Contract No:

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-08SR22470 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

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Mercury Dispersion Modeling 242-25H Evaporator Portable Backup Ventilation

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August 2018

SRNL-STI-2018-00409, Rev.0

SRNL.DOE.GOV

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Prepared for
U.S. Department of Energy

Keywords: *Mercury Emissions; H Tank Farm; 242-25H.*

Retention: *Permanent*

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EXECUTIVE SUMMARY

The SRNL Atmospheric Technologies Group performed an analysis of mercury emissions from the H-Tank Farm 242-25H Evaporator backup ventilation system exhaust to assess worst case 15-minute and 8-hour average concentrations and evaluate whether the ACIGH Short-Term Exposure Limit (STEL), or Threshold Limit Value (TLV) levels for mercury are exceeded following a seismic event. This analysis was also used to establish a minimum stack height at which ambient mercury concentration would not exceed the regulatory limits. The American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) was used as the dispersion modelling tool for this analysis. Results indicate that a stack height of 20 ft result in ground level concentrations that exceed the STEL or TLV standards at ground level only in the areas immediately around the stack, and generally on the slope of the hill beneath the 242-25H and 242-9H buildings.

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LIST OF ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AMS	American Meteorological Society
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
AERMET	AERMOD Meteorological Preprocessor
AGL	Above Ground Level
ASL	Above Sea Level
ATG	Atmospheric Technologies Group
BPIP-Prime	Building Profile Input Program- Prime Algorithm
Cfm	Cubic feet per minute
DSA	Documented Safety Analysis
EPA	Environmental Protection Agency
HEPA	High Efficiency Particulate Air
LIDAR	Light Detection and Ranging
NAD27	North American Datum 1927
NLCD92	National Land Cover Database 1992
NWS	National Weather Service
PVS	Primary Ventilation System
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
STEL	Short Term Exposure Limit
TLV	Threshold Limit Value
USGS	United States Geological Survey
UTM	Universal Transverse Mercator

1.0 Introduction

The American Conference of Governmental Industrial Hygienists (ACGIH) short term exposure limit (STEL) for dimethyl mercury and 8–hour threshold limit value (TLV) for mercury in the workplace are 0.030 mg/m^3 (30 µg/m^3) and 0.025 mg/m^3 (25 µg/m^3), respectively (Ref. 1). Using these standards, the Atmospheric Technologies Group (ATG) has been asked to evaluate the exposure of workers to ambient mercury concentrations resulting from the H-Area tank farm 242-25H Evaporator portable backup ventilation stack emissions. The STEL for dimethyl mercury was used to assess short term exposure because a STEL for elemental mercury has not been reported by the ACGIH ambient concentrations standard. Mercury concentrations were predicted for ground-level breathing height and other specified work areas around the 25H Evaporator building.

In order to predict mercury concentrations from the 25H Evaporator emissions, observed weather data for SRS was taken from a five-year (2007-2011) record of hourly meteorological conditions and used to calculate the amount of atmospheric dispersion for 1-hour and 8-hour time periods. Hourly-averaged modeled concentrations were adjusted to represent 15-minute values for comparison to the 15-minute STEL using the following equation (Ref. 2):

$$\boldsymbol{C_{15min} = C_{60min}\left(\frac{60}{15}\right)^{0.2} = 1.3\ C_{60min}} \qquad (1)$$

By multiplying the hourly concentrations by a factor of 1.3, the concentration is representative of concentrations sampled on a 15-minute time averaged period. Comparisons of the calculated concentrations can be made to the standards and estimates of worker safety and potential mitigation methods can easily be made.

2.0 Methodology

Modeling was conducted with the Environmental Protection Agency (EPA) AMS/EPA Regulatory Model (AERMOD) dispersion model, which is recommended by the EPA for regulatory air quality analyses (Ref. 3). The model allows for variability in wind, turbulence, temperature and incorporates boundary layer parameters for dispersion in both stable and convective atmospheric situations (Refs. 4 and 5). More information on ATG's software quality assurance plan for AERMOD can be found in C-SQP-G-00076 (Ref. 6). For this regulatory modeling, AERMOD was executed in default (regulatory) mode. AERMOD is routinely used for tank and multiple stack emissions, and has physics included to model building wake effects.

Meteorological data files used as input to AERMOD were prepared using EPA's AERMOD Meteorological preprocessor (AERMET, Ref. 7), which incorporates the National Weather Service's (NWS) hourly observations from Bush Field in Augusta, GA, twice-daily upper air soundings from the NWS Atlanta, GA radiosonde station and, quality assured 15-minute values of wind and temperature at four levels (4, 18, 36 and 61 meters) of the Savannah River Site (SRS) Central Climatology tower located near N-area.

For onsite data, values were extracted from the meteorological database and written to a text file only if there were no associated quality flags. When the data did not meet quality control criteria, a missing value code was assigned consistent with AERMET requirements. Quality assurance procedures for SRS meteorological data are described in Reference 8. For details on the processing of the most recent five-year quality assured dataset (2007-2011) see References 9 and 10.

Values used by AERMET for roughness length, Bowen ratio and albedo were determined from EPA's AERSURFACE algorithm. Input to the algorithm consisted of a (United States Geological Survey) USGS National Land Cover Data image for 1992 (NLCD92). This image was analyzed for the area around the Central Climatology tower. Monthly values of the three surface parameters were generated and imported into AERMET.

Building information was included in AERMOD to account for downwash and re-circulation effects from nearby buildings and stacks. Building data was processed using the EPA utility Building Profile Input Program (BPIP-Prime) to determine how these obstacles affect airflow patterns and the transport of effluent discharge. Of concern is the downwash of the plume over areas where workers will spend most of their time during operations. The structures around the 25H building were added to the model domain for inclusion in the BPIP-Prime input (wake) and are specified in Ref. 1. This modeling domain was based on a domain previously generated for use in SRNL-STI-2016-00453 (Tank 22H, Ref. 11) and SRNL-STI-2017-00745 (HPP-7 Ref. 12) and was updated with revised base heights and building information (Ref 1).

There are other ill-defined appurtenances near around the 25H building; however, these were not modeled for atmospheric wake, therefore adding a level of conservatism (wake area adds additional turbulence for dispersion which can lower atmospheric concentrations). The larger buildings need to be retained for AERMOD to enhance the vertical mixing of the plume centerline down to the receptor heights, increasing the near surface ground concentrations. The West Hill was also modeled as a building to ensure that wake impacts from the hill could be evaluated.

