APPENDIX 3.5B

OCA

TECHNICAL MEMORANDUM CH2MHILL

Offsite Consequence Analysis Russell City Energy Center

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Calpine Corporation (Calpine) and GE Capital, propose to construct, own, and operate a merchant energy generating facility in the industrial corridor of the City of Hayward, Alameda County, California, to be known as the Russell City Energy Center (RCEC). The RCEC will be a natural gas-fired, combined-cycle electric generating facility rated at a nominal gross generating capacity of 600 megawatts (MW). The proposed 18.8-acre project site is located in both the City of Hayward and unincorporated Alameda County, west of the City of Hayward's Water Pollution Control Facility.

RCEP will consist of two "F-Class" combustion turbine generators (CTG), two multi-pressure, supplementary-fired heat recovery steam generators (HSRGs), a single 3-pressure, reheat, condensing steam turbine-generator (STG), and a hybrid, wet/dry plume-abated mechanical draft cooling tower. RCEP is required by both the Clean Air Act and the Bay Area Air Quality Management District (BAAQMD) to install Best Available Control Technology to control emissions of criteria air pollutants from the combustion turbines. Nitrogen oxide (NOx) emissions from the combustion turbines will be controlled using selective catalytic reduction (SCR). The SCR control system proposed for RCEP uses ammonia as the reduction reagent Aqueous ammonia (ammonium hydroxide at 29 percent nominal concentration by weight) will be vaporized and injected into the flue gas stream from the turbines, then passed through a catalyst bed. In the presence of the catalyst, the ammonia (NH_3) and NO_X react to form nitrogen (N_2) and water vapor (H_2O) thereby reducing the NOx emissions.

The RCEP facility will store 29-percent aqueous ammonia solution in a single stationary 15,000 gallon aboveground storage tank. The tank will be surrounded by a 66.5-foot by 22-foot by 3-foot secondary containment structure capable of holding the full contents of the tank, plus rainwater. The secondary structure is located 67 feet (20.4 meters) from the nearest point on the property boundary.

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 to a collection trough that will drain into the secondary containment structure of the ammonia tank.

The ammonia tank will be equipped with a pressure relief valve set at 50 pounds per square inch gage (psig), a vapor equalization system, and a vacuum breaker system. The storage tank will be maintained at ambient temperature and atmospheric pressure.

The California Energy Commission requested an offsite consequence analysis (OCA) be conducted for the accidental release of aqueous ammonia at RCEP. The accidental release scenario involves the failure and complete discharge of the contents of the aqueous ammonia storage tank.

Analysis

An analysis of a 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 (USEPA) default (worst case) meteorological data, supplemented by daily temperature data as defined by 19 CCR 2750.2.

The maximum temperature recorded near the RCEP in the past 3 years was 99°F or 310.4° Kelvin, measured at the Oakland Airport, California (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?caokap+sfo). Maximum 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)	310.4 (99)

One modeling run was conducted based on an evaporating pool release caused by the complete failure of a single tank, 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 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 29-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, meteorological data displayed in Table 1 and the dimensions of the secondary containment area. 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.

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 since the concentration of the solution immediately begins to decrease as evaporation begins.

For the release scenario, a release of 85 percent of the contents of the storage tank (12,750 gallons of 29-percent aqueous ammonia) was assumed to be the worst case scenario. The failure of the tank would cause the aqueous ammonia to leak into the containment area and the release of ammonia gas would result from evaporation.

Although the edge of the tank containment area is raised above ground level, the release heights used in the model were set at zero meters above ground level (AGL) to maintain the conservative nature of the analysis. Downwind concentrations of ammonia were calculated at heights of zero and 1.6 meters above ground level. Reported distances to specified toxic endpoints are the maximum distances for concentrations at zero and 1.6 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 alternative to the storage tank failure release scenario was also considered. The release of aqueous ammonia from a tank loading hose failure with a leak below the excess flow valves activation set-point and the subsequent impacts was considered. An alternative release 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 captured 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 “bench mark” exposure levels were evaluated, as follows: (1) the lowest concentration posing a risk of lethality, 2,000 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 one-hour exposure or averaging time; therefore, the modeled distance to ERPG-2 concentrations are presented in terms of one-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).

TABLE 2
Distance to EPA/CalARP and CEC Toxic Endpoints

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	14.73	15.77	16.20	16.42
1.6 m AGL	16.35	17.65	17.94	18.09

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

The results of the offsite consequence analysis for the worst case release scenario of ammonia at RCEP indicate that the concentrations above the most stringent benchmark criteria (CEC's significance value of 75 ppm) does not extend off the project site (see Figure 1).

