APPENDIX A – 5

AIR QUALITY
BACT ANALYSIS

A BACT assessment has been conducted for the natural gas turbine at the Larkspur Generating Facility, which considered all NO_x, CO, VOC, PM_{10}, and SOx control technologies currently proposed or in use on natural gas-fired combustion turbines with more than 50 MMBtu per hour fuel energy input and natural gas-fired engines. To identify feasible emission limits for comparable turbine units, several information sources were consulted, including the following:

- U.S. EPA BACT/Lowest Achievable Emission Rate Clearinghouse (U.S. EPA 1985) and updates
- CARB BACT Clearinghouse database and CARB BACT Guidelines for Power Plants (Adopted 7/22/99)
- Recent California Energy Commission (CEC) Applications for Certification
- Research conducted by Larkspur Generating Facility Project design engineers

Table A-5-1 lists selected recent NO_x BACT proposals and determinations for natural gas-fired advanced technology combustion peaker turbines in California that are similar in size to the Larkspur turbine. Nearly all recent simple-cycle turbine projects in California had a NO_x BACT level of 2.5 ppm dry volume (ppmvd) (at 15 percent oxygen [O_2]), to be achieved by means of dry low-NO_x burners and SCR with ammonia injection. In some cases, SCR in conjunction with water or steam injection has been elected. The combustion turbine proposed for the Larkspur Generating Facility will achieve the BACT concentration of 2.5 ppmvd at 15 percent O_2 using water injection and SCR, except during startup and shutdown events.

TABLE A-5-1
SUMMARY OF RECENT NO_X BACT DETERMINATIONS FOR COMBUSTION TURBINE GENERATORS RATED AT GREATER THAN 40 MW IN PEAKING SERVICE

Name	Location	Rating	Vendor, Model	Emission Limit	Control(s)	Permit Date
Niland Gas Turbine Plant	CA	40+ each, 2 turbines, 97 MW total	GE LM6000 Sprint PC	2.5 ppm	Dry Low-NOx burner and SCR	10/06
Kings River Conservation District Peaking Plant	CA	40+ each, 2 turbines, 97 MW total	GE LM6000 Sprint PC	3.0 ppm	Water injection and SCR	5/04
Modesto Electric Generation Project	CA	40+ each, 2 turbines, 95 MW total	GE LM6000 Sprint	2.5 ppm	Water injection and SCR	2/04
Riverside Energy Resource Center	CA	40+ each, 2 turbines, 96 MW total	GE LM6000 Sprint PC NxGen	2.5 ppm	Water injection and SCR	12/04
San Francisco Electric Reliability Project	CA	40+ each, 3 turbines, 145 MW total	GE LM6000	2.5 ppm	Water injection and SCR	Tentative 4/06

DLE = Dry low emissions combustor
GE = General Electric
MW = megawatt
ppm = Parts per million by volume, dry basis, at 15 percent oxygen
SCR = Selective catalytic reduction

Similarly, most recent simple-cycle turbine projects have been approved with a CO emissions limit of 6 ppmvd and a ROC emissions limit of 2 ppmvd (both at 15 percent O_2), based on the use of an oxidation catalyst. The Larkspur natural gas turbine will achieve these same BACT concentrations for CO and ROC by application of oxidation catalysts. Exclusive use of natural gas fuel has been determined to be BACT for SO_x and PM_{10} in all other comparable projects for several years.

Assessment of NO_x Control Technologies

Based on a review of the materials described above, the following NO_x control technologies were evaluated to determine whether they are able to achieve BACT NO_x levels in practice:

- DLE and Goal Line SCONOx™
- DLE and SCR with ammonia injection

SCONOx™

SCONOx™ is a NO_x reduction system produced by Goal Line Environmental Technologies (now distributed by EmeraChem) for natural gas turbine applications within an exhaust temperature range significantly below the design operating parameters of the simple-cycle LM6000 turbine that will be employed at the Larkspur Generating Facility. This system uses a coated catalyst to oxidize both NO_x and CO and thereby reduce plant emissions. As demonstrated by an initial installation on several gas turbines in co-generation applications, SCONOx™ is capable of achieving NO_x emission concentrations of 2 ppm, based on a maximum inlet concentration of 25 ppm, and 90 percent CO reduction based on a maximum inlet concentration of 50 ppm. CO emissions are reduced in SCONOx™ by the oxidation of CO to CO_2. A two-step process reduces NO_x emissions. First, NO_x emissions are oxidized to NO_2 and then adsorbed onto the catalyst. In the second step, a proprietary regenerative natural gas is passed through the catalyst periodically. This natural gas de-desorbs the NO_2 from the catalyst and reduces it to N_2. The system does not use ammonia as a reagent; rather, it uses natural gas as the basis for a proprietary catalyst regeneration process.

However, the SCONOx™ technology has not been sufficiently demonstrated on higher exhaust temperature simple-cycle peaking natural gas turbines such as those proposed for the Project. The system consists of a catalyst that is installed in the flue gas at a point where the temperature is between 280°F and 650°F. The Larkspur CT operates between 715 to 858°F; therefore, the SCONOx™ application is not appropriate for this high temperature technology.

Potential advantages of the SCONOx™ process include:

- **No Ammonia.** The SCONOx™ process does not use ammonia. This eliminates any ammonia storage and transportation safety issues and the potential for ammonia slip or ammonia-based particulate formation.
- **Carbon Monoxide Reduction.** SCONOx™ will reduce CO emissions as well as NO_x emissions.

