# Appendix 5.5A
# Offsite Consequence Analysis

# Offsite Consequence Analysis Redondo Beach Energy Project

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The Redondo Beach Energy Project (RBEP) will be a natural-gas-fired, combined-cycle electrical generating facility rated at a nominal generating capacity of 495 megawatts[1] at site average ambient temperature (SAAT)[2] conditions. The power block includes three combustion turbine generators, three supplemental-fired heat recovery steam generators, one steam turbine generator, an air-cooled condenser, and related ancillary equipment. RBEP will be constructed entirely within the existing approximately 50-acre Redondo Beach Generating Station site in Redondo Beach, California. Aqueous ammonia (ammonium hydroxide at 19 percent nominal concentration by weight) will be used to reduce $NO_x$ emissions. One 24,000-gallon aqueous ammonia aboveground storage tank (holding 20,400 gallons of aqueous ammonia) will be installed to provide approximately an 8-day supply of aqueous ammonia. The ammonia tank will be 30 feet long and 12 feet in diameter.

The ammonia storage area will also include a covered secondary containment basin measuring 38 feet by 18 feet with depth sufficient to hold the full contents of the tank plus rainwater from a 50-year rain event. The cover of the secondary containment area will effectively reduce the exposed surface area of ammonia to approximately 41 square feet, in the event of a catastrophic tank failure. The ammonia tank will be equipped with a pressure-relief valve set at 50 pounds per square inch gage, a vapor equalization system, and a vacuum breaker system. The storage tank will be maintained at ambient temperature and atmospheric pressure.

Aqueous ammonia will be delivered to the plant by truck transport. The ammonia delivery truck unloading station will include a bermed and sloped pad surface. The bermed truck drainage pad will slope from the south end to a collection trough on the north end that will drain into the secondary containment basin.

## Analysis

An analysis of tank failure and subsequent release of aqueous ammonia was prepared using a numerical dispersion model. The analysis assumed the complete failure of the storage tank, the immediate release of the contents of the tank, and the formation of an evaporating pool of aqueous ammonia within the secondary containment structure. Evaporative emissions of ammonia would be subsequently released into the atmosphere. Meteorological conditions at the time of the release would control the evaporation rate, dispersion, and transport of ammonia released to the atmosphere. For purposes of this analysis, the following meteorological data were used:

- U.S. Environmental Protection Agency (EPA) default (worst-case) meteorological data, supplemented by daily temperature data as defined by 19 California Code of Regulations 2750.2.

The maximum temperature recorded at the Los Angeles International Airport, near the RBEP site, in the past three years was 105°F or 313.7 Kelvin (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca5114). Maximum

[1] Approximate facility net output with three combustion turbines operating at 100 percent load with no inlet air evaporative cooling operating and no duct burner operation.

[2] SAAT is 63.3 °F (Dry Bulb) and 58.5 °F (Wet Bulb) and relative humidity of 75%)

temperatures combined with low wind speeds and stable atmospheric conditions would be expected to result in the highest ammonia concentrations at the furthest distance downwind of the release site.

Table 1 displays the meteorological data values used in the modeling analysis.

TABLE 1
**Meteorological Input Parameters**

| Parameter | Worst-case Meteorological Data |
|---|---|
| Wind Speed meters/second | 1.5 |
| Stability Class | F |
| Relative Humidity, Percent | 50 |
| Ambient Temperature, Kelvin (°F) | 313.7 (105) |

Model runs were conducted based on an evaporating pool release using the meteorological data presented in Table 1. Modeling was conducted using the SLAB numerical dispersion model. A complete description of the SLAB model is available in *User's Manual for SLAB: An Atmospheric Dispersion Model for Denser-Than-Air Releases, D. E. Ermak, Lawrence Livermore National Laboratory, June 1990*. The SLAB user manual contains a substance database, which includes chemical-specific data for ammonia. These data were used in the modeling run without exception or modification.

