ATTACHMENT 16

ATTACHMENT 16A

AIR DISPERSION MODELING FOR OB/OD

ATTACHMENT 16B

HUMAN HEALTH RISK ASSESSMENT FOR OB/OD

ATTACHMENT 16A

AIR DISPERSION MODELING FOR OB/OD

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OB/OD AIR DISPERSION MODELING

This Attachment to the TEAD Permit has been organized based on the information requirements stated in the EPA Region IX Checklist for Technical Review of RCRA Part B Permit Applications for Subpart X Units (USEPA, 1992). Specifically, the major topics discussed are as follows:

- Volume and Physical and Chemical Characteristics of the Waste in the Unit
- Effectiveness and Reliability of Systems and Structures to Reduce or Prevent Emissions
- Operating Conditions at the Unit
- Atmospheric, Meteorological, and Topographic Characteristics at the Unit and Surrounding Areas
- Existing Air Quality (Toxic Pollutants and Other Sources of Contamination)
- Potential Impacts to Human Health and the Environment
- Potential Damage to Domestic Animals, Wildlife, Crops, Vegetation, and Physical Structures

Several other attachments to the Permit also provide significant input for the open burning and open detonation (OB/OD) air pathway screening assessment. For example, waste characteristics data have been based on data presented in Attachment 2. Other related attachments include 20-OB/OD Design and Operations, 22-OB/OD Treatment Effectiveness, 23-OB/OD Alternative Technologies and Waste Minimization, and 24-OB/OD Site Characterization.

The screening air quality assessments conducted for TEAD have been based on numerous conservative assumptions which overestimate potential OB/OD impacts but also serve to streamline the risk assessment process.

The screening assessment conducted for TEAD has accounted for the following potential air emission sources:

- OB/OD operations
  - Pretreatment
  - Treatment
  - Post-treatment
- RCRA onsite sources (i.e., the deactivation furnace to account for local (background) air quality.

Exposure pathways of potential concern are as follows:

- Inhalation,
- Ingestion, and
- Dermal contact.

Inhalation is considered the primary (direct) pathway of concern for air emissions for this screening assessment. Contaminants of potential concern identified in the screening air pathway assessment are further evaluated in Attachment 26-OB/OD Risk Assessment and Risk Management of the Permit. Evaluation of ingestion (via deposition and the food chain) and dermal contact pathways is warranted only if screening results indicate the potential to exceed chronic air toxic and carcinogenic criteria by significant amounts. Indirect pathway assessments are addressed in Attachment 16B.

1.0 VOLUME AND PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE WASTE IN THE UNITS

This section addresses the following:

- Materials to be treated in the OB/OD Unit,
- Treatment at SOP limits,
- Pretreatment emissions,
- OB/OD by-product emission factors,
- Calculation of OD crater ejecta emission factors,
- Summary of emissions, and
- Post-treatment emissions.

The following OB/OD operations were evaluated for the TEAD air pathway assessment:

- OB
- OD
- Static firing (SF) of rocket motors for demilitarization purposes is considered a suboperation of OB.

1.1 MATERIALS TO BE TREATED IN THE UNIT

The OB/OD Unit at TEAD is used for the demilitarization of waste munitions including explosives and propellants. Waste bulk propellants are treated by OB and waste explosives/munitions by OD. Waste rocket motors will be treated by SF to destroy the associated propellants. Additional information on candidate waste is provided in Attachment 2, *Waste Analysis Plan.*

Only energetic materials (which may contain other chemicals in trace amounts) will be treated by OB/OD at TEAD. Chemical composition data for candidate OB/OD treatment items are addressed in Attachment 2, *Waste Analysis Plan*.

1.2 TREATMENT AT SOP LIMITS

The SOPs for the OB/OD Unit at TEAD are discussed in Attachment 1 of this permit.

Treatment quantity scenarios used for the dispersion modeling and risk assessment input are summarized in Sect. 3-Operating Conditions at the Unit. Permit limits, however, will be based on risk assessment results and the TEAD risk management plan as discussed in Attachment 16B.

1.3 PRETREATMENT EMISSIONS

Potential pretreatment air emission sources associated with OB/OD operations are associated with vehicular traffic and, for OD only, excavation.

Waste energetics are delivered by truck to the OB/OD Unit. These vehicles travel at a low speed (generally 25 mph or less) on the unit; some off-road travel may be involved. The potential for fugitive dust from this vehicular traffic is considered insignificant relative to OD ejecta emissions as well as other local and regional fugitive dust sources (e.g., agricultural activities, dirt-road traffic, etc.). However, the pretreatment fugitive dust emissions have been accounted for in the indirect pathway assessment in Attachment 16B.

Pretreatment activities for OD include excavation of pits and placement of the waste energetic material items in the pit/detonation area. The potential for fugitive dust from the excavation has been considered in the wind erosion evaluation (which accounts for soil disturbances).

Waste energetic material items are unloaded from the delivery trucks and placed in burn pans for OB or pit/detonation areas for OD. The wastes are then treated, typically the same day. All materials treated by OB/OD are solids, and the low vapor pressure of the energetics treated results in a negligible potential for volatile emissions.

Generally only granular propellants are treated by OB that are too large to be subject to wind erosion. Some of these propellants are containerized within bags and thermally treated. The high sides of the burn pan prevent spillage during loading operations (as well as minimize ejecta during the burn process). OB operations are generally limited to wind speeds of greater than 3 mph (1.3 m/s) and less than 20 mph (8.9 m/s). If there is any accidental spillage during the loading operation, the material is recovered and placed in the pan.

Energetics treated by SF and OD are all encapsulated so that there are no fugitive particulate or volatile emissions.

1.4 TREATMENT EMISSION FACTORS

Potential emissions from the OB/OD Unit include products of combustion as well as products of incomplete combustion. Together these emissions are referred to in this document as combustion by-products. Energetic compounds are composed principally of carbon, hydrogen, nitrogen, and oxygen. The primary air emissions are products of combustion, which typically include the following:

- Carbon monoxide,
- Carbon dioxide,
- Nitrogen and nitrogen oxides,
- Water,
- Sulfur dioxide, and
- Methane.

Secondary air emissions include various products of incomplete combustion (which can include energetic materials, organic, and trace metals).

Direct measurement of air emissions on a site-specific basis is not practical because of the extremely violent nature and short-term duration of emissions from OB/OD treatment. The Army has conducted special tests (utilizing BangBox chambers) to characterize emissions from OB/OD for the Military Services (U.S. Army, 1992; U.S. Air Force, 1994). A summary of the BangBox test program as well as the BangBox OB/OD emission factors database and summaries are provided in Appendix 1.4-A, (U.S. EPA, February 1998).

A summary of the basis for selection of OB emission factors for TEAD is presented in Appendix 1.4-B.1. The BangBox database was processed to obtain average OB emission factors as a function of the following categories based on the type of energetic material items treated:

- Ammonium perchlorate based propellants
- Organic based propellants
- Ammonium perchlorate waste
- Dunnage
- Miscellaneous items

Only OB emission factors for ammonium perchlorate based propellants and organic based propellants are applicable to TEAD. A composite of these applicable OB emission factor data sets (based on the highest value of the two sets for each chemical) was used to calculate exposure concentrations for the direct air pathway. Lead emissions were evaluated separately for both the Federal/Utah ambient air quality standard and for Utah air toxics criteria. Since SF involves the treatment of propellants, the OB emission factors are also applicable to SF.

A summary of the basis for selection of OD emission factors for TEAD is presented in Appendix 1.4-B.2. The BangBox database was processed to obtain average OD emission factors as a function of the following categories based on the type of explosive waste and treatment configuration:

- Bulk explosives (e.g., TNT or RDX)
- Suppressed detonations (e.g., applicable to buried detonations)
- Encapsulated munitions items (e.g., bombs)
- Miscellaneous items (e.g., GCV-2A propellant-activated gas generator)

Only the first three OD categories are applicable to TEAD. A component of these OD emission factors data sets (based on the highest value of the tree sets for each chemical) was used as input to calculate exposure concentrations for the direct air pathway. Again, lead emissions were considered relative to both ambient air quality standards and toxic air criteria.

Cratering effects associated with OD operations result in the ejection of soil materials into the air, some of which remain suspended and form a dust cloud. Most of the larger soil particles (i.e., greater than 30 microns) fall back to the ground within three to five crater radii of the OD event.

PM10 soil ejecta emission factors have been used based on OD field tests conducted at Dugway Proving Ground (U.S. Army, 1992) and TEAD subsurface soil sampling results for the OD source zone (pits). An average emission factor for particulates of 5.7 lbs of PM10 ejecta per 1 lb of net explosive weight treated has been estimated based on data from the Dugway field tests. This PM10 emission factor was multiplied by the average TEAD OD subsurface soil concentration for each subsurface contaminant of potential concern (i.e., arsenic, beryllium, cadmium, chromium, 2,4,6-TNT and RDX) as identified in Attachment 19.

TEAD frequently uses a donor charge to ensure the most effective destruction of waste energetic material items during OD treatment. The typical quantity of donor charge used is equivalent to the NEW of the waste energetic material items to be treated by OD. Composition C-4 (a bulk explosive with a composition of 90% RDX and 10% plasticizer, such as polyisobutylene) is generally used for the donor charge. The use of a donor charge is not subject to RCRA, since the donor charge is being used for its intended purpose. However, for conservatism, emissions from the donor charge have been accounted for in the OB/OD air pathway assessment.