Terrain elevation was determined from the Savannah River Site (SRS) high resolution Light Detection and Ranging (LIDAR) dataset for SRS (Refs. 13 and 14). The area surrounding 241-92H has been graded to be 88 to 89 meters (m) ASL (Fig. 2-1). The areas on top of the east and west hills are about 98 m and 100 m, respectively.

The modeling domain was defined by a receptor grid of 106 by 62 grid points (6,572 receptors). Receptor grid spacing of 6 m was used to identify any potential excessive concentrations that may occur near the ground. The height of ground level receptors is nominally 1.85 m (6 feet) to represent the breathing zone of a tall worker standing at ground level. The coordinate system used for this domain was a UTM grid, using the NAD27 datum.

The stack discharge temperature range is estimated to be 10°C to 50°C, for conservatism 10°C was used in modelling. The inside diameter of the stack is 8 inches (Ref. 1). Three stack heights were examined (1-, 10- and 20-ft) to examine the areas being impacted by mercury emissions (Ref. 1). The stack is composed of flexible hosing and is only used intermittently.

To have the correct units for input to AERMOD, the concentration of mercury in the stack discharge was converted to a mass release rate by using the flow rate (200 cfm, maximum flow rate) containing mercury at a 1 mg/m^3 and 10 mg/m^3 mercury discharge concentration (Ref. 1). The emission rate for the 25H portable stack (in g/s) was determined using the following calculation based on inputs from Reference 1:

$$\frac{1\text{mg}}{\text{m}^3}\times\frac{1\text{g}}{1000\text{mg}}\times\left(\frac{1\text{m}}{3.28\text{ft}}\right)^3\times\frac{200\text{ ft}^3}{\text{min}}\times\frac{1\text{ min}}{60\text{ sec}} = 0.0000945\text{ g/s} = 9.45\text{x}10^{-5}\text{ g/s}$$

$$\frac{10\text{mg}}{\text{m}^3}\times\frac{1\text{g}}{1000\text{mg}}\times\left(\frac{1\text{m}}{3.28\text{ft}}\right)^3\times\frac{200\text{ ft}^3}{\text{min}}\times\frac{1\text{ min}}{60\text{ sec}} = 0.000945\text{ g/s} = 9.45\text{x}10^{-4}\text{ g/s}$$

Once mercury concentration values were calculated for each receptor on the grid, values were transformed to percent of corresponding standard. This was done by multiplying each value by a scaling factor of 4.3 and 4.0, to obtain a percent of the STEL or TLV for the 15-minute and 8-hour period, respectively. These scaling factors were obtained using the following calculation:

$$\%\text{ of STEL} = \frac{1.3}{30\ \mu g/m^3}\times 100 = 4.3$$

$$\%\text{ of TLV} = \frac{1}{25\ \mu g/m^3}\times 100 = 4.0$$

where the value 1.3 in the first equation is incorporated from Eq. 1 to obtain a value representative of a 15-minute period.

Figure 2-1. Aerial photo of H-Tank farm with LIDAR elevation (green contours) with receptors (dots) around H-tank Farm (Ref. 2).

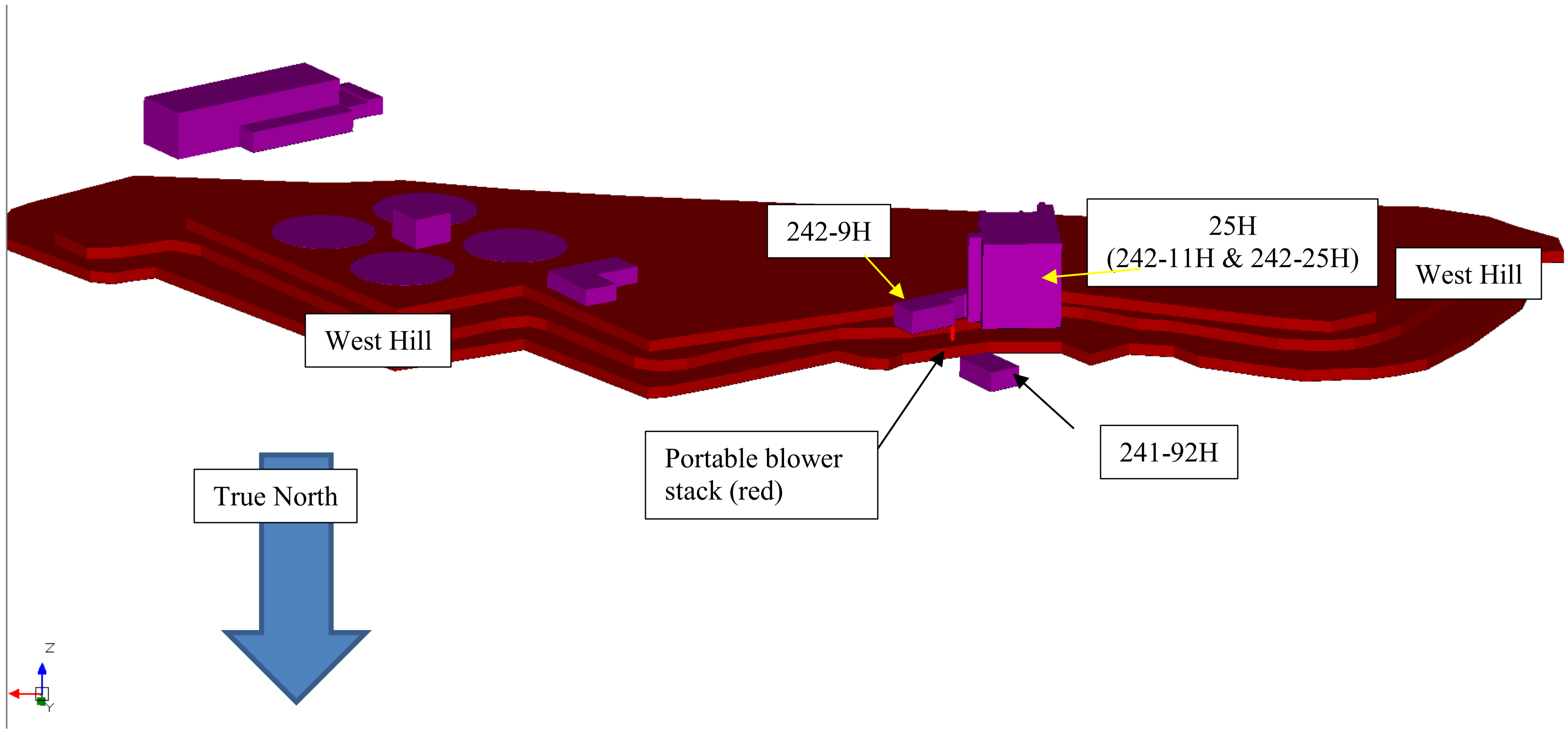

Figure 2-2. Three-dimensional view of the buildings around 242-25H facility for the 20-foot stack height from AERMOD modeling domain. The tanks are represented by purple circles, hills by brown, buildings in purple, and the stack is in red. Blue arrow shows the direction of the True North. View is from the True North direction and down.