Emissions of aqueous ammonia were calculated pursuant to the guidance given in *RMP Offsite Consequence Analysis Guidance, EPA, April 1999* and using the emission calculation tool for evaporating solutions provided in the Area locations of Hazardous Atmospheres (ALOHA) model provided by the EPA (http://www.epa.gov/ceppo/cameo/index.htm).

Release rates for ammonia vapor from an evaporating 19 percent solution of aqueous ammonia were calculated assuming mass transfer of ammonia across the liquid surface occurs according to principles of heat transfer by natural convection. The ammonia release rate was calculated using ALOHA, the meteorological data listed in Table 1, the dimensions of the secondary containment area, and the area of the opening in the containment cover. For the worst-case condition, it was assumed that a complete failure of the storage tank occurred, which resulted in an evaporating pool of aqueous ammonia within the secondary containment area cover in place.

During the worst-case scenario, an initial ammonia evaporation rate was calculated and assumed to occur for one hour after the initial release. For concentrated solutions, the initial evaporation rate is substantially higher than the rate averaged over time periods of a few minutes or more because the concentration of the solution immediately begins to decrease as evaporation begins.

Although the edge of the tank containment area is raised above ground level, the release heights used in the modeling were set at 0 meters above ground level to maintain the conservative nature of the analysis. Downwind concentrations of ammonia were calculated at heights of 1.6 meters above ground level and at 0 meters above ground level. The California Office of Environmental Health Hazard Assessment (OEHHA) has designated 1.6 meters as the breathing zone height for individuals.

An analysis of the tank loading hose failure with a leak below the excess flow valves activation set-point and the subsequent impacts was considered. This analysis would normally be completed under typical or average meteorological conditions for the area. However, after review of the possible failure modes, it was determined that the impact of this leak would be bracketed by the complete tank failure as a worst-case for the hose failure.

## Toxic Effects of Ammonia

With respect to the assessment of potential impacts associated with an accidental release of ammonia, four offsite "benchmark" exposure levels were evaluated, as follows: (1) the lowest concentration posing a risk of lethality, 2,000 parts per million (ppm); (2) the Occupational Safety and Health Administration's (OSHA)

Immediately Dangerous to Life and Health (IDLH) level of 300 ppm; (3) the Emergency Response Planning Guideline (ERPG) level of 150 ppm, which is the American Industrial Hygiene Association's (AIHA) updated ERPG-2 for ammonia; and (4) the level considered by the California Energy Commission (CEC) staff to be without serious adverse effects on the public for a one-time exposure of 75 ppm (*Preliminary Staff Assessment-Otay Mesa Generating Project, 99-AFC-5, May 2000)*.

The odor threshold of ammonia is approximately 5 ppm, and minor irritation of the nose and throat will occur at 30 to 50 ppm. Concentrations greater than 140 ppm will cause detectable effects on lung function, even for short-term exposures (0.5 to 2 hours). At higher concentrations of 700 to 1,700 ppm, ammonia gas will cause severe effects; death occurs at concentrations of 2,500 to 7,000 ppm.

The ERPG-2 value is based on a 1-hour exposure or averaging time; therefore, the modeled distance to ERPG-2 concentrations are presented in terms of 1 hour (or 60 minute) averaging time. The ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action. OSHA's IDLH for ammonia is based on a 30-minute exposure or averaging time; therefore, the IDLH modeling concentrations at all offsite receptors will be given in terms of a 30-minute averaging time.

## Modeling Results

Table 2 shows the modeled distance to the four benchmark criteria concentrations: lowest concentration posing a risk of lethality (2,000 ppm), OSHA's IDLH (300 ppm), AIHA's ERPG-2 (150 ppm), and the CEC significance value (75 ppm). Figure 1 show that location of the ammonia tank on the project site and the distance to the toxic endpoints.