1.5 POST-TREATMENT EMISSIONS

Post detonation activities at an OD area involve some backfilling and leveling the pits/craters typically with equipment such as a bulldozer or a front-end loader. These backfilling operations are generally accomplished the same day as the OD event or soon thereafter. The potential for fugitive dust from this operation and associated vehicular road dust is minimal compared to the detonation cloud due to soil ejecta and local background fugitive dust sources (e.g., agricultural activities or travel on dirt roads). However, this potential post-treatment emission source has been accounted for in the fugitive dust evaluations (i.e., indirect pathway assessment) presented in Attachment 16B.

Past operations may have resulted in contamination of the surface soil in the vicinity of the OD area at TEAD. In addition, there is the potential that ejecta and fallout from current and future OD operations could result in soil contamination. Wind erosion of the contaminated surface soils, therefore, has been evaluated to determine offsite exposure. Surface soil sampling data from the unit (as presented and discussed in Attachment 19) have been used to characterize contamination levels at the OD area (i.e., the source term). Wind erosion is considered an indirect exposure pathway for OB/OD sources and is evaluated in Attachment 16B.

2.0 EFFECTIVENESS AND RELIABILITY OF SYSTEMS AND STRUCTURES TO REDUCE OR PREVENT EMISSIONS

OB/OD consistent pattern of high destruction efficiency for energetics is discussed in Attachment 21.

The effectiveness of treatment is discussed in this section for four operational phases:

- Pretreatment,
- OB treatment,
- OD treatment, and
- Post-treatment.

The following is a synopsis of treatment effectiveness for each of these phases.

2.1 PRETREATMENT

Pretreatment emissions at the unit are negligible compared to OB/OD treatment emissions as explained in Section 1.

2.2 OB/OD TREATMENT

Emission tests conducted by the U.S. Army confirm that OB/OD is a very efficient process for the treatment of energetic wastes (U.S. Army, 1992). The destruction and removal efficiency for energetics has been determined to be 99.9997% for OB, and a range of 99.725% (associated with TNT treatment) to 99.99994% for OD.

There are no systems or structures used to reduce or prevent air emissions from OB/OD. Open burning, including static firing (SF), occurs in burn pans (silos for SF) to prevent the release of residues to the ground.

2.3 POST-TREATMENT

Post-treatment emissions for OB are assumed to be insignificant compared to OB/treatment emission as discussed in Section 1.5.

Backfilling of the OD pit/craters has a minimal potential for fugitive dust and has been considered negligible compared to OD ejecta emissions and background sources. Potential wind erosion of the contaminated OD area soil surface is another potential post-treatment air emission source.

3.0 OPERATING CONDITIONS AT THE UNIT

Detailed information on TEAD OB/OD operations is provided in Attachment 1. In summary, OB is conducted in burn pans and SF in silos; OD is conducted in pits.

Section 3 includes information concerning the following:

- Allowable quantities of waste per unit,
- Operating time frames,
- Ambient air monitoring, and
- Meteorological conditions, requirements, and monitoring.

These operating conditions have been used as input to source scenarios evaluated for the air pathway assessment.

3.1 ALLOWABLE QUANTITIES OF WASTE PER UNIT

The following treatment quantities and operating conditions have been used to evaluate potential OB/OD impacts for the air pathway assessment and multi-media risk assessment:

- OB
  + 10 burn pans
  + 2 burns per day
  + 120 burn days per year
  + Maximum of 1,000 lbs per pan (NEW)
  + Annual NEW weight = 1,200 short tons
  + No wet propellants
  + No dunnage or liquid fuels
- OD
  + 19 pits (max.)
  + Buried (soil cover) depth of charge = 15 ft., if the NEW conducting donor exceeds 50 lbs
  + 2 detonation cycles per day
  + 120 detonation days per year
  + Maximum of 750 lbs per pit (NEW including donor)
  + Maximum of 1,547 lbs per pit (gross including donor)
  + Typical donor to waste ratio of 1:1
  + Donor may be C-4 or other munitions items
  + Annual NEW weight (including donor) = 1,710 short tons
  + Annual gross weight (including donor) = 3,528 short tons
- Static Firing

- Number of silos (max.) = 6
- Number of static firing cycles per day = 2
- Number of static firing days per year = 120
- Maximum gross weight per silo = 3,000 lbs
- Maximum NEW per silo = 1,500 lbs
- Maximum annual gross weight treated = 2,160 tons
- Maximum annual NEW weight treated = 1,080 tons

Permit limits based on risk assessment results are specified elsewhere in this permit.

TEAD routinely uses a donor charge (which typically is equivalent to the NEW of the waste energetic material item to be treated by OD) in addition to the treatment quantities identified above. Composition C-4 (90% RDX and 10% plasticizer, such as polyisobutylene) is generally used for the donor charge at TEAD. The use of a donor charge is not subject to RCRA, since the donor explosive is being used for its intended purpose. However, for conservatism, emissions from the donor charge have been included in the TEAD risk assessment.

3.2 OPERATING TIME FRAMES

TEAD does not conduct OB/OD treatment all year round because of operational constraints associated with winter weather conditions and access road conditions. The typical OB/OD treatment period is from April to November. TEAD limits OB/OD treatment to the daytime hours (i.e., within a half hour after sunrise to a half hour before sunset). OB/OD does not take place between dusk and dawn. OB/OD operations are not conducted during inclement weather and wet ground/road conditions which present a safety hazard.

Only one treatment event is conducted during a one-hour period. However, a treatment event may involve multiple burn pans for OB, multiple silos for SF, and multiple pits for OD. Treatment limits per event have been identified in Sect. 3.1.

3.3 AMBIENT AIR MONITORING

Available regional ambient air quality monitoring data are discussed in Sect. 5.2, Regional Background Air Quality.

The air pathway assessment for TEAD has been based on measured OB/OD emission rates (based on field and chamber tests conducted by the U.S. Army for the Military Services) in conjunction with the conservative application of an OB/OD-specific dispersion model developed by the U.S. Army and accepted by U.S. EPA (U.S. Army, 1992; U.S. Air Force, 1994; U.S. EPA, March 1998; U.S. Army, July, 1997). These tests have DOD-wide applicability and negate the need for installation-specific monitoring programs.

In addition, air monitoring of OB/OD releases is a technical challenge. It is difficult to design a cost-effective air monitoring network for instantaneous and intermittent sources because of plume rise and limited plume size and duration factors (i.e., the probability of detecting the release cloud is low). In addition, standard regulatory guidance is not available for routine air sampling and analysis for many of the potential energetic material constituents and combustion products of interest.

In summary, TEAD does not propose to conduct ambient air monitoring considering such factors as utility, feasibility, and practicability. The TEAD air pathway assessment has been based on a comprehensive OB/OD emission measurement test program conducted by the Army which, used in conjunction with dispersion modeling, negates the need for site-specific monitoring.

3.4 METEOROLOGICAL CONDITIONS, REQUIREMENTS, AND MONITORING

Meteorological limits for OB/OD operations at TEAD are summarized in Table 1. In addition, routine OB/OD operations are only conducted during daytime conditions. Therefore, these limits indicated in Table 3.4-1 generally preclude the conduct of OB/OD operations during surface based inversion conditions. The lower wind speed limit for OD (compared to OB) is based on noise mitigation measures. However, for this air pathway assessment an upper limit of 20 mph was used for all OB/OD operations to conservatively evaluate potential inhalation exposures. Also, the air pathway assessment has been based on sustained wind speeds (commensurate with exposure durations of one-hour or greater) instead of gusts. Meteorological information to support OB/OD operation at TEAD are obtained from the following:

- Atmospheric Sciences Division (ASD), Building 5108, Deseret Chemical Depot (DCD) (ext. 4320);
- Salt Lake City National Weather Service; or
- Internet (http://www.nimbo.wrh.noaa.gov/saltlake).

Two 10-m meteorological towers (measurements to include wind speed and duration) are planned to be in place at the OB/OD Unit and operational by Fall 1998. Real-time meteorological data from these towers will be used by TEAD to better determine if wind conditions are favorable for OB/OD operations.

Table 1 Meteorological limits for OB/OD operations

Parameters	TEAD requirement
Wind speed for OB	3-20 mph (1.3-8.9 m/s) gusts to 30 mph (13.4 m/s)
Wind speed for OD	3-15 mph (1.3-6.7 m/s) gusts to 30 mph (13.4 m/s)
Cloud cover	< 80%
Precipitation	< 75% chance
Thunderstorm/electrical storm	< 50% chance
Clearing index	> 500
Visibility	1 mile

[a]Cloud cover and ceiling limits are in conjunction with each other. Operations shall not be carried out when the cloud cover is greater than 80% and the cloud ceiling is less than 2,000 ft.

4.0 ATMOSPHERIC, METEOROLOGICAL, AND TOPOGRAPHIC CHARACTERISTICS AT THE UNIT AND SURROUNDING AREAS

The following conditions at TEAD are discussed in this Section.

- Climate,
- Frequency of inversions,
- Lake and pond evaporation,
- Annual and 24-hr rainfall data,
- Seasonal temperatures,
- Relative humidity,
- Wind rose, and
- Topography.

Following is information on each of these topics relevant to TEAD.

4.1 CLIMATE

TEAD normally has a semi-arid continental climate with four well-defined seasons. Summers are characterized by hot, dry weather. Winters are cold but not severe. Precipitation is generally light during the summer and early fall but is heavy in the spring, while storms from the Pacific Ocean are moving through the area more frequently than any other season of the year (NOAA, 1983).

