 m
Min Lofting	
Min vertical velocity	0.45 m/s
Corresponding temp	1993 K
Corresponding burn time	8 min
Corresponding ambient temp	35 ºF
Corresponding HE type	PBX 9501
Plume height (stable met)	36 m
TA-16-388 Mixed Waste w/Propane	
Typical mixed-waste mass	50 lb (22.68 kg)
Corresponding burn time	~20 min
Mixed-waste burn area	4-ft × 8-ft = 32 ft^2 (2.97 m^2)
Effective radius	$r_{eff} = \sqrt{A/\pi} =$ 0.97 m
Release height	0.5 m + r_{eff} = 1.47 m
Propane burn rate	1 gal/min = 1.12 MW
Nominal vertical velocity	1.2 m/s
Corresponding ambient temp	85 ºF
Propane temp	1300 ºF (977.6 K)
Plume height (stable met)	48 m

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Table 2-4. Additional information that defines burn-area case studies. (continued)

Site TA-16-399	
Max burn area (full tray)	4-ft × 16-ft = 64 ft^2 (5.95 m^2)
Effective radius	$r_{eff} = \sqrt{A/\pi}$ = 1.38 m
Release Height	1.0 m + r_{eff} = 2.38 m [a]
Max solid HE	1000 lb (453.6 kg)
HE loading concentration	453.6 kg / 5.95 m^2 = 76.24 kg/m^2
Max Lofting	
Max vertical velocity	7.0 m/s
Corresponding temp	1837 K
Corresponding burn time	1.5 min
Corresponding ambient temp	85 ºF
Corresponding HE type	COMPB
Plume height (stable met)	116 m
Min Lofting	
Min vertical velocity	0.89 m/s
Corresponding temp	1993 K
Corresponding burn time	8 min
Corresponding ambient temp	35 ºF
Corresponding HE type	PBX 9501
Plume height (stable met)	57 m
General	
Minimum air temp	35 ºF (275 K)
Maximum air temp	85 ºF (303 K)
Nominal air temp	72 ºF (295.5 K)
Nominal local air pressure	77460 Pa (LANL weather machine)
Dry air density at 7200 ft	0.913 kg/m^3 (ideal gas law $P = \rho RT$)
Air const. press. specific heat	1004.67 J/kg/K (Stull, 1988)
Gas const. for dry air	287.04 J/K/kg (Stull, 1988)

[a] Actual height to the bottom of the tray is approximately 0.381 m and height to the rim of the tray is approximately 0.58 m.

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Table 2-5. Location-Specific Information

Map Ref.	Site	UTM X-Coordinate	UTM Y-Coordinate	Ground Elevation (m MSL)
	TA-16-388 Flash Pad	379720	3967617	2286.3
	TA-16-399 Burn Tray	379783	3967736	2275.03
1	Sombrillo Nursing Care	383951	3971488	2202
2	Los Alamos Middle School	383072	3972775	2254
3	Tsankawi Ruins	389596	3968917	1999
4	Bandelier Visitor Center	385279	3959714	1893
5	San Ildefonso Pueblo	384709	3968497	2154
6	Los Alamos County Hospital	381009	3971563	2226
7	Royal Crest Trailer Park	382152	3970450	2237
8	Ponderosa Campground	379159	3966056	2267

Map Ref. = References location of this receptor site on Figures 3-1, 3-2, 3-3, 3-4, 4-1, and 4-2.
UTM = Universal Transverse Mercator (UTM)
m MSL = meters above mean sea level
Note: Air impacts computed at 1.5 m above ground elevation.

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3.0 Air Quality Impacts Calculations

CALPUFF estimates air quality impacts in micrograms per cubic meter (µg/m^3) for a 1 g/s emission rate. From these estimates, a conversion factor (CF) in µg/m^3 per g/s of a pollutant emitted is calculated for each screening level averaging period. However, to determine which unit has the highest impacts at various locations for the short-term averaging periods, the CF must be weighted by the maximum amount of waste that can be burned at each unit: 250 lb at TA-16-388 and 1000 lb at TA-16-399. The annual averaging period assumes that 20,000 lb of waste and 15,000 gal of propane are burned at the most conservative unit and the burn size is not considered in calculating impacts. Because the maximum fuel amount burned at TA-16-399 is four times higher than at TA-16-388, the TA-16-399 conversion factors were multiplied by 4 and compared to the TA-16-388 conversion factors so that the highest calculated impacts could be estimated. Rather than base the worst-case scenario solely on the highest conversion factor value, the conversion factors were temporarily weighted in order to determine the conversion factor/scenario combinations that would result in the highest calculated air impacts. Based on this weighting, the highest impact receptor locations were chosen and included in Table 3-1. The table shows the averaging period and location for the worst-case CFs. Ambient air impacts were calculated using the unit-specific amount of fuel burned, and the emission factors described in the modeling protocol (LANL, 2007). In accordance with the protocol, the calculated impacts have been compared to the following screening levels in Tables 3-5 through 3-8:

- The NMED and the Environmental Protection Agency's (EPA's) ambient air quality standards (AAQS). (Tables 3-6 and 3-8)
- The EPA Region 9 Preliminary Remediation Goals (PRGs) (EPA, 2004). (Tables 3-7 and 3-8)
- The acute (1 hr) inhalation exposures (AIEC) for toxic air pollutants from the Companion Database to EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA, 2005). (Tables 3-5 and 3-6)

Contaminant-specific emissions for 1-hr, 3-hr, 8-hr and 24-hr averaging periods are presented in Tables 3-2 and 3-3. Emissions were calculated for each of the contaminants listed in Table 3-6 of the modeling protocol (LANL, 2007). The CF for the appropriate scenario located in Table 3-1 was then multiplied by the calculated emissions and included in Tables 3-5 and 3-6 for short-term averaging periods. For example, the highest hourly on-site impacts resulted from burning HE at TA-16-388 were calculated as follows:

$$\frac{\boldsymbol{EF}\ \text{g pollutant}}{\text{g waste}} \times \frac{\boldsymbol{n}}{\boldsymbol{N}} \times \frac{454\ \text{g waste}}{\text{lb waste}} \times \frac{250\ \text{lb waste}}{1\ \text{hr}} \times \frac{1\ \text{hr}}{3600\ \text{s}} \times \frac{\boldsymbol{CF}\ \mu\text{g pollutant/m}^3}{\text{g pollutant/s}} = \frac{\boldsymbol{I}\ \mu\text{g pollutant}}{\text{m}^3}$$

where:

EF = emission factors from Table 3-6 in the modeling protocol (LANL, 2007)
CF = conversion factors from g/s of pollutant emitted to µg/m^3 concentrations of the pollutant in air for a 1-hr averaging period
I = calculated air pollutant concentration in µg/m^3
n = maximum number of burns conducted within averaging period (*n=1* for 1-hr avg.)
N = Number of simulations during the averaging period (*N=1* for 1-hr avg.)

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When the averaging periods for the screening levels span 3-hrs, 8-hrs and 24-hrs, two burns are assumed because that would be the maximum amount of waste that could be burned during these time periods. However, the equation doesn't change because the modeled operations schedule also included two simulations during these averaging periods, thereby cancelling each other.

An example of an impact calculation for 3-, 8-, and 24- hour averaging periods for TA-16-388 is:

$$\frac{EF\ \text{g pollutant}}{\text{g waste}} \times \frac{n}{N} \times \frac{454\ \text{g waste}}{\text{lb waste}} \times \frac{250\ \text{lb waste}}{1\ \text{hr}} \times \frac{1\ \text{hr}}{3600\ \text{s}} \times \frac{CF\ \mu\text{g pollutant/m}^3}{\text{g pollutant/s}} = \frac{I\ \mu\text{g pollutant}}{\text{m}^3}$$

where:

EF = emission factors from Table 3-6 in the modeling protocol
CF = conversion factors from g/s of pollutant emitted to $\mu g/m^3$ concentrations of the pollutant in air for the specific averaging period (3-, 8-, or 24- hours)
I = calculated air pollutant concentration in $\mu g/m^3$
n = maximum number of burns conducted within averaging period (*n=1* for 1-hr avg.)
N = Number of simulations during the averaging period (*N=1* for 1-hr avg.)

Contaminant-specific emissions for the annual averaging period are presented in Table 3-4. Annual impacts assessments assume that 15,000 gal of propane are used and 20,000 lb of burnable waste (HE and combustible wastes) are treated annually. Thus, annual emissions estimations represent a maximum amount of waste burned per year rather than taking into account individual burn sizes. Also, annual emissions were averaged over 508 hours, the number of meteorological hours modeled, to compensate for oversampling the meteorology beyond the number of hours needed to process the maximum projected annual inventory.

The annual on-site impacts resulted from burning HE at TA-16-388 were calculated as follows:

$$\frac{EF\ \text{g pollutant}}{\text{g waste}} \times \frac{20{,}000\ \text{lb waste}}{\text{yr}} \times \frac{454\ \text{g waste}}{\text{lb waste}} \times \frac{1\ \text{yr}}{508\ \text{hr}} \times \frac{1\ \text{hr}}{3600\ \text{s}} = \text{Annual Emissions (g/s)}$$

then:

$$\text{Annual Emission (g/s)} \times \frac{CF\ \mu\text{g pollutant/m}^3}{\text{g/s}} = \frac{I\ \mu\text{g pollutant}}{\text{m}^3}$$

where:

EF = emission factors from Table 3-6 in the modeling protocol
CF = conversion factors from g/s of pollutant emitted to $\mu g/m^3$ concentrations of the pollutant in air for an annual averaging period
I = calculated air pollutant concentration in $\mu g/m^3$

Because the types and quantities of wastes treated vary from year-to-year, the impacts analysis used only the worst-case emissions factors (EFs) from Table 3-6 of the modeling protocol (LANL, 2007) for all wastes. This avoids the need to estimate the quantities of each type of waste stream for the next 10 years and results in a conservative air impacts analysis. The EFs from Table 3-5 of the modeling protocol (LANL, 2007) were used for propane. Tables 3-2 and 3-3 calculate the short-term emissions for TA-16-388 and TA-16-399, respectively. Table 3-4 provides the calculated emissions for the annual averaging period. In addition, propane emissions were not added to impacts analysis tables for any scenarios where burning of HE alone caused the highest impacts (e.g. off-site cases). Accordingly, the propane emissions that are calculated in Table 3-4 have been added to the annual off-site impacts in Table 3-8 only.

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Tables 3-5 through 3-8 compare the calculated worst-case on- and off-site impacts to the applicable screening levels. Note that not all of the tables have the same contaminants. Some contaminants with AIECs do not have PRGs, and vice versa. The AAQS are evaluated only for off-site impacts, in accordance with the EPA's Draft Final Open Burning/Open Detonation Permitting Guidelines (EPA, 2002) and NMED's air quality requirements. Receptors other than the worst-case on- and off-site impact receptors have lower CFs (see Table 3-1) than the worst-case CFs; therefore, the impacts to these other receptors are lower than the worst-case impacts. Other receptor impacts are lower than the worst-case impact in a ratio of the other receptor's CF divided by the worst-case impact CF for each averaging period.

Table 3-5 compares the calculated worst-case on-site emissions impacts to EPA's AIECs. No screening levels are exceeded and only acrolein approaches the short-term level. The acrolein emission factor was derived from the open burning of fuel oil (e.g., a fuel spill), which was used as a very conservative representative of burning oils and solvents. Oils and solvents are a small waste stream treated rarely at the TA-16 Burn Ground and none of the other waste streams at the Burn Ground have acrolein emission factors. Therefore, acrolein is not an environmental concern.

The short-term off-site impacts are compared to EPA's AIECs and short-term AAQS in Table 3-6. All impacts are below the screening levels. To obtain the final impacts, background values from the New Mexico Air Quality Bureau Air Dispersion Modeling Guidelines (NMED, 2007) were added, as appropriate, to the calculated impacts from the TA-16 Burn Ground.

Table 3-7 compares the annual on-site impacts with EPA's PRGs. As described in the modeling protocol (LANL, 2007), a risk assessment is required if the impacts exceed 0.1 times the PRGs. This conservative analysis shows no exceedences of 0.1 times the PRGs and no risk assessment is required. The annual off-site impacts are compared with 0.1 times the EPA's PRGs and long-term AAQS in Table 3-8. No screening levels are exceeded and the impacts are less than the screening levels, with the exception of Particulate Matter. The estimated impact for Particulate Matter is 26.6 $\mu g/m^3$ and the standard is 60 $\mu g/m^3$. The calculated impact from the TA-16 Burn Ground activities is 5.72 E-03 $\mu g/m^3$. The remaining 26.6 $\mu g/m^3$ is the assumed background level in accordance with the NMED's 2007 Modeling Guidelines (NMED, 2007). Therefore, the TA-16 Burn Ground had negligible additive impacts. Based on this analysis, screening levels were not exceeded at any receptor, including the maximum on- and off-site receptors. Therefore, additional analyses are not warranted.

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Table 2-1. Vertical Velocities for Unit/Waste Scenarios¶
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Table 3-1. Unit/Waste Scenarios Creating Maximum Impacts by Averaging Periods

Receptor	Air Impacts Conversion Factors (µg/m^3 per g/s)									
	1 hr	Scenario[1]	3 hr	Scenario	8 hr	Scenario	24 hr	Scenario	Annual	Scenario
Sombrillo Nursing Care	1.09E-01	TA-16-399 HE Max	3.62E-02	TA-16-399 HE Max	1.36E-02	TA-16-399 HE Max	5.03E-03	TA-16-399 HE Min	3.05E-04	TA-16-388 HE Min
Los Alamos Middle School	2.24E-01	TA-16-399 HE Min	8.50E-02	TA-16-399 HE Max	4.80E-02	TA-16-399 HE Min	1.60E-02	TA-16-399 HE Min	5.24E-04	TA-16-399 HE Min
Tsankawi Ruins	4.31E-02	TA-16-399 HE Max	1.54E-02	TA-16-399 HE Max	6.33E-03	TA-16-399 HE Min	2.11E-03	TA-16-399 HE Min	6.70E-05	TA-16-388 HE Min
Bandelier Visitor Center	7.56E-02	TA-16-399 HE Max	2.99E-02	TA-16-399 HE Max	1.41E-02	TA-16-399 HE Max	4.68E-03	TA-16-399 HE Max	7.69E-05	TA-16-388 HE Min
San Ildefonso Pueblo	2.37E-01	TA-16-399 HE Max	1.42E-01	TA-16-399 HE Max	5.36E-02	TA-16-399 HE Max	1.79E-02	TA-16-399 HE Max	3.66E-04	TA-16-388 HE Min
Los Alamos County Hospital	9.90E-01	TA-16-399 HE Min	3.55E-01	TA-16-399 HE Min	1.33E-01	TA-16-399 HE Min	4.49E-02	TA-16-399 HE Min	1.86E-03	TA-16-399 HE Min
Royal Crest Trailer Park	2.80E-01	TA-16-399 HE Max	1.17E-01	TA-16-399 HE Max	4.38E-02	TA-16-399 HE Max	1.46E-02	TA-16-399 HE Max	7.49E-04	TA-16-388 HE Min
Ponderosa Campground	1.92E+00	TA-16-399 HE Min	6.93E-01	TA-16-399 HE Min	2.60E-01	TA-16-399 HE Min	8.76E-02	TA-16-399 HE Min	1.94E-03	TA-16-388 HE Min
HE Max On-Site	1.49E+02	TA-16-388 HE Min	4.95E+01	TA-16-388 HE Min	3.41E+01	TA-16-388 HE Min	1.14E+01	TA-16-388 HE Min	1.48E+00	TA-16-388 HE Min
Max Off-Site	2.87E+00	TA-16-399 HE Min	9.57E-01	TA-16-399 HE Min	4.19E-01	TA-16-399 HE Min	1.40E-01	TA-16-399 HE Min	5.76E-03	TA-16-388 HE Min

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[1] TA-16-388 or TA-16-399 HE Max is based on the explosives Maximum Lofting scenarios. TA-16-388 or TA-16-399 HE Min is based on the Minimum Lofting scenarios. For the short-term impacts, if TA-16-388 is the maximum scenario, impact calculations use 250 lb of waste per burn. If TA-16-399 is the maximum scenario, impact calculations use 1000 lb of waste per burn. TA-16-388 propane only scenario (as discussed in Section 2.1) was never the most conservative weighted conversion factor and is not included in this table. For the annual impacts, 20,000 pounds of wastes and 15,000 pounds of HE were assumed to be burned at the most conservative impact unit.