3.0 Results and Discussion

Two different mercury emissions scenarios were used in this study, stack gas concentration of 1 mg/m^3 and 10 mg/m^3. Each of these two scenarios was modeled for a stack height of 1-, 10- and 20-ft. The 1 mg/m^3 release scenario does not exceed either the STEL or TLV standards. The summary of maximum concentrations modeled (Table 3-1) shows that the STEL and TLV standards were exceeded for the 10 mg/m^3 release scenario for all but the TLV standard for the 20-ft stack height.

Table 3-1. Maximum ambient concentrations (µg/m^3) associated to 242-25H emissions for 15-minute and 8-hour periods for all receptors.

ht (ft)	1 mg/m^3		10 mg/m^3	
	15-min	8-hr	15-min	8-hr
1	23.3	5.2	**233.2**	**51.8**
10	29.1	7.2	**290.9**	**71.5**
20	3.9	0.9	**39.1**	8.7

Values in bold red exceed exposure limits for respective time periods (0.030 mg/m^3 or 30 µg/m^3 for 15-min STEL and 0.025 mg/m^3 or 25 µg/m^3 for 8-hour TLV).

Figures 3-1 through 3-3 show the highest ground level concentrations that are associated with the 1 mg/m^3 release scenario. All three stack heights examine under the release scenario are close to the standard, but only near to the stack (to the West direction). Figure 3-2 shows that for the 10-ft stack, there is an area of where the mercury concentrations above 25% of the STEL standard being confined to the slope of the West Hill, under the buildings between 241-92H and 25H Evaporator building. For a 20-ft stack, the peak concentration moves one grid point to the south but is only 13% of the standard.

For the 10 mg/m^3 release scenario, the STEL is exceeded at all three (3) stack heights and the TLV standard is exceeded at the 1 and 10 ft stack heights. Figure 3-4 shows the area between the 25H, 242-9H and 241-92H is close to (fine green contours) or exceeds (heavy contours) the STEL values. Figure 3-5 shows exceedances of the TLV standard on the receptors immediately surrounding the stack, located under the 242-9H building. Figures 3-6 through 3-8 show similar patterns of mercury dispersion: high concentrations are calculated at receptors near the stack, with sharp gradients in the mercury concentration. Concentration values decrease quickly so that relatively small areas between the 25H, 242-9H and 241-92H buildings are impacted directly by the mercury being emitted.

4.0 Conclusions

The EPA's AERMOD dispersion analysis tool was used to calculate the ground-level concentration of mercury due to emissions from the 25H portable stack. Results show that the STEL and TLV standards were not exceeded for the 25H for the 1 mg/m^3 release scenario. For the 10 mg/m^3 release scenario, low concentrations of mercury mix over the buildings to the top of the West Hill, as well as the areas around and between the 242-25H, 242-9H and 242-92H buildings. Raising the stack from 1-ft to 10-ft increases the peak concentrations, due to the plume centerline (highest concentrations) being located closer to the height of the receptors. The downwash and re-circulation around the buildings and West Hill cause some mercury concentrations to be close to or above the STEL and TLV standards. The 20-ft stack decreases the area over which the exceedance occurs since the plume centerline is further from the receptors.