TEAD is located within the Great Salt Lake Basin. The Great Salt Lake Basin forms a large, generally enclosed air basin of approximately 7,500 square miles. The Great Salt Lake is a shallow body of water covering approximately 2,000 square miles, large enough to create a classic sea breeze circulation. Local wind circulation patterns are affected by the uneven heating and cooling of land and water surfaces. Wind direction tends to be toward the lake at night when the land is warmer than the lake surface and away from the lake during the day when the land is cooler than the lake surface. For the Tooele Valley and TEAD, this results in a tendency for northerly winds during the day and southerly winds at night. Local topography also is a major characteristic influence for these wind flows. This local wind circulation is the predominant wind factor in the area (U.S. Army, August, 1995).

4.2 FREQUENCY OF INVERSIONS

Surface-based inversions generally occur at night. However, OB/OD operations at TEAD are only allowed during the daytime between sunrise and sunset (generally associated with neutral and unstable conditions). Surface-based inversions are generally associated with stable dispersion conditions. Data collected at the Salt Lake City NWS from November 1996 through November 1997 (concurrent period for available wind rose data presented in Sect. 4.7) indicate that on an annual basis, unstable conditions (Stability A, B, and C) occur approximately 24% of the time, neutral conditions (Stability D) approximately 44%, and stable conditions (Stability E, F, and G) approximately 32%, based on 24-hr observations.

Mixing height (as limited by the presence of elevated inversions) are not considered a major meteorological factor for low-level releases such as the OB/OD cloud at TEAD. The mean annual morning mixing height is about 300-m (ranging from 200-m in summer and autumn to 400-m in spring). The mean afternoon mixing heights annual average is 2,400-m (ranging from 1,000-m in winter to 3,800-m in summer) (USEPA, 1972).

4.3 LAKE AND POND EVAPORATION

Average annual lake evaporation for the TEAD area is about 42 in. (NOAA, 1983). The potential average annual pan evaporation is within the 48-64 in. range (80 percent of this annual value is associated with the April through October period (USDOI, 1970). These evaporation rates are not significant for this assessment, since the TEAD OB/OD treatment operations do not involve liquids.

4.4 ANNUAL AND 24-HR RAINFALL DATA

The monthly average temperature and precipitation data from calendar years 1951 through 1993 from the Salt Lake City NWS station for TEAD are shown in Table 4.4.1 (NOAA, 1994). The average precipitation rate is a significant factor when assessing the potential for infiltration of contaminants. Heavy rainfall events can contribute to overland runoff conditions (which could be a potential contamination migration pathway). Precipitation distribution throughout the year is rather uniform; however, the greatest intensities are confined to the summer and early autumn months. The annual precipitation total is approximately 15-16 in.. The highest 24-hr precipitation was reported at 2.41 in. and occurred in April 1957. Snowfall averages under 60 in. a year. The maximum monthly snowfall was 50.3 in. and occurred in January 1993 (NOAA, 1995).

4.5 SEASONAL TEMPERATURES

Temperature is not a major OB/OD operational factor. Energetic wastes treated are in casings or in other forms not subject to volatilization. Monthly average temperatures range from a minimum of 28.0°F in January to a maximum of 77.3°F in July (see Table 4.4-1). The mean annual temperature is 51.8°F (NOAA, 1994).

4.6 RELATIVE HUMIDITY

Humidity is not a significant meteorological parameter for OB/OD operations or impacts. Salt Lake City NWS' data indicate the mean annual humidities range from 75% during the night/early morning hours to 50-51% during the early afternoon hours (NOAA, 1994).

4.7 WIND ROSE

A wind rose indicating the wind direction and wind speed distribution based on Salt Lake City NWS data during the period 1992 to 1996 (most recent available data) is shown in Figure 2. A wind rose based on available onsite data for the period November 1996 - November 1997 (most recent available data) is shown in Fig. 4.7-2. The current onsite TEAD meteorological station is located in the northeastern portion of the installation (see Figure 3). Two meteorological monitoring stations at the OB/OD Unit are planned to become operational during the fall of 1998. A listing of the annual wind direction frequencies for these two data sets are presented in Table 1 and seasonal summaries in Table 2. Prevailing winds are from the south-southeast and south (with the highest frequencies associated with the TEAD onsite data). Annual average wind speed for TEAD and Salt Lake City are summarized in Table 3. Wind speeds are somewhat higher at TEAD. Worst-case wind conditions were assumed to evaluate potential short-term exposures. Average wind speed conditions have also been accounted for in the dispersion modeling of long-term exposures for TEAD. Wind direction frequencies have also been used to evaluate long-term exposures.

Table 1. Monthly average temperatures and precipitations at Salt Lake City NWS[a]

Month	Temperature (°F)	Precipitation (in)
January	28.0	1.20
February	33.3	1.32
March	41.1	1.84
April	49.4	1.98
May	58.4	1.82
June	68.4	0.87
July	77.3	0.63
August	75.5	0.86
September	65.3	0.95
October	53.2	1.43
November	40.4	1.37
December	31.2	1.34

[a]30-year period of record from 1964 to 1993.
Source: NOAA, 1994.

4.8 TOPOGRAPHY

The location of TEAD is illustrated in Figure 3 and site as well as local topography in Figures 4 and 5, respectively. The installation is located in Tooele Valley, which is bounded on the west by the Stansbury Mountains, on the east by the Oquirrh Mountains, on the south by South Mountain, and on the north by the Great Salt Lake. Elevations in the region range from 11,031 ft above sea level at Deseret Park in the Stansbury Mountains, to about 4,200 ft above sea level at the edge of the Great Salt Lake.

Figure 2   Salt Lake City wind rose.

Figure 3 TEAD wind rose.

Figure 4 Location of the current onsite meteorological station at TEAD.

Table 2 Annual wind direction frequencies (percent).

Wind direction[a]	SLC[b]	TEAD[c]
N	11.17	11.37
NNE	2.56	4.44
NE	1.12	2.57
ENE	0.68	1.99
E	1.33	2.25
ESE	3.16	2.21
SE	12.99	4.25
SSE	16.47	28.77
S	16.39	22.29
SSW	2.70	3.61
SW	1.75	1.66
WSW	1.74	1.09
W	3.91	1.18
WNW	4.65	1.36
NW	5.47	3.54
NNW	7.78	7.24
CALM	6.15	0.18

[a]Wind direction is the direction from which the wind is flowing.
[b]January 1992 - January 1996
[c]November 1996 - November 1997
SLC=Salt Lake City NWS

Table 3 Seasonal wind direction frequencies (percent).

Wind direction[a]	Spring (Mar.-May)		Summer (Jun.-Aug.)		Fall (Sep.-Nov.)		Winter (Dec.-Feb.)	
	SLC	TEAD	SLC	TEAD	SLC	TEAD	SLC	TEAD
N	11.66	14.58	13.37	14.04	10.12	9.20	9.41	7.41
NNE	3.00	6.07	2.65	3.94	2.29	3.74	2.22	3.98
NE	1.22	2.72	1.03	1.54	1.12	2.30	1.09	3.75
ENE	0.71	2.13	0.80	1.36	0.70	1.77	0.54	2.69
E	1.37	2.22	1.39	2.94	1.32	1.53	1.24	2.27
ESE	3.17	1.54	2.85	1.99	3.65	2.40	3.03	2.92
SE	11.55	3.58	11.60	4.48	16.55	4.94	12.80	4.03
SSE	16.41	28.76	18.18	24.64	17.11	32.17	14.38	29.72
S	16.47	15.94	18.43	25.54	14.80	23.63	15.76	24.17
SSW	2.65	3.85	2.95	4.26	2.36	3.07	2.80	3.24
SW	1.81	2.08	1.76	1.99	1.39	1.20	2.00	1.34
WSW	1.92	0.91	1.37	1.18	1.32	0.91	2.25	1.34
W	4.46	1.31	2.47	1.36	3.18	0.96	5.30	1.06
WNW	5.38	1.40	3.07	1.09	4.16	1.29	5.77	1.67
NW	5.66	4.30	5.69	2.49	5.90	3.60	4.68	3.80
NNW	7.95	8.47	8.92	7.16	8.13	7.09	6.19	6.20
CALM	4.61	0.14	3.49	0.00	5.92	0.19	10.54	0.42

[a]Wind direction is the direction from which the wind is flowing.
SLC=Salt Lake City NWS

Table 4 Annual average wind speeds.

Period	SLC normal[a]	SLC[b]	TEAD[c]
24-hrs	8.8 mph (3.9 m/s)	8.4 mph (3.8 m/s)	10.9 mph (4.9 m/s)
Daytime	NA	9.2 mph (4.1 m/s)	11.0 mph (4.9 m/s)

[a]1964-1993 (NOAA, 1994)
[b]January 1992 - January 1996
[c]November 1996 - November 1997
SLC=Salt Lake City NWS
NA=Not available

Figure 6 TEAD location.

Figure 7 TEAD site topography.

Figure 8 TEAD local topography.

The average slope of the land surface at TEAD ranges from about 3% near the base of the mountains and flattens to about 1% at the north-central boundary of the installation. Elevations range from about 5,250 ft along the southern boundary (in the vicinity of the OB/OD Unit) to about 4,430 ft along the northern boundary of TEAD.

5.0 EXISTING AIR QUALITY (TOXIC POLLUTANTS AND OTHER SOURCES OF CONTAMINATION)

Section 5 provides information regarding the following:

- Regional emission sources,
- Regional background air quality, and
- TEAD background air quality.

Background air quality associated with RCRA regulated sources at TEAD has also been addressed in this air pathway assessment.