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Table 3-2. Contaminant-Specific Emissions for Short-Term Averaging Times at TA-16-388

Contaminant	Total Waste Burned Over Averaging Period (lb) [1]	Waste Burned (g/s)	Calculated Contaminant Emissions (g/s) [2]
Acenaphthene	250	3.15E+01	3.15E-04
Acetaldehyde	250	3.15E+01	1.99E-03
Acetone	250	3.15E+01	1.10E-03
Acetophenone	250	3.15E+01	5.49E-06
Acrolein	250	3.15E+01	1.23E-03
Aluminum	250	3.15E+01	2.25E-05
Anthracene	250	3.15E+01	4.73E-04
Barium	250	3.15E+01	1.32E-05
Benzaldehyde	250	3.15E+01	3.28E-03
Benzene	250	3.15E+01	3.22E-02
Benzo(a)anthracene	250	3.15E+01	1.58E-04
Benzo(a)pyrene	250	3.15E+01	1.58E-04
Benzo(b,k)fluoranthene	250	3.15E+01	2.21E-04
Benzyl alcohol	250	3.15E+01	1.25E-03
Butadiene [1-3-]	250	3.15E+01	4.22E-05
Butyl benzyl phthalate	250	3.15E+01	3.85E-06
Carbon monoxide - 1 hr	250	3.15E+01	2.84E+00
Carbon monoxide - 8 hr	500	3.15E+01	2.84E+00
Carbon tetrachloride	250	3.15E+01	2.17E-06
Chloromethane (methyl chloride)	250	3.15E+01	8.95E-06
Chromium (total)	250	3.15E+01	1.25E-05
Chrysene	250	3.15E+01	2.84E-04
Crotonaldehyde	250	3.15E+01	1.89E-04
Cyclohexane	250	3.15E+01	8.42E-04
Dibenzo(a,h)anthracene	250	3.15E+01	6.31E-06
Dibutyl phthalate	250	3.15E+01	1.04E-05
Dichloroethylene [1,1-]	250	3.15E+01	6.78E-06
Diethyl phthalate	250	3.15E+01	2.21E-06
Dimethyl phthalate	250	3.15E+01	5.93E-06
Dioctyl phthalate	250	3.15E+01	2.90E-05
Dioxin (2,3,7,8-TCDD)	250	3.15E+01	4.70E-11
Ethylbenzene	250	3.15E+01	1.73E-03
Ethyl chloride	250	3.15E+01	2.17E-06
Fluoranthene	250	3.15E+01	6.31E-04
Fluorene	250	3.15E+01	3.15E-05
Formaldehyde	250	3.15E+01	9.55E-03
Furan	250	3.15E+01	4.73E-06
Hexane	250	3.15E+01	5.04E-04
Hydrogen chloride	250	3.15E+01	3.14E-02
Indeno[1,2,3-cd]pyrene	250	3.15E+01	1.58E-04
Methylcyclohexane	250	3.15E+01	4.92E-03
Methylene chloride	250	3.15E+01	2.35E-05
Methyl ethyl ketone (2-Butanone)	250	3.15E+01	4.10E-04

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Table 3-2. Contaminant-Specific Emissions for Short-Term Averaging Times at TA-16-388 (continued)

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Contaminant	Total Waste Burned Over Averaging Period (lb) [1]	Waste Burned (g/s)	Calculated Contaminant Emissions (g/s) [2]
Methyl isobutyl ketone	250	3.15E+01	3.47E-04
Naphthalene	250	3.15E+01	5.11E-03
Nitrogen dioxide - 24 hr	500	3.15E+01	2.36E+00
Particulate matter (PM-10) - 24 hr	500	3.15E+01	6.31E+00
Particulate matter (TSP) - 24 hr	500	3.15E+01	6.31E+00
Phenanthrene	250	3.15E+01	2.26E-04
Phenol	250	3.15E+01	4.92E-04
Pyrene	250	3.15E+01	6.31E-05
Styrene	250	3.15E+01	1.57E-03
Sulfur dioxide - 3 hr	500	3.15E+01	7.88E-02
Sulfur dioxide - 24 hr	500	3.15E+01	7.88E-02
Toluene	250	3.15E+01	3.85E-03
Trichloroethane [1,1,1-]	250	3.15E+01	1.08E-06
Trimethylbenzene [1,2,4-]	250	3.15E+01	7.66E-03
Trimethylbenzene [1,3,5-]	250	3.15E+01	1.76E-02
Vinyl chloride	250	3.15E+01	7.03E-06
Xylene (Total)	250	3.15E+01	1.82E-02
Zinc	250	3.15E+01	1.97E-03

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[1] Unless noted in the contaminant column, averaging times are 1 hour (hr) and include only one burn at the unit. In the case of the 3-hr, 8-hr, and 24-hr averaging times, two burns are included in the emissions analysis.

[2] Emissions factors used to calculate these emissions can be found in the modeling protocol (LANL, 2007).

hr = hour
g/s = grams per second
lb = pounds
PM-10 = particulate matter less than 10 micrometers
TSP= total suspended particulate

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Table 3-3. Contaminant-Specific Emissions for Short-Term Averaging Times at TA-16-399

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Contaminant	Total Waste Burned Over Averaging Period (lb) [1]	Waste Burned (g/s)	Calculated Contaminant Emissions (g/s) [2]
Acenaphthene	1.00E+03	1.26E+02	1.26E-03
Acetaldehyde	1.00E+03	1.26E+02	7.95E-03
Acetone	1.00E+03	1.26E+02	4.41E-03
Acetophenone	1.00E+03	1.26E+02	2.19E-05
Acrolein	1.00E+03	1.26E+02	4.92E-03
Aluminum	1.00E+03	1.26E+02	8.99E-05
Anthracene	1.00E+03	1.26E+02	1.89E-03
Barium	1.00E+03	1.26E+02	5.30E-05
Benzaldehyde	1.00E+03	1.26E+02	1.31E-02
Benzene-	1.00E+03	1.26E+02	1.29E-01
Benzo(a)anthracene	1.00E+03	1.26E+02	6.31E-04
Benzo(a)pyrene	1.00E+03	1.26E+02	6.31E-04
Benzo(b,k)fluoranthene	1.00E+03	1.26E+02	8.83E-04
Benzyl alcohol	1.00E+03	1.26E+02	4.99E-03
Butadiene [1-3-]	1.00E+03	1.26E+02	1.69E-04
Butyl benzyl phthalate	1.00E+03	1.26E+02	1.54E-05
Carbon monoxide - 1 hr	1.00E+03	1.26E+02	1.14E+01
Carbon monoxide - 8 hr	2.00E+03	1.26E+02	1.14E+01
Carbon tetrachloride	1.00E+03	1.26E+02	8.69E-06
Chloromethane (methyl chloride)	1.00E+03	1.26E+02	3.58E-05
Chromium (total)	1.00E+03	1.26E+02	5.01E-05
Chrysene	1.00E+03	1.26E+02	1.14E-03
Crotonaldehyde	1.00E+03	1.26E+02	7.57E-04
Cyclohexane	1.00E+03	1.26E+02	3.37E-03
Dibenzo(a,h)anthracene	1.00E+03	1.26E+02	2.52E-05
Dibutyl phthalate	1.00E+03	1.26E+02	4.16E-05
Dichloroethylene [1,1-]	1.00E+03	1.26E+02	2.71E-05
Diethyl phthalate	1.00E+03	1.26E+02	8.83E-06
Dimethyl phthalate	1.00E+03	1.26E+02	2.37E-05
Dioctyl phthalate	1.00E+03	1.26E+02	1.16E-04
Dioxin (2,3,7,8-TCDD)	1.00E+03	1.26E+02	1.88E-10
Ethylbenzene	1.00E+03	1.26E+02	6.92E-03
Ethyl chloride	1.00E+03	1.26E+02	8.69E-06
Fluoranthene	1.00E+03	1.26E+02	2.52E-03
Fluorene	1.00E+03	1.26E+02	1.26E-04
Formaldehyde	1.00E+03	1.26E+02	3.82E-02
Furan	1.00E+03	1.26E+02	1.89E-05
Hexane	1.00E+03	1.26E+02	2.02E-03
Hydrogen chloride	1.00E+03	1.26E+02	1.26E-01
Indeno[1,2,3-cd]pyrene	1.00E+03	1.26E+02	6.31E-04
Methylcyclohexane	1.00E+03	1.26E+02	1.97E-02
Methylene chloride	1.00E+03	1.26E+02	9.41E-05
Methyl ethyl ketone (2-Butanone)	1.00E+03	1.26E+02	1.64E-03
Methyl isobutyl ketone	1.00E+03	1.26E+02	1.39E-03

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Table 3-3. Contaminant-Specific Emissions for Short-Term Averaging Times at TA-16-399 (continued)

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Contaminant	Total Waste Burned Over Averaging Period (lb) [1]	Waste Burned (g/s)	Calculated Contaminant Emissions (g/s) [2]
Naphthalene	1.00E+03	1.26E+02	2.04E-02
Nitrogen dioxide - 24 hr	2.00E+03	1.26E+02	9.46E+00
Particulate matter (PM-10) - 24 hr	2.00E+03	1.26E+02	2.52E+01
Particulate matter (TSP) - 24 hr	2.00E+03	1.26E+02	2.52E+01
Phenanthrene	1.00E+03	1.26E+02	9.04E-04
Phenol	1.00E+03	1.26E+02	1.97E-03
Pyrene	1.00E+03	1.26E+02	2.52E-04
Styrene	1.00E+03	1.26E+02	6.29E-03
Sulfur dioxide - 3 hr	2.00E+03	1.26E+02	3.15E-01
Sulfur dioxide - 24 hr	2.00E+03	1.26E+02	3.15E-01
Toluene	1.00E+03	1.26E+02	1.54E-02
Trichloroethane [1,1,1-]	1.00E+03	1.26E+02	4.34E-06
Trimethylbenzene [1,2,4-]	1.00E+03	1.26E+02	3.06E-02
Trimethylbenzene [1,3,5-]	1.00E+03	1.26E+02	7.02E-02
Vinyl chloride	1.00E+03	1.26E+02	2.81E-05
Xylene (Total)	1.00E+03	1.26E+02	7.28E-02
Zinc	1.00E+03	1.26E+02	7.89E-03

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[1] Unless noted in the contaminant column, averaging times are 1 hour (hr) and include only one burn at the unit. In the case of the 3-hr, 8-hr, and 24-hr averaging times, two burns are included in the emissions analysis.
[2] Emissions factors used to calculate these emissions can be found in the modeling protocol (LANL, 2007).
hr = hour
g/s = grams per second
lb = pounds
PM-10 = particulate matter less than 10 micrometers
TSP= total suspended particulate

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Table 3-4. Contaminant-Specific Emissions for the Annual Averaging Period [1]

Contaminant	Amount Waste Burned (lb/yr)	Amount Waste Burned (g/s)	Calculated Waste Emissions [2] (g/s)	Amount Propane Burned [3] (gal/yr)	Calculated Propane Emissions (lb/yr)	Propane Emissions (g/s)	Total Calculated Emissions [2,3] (g/s)
Acenaphthene	2.00E+04	4.97E+00	4.97E-05				4.97E-05
Acetaldehyde	2.00E+04	4.97E+00	3.13E-04				3.13E-04
Acetone	2.00E+04	4.97E+00	1.74E-04				1.74E-04
Acetophenone	2.00E+04	4.97E+00	8.64E-07				8.64E-07
Acrolein	2.00E+04	4.97E+00	1.94E-04				1.94E-04
Aluminum	2.00E+04	4.97E+00	3.54E-06				3.54E-06
Anthracene	2.00E+04	4.97E+00	7.45E-05				7.45E-05
Barium	2.00E+04	4.97E+00	2.09E-06				2.09E-06
Benzaldehyde	2.00E+04	4.97E+00	5.16E-04				5.16E-04
Benzene	2.00E+04	4.97E+00	5.07E-03				5.07E-03
Benzo(a)anthracene	2.00E+04	4.97E+00	2.48E-05				2.48E-05
Benzo(a)pyrene	2.00E+04	4.97E+00	2.48E-05				2.48E-05
Benzo(b,k)fluoranthene	2.00E+04	4.97E+00	3.48E-05				3.48E-05
Benzyl alcohol	2.00E+04	4.97E+00	1.97E-04				1.97E-04
Butadiene [1-3-]	2.00E+04	4.97E+00	6.65E-06				6.65E-06
Butyl benzyl phthalate	2.00E+04	4.97E+00	6.06E-07				6.06E-07
Carbon monoxide	2.00E+04	4.97E+00	4.47E-01	1.50E+04	2.85E+01	3.33E-02	4.80E-01
Carbon tetrachloride	2.00E+04	4.97E+00	3.42E-07				3.42E-07
Chloromethane (methyl chloride)	2.00E+04	4.97E+00	1.41E-06				1.41E-06
Chromium (total)	2.00E+04	4.97E+00	1.97E-06				1.97E-06
Chrysene	2.00E+04	4.97E+00	4.47E-05				4.47E-05
Crotonaldehyde	2.00E+04	4.97E+00	2.98E-05				2.98E-05
Cyclohexane	2.00E+04	4.97E+00	1.33E-04				1.33E-04
Dibenzo(a,h)anthracene	2.00E+04	4.97E+00	9.93E-07				9.93E-07
Dibutyl phthalate	2.00E+04	4.97E+00	1.64E-06				1.64E-06
Dichloroethylene [1,1-]	2.00E+04	4.97E+00	1.07E-06				1.07E-06
Diethyl phthalate	2.00E+04	4.97E+00	3.48E-07				3.48E-07
Dimethyl phthalate	2.00E+04	4.97E+00	9.33E-07				9.33E-07
Dioctyl phthalate	2.00E+04	4.97E+00	4.56E-06				4.56E-06
Dioxin (2,3,7,8-TCDD)	2.00E+04	4.97E+00	7.40E-12				7.40E-12

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Table 3-4. Contaminant-Specific Emissions for the Annual Averaging Period [1] (continued)