TABLE 2
**Distance to EPA/CALARP and CEC Toxic Endpoints (ammonia)**

| Scenario | Distance in Meters to 2,000 ppm | Distance in Meters to IDHL (300 ppm) | Distance in Meters to AIHA's ERPG-2 (150 ppm) | Distance in Meters to CEC Significance Value (75 ppm) |
|---|---|---|---|---|
| 0 m AGL | 5.6 | 7.6 | 8.5 | 9.2 |
| 1.6 m AGL | 8.5 | 12.5 | 14.1 | 15.2 |

Note:
The model input file and the output files are available upon request.

The closest point on the project boundary to the secondary containment area extends 140 meters to the east. The results of the offsite consequence analysis for the worst-case release scenario of ammonia at RBEP indicate that the concentrations exceeding the benchmarks above would not extend beyond the property boundaries at the 0 and 1.6 meter above ground level scenarios.

## Assessment of the Methodology Used

Numerous conservative assumptions were used in the above analysis of the release scenarios. These include the following:

- Modeling & Meteorology
  - Worst case of a constant mass flow, at the highest possible initial evaporation rate for the modeled wind speed and temperature was used, whereas in reality the evaporation rate would decrease with time as the concentration in the solution decreases.
  - Worst-case stability class was used, which almost exclusively occurs during nighttime hours, but the maximum ambient temperature of 105°F was used, which would occur during daylight hours.

- Again, worst-case meteorology corresponds to nighttime hours, whereas the worst-case release of a tank failure would most likely occur during daytime activities at the power plant. At night, activity at a power plant is typically minimal.

## Risk Probability

Accidental releases of aqueous ammonia in industrial use situations are rare. Statistics compiled on the normalized accident rates for RMP chemicals for the years 1994–1999 from *Chemical Accident Risks in U.S. Industry-A Preliminary Analysis of Accident Risk Data from U.S. Hazardous Chemical Facilities, J.C. Belke, Sept. 2000*, indicates that ammonia (all forms) averages 0.017 accidental releases per process per year, and 0.018 accidental releases per million pounds stored per year. Data derived from *The Center for Chemical Process Safety, 1989*, indicates the accidental release scenarios and probabilities for ammonia in general, and are shown in Table 3.