5.1 REGIONAL EMISSION SOURCES

Regional emission sources in Tooele County include agricultural operations, light industrial facilities, transportation, and residential activities. Contributions from these sources relative to TEAD background conditions are considered minor and have been accounted for in the regional air quality monitoring data (as presented in Section 5.2).

Air emissions from the chemical agent demilitarization operations at the Deseret Chemical Depot (DCD) have been evaluated in a risk assessment conducted by a contractor for the Utah Department of Environmental Quality. (UDEQ, February 1996). DCD is located about 17 miles south of TEAD. A summary of risk assessment results is presented in Table 5. These results include emissions from the Tooele Chemical Demilitarization Facility (TOCDF) and the Chemical Agent Munitions Disposal System (CAMDS) based on a 10-year period of operations. Table 5 also includes risk values which have been estimated for potential receptors in the vicinity of TEAD and Grantsville (as well as the Seabase prawn farm), which will be used to characterize regional background conditions for the TEAD risk assessment.

5.2 REGIONAL BACKGROUND AIR QUALITY

Most of Tooele County is in compliance with all federal ambient air quality standards. Portions of the Oquirrh Mountains at elevations above 5,600 ft are designated as a sulfur dioxide nonattainment area. This nonattainment area (which includes portions of Salt Lake County and Tooele County) was established due to emissions from a copper smelter in Salt Lake County. TEAD is outside the boundaries of the designated sulfur dioxide nonattainment area.

The Utah Department of Air Quality operates an air quality monitoring station at Grantsville. Available data (sulfur dioxide and PM10 data for 1993 and 1994) are summarized in Tables 8 and 9. There was no exceedance of sulfur dioxide and only one exceedance for PM10 at

Table 8. Summary of risk assessment results for DCD emission (TOCDF and CAMDS) for 10 years of operations.

Receptor	Locations	Hazard index	Cancer risk
Adult Resident	Maximum concentration location adjacent to DCD	0.21[a]	1E-6[a]
Adult resident	Vicinity of TEAD and Grantsville	(0.002)[b]	(1E-9)[b]
Child resident	Maximum concentration location adjacent to DCD	0.21[a]	2E-6[a]
Child resident	Vicinity of TEAD and Grantsville	(0.00003)[b]	(3E-9)[b]
Farmer/rancher	Vicinity of DCD	0.09[a]	9E-6[a]
Farmer/rancher	Vicinity of TEAD and Grantsville	(0.00003)[c]	(3E-9)[c]
Subsistence fisher	Seabase prawn farm	0.002[a]	5E-8[a]

[a]Based on data included in UDEQ, February 1996.

[b]Interpolated based on data included in UDEQ, February 1996. Risk results at the maximum concentration location near DCD were multiplied by a factor of 1E-3.

[c]Interpolated based on data included in UDEQ, February 1996. Risk results at the farm/ranch location in the vicinity of DCD were multiplied by a factor of 3E-1.

Table 9 Summary of sulfur dioxide monitoring data, Grantsville, UT.

	Annual Mean		24-Hours			3-Hours	
Year	**Standard**	**Measured**	**Standard**	**Highest**	**Second Highest**	**Standard**	**Highest**
1994	0.03 ppm (80 $\mu g/m^3$)	0.001 ppm (3$\mu g/m^3$)	0.141 ppm (365 $\mu g/m^3$)	0.003 ppm (8 $\mu g/m^3$)	0.003 ppm (8$\mu\mu g/m^3$)	0.50 ppm (1,300 $\mu g/m^3$)	0.009 ppm (23 $\mu g/m^3$)
1993	0.03 ppm (80 $\mu g/m^3$)	0.001 (3$\mu g/m^3$)	0.14 ppm (365 $\mu g/m^3$)	0.004 ppm (11 $\mu g/m^3$)	0.003 ppm (8$\mu g/m^3$)	0.50 ppm (1,300 $\mu g/m^3$)	0.011 ppm (29 $\mu g/m^3$)

Table 10 Summary of PM 10 monitoring data, Grantsville, UT.

	Annual Mean		24-Hours		
Year	Standard	Measured	Standard	Highest	Second Highest
1994	50 $\mu g/m^3$	26 $\mu g/m^3$	150 $\mu g/m^3$	133 $\mu g/m^3$	98 $\mu g/m^3$
1993	50 $\mu g/m^3$	26 $\mu g/m^3$	150 $\mu g/m^3$	186 $\mu g/m^3$	75 $\mu g/m^3$

Table 11 Summary of maximum annual air concentrations for the TEAD deactivation furnace.

	Annual concentrations ($\mu g/m^3$)		
Chemical	1-5 km (maximum concentration)	6-10 km[a] (North installation boundary-Grantsville)	20 km[b] (Seabase prawn farm)
Arsenic	4.2E-6	2.5E-6	8.4E-8
Beryllium	1.2E-7	7.2E-8	2.4E-9
Cadmium	4.0E-5	2.4E-5	8.0E-7
Chromium	1.4E-4	8.4E-5	2.8E-6
Lead	6.1E-3	3.7E-3	1.2E-4

[a]A factor of 0.6 was used to adjust maximum annual concentrations (i.e., the results in the 1-5 km column) to obtain the 6-10 km estimates in the vicinity of the northern installation boundary and Grantsville based on available dispersion modeling data (U.S. Army, April 1994).

[b]A factor of 0.02 was used to adjust maximum annual concentrations (i.e., the result in the 1-5 km column) to obtain the 20 km estimates (for the Seabase prawn farm) north of TEAD based on available dispersion modeling data (US Army, April 1994).

Figure 9

Grantsville. However, the PM10 exceedance is attributed to “exceptional events” (i.e., road repair and/or high winds).

5.3 TEAD BACKGROUND AIR QUALITY

Pursuant to the Implementation Plan, the RCRA deactivation furnace has been the only onsite source used to characterize background air concentrations at TEAD (US, Army, June 1997). Other onsite sources are considered insignificant relevant to the OB/OD air pathway assessment and risk assessment. The deactivation furnace at TEAD is located approximately 2.5 km east-northeast of the OB/OD Unit (see Figure 10). Air concentrations for the deactivation furnace have been based on available modeling results pursuant to the Implementation Plan (US Army, April 1994). These results (maximum and average concentrations) are summarized in Table 10.

6.0 POTENTIAL IMPACTS TO HUMAN HEALTH AND THE ENVIRONMENT

This section discusses the following OB/OD air pathway assessments for TEAD:

- Screening assessment (summary of TEAD assessment)
  - + Types and quantities of waste
  - + Number of fabricated devices, burn areas, or detonation pits involved in a burn or detonation event and the number of events per day
  - + Total amounts of each pollutant emitted per event and the total combined amounts of pollutants emitted per year
  - + Duration of release
  - + Description of emission plume to the atmosphere
  - + Dispersion modeling
  - + Comparison of concentrations with existing toxic air pollution standards
  - + Risk analysis
- Detailed assessment (evaluation of applicability to TEAD)
  - + EPA-approved dispersion models
  - + Detailed network of receptor points
  - + Detailed assessment of exposed population
  - + Noninhalation pathways
  - + Estimates of individual excess lifetime cancer risk

6.1 SCREENING ASSESSMENT

The screening assessments have been based on a series of conservative assumptions, OB/OD emissions test results, and air dispersion models.

A combination of emission factors, treatment quantities, and dispersion factors has been used to predict concentrations for each emissions constituent and receptor of concern. These concentrations have been compared to health criteria for various exposure periods (from 1-hr to annual).

Table 9 Summary of treatment quantity scenarios, short tons NEW

Time period	OB	OD[a]	SF
1 hr[b]	5.0	7.125	4.5
3 hr	10.0	14.25	9.0
8 hr	10.0	14.25	9.0
24 hr	10.0	14.25	9.0
Quarterly	400.0	570.0	360.0
Annual	1,200.0	1,710.0	1,080.0

[a]Includes donor charge quantities. A typical donor to waste NEW ratio is 1:1.

[b]TEAD only conducts one treatment event (i.e., only OB, OD, or SF, but not more than one) per hour. However, any treatment event may involve multiple pans (for OB), pits (for OB), or silos (for SF).

Table 10 Treatment device scenarios evaluated

Treatment type	Treatment Device	Number of devices per treatment event	Number of treatment events per treatment day	Number of treatment days per year
OB	Burn pan	10	2	120
OD	Detonation pit	19	2	120
SF	Silo	6	2	120

6.1.1 Types and Quantities of Waste

The types of wastes treated by OB/OD operations at TEAD have been identified and discussed in Attachment 2, *Waste Analysis Plan.* The types and quantities of wastes to be treated by OB/OD have also been specified in Section. 1 of this Attachment. A summary of treatment quantity scenarios used for this air pathway assessment is presented in Table 12.

6.1.2 Number of Fabricated Devices, Burn Areas, or Detonation Pits Involved in a Burn or Detonation Event and the Number of Events per Day

A summary of treatment device scenarios evaluated in the OB/OD air pathway assessment is presented in Table 13.

6.1.3 Total Amounts of Each Pollutant Emitted per Event and Total Combined Amounts of Pollutants Emitted per Year

OB/OD emission factors and their basis have been discussed in Sections 1.3 to 1.5.

Contaminant-specific OB/OD emission quantities per event and annual amounts are provided in Appendix 6.1.3-A. These emission quantities were determined by multiplying emission factors (discussed in Section. 1.3 to 1.5) by associated treatment quantities (as presented in Table 10 and 11).