Contaminant	Amount Waste Burned (lb/yr)	Amount Waste Burned (g/s)	Calculated Waste Emissions [2] (g/s)	Amount Propane Burned [3] (gal/yr)	Calculated Propane Emissions (lb/yr)	Propane Emissions (g/s)	Total Calculated Emissions [2,3] (g/s)
Ethylbenzene	2.00E+04	4.97E+00	2.73E-04				2.73E-04
Ethyl chloride	2.00E+04	4.97E+00	3.42E-07				3.42E-07
Fluoranthene	2.00E+04	4.97E+00	9.93E-05				9.93E-05
Fluorene	2.00E+04	4.97E+00	4.97E-06				4.97E-06
Formaldehyde	2.00E+04	4.97E+00	1.50E-03				1.50E-03
Furan	2.00E+04	4.97E+00	7.45E-07				7.45E-07
Hexane	2.00E+04	4.97E+00	7.94E-05				7.94E-05
Hydrogen chloride	2.00E+04	4.97E+00	4.95E-03				4.95E-03
Indeno[1,2,3-cd]pyrene	2.00E+04	4.97E+00	2.48E-05				2.48E-05
Methylcyclohexane	2.00E+04	4.97E+00	7.75E-04				7.75E-04
Methylene chloride	2.00E+04	4.97E+00	3.70E-06				3.70E-06
Methyl ethyl ketone (2-Butanone)	2.00E+04	4.97E+00	6.45E-05				6.45E-05
Methyl isobutyl ketone	2.00E+04	4.97E+00	5.46E-05				5.46E-05
Naphthalene	2.00E+04	4.97E+00	8.04E-04				8.04E-04
Nitrogen dioxide	2.00E+04	4.97E+00	3.72E-01	1.50E+04	2.10E+02	2.55E-02	3.98E-01
Particulate matter (TSP)	2.00E+04	4.97E+00	9.93E-01	1.50E+04	6.00E+00	1.49E-03	9.94E-01
Phenanthrene	2.00E+04	4.97E+00	3.56E-05				3.56E-05
Phenol	2.00E+04	4.97E+00	7.75E-05				7.75E-05
Pyrene	2.00E+04	4.97E+00	9.93E-06				9.93E-06
Styrene	2.00E+04	4.97E+00	2.48E-04				2.48E-04
Sulfur dioxide	2.00E+04	4.97E+00	1.24E-02	1.50E+04	2.70E-01	6.70E-05	1.25E-02
Toluene	2.00E+04	4.97E+00	6.06E-04				6.06E-04
Trichloroethane [1,1,1-]	2.00E+04	4.97E+00	1.71E-07				1.71E-07
Trimethylbenzene [1,2,4-]	2.00E+04	4.97E+00	1.21E-03				1.21E-03
Trimethylbenzene [1,3,5-]	2.00E+04	4.97E+00	2.77E-03				2.77E-03
Vinyl chloride	2.00E+04	4.97E+00	1.11E-06				1.11E-06
Xylene (Total)	2.00E+04	4.97E+00	2.86E-03				2.86E-03
Zinc	2.00E+04	4.97E+00	3.11E-04				3.11E-04

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[1] Annual averaging period assumes that 15,000 gallons of propane are burned a year and 20,000 pounds of burnable waste (high explosives and combustible wastes).
[2] Emissions factors used to calculate these emissions can be found in the modeling protocol (LANL, 2007).
[3] Propane emissions were not added for scenarios where burning of high explosives alone caused the highest impacts.

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Table 3-4. Contaminant-Specific Emissions for the Annual Averaging Period [1] (continued)

lb/yr = pounds per year
g/s = grams per second
gal/yr = gallons per year
PM-10 = particulate matter less than 10 micrometers
TSP = total suspended particulate

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Table 3-5. Short-Term On-Site Impacts [1]

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Contaminant	Calculated Emissions[2] (g/s)	On-site Conversion Factor ($\mu g/m^3$ per g/s)	On-Site Impacts [3] ($\mu g/m^3$)	Acute Limits [4] ($\mu g/m^3$)
Acenaphthene	3.15E-04	1.5E+02	4.70E-02	1.3E+03
Acetaldehyde	1.99E-03	1.5E+02	2.96E-01	8.1E+04
Acetone	1.10E-03	1.5E+02	1.64E-01	4.8E+05
Acetophenone	5.49E-06	1.5E+02	8.17E-04	3.0E+04
Acrolein	1.23E-03	1.5E+02	1.83E-01	1.9E-01
Anthracene	4.73E-04	1.5E+02	7.05E-02	6.0E+03
Barium	1.32E-05	1.5E+02	1.97E-03	1.5E+03
Benzaldehyde	3.28E-03	1.5E+02	4.89E-01	1.5E+04
Benzene	3.22E-02	1.5E+02	4.80E+00	1.3E+03
Benzo[a]anthracene	1.58E-04	1.5E+02	2.35E-02	3.0E+02
Benzo[a]pyrene	1.58E-04	1.5E+02	2.35E-02	6.0E+02
Benzo[b&k]fluoanthene	2.21E-04	1.5E+02	3.29E-02	6.0E+02
Benzyl alcohol	1.25E-03	1.5E+02	1.86E-01	6.0E+04
Butyl benzyl phthalate	3.85E-06	1.5E+02	5.73E-04	1.5E+04
Carbon tetrachloride	2.17E-06	1.5E+02	3.24E-04	1.9E+03
Chloromethane (methyl chloride)	8.95E-06	1.5E+02	1.33E-03	2.0E+05
Chromium	1.25E-05	1.5E+02	1.86E-03	1.5E+03
Chrysene	2.84E-04	1.5E+02	4.23E-02	6.0E+02
Dibenzo[ah]anthracene	6.31E-06	1.5E+02	9.40E-04	3.0E+04
Dibutyl phthalate	1.04E-05	1.5E+02	1.55E-03	1.5E+04
Dichloroethylene [1,1-]	6.78E-06	1.5E+02	1.01E-03	7.5E+04
Diethyl phthalate	2.21E-06	1.5E+02	3.29E-04	1.5E+04
Dimethyl phthalate	5.93E-06	1.5E+02	8.83E-04	1.5E+04
Dioctyl phthalate	2.90E-05	1.5E+02	4.32E-03	5.0E+04
Dioxin	4.70E-11	1.5E+02	7.00E-09	1.3E+00
Ethylbenzene	1.73E-03	1.5E+02	2.58E-01	5.0E+05
Fluoranthene	6.31E-04	1.5E+02	9.40E-02	1.5E+01
Fluorene	3.15E-05	1.5E+02	4.70E-03	1.2E+04
Formaldehyde	9.55E-03	1.5E+02	1.42E+00	9.4E+01
Furan	4.73E-06	1.5E+02	7.05E-04	8.0E-02
Hydrogen chloride	3.14E-02	1.5E+02	4.68E+00	2.1E+03
Indeno[1,2,3-cd]pyrene	1.58E-04	1.5E+02	2.35E-02	5.0E+02
Methylene chloride	2.35E-05	1.5E+02	3.50E-03	1.4E+04
Methyl ethyl ketone	4.10E-04	1.5E+02	6.11E-02	1.3E+04
Methyl isobutyl ketone	3.47E-04	1.5E+02	5.17E-02	3.0E+05
Naphthalene	5.11E-03	1.5E+02	7.61E-01	7.5E+04
Phenanthrene	2.26E-04	1.5E+02	3.37E-02	1.0E+03
Phenol	4.92E-04	1.5E+02	7.33E-02	5.8E+03
Pyrene	6.31E-05	1.5E+02	9.40E-03	1.5E+04
Styrene	1.57E-03	1.5E+02	2.34E-01	2.1E+04

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Table 3-5. Short-Term On-Site Impacts (continued)

Contaminant	Calculated Emissions[2] (g/s)	On-site Conversion Factor ($\mu g/m^3$ per g/s)	On-Site Impacts [3] ($\mu g/m^3$)	Acute Limits [4] ($\mu g/m^3$)
Toluene	3.85E-03	1.5E+02	5.73E-01	3.7E+04
Trichloroethane [1,1,1-]	1.08E-06	1.5E+02	1.62E-04	6.8E+04
Trimethylbenzene [1,3,5-]	1.76E-02	1.5E+02	2.62E+00	1.3E+05
Vinyl chloride	7.03E-06	1.5E+02	1.05E-03	1.8E+05
Xylenes	1.82E-02	1.5E+02	2.71E+00	2.2E+04
Zinc	1.97E-03	1.5E+02	2.94E-01	3.0E+04

[1] Assumes 250 pounds per hour burned, converted to grams per second (31.5 g/s)
[2] See Table 3-2 for the method of calculating these emissions
[3] Background included, as appropriate (NMED, 2007)
[4] Screening limits are from acute limits (1 hr) inhalation exposures (AIEC) for toxic air pollutants (EPA, 2005)
g/s = grams per second
$\mu g/m^3$ = micrograms per cubic meter

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Table 3-6. Short-Term Off-Site Impacts

Contaminant	Calculated Emissions [1] (g/s)	Off-site Conversion Factor ($\mu g/m^3$ per g/s)	Off-Site Impacts [2] ($\mu g/m^3$)	Acute Limits [3] ($\mu g/m^3$)
Acenaphthene	1.26E-03	2.87E+00	3.62E-03	1.3E+03
Acetaldehyde	7.95E-03	2.87E+00	2.28E-02	8.1E+04
Acetone	4.41E-03	2.87E+00	1.27E-02	4.8E+05
Acetophenone	2.19E-05	2.87E+00	6.30E-05	3.0E+04
Acrolein	4.92E-03	2.87E+00	1.41E-02	1.9E-01
Anthracene	1.89E-03	2.87E+00	5.43E-03	6.0E+03
Barium	5.30E-05	2.87E+00	1.52E-04	1.5E+03
Benzaldehyde	1.31E-02	2.87E+00	3.76E-02	1.5E+04
Benzene	1.29E-01	2.87E+00	3.70E-01	1.3E+03
Benzo[a]anthracene	6.31E-04	2.87E+00	1.81E-03	3.0E+02
Benzo[a]pyrene	6.31E-04	2.87E+00	1.81E-03	6.0E+02
Benzo[b&k]fluoanthene	8.83E-04	2.87E+00	2.53E-03	6.0E+02
Benzyl alcohol	4.99E-03	2.87E+00	1.43E-02	6.0E+04
Butyl benzyl phthalate	1.54E-05	2.87E+00	4.42E-05	1.5E+04
Carbon Monoxide 1-hr	1.14E+01	4.19E-01	4.76E+00	7.9E+03 [4]
Carbon Monoxide 8-hr	1.14E+01	2.87E+00	3.26E+01	1.2E+04 [5]
Carbon tetrachloride	8.69E-06	2.87E+00	2.49E-05	1.9E+03
Chloromethane	3.58E-05	2.87E+00	1.03E-04	2.0E+05
Chromium	5.01E-05	2.87E+00	1.44E-04	1.5E+03
Chrysene	1.14E-03	2.87E+00	3.26E-03	6.0E+02
Dibenzo[ah]anthracene	2.52E-05	2.87E+00	7.24E-05	3.0E+04
Dibutyl phthalate	4.16E-05	2.87E+00	1.19E-04	1.5E+04
Dichloroethylene [1,1-]	2.71E-05	2.87E+00	7.78E-05	7.5E+04
Diethyl phthalate	8.83E-06	2.87E+00	2.53E-05	1.5E+04
Dimethyl phthalate	2.37E-05	2.87E+00	6.80E-05	1.5E+04
Dioctyl phthalate	1.16E-04	2.87E+00	3.33E-04	5.0E+04
Dioxin	1.88E-10	2.87E+00	5.39E-10	1.3E+00
Ethylbenzene	6.92E-03	2.87E+00	1.99E-02	5.0E+05
Fluoranthene	2.52E-03	2.87E+00	7.24E-03	1.5E+01
Fluorene	1.26E-04	2.87E+00	3.62E-04	1.2E+04
Formaldehyde	3.82E-02	2.87E+00	1.10E-01	9.4E+01
Furan	1.89E-05	2.87E+00	5.43E-05	7.5E-02
Hydrogen chloride	1.26E-01	2.87E+00	3.61E-01	2.1E+03
Indeno[1,2,3-cd]pyrene	6.31E-04	2.87E+00	1.81E-03	5.0E+02
Methylene chloride	9.41E-05	2.87E+00	2.70E-04	1.4E+04
Methyl ethyl ketone	1.64E-03	2.87E+00	4.71E-03	1.3E+04
Methyl isobutyl ketone	1.39E-03	2.87E+00	3.98E-03	3.0E+05
Naphthalene	2.04E-02	2.87E+00	5.86E-02	7.5E+04
Nitrogen dioxide 24-hr	9.46E+00	1.40E-01	1.32E+00	1.5E+02 [6]
Particulate matter (PM-10) 24-hr	2.52E+01	1.40E-01	2.35E+01	1.5E+02 [6]
Particulate matter (TSP) 24-hr	2.52E+01	1.40E-01	3.01E+01	1.5E+02 [6]
Phenanthrene	9.04E-04	2.87E+00	2.60E-03	1.0E+03

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Table 3-6. Short-Term Off-Site Impacts (continued)

Contaminant	Calculated Emissions [1] (g/s)	Off-site Conversion Factor ($\mu g/m^3$ per g/s)	Off-Site Impacts [2] ($\mu g/m^3$)	Acute Limits [3] ($\mu g/m^3$)
Phenol	1.97E-03	2.87E+00	5.65E-03	5.8E+03
Pyrene	2.52E-04	2.87E+00	7.24E-04	1.5E+04
Styrene	6.29E-03	2.87E+00	1.81E-02	2.1E+04
Sulfur Dioxide 3-hr	3.15E-01	9.57E-01	3.02E-01	1.1E+03 [7]
Sulfur Dioxide 24-hr	3.15E-01	1.40E-01	4.41E-02	2.1E+02 [6]
Toluene	1.54E-02	2.87E+00	4.42E-02	3.7E+04
Trichloroethane [1,1,1-]	4.34E-06	2.87E+00	1.25E-05	6.8E+04
Trimethylbenzene [1,3,5-]	7.02E-02	2.87E+00	2.02E-01	1.3E+05
Vinyl chloride	2.81E-05	2.87E+00	8.07E-05	1.8E+05
Xylenes	7.28E-02	2.87E+00	2.09E-01	2.2E+04
Zinc	7.89E-03	2.87E+00	2.27E-02	3.0E+04

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[1] Calculated using 1000 pounds per hour of waste burned, converted to 126 grams/second (g/s). See Table 3-3 for the method of calculating emissions
[2] Background included, as appropriate (NMED, 2007)
[3] Except where noted, screening limits are from acute limits (1 hr) inhalation exposures (AIEC) for toxic air pollutants (EPA, 2005).
[4] Acute limits for these contaminants are from the Environmental Protection Agency's (EPA's) Ambient Air Quality Standards (AAQS) for a 8 hour averaging period.
[5] Acute limit for this contaminant is from the EPA's AAQS for a 1 hour averaging period.
[6] Acute limit for this contaminant is from the EPA's AAQS for a 24 hour averaging period.
[7] Acute limit for this contaminant is from the EPA's AAQS for a 3 hour averaging period.