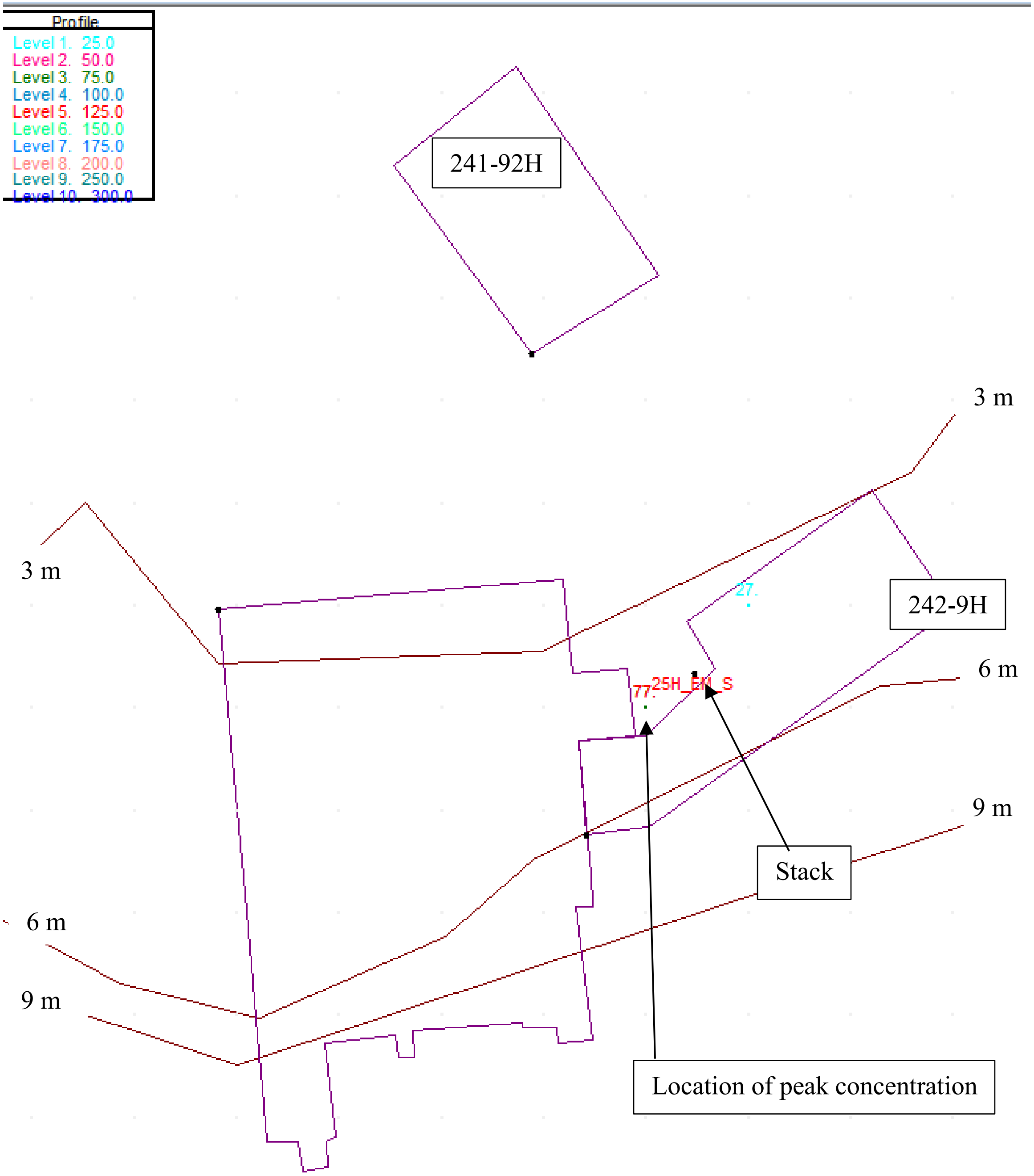

Figure 3-1. STEL Exceedances expressed as percent of standard for 25H Evaporator Building with a 1-foot stack and 1 mg/m^3 release concentration scenario. Numerical receptor values shown for values above 25 percent of STEL (>30 µg/m^3). Contours show values that exceed 25% of STEL. Brown lines are the elevation contours of the hill. Purple lines are the outlines of the buildings. True North is at the top of the page.

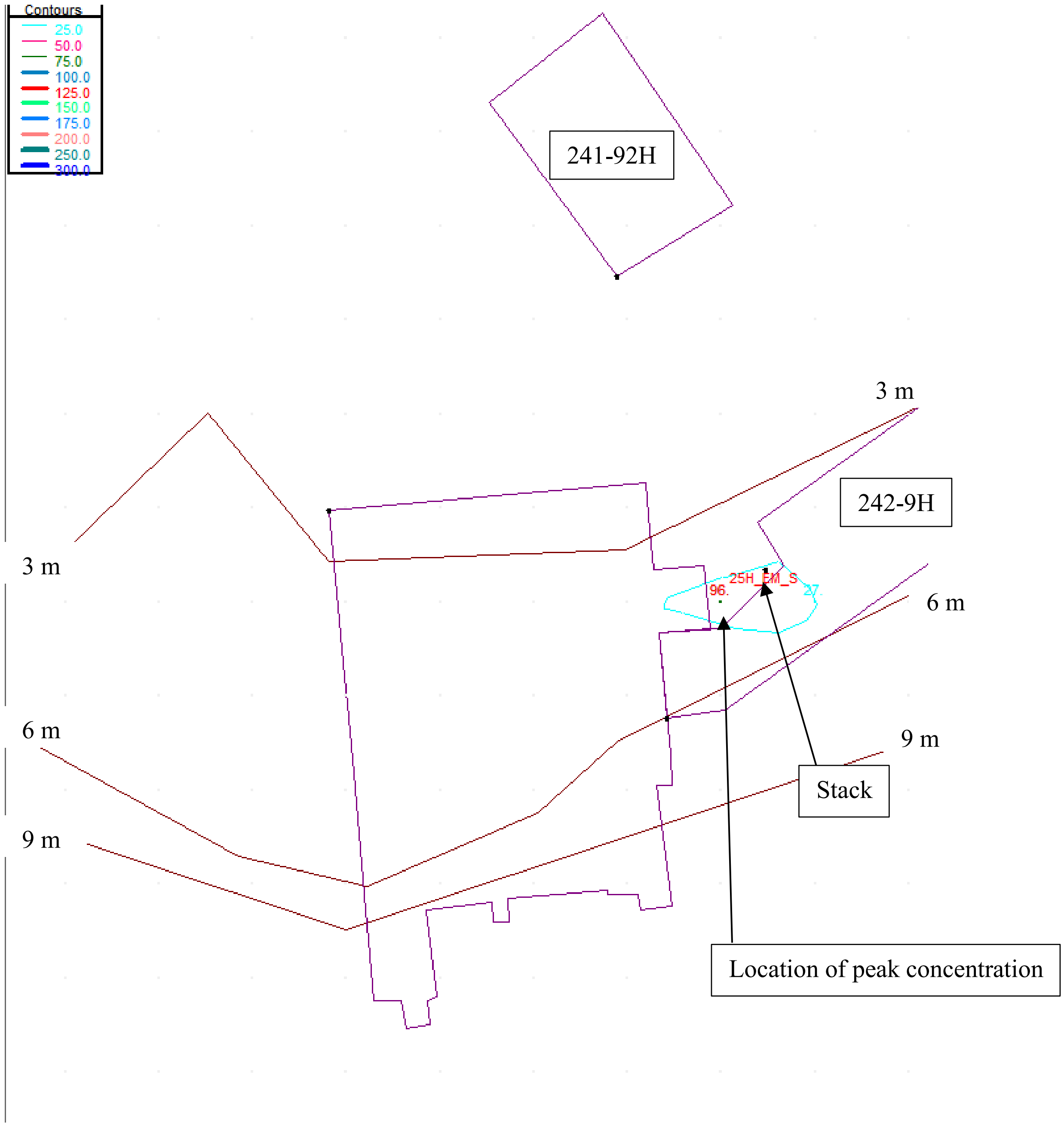

Figure 3-2. STEL Exceedances expressed as a percent of standard for 25H Evaporator Building with a 10-foot stack and 1 mg/m^3 release concentration scenario. Numerical receptor values shown for values above 25 percent of STEL (>30 µg/m^3). Contours show values that exceed 25% of STEL. Brown lines are the elevation contours of the hill, labeled in meters AGL. Purple lines are the outlines of the buildings. True North is at the top of the page.