6.1.4 Duration of Release

A summary of OB/OD duration of release information is summarized in Table 12. OB events at TEAD are considered to be a quasi-instantaneous/quasi-continuous source with a release duration of 60 sec., for a 1,000 lb NEW treatment event. This burn rate was based on tests conducted by TEAD for bulk propellants (U.S. Army, March 1996). SF treatment release may range from 1 to 10 min. However, releases of 15 min. or less are still considered to be quasi-instantaneous/quasi-continuous for Open Burn/Open Detonation Dispersion Model (OBODM) modeling purposes.

6.1.5 Description of Emission Plume to the Atmosphere

The OBODM has been used to simulate OB, OD, and SF release (U.S. Army, July 1997). This model has been specifically developed for OB/OD/SF sources. Source scenario assumptions used for this OBODM are summarized in Table 13.

OB was modeled as a line source. Pursuant to the OBODM user's guidance, the OD source was also considered as a line source. The SF silo release was considered to be a volume source. Only one treatment device (i.e., pan, pit, or silo) was modeled. However, the results were scaled to repeat the total number of treatment devices used for each source scenario evaluated.

The OBODM includes a data base of candidate energetics for OB/OD treatment. The data base includes the heat content of the energetic (needed for cloud height calculation) and emission
40%

factors for some pollutants. A double base propellant was selected to represent a typical energetic treated by OB and SF. Double base propellants consist of about 60% nitrocellulose and
nitroglycerin. Composition B was selected to represent a typical OD treatment energetic. Composition B is comprised of approximately 60% RDX and 40% TNT. The heat content for these example energetics also approximates an average considering the range of values for other candidate energetics. The default emission factors for CO_2 were used for Composition B and the double base propellant to obtain dispersion factors. These dispersion factor results were subsequently adjusted to represent an emission factor of 1.0 (mass emitted per NEW treated). The modified dispersion factors were then used with BangBox emission factors (as discussed in Section 1.4) to estimate air concentrations.

Table 14 OB/OD duration of release

Treatment type	Duration of release	Type release
OB	1 min.	Quasi-instantaneous/ quasi-continuous
OD	2-3 sec.	Instantaneous
SF	1-10 min.	Quasi-instantaneous/ quasi-continuous

Table 15 Summary of source release scenarios

Source description	**OB**	**OD**	**SF**
Source type	1 pan (line source)	1 pit (line source)	1 silo (volume source)
Source release height	Ground level	Ground level	Ground level
Example energetic	Double-base propellant	Composition B	Double-base propellant
Default energetic heat content (ca/g)	2,222	1,240	2,222
Example pollutant	CO_2	CO_2	CO_2
Default CO_2 pollutant emission factor (g/g)[b]	1.00	0.87	1.00
Terrain option	Flat and complex	Flat and complex	Flat and complex
Ambient temperatures (°K)	284	284	284
Stability and wind speed	Operational conditions	Operational conditions	Operational conditions
Default mixing height	Model calculated	Model calculated	Model calculated
Cloud height	Final	Final	Final
Concentration output used for impact assessment	1-hr time-weighted average[a]	1-hr time-weighted average[a]	1-hr time-weighted average[a]

[a]Peak concentrations within a 1-hr period were also calculated but not used for the assessment.
[b]Based on OBODM default values and used only for CO_2 dispersion modeling. BangBox emission factors used to calculate concentrations for other pollutants (CO, Nox, SO2, PM-10, etc.).

6.1.6 Dispersion Modeling

Dispersion modeling was conducted to evaluate potential impacts associated with air emissions from the OB/OD Unit at TEAD. The source scenarios previously discussed were used as modeling input. Dispersion modeling was conducted in conformance with the Implementation Plan (U.S. Army, June 1997). Following is a discussion of the following modeling considerations:

- Dispersion model
- Meteorological conditions
- Receptors
- Dispersion factor results
- Exposure periods
- Calculated concentrations
- Deposition

These factors are discussed in Sections 6.1.6.1 through 6.1.6.7, respectively.

6.1.6.1 Dispersion Model

The OBODM has been selected for the air pathway assessment for the TEAD OB/OD Unit commensurate with the Implementation Plan (U.S. Army, June 1997). The OBODM is intended for use in evaluating the potential air quality impacts of the OB/OD sources and is listed as a candidate model in U.S. EPA Subpart X draft guidance (U.S. EPA, June 1997). OBODM predicts the downwind transport and dispersion of air pollutants using cloud rise and dispersion model algorithms from existing dispersion models such as the REEDM, DPG's Real-Time Volume Source Dispersion Model (RTVSM), and the EPA's Industrial Source Complex (ISC) model. The model can be used to calculate peak concentration, time-mean concentration, dosage (time-integrated concentration), and particulate gravitational deposition for emissions from multiple OB/OD sources for either a single event or up to a year of sequential hourly source and meteorological inputs. Additional technical implementation is provided in the OBODM user's manuals (U.S. Army, July 1997).

6.1.6.2 Meteorological Conditions

Screening meteorological conditions were limited to those associated with OB/OD operations at TEAD. Specifically, the following range of conditions were evaluated:

- Wind speeds greater than 3 mph (1.3 m/s) and less than 20 mph (8.9 m/s),
- Non-inversion conditions (i.e., stability classes A-D), and
- Non-precipitation conditions.

Separate modeling runs were made for each stability class (wind speed combinations identified in Table 15 for each receptor of interest). The predicted worst-case concentrations were selected for screening purposes to represent short-term exposures at each receptor point.

Long-term exposure for all receptors based on the following approach for screening purposes:

- Quarterly (selection of most restrictive condition considering all applicable quarters)
  + Wind direction frequency for receptor of interest
  + Predominant stability class (D=neutral)
  + Average wind speed (5 m/s)
- Annual
  + Wind direction frequency for receptor of interest
  + Predominant stability class (D=neutral)
  + Average wind speed(5m/s)

Table 15 Stability and wind speed conditions modeled

Stability	Wind Speed (m/s)						
Class	1.3	2	3	4	5	7	8.9
A	√	√	√				
B	√	√	√	√	√		
C	√	√	√	√	√	√	√
D	√	√	√	√	√	√	√

6.1.6.3 <u>Receptors</u>

Points of interest include three sets of potential receptors:

- Installation boundary distances for 16 sectors,
- Reference downwind distances (from 0.1 to 50.0 km),
- Special receptors of interest

These receptors are identified in Tables 16 through 18. Flat terrain and complex terrain modeling runs were made for reference downwind distances for comparative purposes. Since OB/OD is conducted only during the daytime (i.e., neutral and unstable conditions), the cloud release is expected to flow over (and not be diverted by high terrain features).

A review of locations of potential sensitive receptors in the vicinity of the OB/OD Unit was conducted. This included considerations of the following special receptors:

- Resident
- Farmers, ranchers, and fishers
- Hospital
- School
- Day care facility

Table 15 Reference downwind locations from TEAD OB/OD Unit

Distance (km)	Maximum terrestrial height(m)
0.1	1,530
0.2	1,540
0.3	1,545
0.4	1,550
0.5	1,550
0.6	1,550
0.7	1,550
0.8	1,560
0.9	1,575
1.0	1,575
2.0	1,575
3.0	1,650
4.0	[a]
5.0	[a]
6.0	[a]
7.0	[a]
8.0	[a]
9.0	[a]
10.0	[a]
20.0	[a]
30.0	[a]
40.0	[a]
50.0	[a]

Note: Terrain height at OB/OD Unit = 1,525m, MSL

[a]Terrain height exceeds OB/OD cloud height model defaults to a terrain height of 300m above the OB/OD source elevation (i.e., 300m + 1,525m = 1,825m, MSL

Table 16 Installation boundary (point of compliance)

Sector	Distance (km) OB	Distance (km) OD	Distance (km) SF	Terrain height (m, MSL)
N	5.8	5.5	5.8	1,445
NNE	7.9	7.3	7.9	1,370
NE	10.3	9.5	10.3	1,375
ENE	11.5	11.1	11.5	1,462
E	16.5	11.4	11.5	1,425
ESE	1.3	2.8	1.3	1,490
SE	0.8	1.5	0.8	1,520
SSE	0.7	1.2	0.7	1,525
S	0.6	1.2	0.6	1,530
SSW	0.7	1.3	0.7	1,540
SW	0.8	1.1	0.8	1,545
WSW	0.6	0.8	0.6	1,540
W	0.5	0.7	0.5	1,560
WNW	0.6	0.8	0.6	1,575
NW	0.8	1.1	0.8	1,575
NNW	1.4	4.0	1.4	1,510

Note: Terrain height at OB/OD Unit = 1,525 m, MSL.

Table 17 Population centers (special/sensitive receptors)

Sector	Description	Distance (km) OB	Distance (km) OD	Distance (km) SF	Terrain height (m, MSL)
NNE	Grantsville	9.6	9.1	9.3	1,330
ENE	Tooele	13.8	13.4	13.4	1,507
ESE	Stockton	9.6	9.7	9.4	1,586
N	Seabase prawn farm	20.0	20.0	20.0	1,281

Note: Terrain height at OB/OD Unit = 1,525m, MSL.

- Retirement home
- Religious center
- Youth center
- Jail or prison

The nearest special receptors are expected to be located in or near the following population center in the vicinity of TEAD:

- Grantsville
- Tooele

- Stockton
- Seabase prawn farm (potential subsistence fisher)

Dispersion modeling screening results will be used to select the population center with the highest potential OB/OD impacts for risk characterization purpose. The Seabase prawn farm will be used to evaluate the subsistence fisher scenario. The receptor locations with the maximum offsite impacts will also be evaluated to characterize the Reasonable Maximum Exposure (RME) receptors. These receptors will be selected and evaluated considering worst-case meteorology and typical meteorology.