g/s = grams per second
$\mu g/m^3$ = micrograms per cubic meter
PM-10 = particulate matter less than 10 micrometers
TSP= total suspended particulate

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Table 3-7. Annual On-Site Impacts

Contaminant	Calculated Emissions [1] (g/s)	On-site Conversion Factor ($\mu g/m^3$ per g/s)	Annual Impact [2] ($\mu g/m^3$)	Screening Level [3] ($\mu g/m^3$)
Acenaphthene	4.97E-05	1.48E+00	7.35E-05	2.2E+01
Acetaldehyde	3.13E-04	1.48E+00	4.63E-04	8.7E-02
Acetone	1.74E-04	1.48E+00	2.57E-04	3.3E+02
Acrolein	1.94E-04	1.48E+00	2.87E-04	2.1E-03
Aluminum	3.54E-06	1.48E+00	5.24E-06	5.1E-01
Anthracene	7.45E-05	1.48E+00	1.10E-04	1.1E+02
Barium	2.09E-06	1.48E+00	3.09E-06	5.2E-02
Benzaldehyde	5.16E-04	1.48E+00	7.64E-04	3.7E+01
Benzene	5.07E-03	1.48E+00	7.51E-03	2.5E-02
Benzo(a)anthracene	2.48E-05	1.48E+00	3.67E-05	9.2E-04
Benzo(a)pyrene	2.48E-05	1.48E+00	3.67E-05	9.2E-05
Benzo(b,k)fluoranthene	3.48E-05	1.48E+00	5.14E-05	2.6E-03
Benzyl alcohol	1.97E-04	1.48E+00	2.91E-04	1.1E+02
Butadiene [1-3-]	6.65E-06	1.48E+00	9.85E-06	1.1E-03
Butyl benzyl phthalate	6.06E-07	1.48E+00	8.96E-07	7.3E+01
Carbon tetrachloride	3.42E-07	1.48E+00	5.06E-07	1.3E-02
Chloromethane (methyl chloride)	1.41E-06	1.48E+00	2.09E-06	9.5E+00
Chromium (total)	1.97E-06	1.48E+00	2.92E-06	1.6E-05
Chrysene	4.47E-05	1.48E+00	6.61E-05	1.7E-02
Crotonaldehyde	2.98E-05	1.48E+00	4.41E-05	3.5E-04
Cyclohexane	1.33E-04	1.48E+00	1.96E-04	6.2E+02
Dibenzo(a,h)anthracene	9.93E-07	1.48E+00	1.47E-06	9.2E-05
Dibutyl phthalate	1.64E-06	1.48E+00	2.42E-06	3.7E+01
Dichloroethylene [1,1-]	1.07E-06	1.48E+00	1.58E-06	2.1E+01
Diethyl phthalate	3.48E-07	1.48E+00	5.14E-07	2.9E+02
Dimethyl phthalate	9.33E-07	1.48E+00	1.38E-06	3.7E+03
Dioctyl phthalate	4.56E-06	1.48E+00	6.75E-06	1.5E+01
Dioxin (2,3,7,8-TCDD)	7.40E-12	1.48E+00	1.09E-11	4.5E-09
Ethylbenzene	2.73E-04	1.48E+00	4.03E-04	1.1E+02
Ethyl chloride	3.42E-07	1.48E+00	5.06E-07	2.3E-01
Fluoranthene	9.93E-05	1.48E+00	1.47E-04	1.5E+01
Fluorene	4.97E-06	1.48E+00	7.35E-06	1.5E+01
Formaldehyde	1.50E-03	1.48E+00	2.23E-03	1.5E-02
Furan	7.45E-07	1.48E+00	1.10E-06	3.7E-01
Hexane	7.94E-05	1.48E+00	1.18E-04	2.1E+01
Hydrogen chloride	4.95E-03	1.48E+00	7.33E-03	2.1E+00
Indeno[1,2,3-cd]pyrene	2.48E-05	1.48E+00	3.67E-05	9.2E-04
Methylcyclohexane	7.75E-04	1.48E+00	1.15E-03	3.1E+02
Methylene chloride	3.70E-06	1.48E+00	5.48E-06	4.1E-01
Methyl ethyl ketone (2-Butanone)	6.45E-05	1.48E+00	9.55E-05	5.1E+02
Methyl isobutyl ketone	5.46E-05	1.48E+00	8.08E-05	3.1E+02
Naphthalene	8.04E-04	1.48E+00	1.19E-03	5.6E-03
Phenol	7.75E-05	1.48E+00	1.15E-04	1.1E+02
Pyrene	9.93E-06	1.48E+00	1.47E-05	1.1E+01

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Table 3-7. Annual On-Site Impacts (continued)

Contaminant	Calculated Emissions [1] (g/s)	On-site Conversion Factor ($\mu g/m^3$ per g/s)	Annual Impact [2] ($\mu g/m^3$)	Screening Level [3] ($\mu g/m^3$)
Styrene	2.48E-04	1.48E+00	3.67E-04	1.1E+02
Toluene	6.10E-04	1.48E+00	9.03E-04	4.0E+01
Trichloroethane [1,1,1-]	1.72E-07	1.48E+00	2.55E-07	2.3E+02
Trimethylbenzene [1,2,4-]	1.22E-03	1.48E+00	1.80E-03	6.2E-01
Trimethylbenzene [1,3,5-]	2.79E-03	1.48E+00	4.12E-03	6.2E-01
Vinyl chloride	1.12E-06	1.48E+00	1.65E-06	1.1E-02
Xylene (Total)	2.89E-03	1.48E+00	4.27E-03	1.1E+01

[1] Calculated assuming the amount of waste burned is 20,000 lb and 15,000 gal of propane. See Table 3-4 for the method of calculating emissions
[2] Background included, as appropriate (NMED, 2007)
[3] Source for annual screening levels are from Environmental Protection Agency's Region 9 Preliminary Remediation Goals (PRGs), (EPA, 2004). The levels are multiplied by 0.1 as described in the modeling protocol (LANL, 2007).

g/s = grams per second
$\mu g/m^3$ = micrograms per cubic meter

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Table 3-8. Annual Off-Site Impacts

Contaminant	Calculated Emissions [1] (g/s)	Off-site Conversion Factor (µg/m^3 per g/s)	Annual Impact [2] (µg/m^3)	Screening Level [3] (µg/m^3)
Acenaphthene	4.97E-05	5.76E-03	2.86E-07	2.2E+01
Acetaldehyde	3.13E-04	5.76E-03	1.80E-06	8.7E-02
Acetone	1.74E-04	5.76E-03	1.00E-06	3.3E+02
Acrolein	1.94E-04	5.76E-03	1.12E-06	2.1E-03
Aluminum	3.54E-06	5.76E-03	2.04E-08	5.1E-01
Anthracene	7.45E-05	5.76E-03	4.29E-07	1.1E+02
Barium	2.09E-06	5.76E-03	1.20E-08	5.2E-02
Benzaldehyde	5.16E-04	5.76E-03	2.97E-06	3.7E+01
Benzene	5.07E-03	5.76E-03	2.92E-05	2.5E-02
Benzo(a)anthracene	2.48E-05	5.76E-03	1.43E-07	9.2E-04
Benzo(a)pyrene	2.48E-05	5.76E-03	1.43E-07	9.2E-05
Benzo(b,k)fluoranthene	3.48E-05	5.76E-03	2.00E-07	2.6E-03
Benzyl alcohol	1.97E-04	5.76E-03	1.13E-06	1.1E+02
Butadiene [1-3-]	6.65E-06	5.76E-03	3.83E-08	1.1E-03
Butyl benzyl phthalate	6.06E-07	5.76E-03	3.49E-09	7.3E+01
Carbon tetrachloride	3.42E-07	5.76E-03	1.97E-09	1.3E-02
Chloromethane (methyl chloride)	1.41E-06	5.76E-03	8.12E-09	9.5E+00
Chromium (total)	1.97E-06	5.76E-03	1.14E-08	1.6E-05
Chrysene	4.47E-05	5.76E-03	2.57E-07	1.7E-02
Crotonaldehyde	2.98E-05	5.76E-03	1.72E-07	3.5E-04
Cyclohexane	1.33E-04	5.76E-03	7.64E-07	6.2E+02
Dibenzo(a,h)anthracene	9.93E-07	5.76E-03	5.72E-09	9.2E-05
Dibutyl phthalate	1.64E-06	5.76E-03	9.44E-09	3.7E+01
Dichloroethylene [1,1-]	1.07E-06	5.76E-03	6.15E-09	2.1E+01
Diethyl phthalate	3.48E-07	5.76E-03	2.00E-09	2.9E+02
Dimethyl phthalate	9.33E-07	5.76E-03	5.38E-09	3.7E+03
Dioctyl phthalate	4.56E-06	5.76E-03	2.63E-08	1.5E+01
Dioxin (2,3,7,8-TCDD)	7.40E-12	5.76E-03	4.26E-14	4.5E-09
Ethylbenzene	2.73E-04	5.76E-03	1.57E-06	1.1E+02
Ethyl chloride	3.42E-07	5.76E-03	1.97E-09	2.3E-01
Fluoranthene	9.93E-05	5.76E-03	5.72E-07	1.5E+01
Fluorene	4.97E-06	5.76E-03	2.86E-08	1.5E+01
Formaldehyde	1.50E-03	5.76E-03	8.67E-06	1.5E-02
Furan	7.45E-07	5.76E-03	4.29E-09	3.7E-01
Hexane	7.94E-05	5.76E-03	4.58E-07	2.1E+01
Hydrogen chloride	4.95E-03	5.76E-03	2.85E-05	2.1E+00
Indeno[1,2,3-cd]pyrene	2.48E-05	5.76E-03	1.43E-07	9.2E-04
Methylcyclohexane	7.75E-04	5.76E-03	4.46E-06	3.1E+02
Methylene chloride	3.70E-06	5.76E-03	2.13E-08	4.1E-01
Methyl ethyl ketone (2-Butanone)	6.45E-05	5.76E-03	3.72E-07	5.1E+02
Methyl isobutyl ketone	5.46E-05	5.76E-03	3.15E-07	3.1E+02
Naphthalene	8.04E-04	5.76E-03	4.63E-06	5.6E-03

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Table 3-8. Annual Off-Site Impacts (continued)

Contaminant	Calculated Emissions [1] (g/s)	Off-site Conversion Factor ($\mu g/m^3$ per g/s)	Annual Impact [2] ($\mu g/m^3$)	Screening Level [3] ($\mu g/m^3$)
Nitrogen dioxide	3.98E-01 [5]	5.76E-03	2.29E-03	7.5E+01 [4]
Particulate matter (TSP)	9.94E-01 [5]	5.76E-03	2.66E+01	6.0E+01 [4]
Phenol	7.75E-05	5.76E-03	4.46E-07	1.1E+02
Pyrene	9.93E-06	5.76E-03	5.72E-08	1.1E+01
Styrene	2.48E-04	5.76E-03	1.43E-06	1.1E+02
Sulfur dioxide	1.25E-02 [5]	5.76E-03	7.22E-05	4.2E+01 [4]
Toluene	6.10E-04	5.76E-03	3.51E-06	4.0E+01
Trichloroethane [1,1,1-]	1.72E-07	5.76E-03	9.91E-10	2.3E+02
Trimethylbenzene [1,2,4-]	1.22E-03	5.76E-03	7.00E-06	6.2E-01
Trimethylbenzene [1,3,5-]	2.79E-03	5.76E-03	1.60E-05	6.2E-01
Vinyl chloride	1.12E-06	5.76E-03	6.42E-09	1.1E-02
Xylene (Total)	2.89E-03	5.76E-03	1.66E-05	1.1E+01

[1] Calculated assuming the amount of waste burned is 20,000 lb and 15,000 gallons of propane. See Table 3-4 for the method of calculating emissions

[2] Background included, as appropriate (NMED, 2007)

[3] Except as noted, source for annual screening levels are from Environmental Protection Agency's Region 9 Preliminary Remediation Goals (PRGs), (EPA, 2004). The levels are multiplied by 0.1 as described in the modeling protocol (LANL, 2007).

[4] Source for this annual screening level is the Environmental Protection Agency's (EPA's) Ambient Air Quality Standards (AAQS).

[5] Calculated emissions include the addition of propane emissions, see Table 3-4.

g/s = grams per second
$\mu g/m^3$ = micrograms per cubic meter
TSP= total suspended particulate

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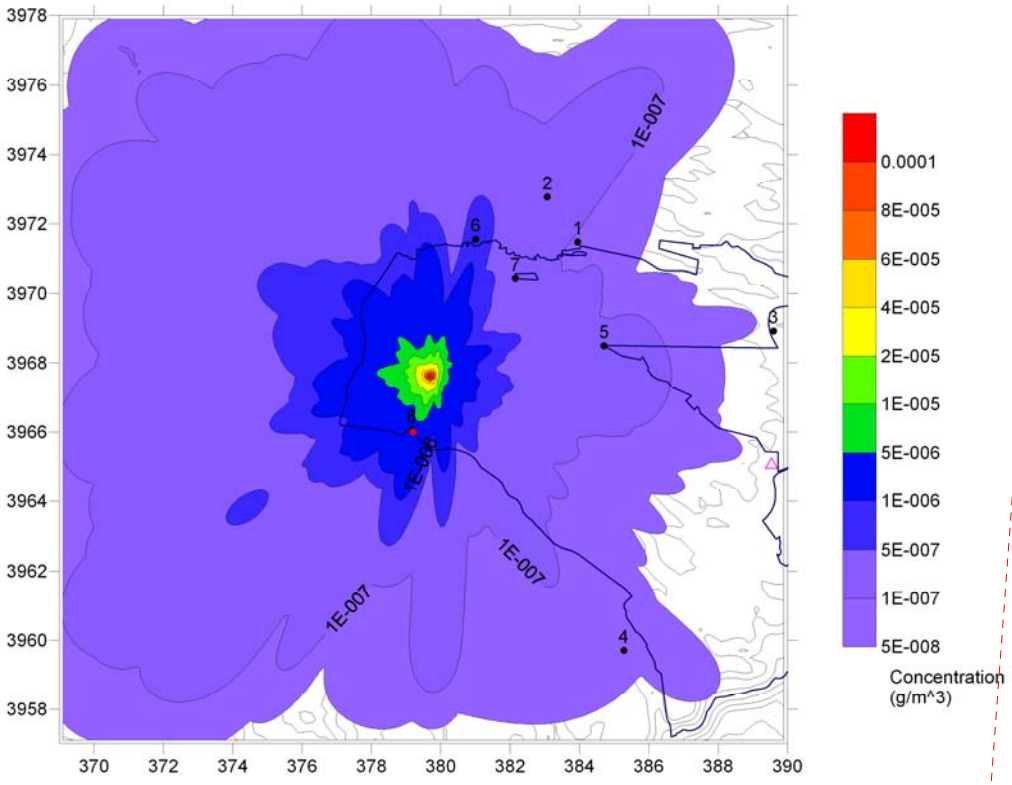

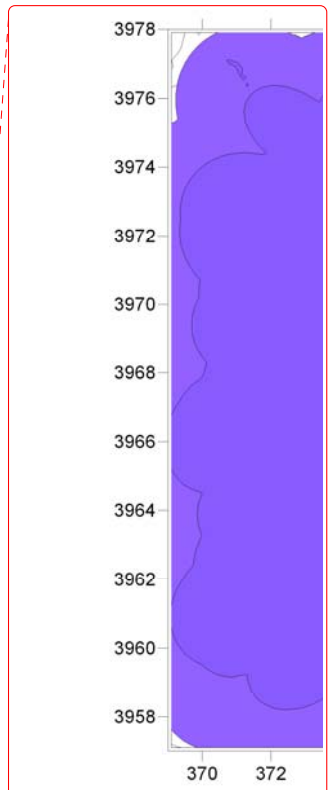

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Figure 3-1. Peak 1-hour average air concentrations for the TA-16-388 minimum lofting case study for a 1 gram per second release rate.