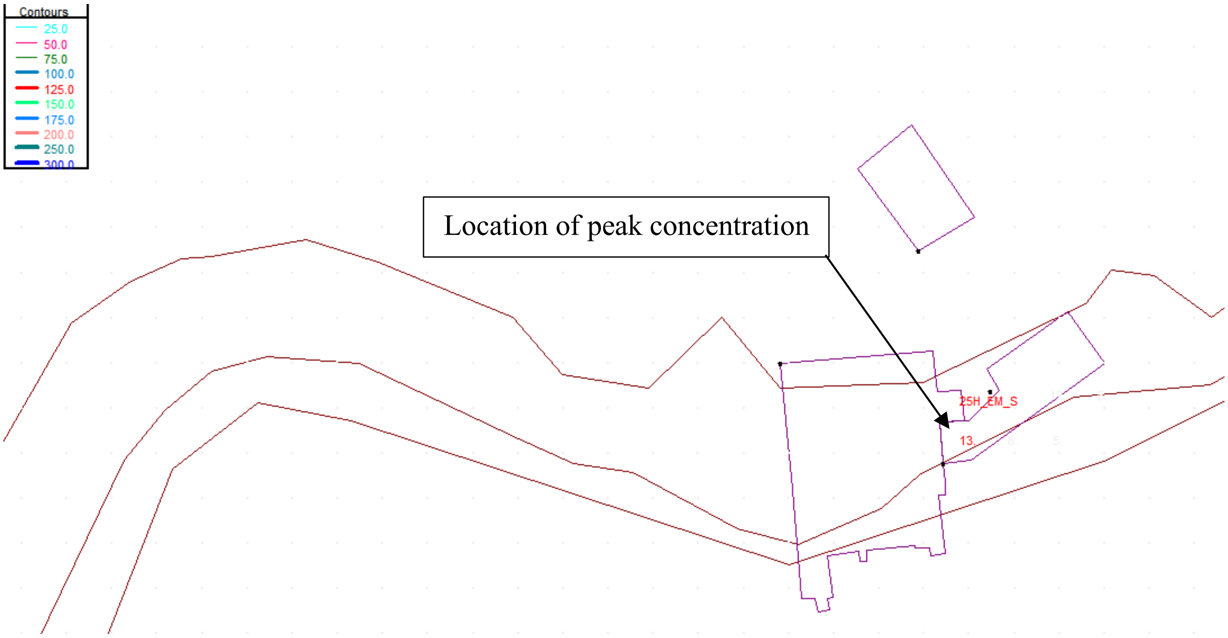

Figure 3-3. STEL Exceedances expressed as a percent of standard for 25H Evaporator Building with a 20-foot stack and 1 mg/m³ release concentration scenario. Numerical receptor values shown for values above 5 percent of STEL (>30 µg/m³). Purple lines are the outlines of the buildings. True North is at the top of the page.

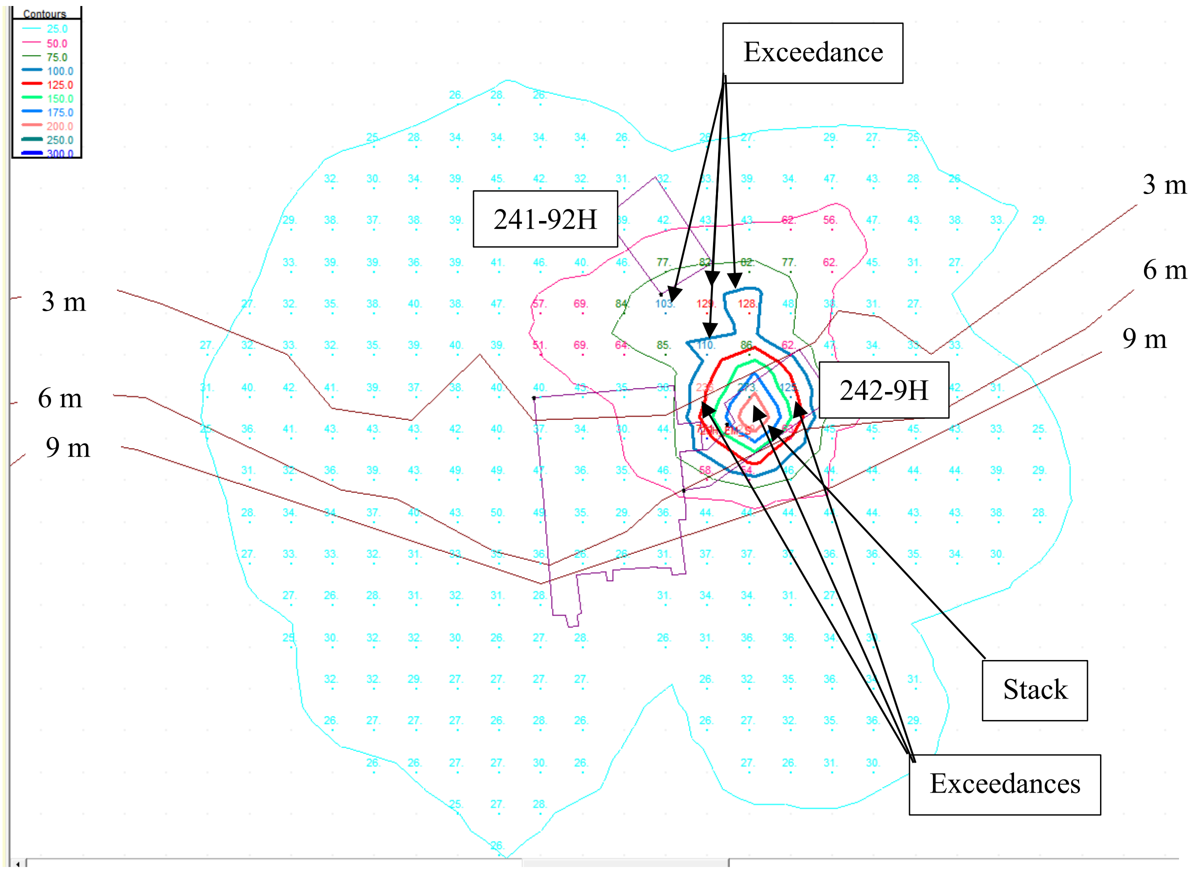

Figure 3-4. STEL Exceedances expressed as a percent of standard for 25H Evaporator Building with a 1-foot stack and 10 mg/m^3 release concentration scenario. Numerical receptor values shown for values above 25 percent of STEL (>30 µg/m^3). Contours show values that exceed 25% of STEL. Heavy contour lines show regions that exceed the STEL (100% or greater). Brown lines are the elevation contours of the hill, labeled in in meters AGL. Purple lines are the outlines of the buildings. True North is at the top of the page.