6.1.6.4 Dispersion Factor Results

Dispersion factors were evaluated to determine the location of the maximum ground-level air concentration from the OB/OD Unit as well as for the selection of reasonable maximum exposure (RME) potential receptors. This involved evaluation of both flat terrain and complex terrain dispersion modeling results. Flat terrain reference locations from 0.1 km to 50 km were modeled. Based on flat terrain assumptions the maximum 1-hr air concentration is extended to occur within 1-2 km of the OB/OD Unit (associated with neutral and 5 m/s conditions). These results are summarized in Table 19. Additional data for the selection of maximum concentration locations for flat terrain are provided in Appendix 6.1.6.4-A.

Complex terrain dispersion modeling (i.e., terrain heights were accounted for) was also conducted for reference distances from 0.1 km to 50 km. In addition, concentration estimates were obtained for the TEAD installation boundary and nearby population centers. The maximum 1-hr ground-level air concentration was predicted to occur 0.9 km from the OB/OD modeling based on complex terrain modeling results. These maximum concentrations are associated with (neutral) stability conditions and wind speeds of 1.3 – 7.0 m/s. These complex terrain results are summarized in Table 6.1.6.4-1 with additional details provided in Appendix 6.1.6.4-B.

The maximum ground-level air concentration (i.e., 900 m from the OB/OD Unit) has been assumed to occur just to the south (approximately 150 – 350 m) of the TEAD and OB/OD Unit boundary. This location is associated with the maximum “offsite” air concentration considering distances to the boundary and wind direction frequencies. The wind direction frequency data for downwind release transport conditions are summarized in Table 19.

A comparison of maximum 1-hr air concentrations (complex terrain) for nearby population centers is presented in Table 6.1.6.4-3. The results are very similar for Stockton and Grantsville. However, Grantsville is associated with prevailing wind flows and is more likely to be downwind of the OB/OD Unit than Stockton (refer to the wind direction frequency data in Table 6.1.6.4-2). Therefore, Grantsville (in addition to the maximum air concentration 900 m south of the OB/OD Unit) has also been selected to represent adult resident, child resident, and subsistence farmer/rancher RME receptors.

In summary, the following RME receptor locations and types have been further evaluated (i.e., concentration, deposition, and risk characterization values calculated):

- Maximum air concentration location (approximately 900 m south of OB/OD operations).
  - + Adult resident
  - + Child resident
  - + Subsistence farmer/rancher

- Grantsville
  - + Adult resident
  - + Child resident
  - + Subsistence farmer/rancher

- Seabase prawn farm
  - + Subsistence fisher

The locations of these potential RME receptors illustrated in Figure 15.

Table 22 Maximum 1-hour air concentration locations (distance in km from OB/OD Unit)

Source	Flat terrain	Complex Terrain
OB	1.0 (D 5.0 m/s)	0.9[a] (D 5.0 m/s)
OD	1.0 – 2.0(D 1.3 m/s)	0.9 [a] (D 1.3 m/s)
SF	2.0 (D 5.0 m/s)	0.9 [a] (D 7.0 m/s)

[a]Selected to represent maximum air concentration location (potential receptor types are adult resident, child resident, and subsistence farmer/rancher).

( ) = Stability class and wind speed associated with the maximum concentration.

Table 23 Maximum wind direction (downwind of the OB/OD Unit) frequency (considering the direct downwind sector and ±2 adjacent sectors from OB/OD Unit (percent)

Exposure Period	Maximum Air Concentration Location (900m south of OB/OD Unit)	Stockton	Grantsville	Tooele	Seabase Prawn Farm
Annual	11.67 (SLC)	7.78 (SLC)	28.77 (TEAD)	4.65 (SLC)	28.77 (TEAD)
Quarterly	14.58 (TEAD)	8.92 (SLC)	25.54 (TEAD)	5.38 (SLC)	25.54 (TEAD)

( ) = Meteorological station location.
SLC = Salt Lake City

Table 24 Maximum 1-hour CO_2 concentration (g/m^3) comparisons (complex terrain)

Source	Stockton	Grantsville[a]	Tooele	Seabase[b] Prawn Farm
OB (1,000 lb NEW)	5.0 E-5 (D 5.0m/s)	5.0 E-5 (D 5.0 m/s)	3.7 E-5 (D 5.0 m/s)	2.7 E-5 (D 5.0 m/s)
OD (750 lb NEW)	6.0 E-5 (D 1.3 m/s)	6.4 E-5 (D 1.3 m/s)	4.2 E-5 (D 1.3 m/s)	2.5 E-5 (D 1.3 m/s)
SF (1,500 lb NEW)	7.5 E-5 (C 1.3 m/s)	7.6 E-5 (C 1.3 m/s)	5.6 E-5 (C 1.3 m/s)	3.6 E-5 (C 1.3 m/s)

[a]Selected to represent reasonable maximum exposure (RME) population centers based on relative concentration magnitude and consideration of prevailing wind directions (potential receptor types are adult resident, child resident, and subsistence farmer/rancher).
[b]Selected to represent the RME subsistence fisher.
( )=Stability class and wind speed associated with the maximum concentration.

6.1.6.5 Exposure Periods

Maximum dispersion modeling results were adjusted to provide maximum dispersion factors (concentrations associated with a 1-lb release) for all exposure periods commensurate with relevant health criteria. This involved the following standard exposure periods:

- 1 hr,
- 3 hr,
- 8 hr,
- 24 hr,
- Quarterly, and
- Annual.

Figure 22 Potential RME receptor locations.

Maximum dispersion factors (associated with a 1-lb emission) for the OB/OD operations for exposure periods of 24 hours or less were based on adjusting the 1-hr dispersion factor as follows:

$$DF_T = \sum_{t=1}^{T} \left(\frac{DF_{1\text{-}hr_t}}{T} \right) (F) \qquad \text{Eq. 6.1.6.5-1}$$

where

DF_T = dispersion factor, or concentration, for exposure period of T hr for emission constituent of interest associated with a 1-lb/hr emission rate for a single OB/OD event (μg/m^3/lb)

$DF_{1\text{-}hr_t}$ = 1-hr dispersion factor for the tth hr for single OD event, the release assumed to be 1 lb/hr for the first hour and 0.0 thereafter (μg/m^3/lb)
T = number of hours in the exposure period of interest,
F = prevailing wind direction frequency in a fraction format (0.0-1.0), assumed to be 1.0 for exposures of 24 hr or less (dimensionless).

Routine OB/OD operates under favorable meteorological conditions only. Therefore, maximum dispersion factors (associated with a 1-lb emission) for routine OB/OD operations for quarterly and annual exposure periods were based on adjusting the 1-hr dispersion factors as follows:

$$DF_T = \frac{\left[\sum_{t=1}^{T} \left(DF_{1\text{-}hr_t} * (F) \right) \right]}{T} \qquad \text{Eq. 6.1.6.5-2}$$

where

DF_T = dispersion factor, or concentration, for quarterly or annual exposure periods for emission constituent of interest associated with a 1-lb/hr emission rate for a single OB/OD event (μg/m^3/lb)
$DF_{1\text{-}hr_t}$ = 1-hr dispersion factor for each wind speed and stability combination modeled for the tth hr for single OB/OD event, the release assumed to be 1 lb/hr for the first hour and 0.0 thereafter (μg/m^3/lb)
T = number of hours in the exposure period of interest,
F = maximum prevailing wind direction frequency for each wind speed and stability combination modeled in a fraction format (0.0-1.0) (dimensionless).

A summary of this approach as applied to the TEAD assessment is given in Table 6.1.6.5-1.

6.1.6.6 Calculated Concentrations

Dispersion factors (associated with one OB/OD event of 1-lb emission) for each exposure period were used as input to calculate exposure concentrations for each potential emission contaminant for every receptor of interest as follows:

$$EC_{TC} = (DF_T)(EF_C)(TQ_T) \qquad \text{Eq. 6.1.6.6-1}$$

where

EC_{TC} = concentration for exposure period T of contaminant C for receptor of interest (μg/m^3)

Table 25 Summary of maximum dispersion factor calculation method for various exposure periods

Exposure period	Meteorology	Calculation method
1 hr	Worst-case[a]	Model output
3 hr	Worst-case[a]	1-hr conc. ÷ 3
8 hr	Worst-case[a]	1-hr conc. ÷ 8
24 hr	Worst-case[a]	1-hr conc. ÷ 24
Quarterly	"D" 5m/sec	1-hr conc. ÷ 24 ÷ 91.25 x F_q
Annual	"D" 5m/sec	1-hr conc. ÷ 24 ÷ 365 x F_a

[a]Short-term exposures are also evaluated for typical meteorological conditions (i.e., "D", 5m/sec) in addition to worst-case conditions.
F_q = maximum seasonal prevailing unit direction frequency as a fraction
F_a = annual prevailing wind direction frequency as a fraction

DF_T = dispersion factor (based on 1-lb emission) for exposure period T for receptor of interest (μg/m^3/lb)
EF_C = emission factor for contaminant C
TQ_T = treatment quantity for exposure period T (lb)

Exposure concentrations were determined for the following data sets:

- OB + OD + SF,
- Background, and
- Background + OB + OD + SF.

These modeling estimates were used to evaluate potential impacts on human health and the environment.

To simplify the screening process, only potential RME receptor scenarios were evaluated. Tabular summaries of predicted contaminant-specific concentrations for the two exposure scenarios evaluated are provided in Appendix 6.1.6.6-A.