TABLE 3
**General Accidental Release Scenarios and Probabilities for Ammonia**

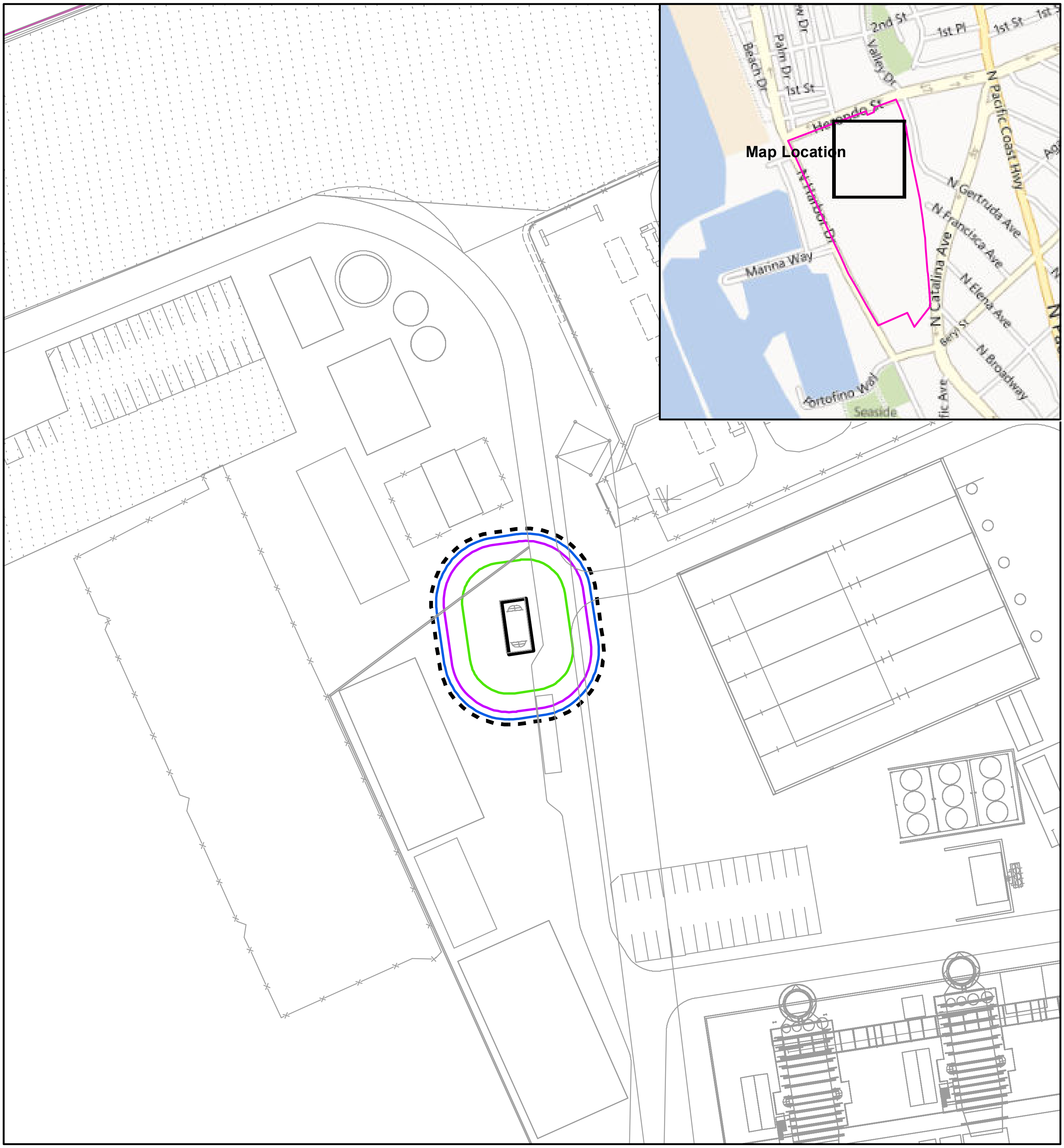
| Accident Scenario | Failure Probability |
|---|---|
| Onsite Truck Release | 0.0000022 |
| Loading Line Failure | 0.005 |
| Storage Tank Failure | 0. 000095 |
| Process Line Failure | 0.00053 |
| Evaporator Failure | 0.00015 |

## Conclusions

Several factors need to be considered when determining the potential risk from the use and storage of hazardous materials. These factors include the probability of equipment failure, population densities near the project site, meteorological conditions, and the process design. Considering the results of the above analysis, and accounting for the probabilities of a tank failure resulting in the modeled ammonia concentrations at the conditions modeled, the risk posed to the local community from the storage of aqueous ammonia at RBEP is not significant.

The results of the catastrophic scenario analysis indicate that the probability of a complete storage tank failure in combination with the conservatively modeled meteorological conditions would not pose a significant threat because ammonia concentrations above the four “benchmark” thresholds of 2,000, 300, 150, and 75 ppm would not be accessible to the public.

As described above, numerous conservative assumptions have been made at each step in this analysis. The conservative nature of these assumptions has resulted in a significant overestimation of the probability of an ammonia release at the RBEP site, and the predicted distances and elevations to toxic endpoints do not pose a threat to the public. Therefore, it is concluded that risk from exposure to aqueous ammonia due to RBEP is less than significant.




Ammonia Tank

Downwind Distance to Toxic Endpoints at 1.6 m AGL

2,000 ppm (8.5 meters)

300 ppm (12.5 meters)

150 ppm (14.1 meters)

75 ppm (15.2 meters)

0 50 100 Feet

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**FIGURE 1**
**Offsite Consequence Analysis**
**Distance to Toxic Endpoints**
AES Redondo Beach Energy Project
Redondo Beach, CA

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