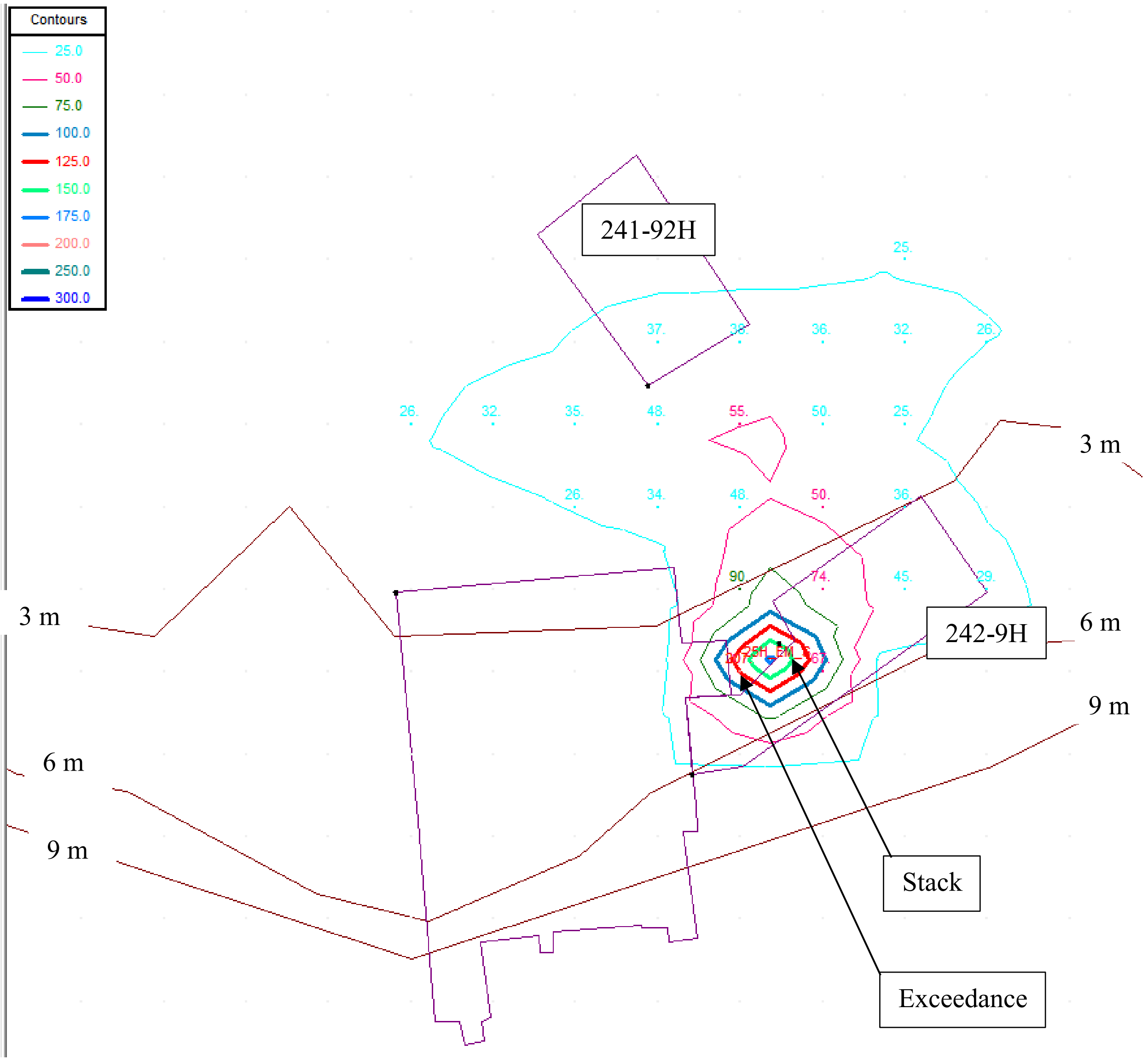

Figure 3-5. TLV Exceedances expressed as a percent of standard for 25H Evaporator Building with a 1-foot stack and 10 mg/m^3 release concentration scenario. Numerical receptor values shown for values above 25 percent of TLV (>25 µg/m^3). Contours show values that exceed 25% of TLV. Heavy contour lines show regions that exceed the STEL (100% or greater). Brown lines are the elevation contours of the hill, labeled in meters AGL. Purple lines are the outlines of the buildings. True North is at the top of the page.