6.1.6.7 Deposition

Annual deposition quantities for OB/OD emissions were estimated as follows for screening purposes:

$$DQ_{C\text{-}ANL} = (EC_{C\text{-}ANL})\,(DV)\,(3.15E+07) \qquad \text{Eq. 6.1.6.7-1}$$

where

$DQ_{C\text{-}ANL}$	=	annual deposition quantity for contaminant C at locations of interest ($\mu g/m^2$)
$EC_{C\text{-}ANL}$	=	annual exposure concentration of contaminant C at locations of interest ($\mu g/m^3$)
DV	=	deposition velocity (m/s)
3.15E+07	=	number of seconds in one yr

Deposition estimates based on this screening approach are presented for potential RME receptor locations in Appendix 6.1.6.7-A. Only dry disposition has been evaluated, since OD operations are limited to non-precipitation conditions. Deposition estimates are based on two deposition velocity values. The first data set is based on a conservative default value of 0.05 m/sec (CAPCOA, 1993). The second is based on a standard default value of 0.001 m/sec as referenced in the Multimedia Environmental Pollutant Assessment System (MEPAS) database (DOE, 1995).

6.2 COMPARISON OF CONCENTRATIONS WITH EXISTING TOXIC AIR POLLUTION STANDARDS

Concentration estimates based on dispersion modeling results have been compared to screening health criteria for various exposure periods (from 1 hr to annual). This process has been used to identify contaminants of potential concern (COPCs) for further evaluation in the risk assessment (Attachment 16B).

6.2.1 <u>Health Criteria</u>

The most restrictive screening health criteria based on available data have been identified for each potential emission contaminant for exposure periods from 1 hr to annual. The primary information source used for identifying applicable and relevant health criteria for potential OB/OD emission contaminants are as follows:

- National Ambient Air Quality Standards (NAAQS)
- Utah has adopted the NAAQS for criteria pollutants (UAAQS), (UDAQ, February 1998).
- Utah Toxic Screening Levels (TSLs), (UDAQ, February 1998).
- U.S. EPA Region 9 Preliminary Remediation Goals (PRGs), (U.S. EPA, June 1998).

OB/OD emission factors are not available to evaluate the new PM 2.5 NAAQS/UAAQS criteria. Therefore, the PM10 criteria will be the primary basis to evaluate particulate emissions.

The UDAQ has adopted Toxic Screening Levels (TSLs) to assist in the evaluation of hazardous air pollutants released into the atmosphere from sources. The TSLs do not constitute a standard which the impact of a source's toxic emissions cannot exceed. Rather, they are screening levels above which the UDAQ has determined that additional information should be obtained to substantiate that the model-predicted concentration would not expose sensitive individuals, animals, or vegetation to unnecessary health risks.

TSLs are derived from Threshold Limit Values (TLVs) listed in the American Conference of Governmental Industrial Hygienists (ACGIH), "Threshold Limit Values for Chemical Substances and Physical Agent." Values reported in the ACGIH handbook are based on specific exposure limits to a healthy adult in the work place. Persons who would be overly sensitive to such an exposure, such as children, the elderly, or the physically ill, would require thresholds lower than the TLVs. To ensure protection for sensitive individuals and to facilitate the use of longer concentration averaging periods for chronic and carcinogenic, uncertainty factors were applied as follows:

- TLV divided by 10 - relates the threshold of an average healthy adult to that of a sensitive individual.

- TLV divided by 3 - converts the 8-hour TLV to a 24-hour concentration (chronic and carcinogenic (HAPs only)).

- TLV divided by 3 – provides an additional safety factor for carcinogens.

The above uncertainty factors, when applied to the TLVs, result in the following TSLs and concentration averaging periods for comparison with model-predicted concentrations:

- Acute TSLs - TLV/10 (noncarcinogens), averaging period of 1-hour or less depending on model used;

- Chronic TSLs - TLV/30, noncarcinogens (24-hour averaging period);

- Carcinogenic TSL's - TLV/90 (24-hour averaging period applicable only to known or suspected carcinogenic hazardous air pollutants).

The Region 9 Preliminary Remediation Goals (PRGs) combine current EPA toxicity values with "standard" exposure factors to estimate contamination concentrations in environmental media (including air) that are protective of humans, including sensitive groups, over a lifetime. Thus, the air pathway PRGs represent long-term annual exposures. Chemical concentrations above the PRG levels do not automatically designate a health impact problem. However, those PRGs represent screening criteria to identify contaminants which warrant further evaluation.

A compilation of the most restrictive Utah and EPA Region 9 screening air criteria is presented in Appendix 6.2.1-.A.3. These criteria were used to evaluate potential OB/OD impacts.

6.2.2 Hazard Index

The overall risk posed by one or more air emission constituents has been evaluated using contaminant-specific Hazard Quotient (HQ) values. For systemic toxicants with similar systemic effects, the Hazard Index (HI) takes the following form:

$$HI = \sum_{i=1}^{N} HQ_i \qquad \text{Eq. 6.2.2-1}$$

where

HI = Hazard Index (dimensionless)
HQ = Hazard Quotient for the i^{th} contaminant
N = Total number of contaminants

$$HQ_{TOX_i} = \frac{C_i}{HC_{TOX_i}} \qquad \text{Eq. 6.2.2-2}$$

where

HQ_{TOX_i} = Hazard Quotient for the i^{th} toxicant (dimensionless)
C_i = Concentration (exposure level) of the i^{th} toxicant ($\mu g/m^3$)
HC_{TOX_i} = Health criterion for the i^{th} toxicant ($\mu g/m^3$)

The HI for carcinogens (HI_{CAN}) is similar:

$$HQ_{CAN_i} = \frac{C_i}{HC_{CAN_i}} \qquad \text{Eq. 6.2.2-3}$$

where

HQ_{CAN_i} = Hazard Quotient for the i^{th} carcinogen (dimensionless)
C_i = concentration (exposure level) of the i^{th} carcinogen ($\mu g/m^3$)
HC_{CAN_i} = health criterion concentration (exposure level) associated with an reference level of risk for the i^{th} carcinogen ($\mu g/m^3$), typically10^{-6} for Class A/B carcinogens and 10^{-5} for Class C

Health impacts may be unacceptable if any calculated HI exceeds unity (i.e., 1.0). HI values are computed for each standard exposure period based on the associated health criteria.

The total HI values for toxicants and separate HI value for carcinogens were calculated without regard to health impact endpoints (i.e., affected organs). This is a very conservative screening approach to characterizing potential health impacts.

The emission constituents regulated by the Utah and National Ambient Air Quality Standards (NAAQS) were not included in the HI computations, since they are not enforced on an "additive basis" and these criteria were established considering the potential for synergistic effects.

6.2.3 Comparisons

Comparisons of maximum calculated exposure concentrations with human health criteria are included in Attachment 16B. These results are summarized in Table 24 and 25. Air pathway contaminants of potential concern (COPCs) are identified in Table 26.

A comparison of predicted worst-case concentrations of criteria pollutants to the most restrictive of the UAAQS and NAAQS (considering both primary and secondary standards) is presented in Table 27 (without background) and -2 (with background). Additional details regarding these comparisons are presented in Attachment 16B. These Ambient Air Quality Standards are only directly applicable to offsite locations. Primary standards are intended to protect human health and secondary standards to protect human welfare (including damage to physical structures and the environment). Ozone predictions are not included in these tables, since the OBODM is not a photochemical model. Ozone formation due to OB/OD emissions is not significant due to low emission quantities of nitrogen oxides and volatile organic compounds. Modeling results indicate the potential to exceed 24-hr PM-10 standard at the maximum concentration location as well as Grantsville and the Seabase prawn farm. There is also the potential to exceed the annual PM-10 standard at the maximum concentration location (Grantsville would be close if background levels are accounted for). However, these measured background concentrations at Grantsville also include concentrations from TEAD OB/OD emissions during 1993 and 1994 (i.e., there has been some double-counting of the OB/OD PM-10 emissions). The PM-10 concentrations based on modeling results are dominated by OD ejecta emissions.

Table 24 presents a summary of HI values for the air pathway for human exposures. Hazard Index values of 1.0 or greater are associated with the following receptors and exposure periods:

- Maximum air concentration location
  - 1-hr. exposure (non-carcinogens)
  - 24-hr exposure (carcinogens)
  - Annual exposure (carcinogens)

- Grantsville
  - Annual exposure (carcinogens)

- Seabase prawn farm
  - Annual exposure (carcinogens)

The HI values of 1.0 or greater are mainly attributed to OD ejecta emissions contaminants of potential concern (COPCs) as identified in Table 25 (for 1-hr and 24-hr exposure). The COPCs for the exposures are based on worst-case meteorological conditions. Therefore, additional administrative controls will be implemented to reduce the 1-hr HI value to less than 1.0 at the maximum (offsite) air concentration location. These controls have been addressed in Attachment 16B.

The following COPCs for 24-hrs and annual exposure are all carcinogens and all attributed to OD ejecta emissions:

- Arsenic
- Cadmium
- Chromium
- Hexachlorobenzene
- Hydrogen chloride
- RDX

These COPCs have been further evaluated in Attachment 16B.

6.2.4 Risk Analysis

The HI calculations for carcinogens (as discussed in Sects. 6.2.2 and 6.2.3) have been used to identify COPCs for carcinogens. These carcinogenic COPCs have been further evaluated in Attachment 16B.