Potential disadvantages of the SCONOx™ process include:

- **High Capital and Operating Cost.** SCONOx™ is significantly more expensive than SCR with ammonia injection, primarily due to the higher cost of initial and replacement catalyst. The SCONOx™ catalyst is a precious metal catalyst, which is very expensive.
- **Not Suitable for Exhaust Temperatures of Simple-Cycle Natural Gas Turbine Peaking Applications**. SCONOx™ has been primarily installed on small co-generation systems. The Larkspur Generating Facility will be a simple-cycle peaking operation. Peaking units require more rapid startup and more frequent load changes than typical co-generation systems. The main concerns are the damper systems that would be required with SCONOx™ for the units and assuring proper regeneration gas distribution. The effectiveness and longevity of these damper systems have not been demonstrated on simple-cycle natural gas turbines, and their cost of replacement would be substantial. In addition, steam is required to produce the SCONOx™ regeneration gas. The Larkspur Generating Facility will have no steam production.
- **Catalyst "Washing."** A proprietary catalyst washing system must be used and an on-line catalyst washing system design has not yet been fully developed. If an on-line catalyst washing system is not used, then the facility must be shut down for cleaning.

Because the low NO_x emission rates attainable on natural gas turbines in co-generation systems with SCONOx™ have not been sufficiently "achieved in practice" on simple-cycle natural gas turbine applications and the other factors discussed above, SCONOx™ does not represent current BACT for the Larkspur Generating Facility.

SCR with Ammonia Injection

SCR with ammonia injection systems for reduction of NO_x emissions have been widely used in simple-cycle natural gas turbine applications for many years and are considered a proven technology. SCR systems are commercially available from several vendors, unlike SCONOx™, which is available from a single vendor. The SCR process involves the injection of ammonia into the flue gas stream by means of an ammonia injection grid upstream of the catalyst. The ammonia reacts with NO_x natural gases in the presence of the catalyst. The catalyst is not regenerated and requires periodic replacement. SCR vendors typically offer a 3-year guarantee on catalyst life. SCR with ammonia injection systems have been used in numerous simple-cycle applications in California and throughout the world, including many LM6000 class turbines.

The Project will use water injection and SCR with ammonia injection designed to achieve a NO_x emission limit of 2.5 ppm (at 15 percent O_2). As noted in Table A-5-1, SCR with either water injection or dry-low emissions (DLE) has recently been permitted at a NO_x emission level of 2.5 ppmvd (at 15 percent O_2) for numerous California turbines that are similar in capacity to the proposed Larkspur turbine. Accordingly, water injection and SCR with ammonia injection is considered to be BACT for the Larkspur Generating Facility.

Other Technologies

Technologies that cannot achieve a NO_x emissions limit of 2.5 ppmvd (at 15 percent O_2) in practice were not considered as BACT candidates for the Larkspur Generating Facility. These technologies include SCR without DLE, SCR without water injection, DLE without SCR, and steam injection without SCR.

Assessment of CO Control Technologies

The Larkspur Generating Facility turbine is guaranteed to emit no more than 6 ppm of CO (at 15 percent O_2), with natural gas fuel and use of a CO oxidation catalyst (except during startup and shutdown). Use of a CO oxidation catalyst will result in emissions of CO that will conform to current SDAPCD BACT requirements.

The following CO control technologies are evaluated:

- Combustion design/control
- Oxidizing catalyst

Combustion Design/Control

Natural gas turbine combustion technology has significantly improved over recent years with regard to lowering CO emissions. For other installations, these turbines have been guaranteed by the manufacturer to achieve a CO rate of 9 ppm (at 15 percent O_2) without post-combustion control technologies under a wide range of operating conditions (60 percent to 100 percent load) and ambient conditions (15°F to 115°F).

Oxidizing Catalyst

CO oxidizing catalysts have been used with natural gas-fired turbines for over a decade when uncontrolled CO emission levels are unacceptably high. CO catalysts operate at elevated temperatures within the exhaust stream. CO-oxidizing catalysts can be considered technically feasible for use in simple-cycle peaking applications. Thus, installation of a CO-oxidizing catalyst on the natural gas turbines is considered to be BACT for the Larkspur Generating Facility.

Assessment of ROC Control Technologies

The proposed BACT level of 2 ppmvd (at 15 percent O_2) for ROC control with water injection, SCR, and an oxidation catalyst is consistent with the most stringent level of control found among recent BACT determinations for simple-cycle natural gas turbines and is therefore considered to be BACT for the Larkspur Generating Facility.

Assessment of SO_2 and PM_{10} Control Technologies

Sulfur dioxide and PM_{10} emissions will be controlled through the exclusive use of clean-burning pipeline quality natural gas. This control technology has been widely and uniformly implemented for control of SO_2 and PM_{10} emissions from combustion turbines in California and throughout the United States, and is considered to be BACT for the Larkspur Generating Facility.

Assessment of Ammonia Slip Control Technologies

The proposed BACT level of 5 ppmvd (at 15 percent O_2) is the most rigorous control requirement that has been imposed to date on any natural gas turbine power plant project in California, and is thus considered to represent an appropriate BACT level for the Larkspur Generating Facility.