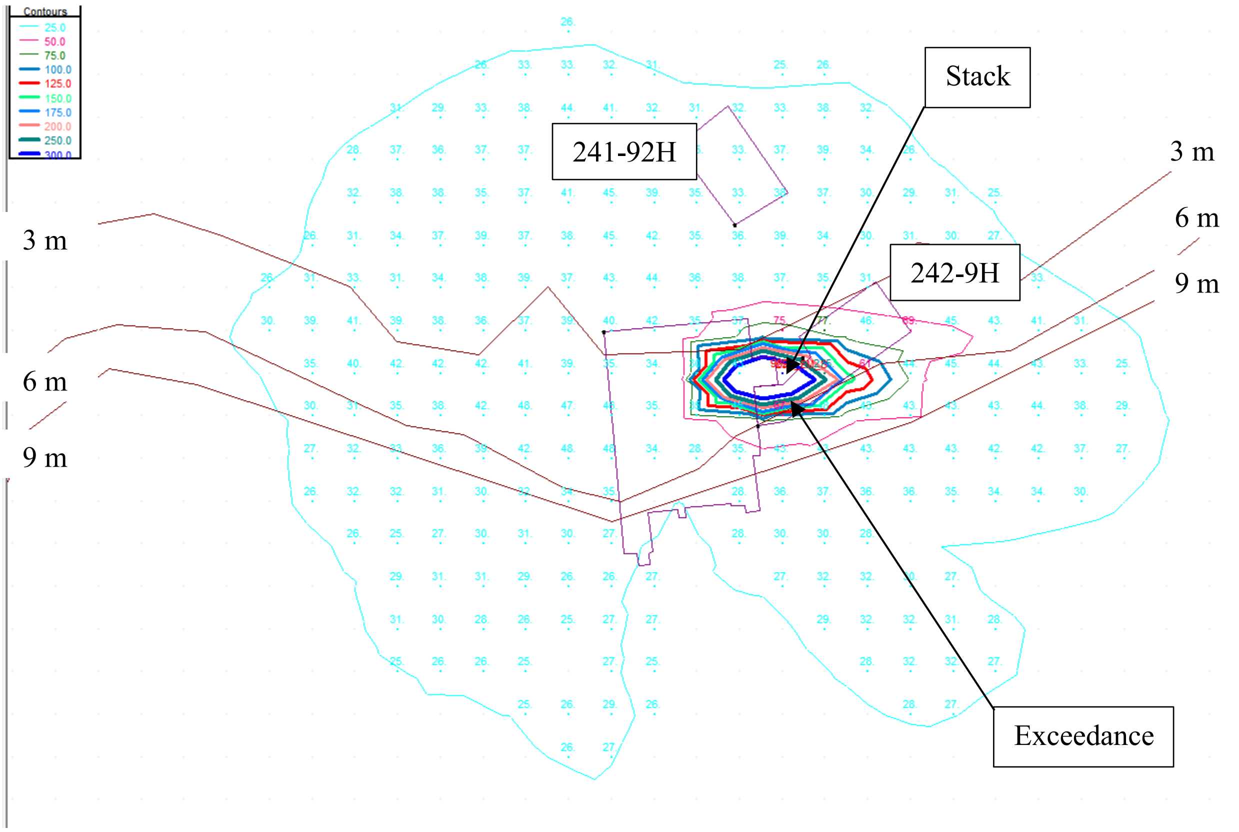

Figure 3-6. STEL Exceedances expressed as a percent of standard for 25H Evaporator Building with a 10-foot stack and 10 mg/m^3 release concentration scenario. Numerical receptor values shown for values above 25 percent of STEL (>30 µg/m^3). Contours show values that exceed 25% of STEL. Heavy contour lines show regions that exceed the STEL (100% or greater). Brown lines are the elevation contours of the hill, labeled in in meters AGL. Purple lines are the outlines of the buildings. True North is at the top of the page.

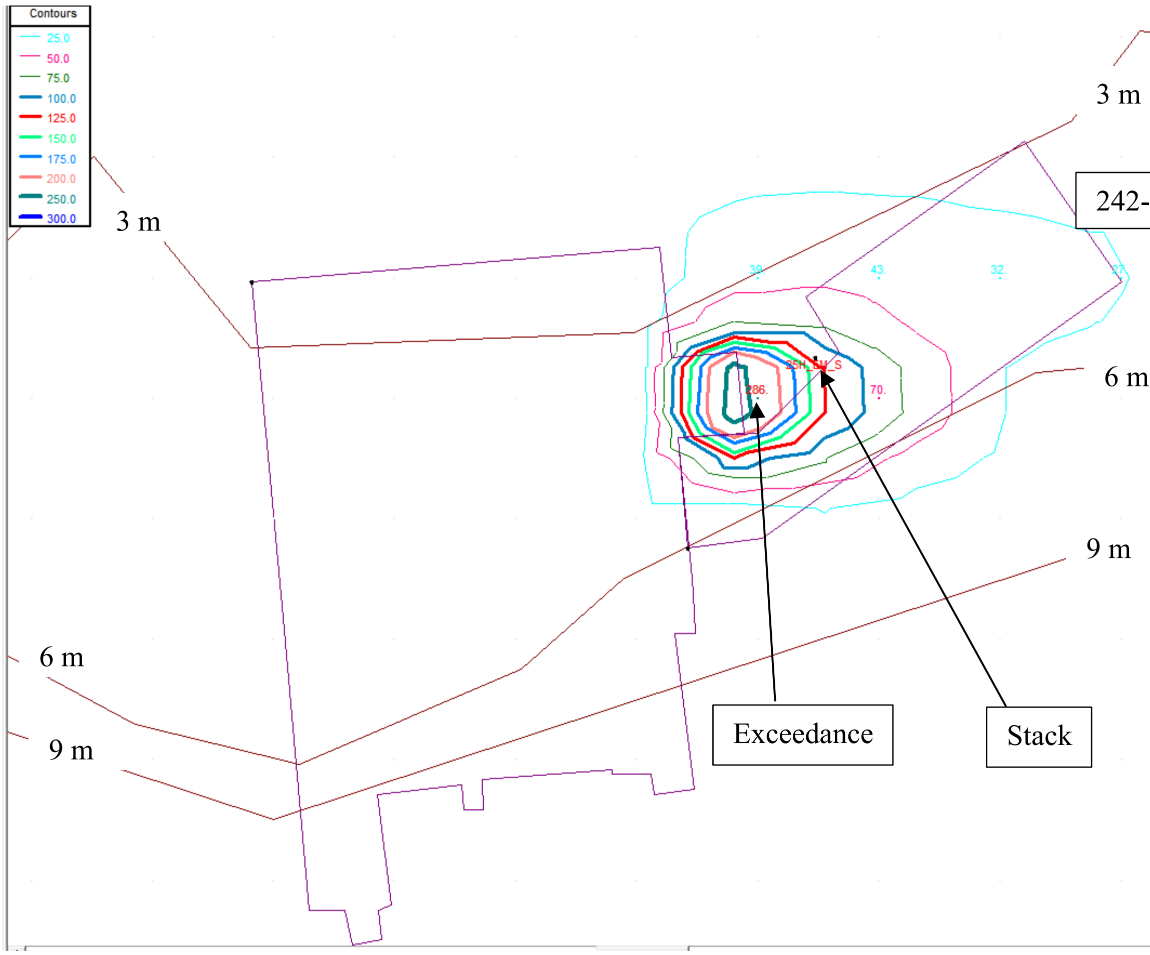

Figure 3-7. TLV Exceedances expressed as a percent of standard for 25H Evaporator Building with a 10-foot stack and 10 mg/m^3 release concentration scenario. Numerical receptor values shown for values above 25 percent of TLV (>25 µg/m^3). Contours show values that exceed 25% of TLV. Heavy contour lines show regions that exceed the STEL (100% or greater). Brown lines are the elevation contours of the hill, labeled in in meters AGL. Purple lines are the outlines of the buildings. True North is at the top of the page.