6.2.5 Potential Damage To Domestic Animals, Wildlife, Crops, Vegetation, And Physical Structures

6.2.5.1 Environmental Impacts

A comparison of predicted worst-case concentrations of criteria pollutants to the most restrictive of the UAAQS and NAAQS (considering both primary and secondary standards) is provided in Section. 6.2.3. Secondary standards (which are equivalent to or more restrictive than primary standards) are intended to protect human welfare and the environment (e.g., soils, vegetation, wildlife).

Data presented in Table 26 indicate that OB/OD emissions will be significantly less than primary and secondary UAAQS state and NAAQS, with the possible exception of PM10 for some local areas.

A screening ecological assessment for the TEAD OB/OD Unit is provided in Attachment 17.

6.2.5.2 Physical Structures

The low levels of concentrations due to OB/OD emissions of acids and other contaminants are not expected to impact physical structures in the vicinity of TEAD. Secondary standards for criteria pollutants (which have been established also to protect against the degradation of buildings and physical structures) are not predicted to be exceeded at any offsite structure. These buildings and structures are also located at such a distance from the OB/OD areas that shock waves, shrapnel, and ejecta will not impact them.

Table 27 Summary of compliance with ambient air quality standards (without background)

		Maximum ambient concentration (($\mu g/m^3$)[a]			NAAQS/UAAQS ($\mu g/m^3$)	
Pollutant	**Averaging time**	**Max. Conc. locations**	**Grantsville**	**Seabase Prawn Farm**	**Primary**	**Secondary**
PM_{10}	Annual	68	36	17	50	50
	24 hr	4,790	719	287	150	150
$PM_{2.5}$	Annual	NA	NA	NA	15	15
	24 hr	NA	NA	NA	65	65
Sulfur dioxide	Annual	<1	<1	<1	80	—
	24 hr	2	<1	<1	365	—
	3 hr	13	2	<1	—	1,300
Carbon monoxide	8 hr	586	87	35	10,000	—
	1 hr	2,340	347	138	40,000	—
Nitrogen dioxide	Annual	<1	<1	<1	100	100
Ozone	1 hr	NA	NA	NA	157	157
Lead	Quarter	0.1	<0.1	<0.1	1.5	1.5

Sources: UDAQ, February 1998.
NA = Not available
— = Greater than ambient air quality standard.
[a] = OB + OD + OD ejecta + SF

Table 28 Summary of compliance with ambient air quality standards (with background)

Pollutant	Averaging time	Maximum ambient Concentration (($\mu g/m^3$)[a]			NAAQS/UAAQS ($\mu g/m^3$)	
		Max. Conc. locations	Grantsville	Seabase Prawn Farm	Primary	Secondary
PM_{10}	Annual	94	52	43	50	50
	24 hr	4,816	745	313	150	150
$PM_{2.5}$	Annual	NA	NA	NA	15	15
	24 hr	NA	NA	NA	65	65
Sulfur dioxide	Annual	3	3	3	80	—
	24 hr	5	3	3	365	—
	3 hr	16	5	4	—	1,300
Carbon monoxide	8 hr	586	87	35	10,000	—
	1 hr	2,340	347	138	40,000	—
Nitrogen dioxide	Annual	<1	<1	<1	100	100
Ozone	1 hr	NA	NA	NA	157	157
Lead	Quarter	0.1	<0.1	<0.1	1.5	1.5

Sources: UDAQ, February 1998.

NA = Not available

— = Greater than ambient air quality standard.

[a] = OB + OD + OD ejecta + SF

Table 29 Summary of hazard index values (air pathway)

Location Source	Hazard index						
	1 hr	3 hr	8 hr	24 hr	Quarterly	Annual	Cancer
Max. conc.							
• OB/OD[a]	1.3 E0	NA	NA	5.1 E0	NA	1.3 E-1	8.8 E+1
• Background	2.8 E-6	NA	NA	3.7 E-4	NA	1.5 E-6	6.1 E0
• Total	1.3 E0	NA	NA	5.1 E0	NA	1.3 E-1	9.4 E+1
Grantsville							
• OB/OD[a]	1.9 E-1	NA	NA	7.4 E-1	NA	7.3 E-2	3.8 E+1
• Background	1.7 E-6	NA	NA	2.2 E-4	NA	9.0 E-7	3.7 E0
• Total	1.9 E-1	NA	NA	7.5 E-1	NA	7.3 E-2	4.2 E+1
Seabase							
• OB/OD[a]	7.4 E-2	NA	NA	2.9 E-1	NA	5.4 E-3	1.5 E+1
• Background	5.6 E-8	NA	NA	7.4 E-6	NA	3.0 E-8	1.2 E-1
• Total	7.4 E-2	NA	NA	2.9 E-6	NA	5.4 E-3	1.5 E+1

NA = Not applicable

— = Hazard Index of 1.0 or greater.

[a] = OB + OD + OD ejects + SF

Table 30 Identification of air pathway COPCs (24-hrs or less exposure).

COPC	Hazard Quotient					
	1-Hr			24-Hrs		
	Maximum Concentration Location	Grantsville	Seabase prawn farm	Maximum Concentration Location	Grantsville	Seabase prawn farm
Aluminum	1.2 E-1	—	—	—	—	—
Barium	1.9 E-1	—	—	—	—	—
Cadmium[a,b]	—	—	—	4.7 E0	6.8 E-1	2.7 E-1
Hexachlorobenzene[a]	4.1 E-1	—	—	1.0 E-1	—	—
RDX[a,b]	4.6 E-1	—	—	1.2 E-1	—	—

[a]Constituents of OD ejecta.
[b]Carcinogen HQ for 24-hrs based on Utah carcinogenic TSL.
—=HQ less than 1.0 E-1.

Table 31 Identification of air pathway COPCs (annual exposure).

COPC	Hazard Quotient					
	Noncarcinogens			Carcinogens		
	Maximum Concentration Location	Grantsville	Seabase prawn farm	Maximum Concentration Location	Grantsville	Seabase prawn farm
Arsenic[a]	—	—	—	5.4 E-1	2.9 E-1	1.4E-1
Cadmium[a]	—	—	—	2.4 E+1	3.7 E0	1.8 E0
Chromium[a]	—	—	—	6.3 E+1	3.4 E1	1.3 E+1
Hydrogen chloride	1.1 E-1	—	—	—	—	—
RDX[a]	—	—	—	4.3 E-1	2.3 E-1	1.1 E-1

[a]Constituent of OD ejecta.
—=HQ less than 1.0 E-1.

7.0 REFERENCES

CAPCOA (California Air Pollution Control Officers Association), 1993. Air Toxics "Hot Spots" Program Revised 1992 Risk Assessment Guidelines. Cameron Park, CA.

DOE (U.S. Department of Energy), 1995. Multimedia Environmental Pollutant Assessment System (MEPAS) Application Guidance. Pacific Northwest Laboratories, Richland, WA.

NOAA (National Oceanic and Atmospheric Administration), 1994. Local Climatological Data, Salt Lake City, Utah. Asheville, NC.

NOAA (National Oceanic and Atmospheric Administration), 1983. Climatic Atlas of the United States. Asheville, NC.

UDAQ, February 1998. Utah Division of Air Quality Modeling Guidelines Revised Draft. Salt Lake City, UT.

UDEQ, February 1996. Tooele Chemical Demilitarization Facility Tooele Army Depot South Screening Risk Assessment. Prepared by A.T. Kearny, Inc., for the Utah Department of Environmental Quality. Salt Lake City, UT.

U.S. Air Force, January 1994. Characterization of Emissions Resulting from Thermal Treatment of Selected Explosive Munitions. Prepared by U.S. Army for the U.S. Air Force Air Combat Command, Dugway Proving Ground, UT.

U.S. Army, July 1997. Open Burn/Open Detonation Dispersion Model (OBODM) User's Guide. U.S. Army. Dugway Proving Ground, UT.

U.S. Army, June 1997. Tooele Army Depot Inplementation Plan to Address the Utah OB/OD Permitting Guidance. Tooele Army Depot, UT.

U.S. Army, August 1995. Disposal and Reuse of the BRAC Parcel at Tooele Army Depot - Draft Environmental Impact Statement. Tooele Army Depot, UT.

U.S. Army, May 1995. Air Pathway Screening Assessments in RCRA Subpart X Permitting. U.S. Army Environmental Center. Aberdeen Proving Ground, MD.

U.S. Army, April 1994. Methods Tier III Site-Specific Direct Health Risk Assessment Air Pollution Emission Assessment No. 42-21-M3C4-94 Deactivation Furnace Trial Barn Testing Tooele Army Depot, Tooele, Utah. U.S. Army Hygiene Agency. Aberdeen Proving Ground, MD.

U.S. Army, January 1992. Development of Methodology and Technology for Identifying and Quantifying Emission Products from Open Burning and Open Detonation Thermal Treatment Methods. U.S. Army Armament, Munitions and Chemical Command. Rock Island, IL.

U.S. DOI (U.S. Department of Interiors), 1970. The National Atlas. Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency), "Region 9 Preliminary Remediation Goals (PRGs)". San Francisco, CA.

U.S. EPA (U.S. Environmental Protection Agency), March 1998. Documentation for Validated OB/OD BangBox Emission Factors Data Base.). Research Triangle Park, NC.

U.S. EPA, June 1997. RCRA 40 CFR Part 264, Subpart X Permit Writers Technical Resource Document (Draft). Washington, DC.

U.S. EPA, March 1992. Checklist for Technical Review of RCRA Part B Permit Applications, Draft Guidance.

U.S. EPA, January 1972. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. Research Triangle Park, NC.

APPENDICES