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Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^3 = grams per cubic meter

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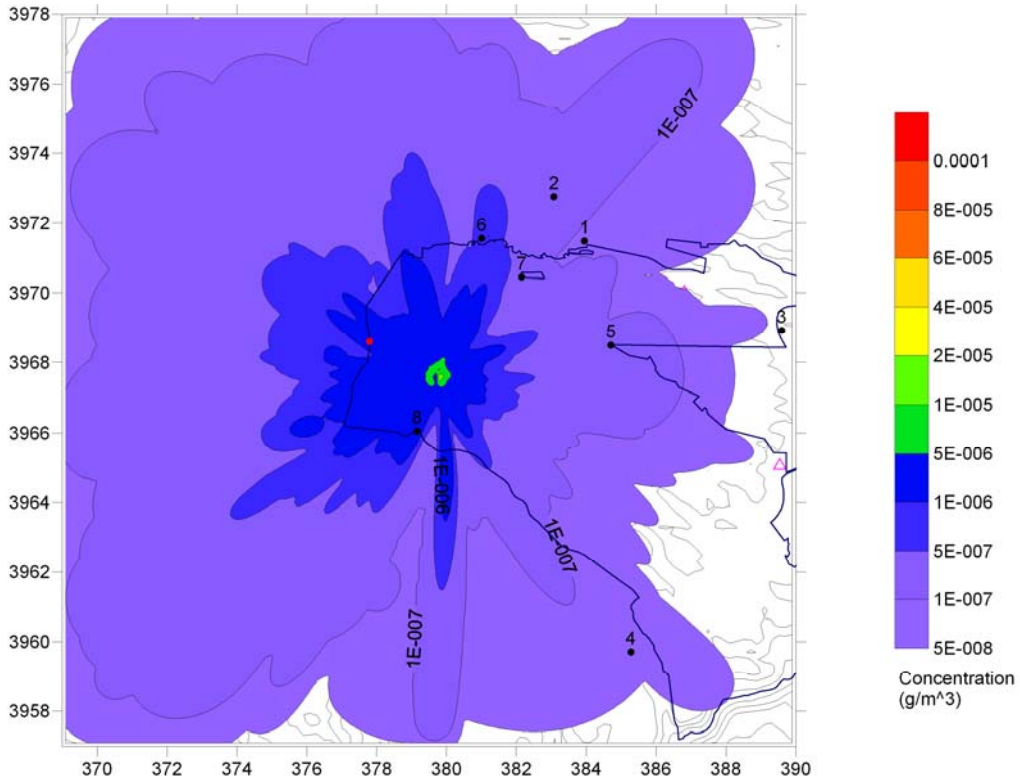

Figure 3-2. Peak 1-hour average air concentrations for the TA-16-388 maximum lofting case study with a 1 gram per second release rate.

Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^3 = grams per cubic meter

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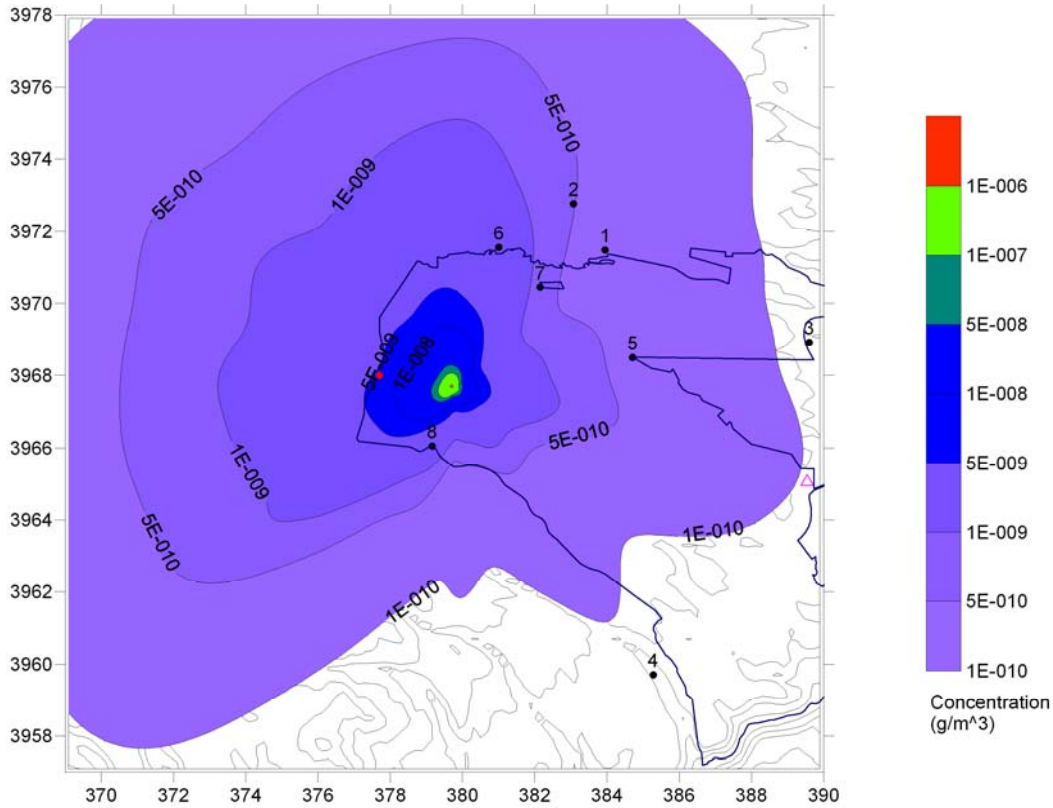

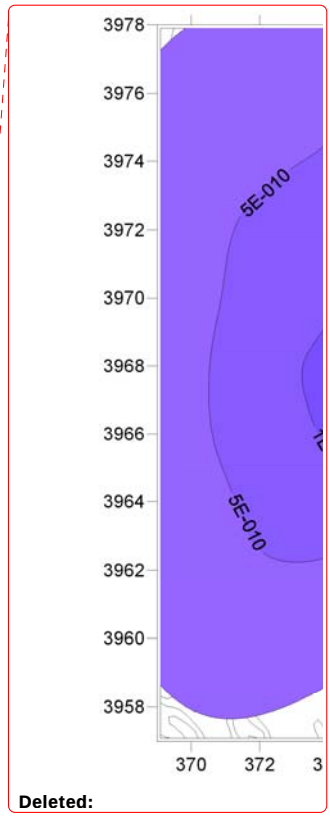

Figure 3-3. Peak annual average air concentration for the TA-16-388 minimum lofting case study with a 1 gram per second release rate.

Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^3 = grams per cubic meter

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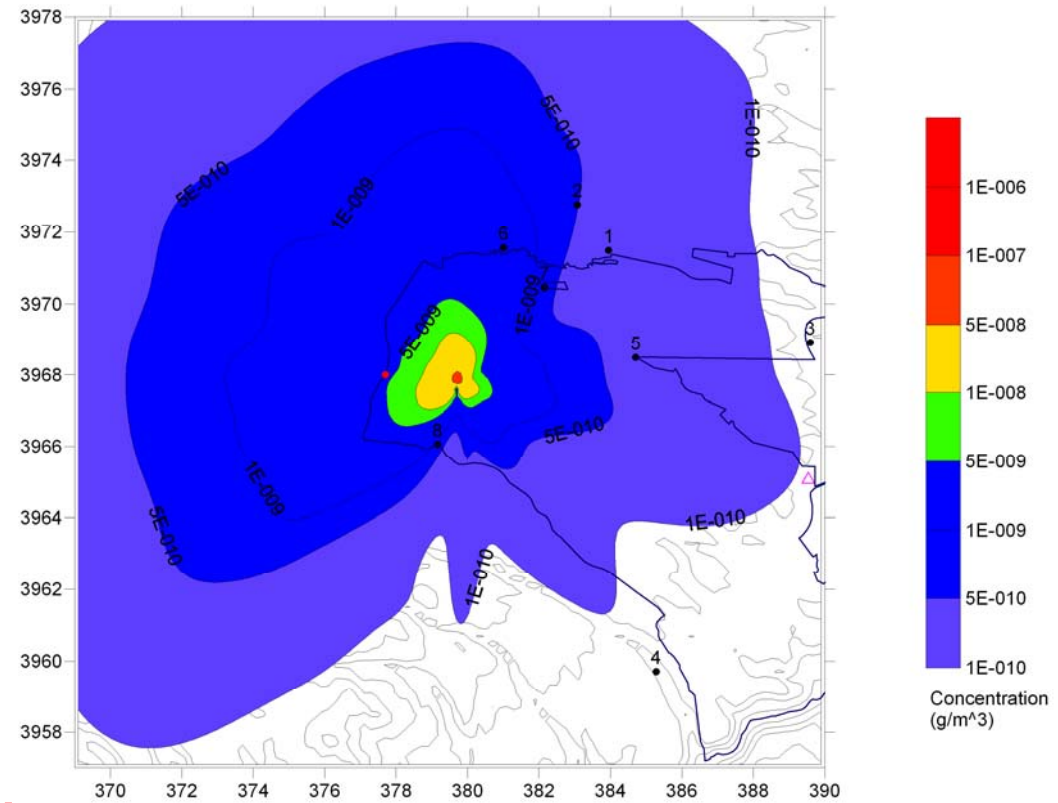

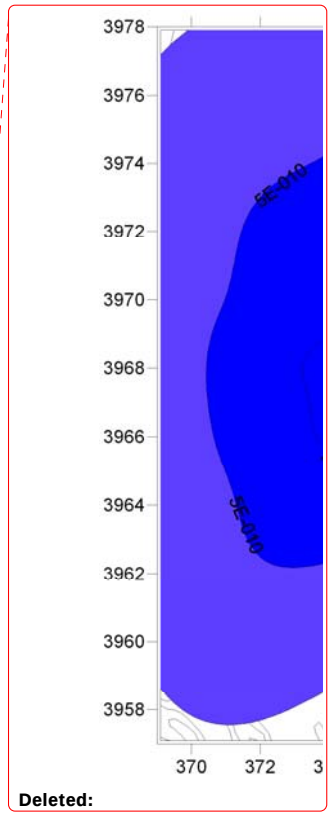

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Figure 3-4. Peak annual-average air concentration for the TA-16-388 maximum lofting case study with a 1 gram per second release rate.

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Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^3 = grams per cubic meter

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4.0 Deposition Modeling Results

Deposition modeling was performed using the same worst-case unit/waste scenarios explained at the beginning of Section 3.0. CALPUFF's deposition option uses the same air concentrations calculated for air quality impacts then "deposits" the pollutants on surfaces using pollutant-specific deposition rates. The pollutant-specific deposition parameters are complex and, because LANL-specific information is not available, representative model parameter defaults were used. CALPUFF provides a library of information for particulate matter, sulfur dioxide, various oxides of nitrogen, nitric acid, odor, toluene, xylene, and pinenes. It does not, however, contain data for many of the contaminants from the worst-case waste scenario described in Section 3.3 of the modeling protocol (LANL, 2007). To best reflect the types of pollutants that may be emitted from the TA-16 Burn Ground, the CALPUFF parameters for particulate matter represented total suspended particulate and PM_{10}; oxides of nitrogen represented inorganic gaseous pollutants such as carbon monoxide and nitrogen dioxide; and toluene represented emissions of gaseous hydrocarbons. These assumptions introduce additional uncertainty to the deposition impact analysis because surrogates have been chosen that may not completely represent each constituent. However, the most similar surrogate for each worst-case scenario contaminant is used to represent that contaminant and the use of surrogates allows for the impact analysis to extend to all of the contaminants for which emissions factors have been identified rather than only those in the CALPUFF library.

CALPUFF derives annual deposition fluxes (DF) in g of pollutant deposited per m^2 of soil per second (g/m^2 s) for each g/s of pollutant released. Illustrations of the deposition fluxes are located in Figures 4-1 and 4-2 for the TA-16-388 minimum and maximum lofting scenarios. Table 4-1 shows the deposition fluxes for particulates and particulate matter, hydrocarbons, and inorganic gases for the worst-case on-site and off-site impacts scenarios. However, the screening levels used are in milligrams of pollutant deposited per kilogram of soil (mg/kg) so the deposition fluxes must be converted to unit soil input concentrations as follows:

$$\frac{\boldsymbol{DF}\ (\text{g waste})}{(\text{m}^2\ \text{soil} * \text{s})(\text{g/s})} * \frac{1}{\boldsymbol{D}\ (\text{m soil})} * \frac{(\text{m}^3\ \text{soil})}{\boldsymbol{BD}\ (\text{kg soil})} = \frac{\boldsymbol{SC}\ \text{g waste}}{\text{kg soil} * \text{s (g/s)}}$$

Where:

SC = Soil input concentration rate (g pollutant/kg soil * s) per g/s pollutant emission rate
DF = the annual deposition flux in g/m^2 s per g/s pollutant emission rate
D = depth of the soil mixing layer = 2 cm = 0.02 m (EPA, 2005)
BD = bulk soil density = 1.5 g/cm^3 = 1500 kg/m^3 (EPA, 2005)

Then soil deposition is calculated as follows:

$$\frac{\boldsymbol{EF}\ \text{g pollutant}}{\text{g waste}} \times \frac{\boldsymbol{SC}\ \text{g waste}}{\text{kg soil} * \text{s (g/s)}} \times \frac{20\ \text{burns/yr}}{508\ \text{sims/yr}} \times \frac{1{,}000\ \text{lb waste}}{1\ \text{hr}} \times \frac{1\text{hr}}{3600\ \text{s}} \times \frac{454\ \text{g waste}}{1\ \text{lb waste}} \times$$

$$\frac{1000\ \text{mg pollutant}}{\text{g pollutant}} \times \frac{8760\ \text{hr}}{\text{yr}} \times \frac{3600\ \text{s}}{\text{hr}} = \frac{\boldsymbol{AD}\ \text{mg pollutant}}{\text{kg soil} * \text{yr}}$$

where:

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EF = emission factors from Table 3-6 in the modeling protocol (LANL, 2007)
AD = calculated air pollutant deposition in mg/kg*yr

The worst-case depositions flux values listed in Table 4-1 were chosen because they were the highest model calculated DFs. Since deposition impact analysis is conducted based on a maximum annual waste quantity of 20,000 pounds, weighted DF values were not considered as weighted conversion factors as they were for the dispersion impact analysis. Both the maximum on-site and off-site worst-case DF values occurred with the TA-16-388 minimum lofting scenario. Table 4-1 shows the DFs that have been determined to result in the highest deposition concentrations and Table 4-2 shows the calculated SCs. The SC rates are multiplied by pollutant emissions rates to calculate deposition. The contaminant-specific annual emissions rates are the same as those used for the chronic air quality impacts analysis (Table 3-4). These emission rates assume that 20,000 lb/yr of burnable wastes (this does not include non-combustibles associated with the waste, such as scrap metal or soil) are treated annually and 15,000 gal of propane is used as supplemental fuel annually. Annual deposition was multiplied by 10 to estimate a 10-year impact, which provides an incremental change over the lifetime of the permit. The 10-year deposition quantities are then compared to deposition screening levels. In accordance with the modeling protocol (LANL, 2007), the screening levels used were:

- The NMED Human Health Industrial/Occupational Soil Screening Levels (SSLs) (NMED, 2006)
- The EPA Region 6 Human Health Medium-Specific Screening Levels (EPA, 2007), contaminants which are not on the NMED SSL table. EPA guidance uses a 10^{-6} cancer risk level and NMED uses a 10^{-5} cancer risk level for chemical carcinogens. To equalize the deposition pollutant assessment, EPA carcinogen screening levels are multiplied by 10 to reflect the 10^{-5} cancer risk.
- The LANL Ecological Screening Levels (ESLs).