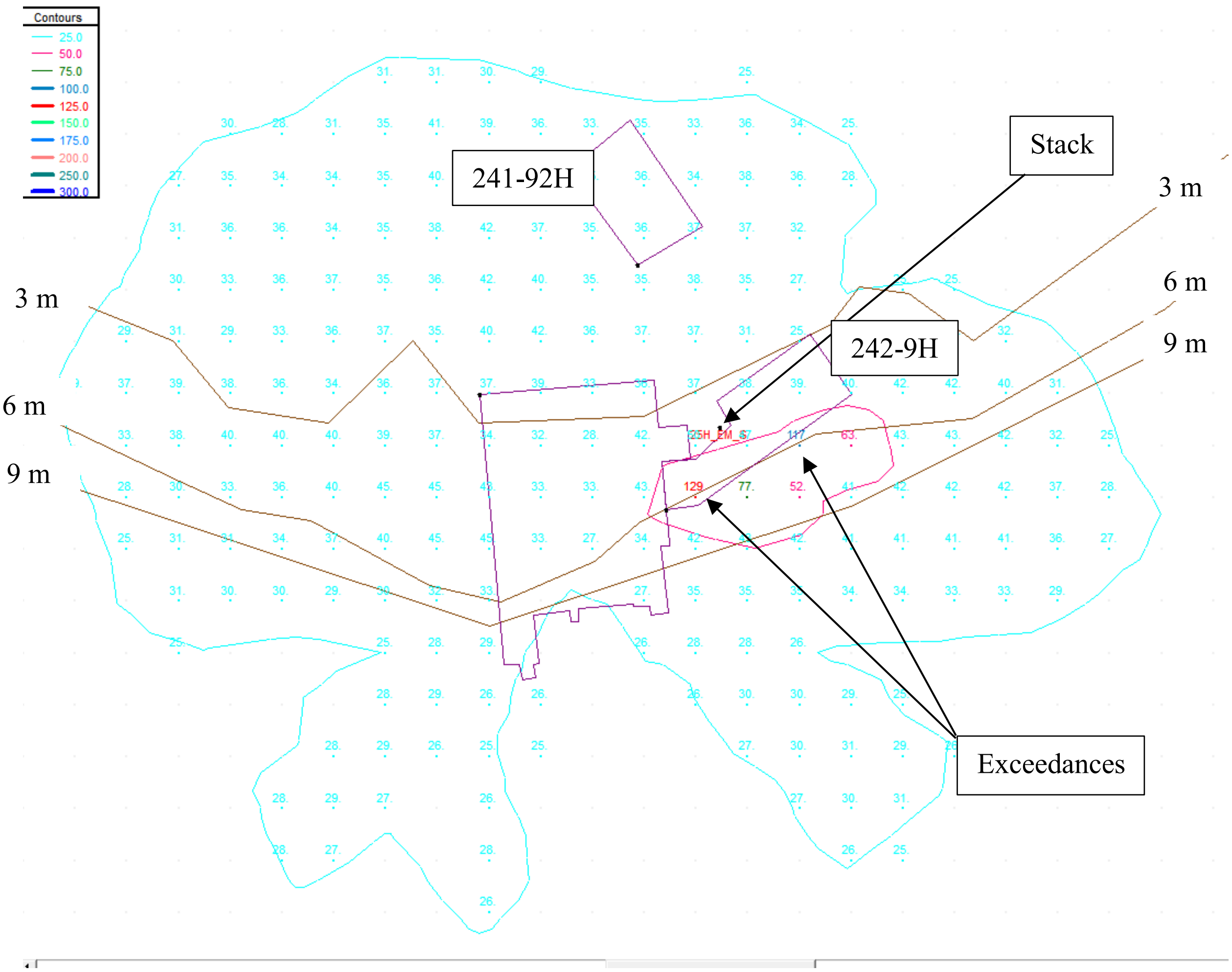

Figure 3-8. STEL Exceedances expressed as a percent of standard for 25H Evaporator Building with a 20-foot stack and 10 mg/m^3 release concentration scenario. Numerical receptor values shown for values above 25 percent of STEL (>30 µg/m^3). Contours show values that exceed 25% of STEL. Heavy contour lines show regions that exceed the STEL (100% or greater). Brown lines are the elevation contours of the hill, labeled in meters AGL. Purple lines are the outlines of the buildings. True North is at the top of the page.

5.0 References

1. Corey, G., Mercury Dispersion Modeling 242-25H Evaporator Portable Backup Ventilation, M-TTR-H-00098, Rev. 0.

2. Hanna, S.R., G.A. Briggs and R.P. Hosker, 1982: Handbook on Atmospheric Diffusion. DOE/TIC-11223, Department of Energy, 102 pp.

3. U.S. Environmental Protection Agency, Guideline on Air Quality Models, 40 Code of Federal Regulations, Part 51, Appendix W.

4. U. S. Environmental Protection Agency, AERMOD: Description of Model Formulation, EPA-454/R-03-004 (2004).

5. U. S. Environmental Protection Agency, User's Guide for the AMS/EPA Regulatory Model – AERMOD and Addendum, EPA-454/B-03-001 (2004).

6. Savannah River Nuclear Solutions, Software Quality Assurance Plan for the AMS/EPA Regulatory Model (AERMOD) Software Package, C-SQP-G-0076 (2017).

7. U. S. Environmental Protection Agency, User's Guide for the AERMOD Meteorological Preprocessor (AERMET) and Addendum, EPA-454/B03-002 (2004).

8. Westinghouse Savannah River Company, Quality Assurance of Meteorological Data, Procedure Manual 15.3, Meteorological Monitoring Procedures, NTSP T-113 (2002).

9. Viner, B.J. Summary of Data Processing for the 2007-2011 SRS Meteorological Database, SRNL-STI-2013-00268, Savannah River National Laboratory (2013).

10. Scott, K.E. AERMET Meteorological Files, 2007-2011, SRNL-L2200-2013-00045, Savannah River National Laboratory (2013).

11. Weinbeck, S.W. Mercury Dispersion Modeling and Purge Ventilation Stack Height Determination for Tank22H, SRNL-STI-2016-00453, Rev. 0

12. Weinbeck, S.W., Mercury Dispersion Modeling and Purge Ventilation Stack Height Determination for Transfer Facility HPP-7, SRNL-STI-2017-00745, Rev. 0.

13. SRS Explorer, http://egis4.srs.gov/srsexplorer/?app=srsroute, accessed on various dates 11/30/2017 through 12/6/2017.

14. McGaughtey, R, J., and S.E. Reutebuch, 2009: Savannah River Site 2009 LIDAR Project, FY09 Final Report., United States Department of Agriculture, Forest Service, 11pp

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