Assessment of the Methodology Used

Numerous conservative assumptions were used in the above analysis of the tank failure. 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 99°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 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 occurrence, population densities near the project site, meteorological conditions, and the process design. Considering the results of this analysis, the probability of a catastrophic storage tank failure resulting in the modeled ammonia concentrations, and the probability of a tank failure occurring under low wind speeds, maximum potential air temperatures and F class atmospheric stability, the risk posed to the public from the storage of aqueous ammonia at the RCEP site is insignificant.

As described above, numerous conservative assumptions have been made at each step in the analysis. This compounding of conservative assumptions has resulted in a significant overestimation of the probability of an ammonia release at the RCEP and the predicted distances to the benchmark criteria do not extend off the project site and pose no threat to public receptors. Therefore, it is concluded that the risk from exposure to aqueous ammonia due to the RCEP is less than significant.

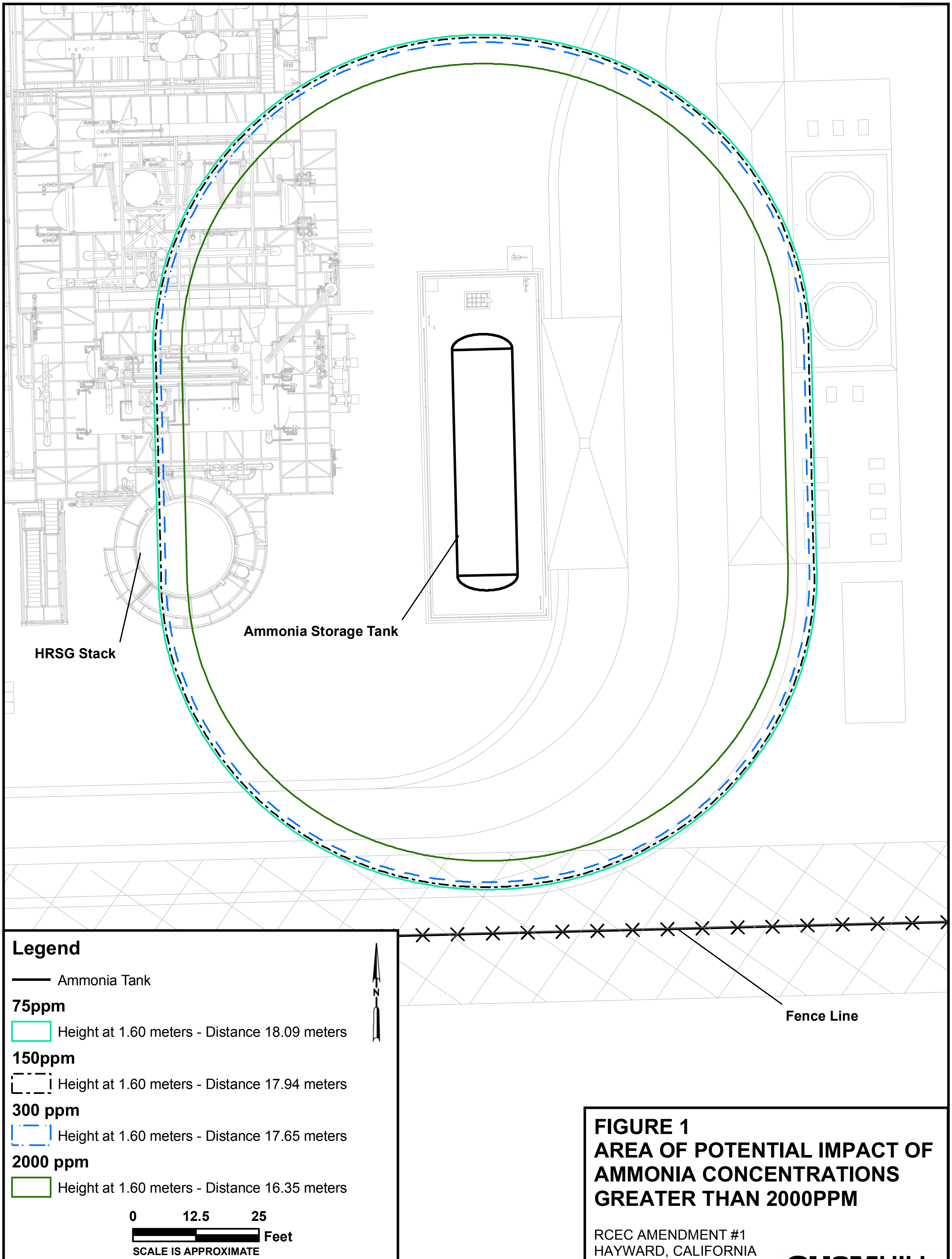

FIGURE 1
AREA OF POTENTIAL IMPACT OF AMMONIA CONCENTRATIONS GREATER THAN 2000PPM

RCEC AMENDMENT #1
HAYWARD, CALIFORNIA

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