Table 4-3 shows the worst-case pollutant-specific annual deposition and 10-yr deposition and the screening levels. Based on Table 4-3, screening levels would not be approached until orders of magnitude more material was burned than the maximum limit assessed. This confirms that the air pathway will not create unacceptable soil contamination.

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Table 4-1. Deposition Fluxes[1]

	Worst-Case On-Site		
Pollutant Type	**x (UTM km)**	**y (UTM km)**	**Deposition Flux[1]**
Particulate matter	380	3968	9.68E-09
Volatile organic gases	380	3968	1.19E-08
Inorganic gases	380	3968	9.45E-09
	Worst-Case Off-Site		
Pollutant Type	**x (UTM km)**	**y (UTM km)**	**Deposition Flux[1]**
Particulate matter	380	3971	1.70E-11
Volatile organic gases	379	3971	2.55E-11
Inorganic gases	379	3971	2.10E-11

[1] All deposition maxima arise from the minimum lofting scenario at TA-16-388.
[2] Units are grams of pollutant deposited per square meter of soil per second for a standard gram per second pollutant emissions rate

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Table 4-2. Soil Input Concentrations

Pollutant Type	Soil Input Concentration[1]	
	Worst-Case On-Site	Worst- Case Off-Site
Particulate matter	3.23E-10	5.66E-13
Volatile organic gases	3.97E-10	8.50E-13
Inorganic gases	3.15E-10	6.99E-13

[1] Units are grams of pollutant deposited per kilogram of soil per second for a standard gram per second pollutant emissions rate

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Table 4-3. Worst-Case On-Site 10-year Deposition

Contaminant	Emissions Factor (g/g)	Conversion Factor Source [1]	Worst-Case On-site Conversion Factor [2]	Annual Deposition (mg/kg)	10-year Deposition (mg/kg)	ESL[3] (mg/kg)	SSL[4] (mg/kg)
Acenaphthene	1.00E-05	HC	3.97E-10	6.21E-04	6.21E-03	2.50E-01	3.35E+04
Acetaldehyde	6.30E-05	HC	3.97E-10	3.91E-03	3.91E-02		3.84 E+02
Acetone	3.50E-05	HC	3.97E-10	2.17E-03	2.17E-02	1.20E+00	1.00E+05
Acrolein	3.90E-05	HC	3.97E-10	2.42E-03	2.42E-02		7.52 E-01
Aluminum	7.13E-07	PM	3.23E-10	3.60E-05	3.60E-04		1.00E+05
Anthracene	1.50E-05	HC	3.97E-10	9.32E-04	9.32E-03	2.10E+02	1.00E+05
Barium	4.20E-07	PM	3.23E-10	2.12E-05	2.12E-04	1.10E+02	1.00E+05
Benzaldehyde	1.04E-04	HC	3.97E-10	6.46E-03	6.46E-02		6.80E+04
Benzene	1.02E-03	HC	3.97E-10	6.35E-02	6.35E-01	2.40E+01	2.58E+01
Benzo(a)anthracene	5.00E-06	HC	3.97E-10	3.11E-04	3.11E-03	3.00E+00	2.34E+01
Benzo(a)pyrene	5.00E-06	HC	3.97E-10	3.11E-04	3.11E-03	9.60E+00	2.34E+00
Benzo(b,k)fluoranthene	7.00E-06	HC	3.97E-10	4.35E-04	4.35E-03	1.80E+01	2.34E+01
Benzyl alcohol	3.96E-05	HC	3.97E-10	2.46E-03	2.46E-02		1.00E+05
Butadiene [1-3-]	1.34E-06	HC	3.97E-10	8.32E-05	8.32E-04		2.38E+00
Butyl benzyl phthalate	1.22E-07	HC	3.97E-10	7.58E-06	7.58E-05	9.00E+01	2.40E+02
Carbon tetrachloride	6.89E-08	HC	3.97E-10	4.28E-06	4.28E-05		8.64E+00
Chloromethane	2.84E-07	HC	3.97E-10	1.76E-05	1.76E-04		5.34E+01
Chromium (total)	3.97E-07	PM	3.23E-10	2.01E-05	2.01E-04	2.30E+00	5.00E+03
Chrysene	9.00E-06	HC	3.97E-10	5.59E-04	5.59E-03	2.40E+00	2.31E+03
Crotonaldehyde	6.00E-06	HC	3.97E-10	3.73E-04	3.73E-03		1.70E-01
Cyclohexane	2.67E-05	HC	3.97E-10	1.66E-03	1.66E-02		1.40E+02
Dibenzo(a,h)anthracene	2.00E-07	HC	3.97E-10	1.24E-05	1.24E-04	1.20E+01	2.34E+00
Dibutyl phthalate	3.30E-07	HC	3.97E-10	2.05E-05	2.05E-04	1.10E-02	6.84E+04
Dichloroethylene [1,1-]	2.15E-07	HC	3.97E-10	1.34E-05	1.34E-04	1.10E+01	7.77E+02
Diethyl phthalate	7.00E-08	HC	3.97E-10	4.35E-06	4.35E-05		1.00E+05

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Table 4-3. Worst-Case On-Site 10-year Deposition (continued)

Contaminant	Emissions (g/s)	Conversion Factor Source [1]	Worst-Case On-site Conversion Factor [2]	Annual Deposition (mg/kg)	10-year Deposition (mg/kg)	ESL[3] (mg/kg)	SSL[4] (mg/kg)
Dimethyl phthalate	1.88E-07	HC	3.97E-10	1.17E-05	1.17E-04	1.17E-04	1.00E+05
Dioctyl phthalate	9.19E-07	HC	3.97E-10	5.71E-05	5.71E-04	5.71E-04	
Dioxin (2,3,7,8-TCDD)	1.49E-12	HC	3.97E-10	9.25E-11	9.25E-10	9.25E-10	1.80E-04
Ethylbenzene	5.49E-05	HC	3.97E-10	3.41E-03	3.41E-02	3.41E-02	1.28E+02
Ethyl chloride	6.89E-08	HC	3.97E-10	4.28E-06	4.28E-05	4.28E-05	1.54E+02
Fluoranthene	2.00E-05	HC	3.97E-10	1.24E-03	1.24E-02	1.24E-02	2.44E+04
Fluorene	1.00E-06	HC	3.97E-10	6.21E-05	6.21E-04	6.21E-04	2.65E+04
Formaldehyde	3.03E-04	HC	3.97E-10	1.88E-02	1.88E-01	1.88E-01	4.20E+02
Furan	1.50E-07	HC	3.97E-10	9.32E-06	9.32E-05	9.32E-05	2.12E+01
Hexane	1.60E-05	HC	3.97E-10	9.94E-04	9.94E-03	9.94E-03	3.80E+01
Hydrogen chloride	9.97E-04	INORG	3.15E-10	4.92E-02	4.92E-01	4.92E-01	1.00 E+05
Indeno[1,2,3-cd]pyrene	5.00E-06	HC	3.97E-10	3.11E-04	3.11E-03	3.11E-03	2.34E+01
Methylcyclohexane	1.56E-04	HC	3.97E-10	9.69E-03	9.69E-02	9.69E-02	7.89E+01
Methylene chloride	7.46E-07	HC	3.97E-10	4.63E-05	4.63E-04	4.63E-04	4.90E+02
Methyl ethyl ketone (2-Butanone)	1.30E-05	HC	3.97E-10	8.07E-04	8.07E-03	8.07E-03	4.87E+04
Methyl isobutyl ketone	1.10E-05	HC	3.97E-10	6.83E-04	6.83E-03	6.83E-03	7.01E+03
Naphthalene	1.62E-04	HC	3.97E-10	1.01E-02	1.01E-01	1.01E-01	3.00E+02
Nitrogen dioxide	7.50E-02	INORG	3.15E-10	3.70E+00	3.70E+01	3.70E+01	1.00E+05
Phenanthrene	7.17E-06	HC	3.97E-10	4.45E-04	4.45E-03	4.45E-03	2.05E+04
Phenol	1.56E-05	HC	3.97E-10	9.69E-04	9.69E-03	9.69E-03	1.00E+05
Pyrene	2.00E-06	HC	3.97E-10	1.24E-04	1.24E-03	1.24E-03	3.09E+04
Styrene	4.99E-05	HC	3.97E-10	3.10E-03	3.10E-02	3.10E-02	1.00E+02
Toluene	1.22E-04	HC	3.97E-10	7.58E-03	7.58E-02	7.58E-02	2.52E+02
Trichloroethane[1,1,1-]	3.44E-08	HC	3.97E-10	2.14E-06	2.14E-05	2.14E-05	5.63E+02
Trimethylbenzene [1,2,4-]	2.43E-04	HC	3.97E-10	1.51E-02	1.51E-01	1.51E-01	2.13E+02
1,3,5-Trimethylbenzene	5.57E-04	HC	3.97E-10	3.46E-02	3.46E-01	3.46E-01	6.92E+01
Vinyl chloride	2.23E-07	HC	3.97E-10	1.39E-05	1.39E-04	1.39E-04	1.40E+01

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Table 4-3. Worst-Case On-Site 10-year Deposition (continued)

Contaminant	Emissions (g/s)	Conversion Factor Source [1]	Worst-Case On-site Conversion Factor [2]	Annual Deposition (mg/kg)	10-year Deposition (mg/kg)	ESL[3] (mg/kg)	SSL[4] (mg/kg)
Xylene (Total)	5.77E-04	HC	3.97E-10	3.58E-02	3.58E-01	1.40E+00	8.20E+01
Zinc	6.26E-05	PM	3.23E-10	3.16E-03	3.16E-02	1.00E+01	1.00E+05

[1] The source of the conversion factor (CF) is either the Table 4-2 particulate matter (PM) deposition rate, the inorganic gases (INORG) deposition rate, based on oxides of nitrogen, or the hydrocarbon (HC) deposition rate, based on toluene.
[2] The units of the CF are grams of pollutant deposited per kilogram of soil per second (mg/kg*s) per gram per second pollutant emission rate.
[3] ESL = The LANL Ecological Screening Levels
[4] SSL = The NMED Human Health Industrial/Occupational Soil Screening Levels (SSLs) (NMED, 2006) or the EPA Region 6 Human Health Medium-Specific Screening Levels (EPA, 2007), which are used for contaminants not appearing on the NMED SSL table

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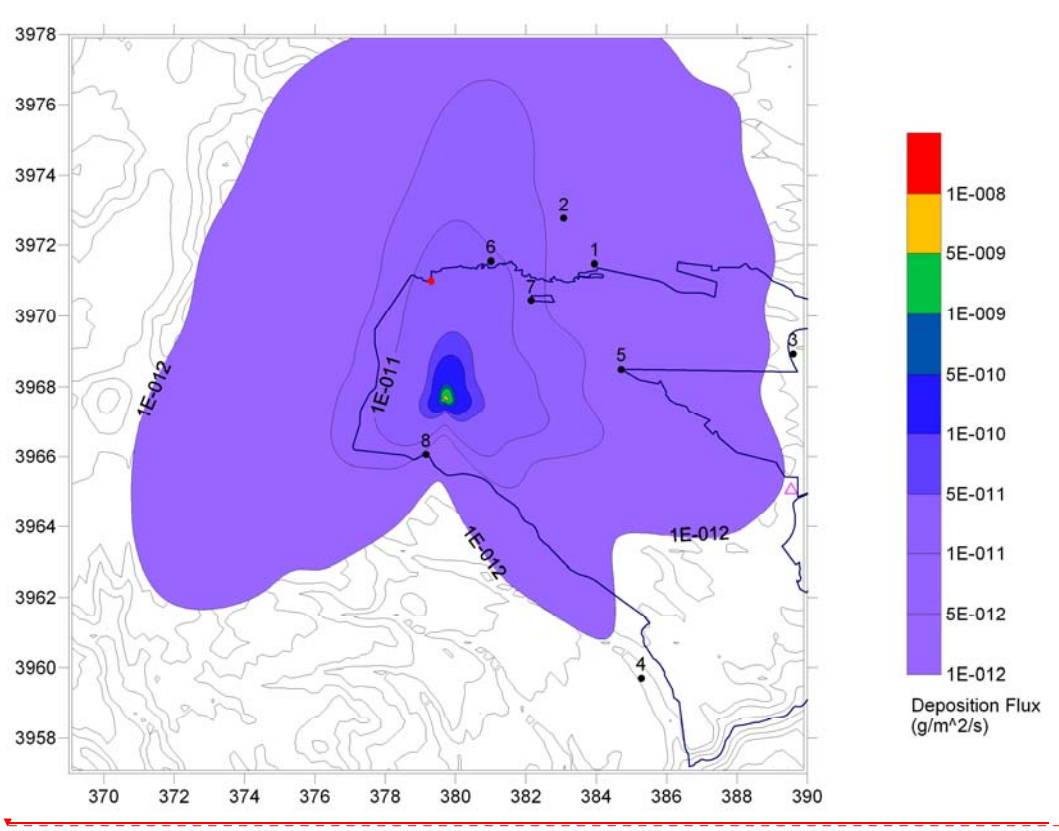

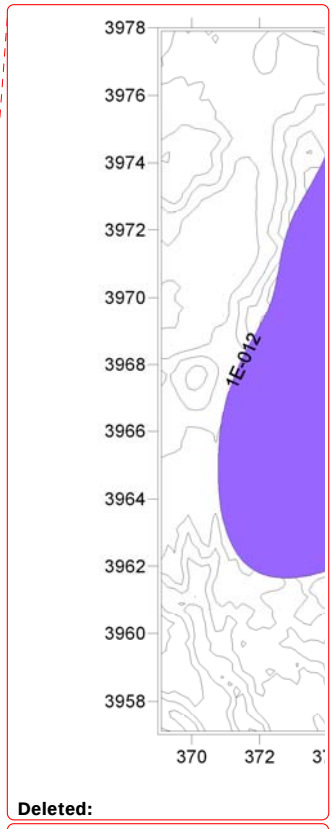

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Figure 4-1. Peak annual average deposition flux for the TA-16-388 minimum lofting case with a 1 gram per second release rate.

Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^2-s = grams per square meter seconds

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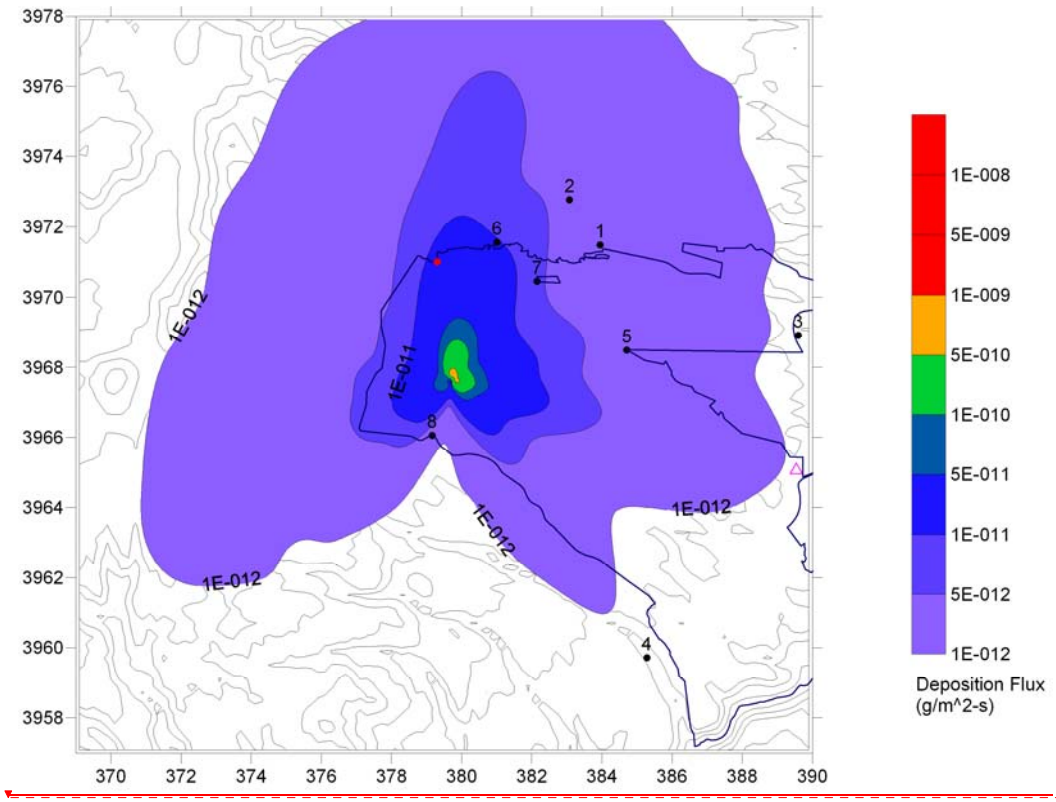

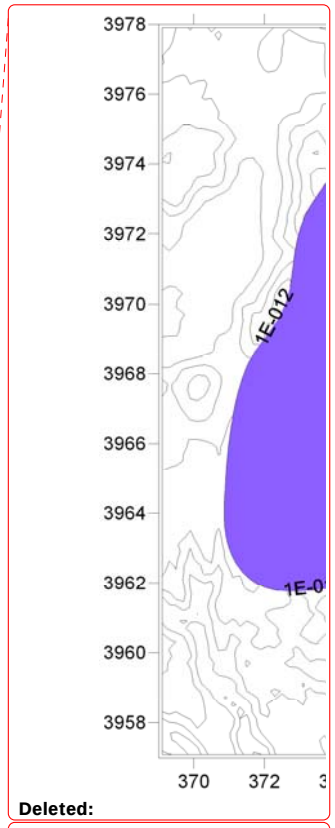

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Figure 4-2. Peak annual average deposition flux for the TA-16-388 maximum lofting case with a 1 gram per second release rate.

Blue line = LANL boundary
Numbered black-dot = receptor reference to Table 2-5
Black/gray lines = background elevation contours
Red dot = location of off-site maximum
Pink triangle = meteorological stations
g/m^2-s = grams per square meter seconds

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5.0 Regulated Solvent Impacts Analysis

Specific individual solvents burned at the TA-16 Burn Ground cannot be modeled as described in Sections 2 and 3 because there are no solvent-specific emission factors for open burning of solvents. Emission factors for the open burning of spilled fuel oil were used to conservatively estimate the products of combustion that result from burning solvents.

Solvents treated at TA-16 are produced mainly from research and development processes, which may change frequently. Therefore, the types and amounts of solvents cannot be estimated. Solvent emissions calculated in the past were snapshots of a single year's activities and cannot be extrapolated to other years with certainty. Over the past several years, alternatives have been implemented to reduce the amount of HE-contaminated solvents that require treatment. As a result, no RCRA regulated HE-contaminated solvents have been treated for several years and <300 gallons of HE-contaminated dimethylsulfoxide (DMSO) were treated in 2006. Small amounts of a few solvents are present at trace levels on combustibles treated at the TA-16 Burn Ground. Regulated solvents in liquid form were last treated at the TA-16 Burn Ground in April 2004 as part of a 0.5 gallon HE-contaminated oil/solvent/water mixture that carried the EPA Hazardous Waste Numbers D001, D003, F003, and F005.

To put into perspective the acceptable releases of regulated solvents that can be treated at the TA-16 Burn Ground, LANL used the worst-case hourly and annual CFs to back-calculate acceptable release impacts and compared the impacts to the air quality screening levels described in Section 3 of this document. The solvents analyzed were those listed in the most recent version of the LANL General Part A Permit Application (LANL, 2006). Many of these are F-listed and are not expected to be treated at the TA-16 Burn Ground, but are included to provide a worst-case analysis. The estimation process outlined below is designed to conservatively estimate how much of each solvent could be treated at the TA-16-388 before screening levels were approached. One of the largest assumptions in this process is that 95% of the solvent would be destroyed by the propane burners. For consistency with past estimations (LANL, 2002) and based upon the operator's observation during burn events, it is assumed that the burners would have 95% combustion efficiency, with the other 5% being emitted as the parent chemical for this impact analysis. There are no measured data on the efficiency of burning oils and solvents at TA-16-388 and from the operator's observation during burn events, it is likely that combustion efficiency is high based on opacity (visible emissions) during burning. Additionally, as discussed earlier, it is not likely that large amounts of any regulated solvents would be treated at TA-16-388 throughout the rest of its operating life.

The screening levels for acute (1-hr) and chronic (annual) exposures and the CFs calculated by CALPUFF can be used to estimate the amount of a pollutant that could be released from the TA-16 Burn Ground operations before the screening level is reached. Note that the amount released is not the same as the amount burned because burning destroys most of the material. Below is an example using benzene as the pollutant, with a screening level of 1300 µg/m^3, and the hourly worst-case on-site CF of 1.49 E+02 µg/m^3 of pollutant per g/s of solvent burned. Assuming a 95% destruction efficiency:

Hourly example:

$$\frac{1300\ \mu g/m^3}{} \times \frac{g/sec}{1.49E{+}02\ \mu g/m3} \times \frac{3600\ sec}{hr} \times \frac{1\ lb}{454\ g} \times \frac{100\ lb\ burned}{5\ lb\ released} = 1384\ lb/hr$$

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Therefore, 1384 lb/hr of benzene could be burned before the acute screening level was exceeded. Since only 250 lb of waste can be burned per hour at TA-16-388, the screening level will not be exceeded.

Annual example:

$$0.025\ \mu g/m^3 \times \frac{g/sec}{1.48\ \mu g/m3} \times \frac{3600\ sec}{hr} \times \frac{508\ hr}{yr} \times \frac{1\ lb}{454\ g} \times \frac{100\ lb\ burned}{5\ lb\ released} = 1.79E+07\ lb/yr$$

Deposition to soil was not considered in the calculation of annual solvent limits. The chronic screening levels used for annual calculations are 0.1 times the PRGs because a risk assessment is required if the impacts exceed 0.1 times the PRGs. This conservative analysis shows that a very large amount of each of the solvents estimated would have to be burned each year to approach the screening levels. Additionally, calculated annual solvent limits assume open burning of solvent during 508 hours per year for consistency with the number of meteorological hours modeled, to provide a more conservative estimate than averaging over 520 hours.

Table 5-1 shows the hourly and annual contaminant-specific screening levels, the CFs, and the calculated quantities of bulk solvents that could be treated (assuming a 95 % destruction efficiency) before the screening levels were reached. These quantities were calculated using the on-site CFs. If calculated with the off-site CFs, the calculated quantities would be even larger.

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Table 5-1. Short-Term and Annual Solvents Impacts Estimation [1]

Contaminant	Acute Screening Limit [2] ($\mu g/m^3$)	On-site 1 Hour Conversion Factor ($\mu g/m^3$ per g/s)	1-Hour Solvent Limits [3] (lb/hr)	Chronic Screening Level [4] ($\mu g/m^3$)	On-site Annual Conversion Factor ($\mu g/m^3$ per g/s)	Annual Solvent Limits (lb/yr)[5]
Acetone	4.75E+05	1.49E+02	5.06E+05	3.29E+02	1.48E+00	1.79E+07
Benzene	1.30E+03	1.49E+02	1.38E+03	2.50E-02	1.48E+00	1.36E+03
Carbon disulfide	6.20E+03	1.49E+02	6.60E+03	7.50E+01	1.48E+00	4.08E+06
Carbon tetrachloride	1.90E+03	1.49E+02	2.02E+03	1.30E-02	1.48E+00	7.08E+02
Chlorobenzene	1.25E+05	1.49E+02	1.33E+05	6.20E+00	1.48E+00	3.37E+04
Chloroform	1.50E+02	1.49E+02	1.60E+02	3.50E-02	1.48E+00	1.91E+03
Cresols	2.00E+04	1.49E+02	2.13E+04	NA[6]	NA	NA
Dichlorobenzene, o-	3.00E+05	1.49E+02	3.19E+05	2.10E+01	1.48E+00	1.14E+06
Dichloroethane [1,2-]	2.02E+05	1.49E+02	2.15E+05	5.10E-01	1.48E+00	2.78E+04
Dichloroethylene [1,1-]	7.50E+04	1.49E+02	7.98E+04	2.10E+01	1.48E+00	1.14E+06
Dichlorodifluoromethane	1.50E+07	1.49E+02	1.60E+07	NA	NA	NA
Ethyl benzene	5.00E+05	1.49E+02	5.32E+05	1.10E+02	1.48E+00	5.99E+06
Methanol	2.80E+04	1.49E+02	2.98E+04	NA	NA	NA
Methyl ethyl ketone	1.30E+04	1.49E+02	1.38E+04	5.10E-04	1.48E+00	2.78E+01
Methyl isobutyl ketone	3.00E+05	1.49E+02	3.19E+05	3.10E+02	1.48E+00	1.69E+07
Methylene chloride	1.40E+04	1.49E+02	1.49E+04	3.10E+02	1.48E+00	1.69E+07
Nitrobenzene	1.50E+04	1.49E+02	1.60E+04	2.10E-01	1.48E+00	1.14E+04
Pyridine	5.00E+04	1.49E+02	5.32E+04	3.70E-01	1.48E+00	2.01E+04
Tetrachloroethylene	2.00E+04	1.49E+02	2.13E+04	3.20E-02	1.48E+00	1.74E+03
Toluene	3.70E+04	1.49E+02	3.94E+04	4.00E+01	1.48E+00	2.18E+06
Trichloroethane, 1,1,1-	6.80E+04	1.49E+02	7.24E+04	2.30E+04	1.48E+00	1.25E+07
Trichloroethane, 1,1,2-	5.00E+04	1.49E+02	5.32E+04	1.50E+00	1.48E+00	8.17E+04
Trichloroethylene	6.98E+05	1.49E+02	7.43E+05	9.60E-02	1.48E+00	5.23E+03
Trichlorofluoromethane	2.50E+06	1.49E+02	2.66E+06	7.30E+01	1.48E+00	3.97E+06
Xylenes	2.20E+04	1.49E+02	2.34E+04	1.10E+01	1.48E+00	5.99E+05

1 Quantities calculated assume 95% destruction of the solvent while burning.
2 Screening limits are from acute limits (1 hour) inhalation exposure (AIEC) for toxic air pollutants (EPA, 2005)

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[3] Calculated solvent limits illustrate the amount of solvent that could be burned before the respective screening limit was reached

[4] Annual screening limits are from the Environmental Protection Agency's Region 9 Preliminary Remediation Goals (PRGs), (EPA, 2004) and have been multiplied by 0.1 for comparison purposes as described in as described in the modeling protocol (LANL, 2007).

[5] Calculated solvent limits assume 508 hours of treatment occurring per year.

[6] NA indicates that there is no screening limit for the contaminant

g/s = grams per second
µg/m^3 = micrograms per cubic meter
lb/yr = pounds per year

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6.0 Results and Conclusions

The following discusses the results of the on-site and off-site air dispersion impact analysis and the on-site deposition impact analysis as conducted for this report. The results show, in addition to the explanations included below, the operations at the TA-16 Burn Ground are protective of human health and the environment and pose no adverse effects due to migration of waste constituents in the air.

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Short-term on-site air dispersion impacts were assessed for 46 contaminants with only two concerns—furan and acrolein. Impacts for all contaminants assessed were calculated to be below the AIECs, the majority by a factor of at least two orders of magnitude. Furan and acrolein were closer to the AIECs. The emissions factor for furan was taken from the Open Burn/Open Detonation Dispersion Model (OBODM) User's Guide (EPA, 1998a) emissions for Manufacturer's Waste which consisted of 65% aluminized ammonium perchlorate, 20% plastic material, 11% paper/wood/cloth and 4% diesel fuel. The emissions factor for acrolein is based on the burning of 500 gallons of No. 2 fuel oil (a petroleum product) in a 15-30 minute time span from Emissions of Organic Air Toxics from Open Burning (EPA, 2002a). The calculated 1-hour air quality impacts for furan were within two orders of magnitude of the acute inhalation exposure limit. Acrolein impacts were calculated to be just under the exposure limit. While these calculations put estimated impacts near the range of the AIEC limits, these contaminants are not an environmental concern at the TA-16 Burn Ground and will not have adverse effects on human health or the environment due to migration of waste constituents in the air. The contaminants do not pose unacceptable risk because of the following:

- The example waste streams that were used for this analysis are much "dirtier" wastes than the waste streams that are treated at TA-16-388.
  - The HE-contaminated combustible waste streams that are treated at TA-16-388 consist of pieces or powder HE, cloth, some cardboard, kim wipes, limited plastic bags, small amounts of solvent or oil on kim wipes or filters, small glass pieces, and small metal pieces. In most cases this waste stream does not contain a high percentage of plastics, wood, or paper as does the waste that the emissions factor was based on and would lead to the higher production of furan.
  - The HE-contaminated oils and solvents that are treated at TA-16-388 which are oils and solvents that contain high enough dissolved concentrations of HE (all pieces are filtered out and treated as part of a combustible waste stream) to be considered a detonation risk. Small amounts of kerosene or other petroleum products (which could lead to the production of acrolein) are also used to start bulk HE burns at both treatment units at the TA-16 Burn Ground. It is unlikely that bulk amount of fuel oil (or other petroleum product) ever has to be treated at TA-16-388. Most of the oils and solvents that may be used during HE manufacturing or within research and development activities are of a grade that is more refined than fuel oil and would generally contain less contaminants.
- The air impact calculations were conducted assuming that 250 lb of waste was treated per 1-hour long burn. This is larger than typical treatment activities at TA-16-388.
  - Routine treatment weights range from 30 to 160 lb and would have less air quality impact.

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- Sources for these contaminants are not regularly burned at TA-16-388 and would never be treated in the volumes modeled; therefore, impacts from these contaminants would be less than those calculated.
  - Furan is generally produced through the burning of polychlorinated biphenyls or burning in barrels, pits, woodstoves, or outdoor boilers. Waste treatment of combustible waste streams at TA-16-388 is always conducted with the assistance of the propane burners to ensure the destruction of HE compounds. Therefore, the waste burns hotter and more completely than a simple fire alone and decreases the potential for the formation and release of furan.
  - Sources of acrolein in the air come mainly from cigarette smoke, forest fire emissions, and gasoline and diesel exhaust. Generally, acrolein does not seem to be a measured release associated with the burning of solvents. The small amounts of petroleum products that are treated at the TA-16 Burn Ground (or used for ignition) would not result in as high an impact as calculated for this analysis.
- During burning operations personnel are not allowed within the area where burning is occurring.
  - Since the highest calculated on-site impacts occur at the unit, this decreases the potential for human exposure to contaminants in the air during the treatment and directly after.

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Both of these contaminants are produced during the combustion process rather than originally present within the waste stream, so the prohibition of their treatment at the TA-16 Burn Ground is not a feasible option. Additionally, analysis for these constituents within a waste stream would often require chemical analysis which cannot be conducted for all HE-contaminated waste streams because of reactivity concerns associated with safety.

Short-term off-site air dispersion impacts were assessed for 53 contaminant/averaging-period combinations, all of which are below screening levels. Calculated impacts for off-site receptors were generally at least and order of magnitude less than the air impacts calculated for on-site. Three of the calculations come within one order of magnitude of the screening level and one comes within two orders of magnitude. These contaminants are acrolein, the two calculations for particulate matter, and formaldehyde.

Acrolein is not an environmental concern at the burn units for the reasons outlined above. Furthermore, off-site impacts were assessed assuming a maximum waste quantity of 1,000 lb of waste treated per 1-hour burn, so the waste quantity estimate for this calculation is higher than the typical waste treatment occurring at the TA-16-388. Particulate matter calculations for PM_{10} and TSP include the background concentration within the air impacts analysis and it is that concentration that brings the off-site impact calculation within an order of magnitude of the AIECs. Actual TA-16 Burn Ground impact was calculated to be 2.94E-01 $\mu g/m^3$ for both, greater than three orders of magnitude below the AIEC. Therefore, the particulate matter contribution associated with open burning operations is not a concern.

The emissions factor for formaldehyde, like acrolein, is also taken from Emissions of Organic Air Toxics from Open Burning (EPA, 2002a) and is based on the burning of fuel oil. Calculated short-term off-site air impacts for formaldehyde come within two orders of magnitude of the AIEC, however, this is not an environmental concern because sources of formaldehyde in the air come from plywood, veneered or laminated furniture and cabinets, fuel combustion, and adhesives. Although some adhesive may be present within the HE-contaminated combustible

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waste streams treated at the TA-16 Burn Ground, it is not a significant percentage of the waste stream. Additionally, as with acrolein, the small amounts of petroleum products that are treated at the TA-16 Burn Ground (or used for ignition) would not result in as high an impact as calculated for this analysis. Consequently, formaldehyde concentration in air due to TA-16 Burn Ground operations does not pose an unacceptable risk to human health and the environment. Plus, chemical analysis for this constituent within a waste stream would pose the same problem as mentioned above.

Annual on-site air impacts were assessed for 51 contaminants, all of which are below screening levels. Calculated annual off-site air impacts were all below one tenth the PRG screening limits so they will not be discussed further. The three the calculations for annual on-site air impacts that come within one order of magnitude of one tenth the EPA preliminary remediation goal (PRG) screening limits are associated with the contaminants acrolein, benzene, and indeno[1,2,3-cd]pyrene. Acrolein is discussed above and should not be considered a concern.

Benzene also does not pose an unacceptable risk to human health and the environment. The emissions factor used for benzene, like acrolein and formaldehyde, is also taken from Emissions of Organic Air Toxics from Open Burning (EPA, 2002a) and is based on the burning of fuel oil. Other emissions factors are available for benzene for the combustible solid waste and the HE waste that were chosen for assessment in the modeling protocol (LANL, 2007). The largest of the emissions factors (fuel oil) was used for this assessment as part of a very conservative analysis. The other two smaller emissions factors represent wastes that are generally more routinely treated at the TA-16 Burn Ground. Annual on-site air impact calculations conducted for the other two wastes result in lesser impacts: 5.76E-04 $\mu g/m^3$ for the combustible solid waste and 3.59E-05 $\mu g/m^3$ for the HE waste. These are both more than two orders of magnitude from 10% of the PRG screening limit. Sources of benzene include crude oil, gasoline, cigarette smoke, plastics, resins, nylon and synthetic fibers, lubricants, rubbers, dyes, detergents, drugs, and pesticides; therefore, it would not be practical to prohibit the treatment of waste streams that contain benzene. Chemical analysis for benzene within a waste stream poses the same problem in HE-contaminated waste streams due to reactivity concerns as mentioned above. Also, the quantity of benzene in the actual waste streams treated at the TA-16 Burn Ground is likely much less than for the wastes that the emissions factors are based upon. The maximum quantity of waste used in the calculation for annual air impacts is 20,000 lb/yr which is larger than the average quantity that is generally treated at the TA-16 Burn Ground (less than 5,000 lb/yr). This would further decrease the potential air impact of benzene at the TA-16 Burn Ground. It is also important to consider that this estimated impact is being compared to 0.1 times a screening limit, not the actual limit.

Comparisons similar to benzene can be made for indeno[1,2,3-cd]pyrene which also does not pose an unacceptable risk to human health and the environment. The emissions factor is also conservatively based on the burning of fuel oil and another lower emissions factor is available for the burning of combustible solid waste. Calculation of the annual on-site air impact using the other available emissions factor results in an estimated impact of 2.08E-06 $\mu g/m^3$, adding an another order of magnitude to the difference between the estimated impact and 0.1 screening limit. Indeno(1,2,3-cd)pyrene is formed in most combustion or elevated temperature processes that involve compounds containing carbon and hydrogen and known sources include coal, wood, and gasoline combustion, municipal waste incineration, coke ovens and cigarette smoke. Thus, the compound is a product of combustion rather than originally present within the waste stream,

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so the prohibition of its treatment is not a viable option. The potential for this contaminant to have impacts associated with TA-16 Burn Ground operations is decreased by the actual quantity of waste treated at the TA-16 Burn Ground rather than the maximum quantities and the less impact-likely type of waste that is treated at the open burn treatment units.

Annual and 10-year deposition impacts were all calculated for 56 contaminants and all were estimated to be below the NMED Human Health Industrial/Occupational Soil Screening Levels (SSLs) (NMED, 2006) and the EPA Region 6 Human Health Medium-Specific Screening Levels (EPA, 2007). Two of the 10-year deposition impact calculations come within one order of magnitude of one of the screening levels assessed and one is within the same order of magnitude as the Medium-Specific Screening Level. These contaminants are acrolein and total xylene within two orders of magnitude and naphthalene within the same range as the Medium-Specific Screening Level. Acrolein is discussed above and should not be considered a concern.

Naphthalene and total xylene also do not pose unacceptable risk to human health and the environment. The emissions factor used for naphthalene, like acrolein, is also taken from Emissions of Organic Air Toxics from Open Burning (EPA, 2002a) and is based on the burning of fuel oil. Another emissions factors within the protocol document (LANL, 2007) is available for naphthalene for the combustible solid waste. This smaller emissions factor represents wastes that are generally more routinely treated at the TA-16 Burn Ground because liquids are rarely treated. 10-year depositional impact calculation conducted for this emissions factor results in lesser impacts: 5.20E-02 mg/kg. This is one order of magnitude from the EPA Region 6 Human Health Medium-Specific Screening Levels and four orders of magnitude from the SSLs. Naphthalene is produced when wood and tobacco are burned, and manufactured from coal tar distillation and petroleum refining. It is also used to make dyes, some plastics, leather tanning agents, and insecticide carcaryl. The emissions factor used for total xylene, like furan, was taken from the Open Burn/Open Detonation Dispersion Model (OBODM) User's Guide (EPA, 1998a) emissions for Manufacturer's Waste and is not as segregated and carefully assessed as the HE-contaminated combustible waste streams that are treated at TA-16-388. The 10-year deposition impact calculations conducted for the other two wastes result in lesser impacts: 1.04E-03 mg/kg for the HE waste and 1.55E-02 mg/kg for the He contaminated burning liquids. These are two or more orders of magnitude from the EPA Region 6 Human Health Medium-Specific Screening Levels and the SSLs. Additionally, sources of xylene range from petrol and automotive exhaust to aerosol paints, architectural coatings, caulks, hard surface cleaners, markers, and adhesives.

It would not be practical to prohibit the treatment of waste streams that contain naphthalene or total xylene because it is so widely used in production and naphthalene is also a product of combustion. Chemical analysis for naphthalene and xylene within a waste stream pose the same problems in HE-contaminated waste streams due to reactivity concerns as mentioned above. Also, the quantities of naphthalene and total xylene in the actual waste streams treated at the TA-16 Burn Ground are likely much less than for the wastes that the emissions factors are based upon. The maximum quantity of waste used in the calculation for annual deposition impacts is 20,000 lb/yr which is larger than the average quantity that is generally treated at the TA-16 Burn Ground (less than 5,000 lb/yr). Additionally, these levels are estimated impacts after 10 years of deposition and neither naphthalene and xylene have proven to persist in the environment.

The air pathway assessment conducted by LANL and detailed within this report was designed to provide a very conservative air dispersion and deposition impact analysis. CALPUFF input parameters were used as conservatively as deemed reasonable, and the unit/waste scenarios

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modeled were chosen to represent the types of burning that occur at the TA-16 Burn Ground. The emissions factors used for the impacts calculations within this assessment were chosen from wastes that are generally not as refined as the research and development laboratory wastes or the manufacturing wastes that are treated through open burning at LANL. Also, the quantities of waste used within the assessment were the maximum amounts of waste that could possibly be treated at the TA-16 Burn Ground. Daily operations at LANL are less than a third of the quantity assessed. Due to the very conservative nature of this analysis and for the reasons outlined above, the operations at the TA-16 Burn Ground are protective of human health and the environment and pose no adverse effects due to migration of waste constituents in the air.

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H_c is unique to the type of material burned. The heats of combustion for the HE used in this analysis were obtained from Gibbs and Popolato (1980) for pure HE and adjusted for inert constituents.

8.87 million J/kg (MJ/kg) was used for PBX 9501

11.58 MJ/kg was used for COMPB

The heat content of propane was assumed to be 1 million British Thermal Units (MBtu) per 15.7 gallons (gal) (Glover, 1998).

R can be expressed as M_b/t_b, where M_b is the amount of material burned in a given time period and t_b is the burn time for specific materials determined from the referenced literature.

For the HE burning scenarios, the maximum allowable HE unit limits were used for M_b:

1000 lb (453.6 kg) per burn for TA-16-399

250 lb (113.4 kg) per burn for TA-16-388

The values for t_b vary by the type of material being burned.

For PBX 9501, used in the minimum lofting HE scenarios for both units the burn time used was 8 minutes (28,800 s) (Hatler, 1982) based on measurements for burning solids.

For COMPB, the HE used for the maximum lofting HE scenarios for both units, the burn time used was estimated to be 1.5 minutes (5400 s). This was based on data for chips of COMPB (Hatler, 1982) adjusted to reflect the slower burn time for a solid composition. Other data in this reference for PBX 9501 or PBX 9502 show that solids burn 2 to 4 times longer than the same HE burned as chips. The COMPB burn time was adjusted accordingly.

Specific M_b and t_s were not necessary for propane because the propane-only scenario for TA-16-388 assumed a burn rate of 1 gal per minute (gal/min) based on operational observations.

Dry air density at 7200 feet (ft) (P_a = 0.913 kg/m^3) was calculated using the ideal gas law to adjust air density at standard conditions (Stull, 1988) to 7200 ft (T_a).

The heat capacity of air (c_p = 1004.67 J/kg/K) was obtained from Stull (1988).

Air temperatures (T_a) of 35 degrees Fahrenheit (^{o}F) were used to calculate the minimum vertical velocities and 85 ºF was used to calculate the maximum vertical velocities for both units.

T_s values were obtained from experimental data (Hatler, 1982).

Based on direct thermocouple measurements, 993 K was used for PBX 9501. Temperature measurements were only available for COMPB chips so the COMPB T_s was estimated to be 1840 K. The estimation was based on PBX

9501 and PBX 9502 solid HE temperature measurements applied to the COMP chip data in a manner similar to the description above for t_b.

A_s is based on the size of the tray used to treat M_b:

TA-16-388, 4 ft × 8 ft = 32 square feet (ft^2) = 2.97 m^2
TA-16-399, 4 ft x 16 ft = 64 ft^2 = 5.95 m^2

Other source-specific variables required by CALPUFF, but not required for calculating vertical velocity, are the effective radius (r_{eff}) and release height. The r_{eff} (r_{eff} = *square root(A/π)*) for TA-16-388 is 0.97 m^2 and for TA-16-399 it is 1.38 m^2. The release height is defined as the height of the base of the burn tray + r_{eff} : 1.47 m for TA-16-388 (using a base tray height of 0.5 m) and 2.38 m for TA-16-399 (using a tray base height of 1 m). Finally, data specific to the unit location are required: UTM Zone 13 coordinates and the ground elevation in m above mean sea level (m MSL), which are shown in Table 2-2.

As requested by NMED, LANL is providing an electronic copy of model run input and output along with the program files as part of this report. Source-specific information is described above and the model runs provide model flag settings and other general information.

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Table 2-1. Vertical Velocities for Unit/Waste Scenarios

TA-16-388	
Maximum Lofting (250 lb COMPB)	3.49 m/s
Minimum Lofting (250 lb PBX 9501)	0.45 m/s
TA-16-399	
Maximum Lofting (1000 lb COMPB)	7.0 m/s
Minimum Lofting (1000 lb PBX 9501)	0.89 m/s

lb = pound(s)
COMPB = Composition B composed of 60 percent by weight (wt. %) cyclonite (RDX) and 40 wt. % trinitrotoluene (TNT)
PBX 9501 = plastic bonded explosive composed of 95 wt. % Cyclotetramethylenetetranitramine (HMX) and 5 wt. % inert binder
m/s = meters per second
gal/min = gallon(s) per minute

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Table 2-2. Location-Specific Information

Unit	UTM X-Coordinate	UTM Y-Coordinate	Elevation (m MSL)
TA-16-388 Flash Pad	379720.1133	3967617.404	2286.3
TA-16-399 Burn Tray	379783.1419	3967735.864	2275.03

UTM = Universal Transverse Mercator (UTM)
m MSL = meters above mean sea level

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