

Research Division

Contractor: IRTA
Contract # 07-313

FUNDING FISCAL YEAR	FY 07/08	FY 08/09	FY 09/10	
TERM	05/01/08-04/30/10	05/01/08-04/30/10	05/01/08-04/30/10	
PCA	72350	72350	72350	
LINE ITEM/OBJECT	418.20	418.20	418.20	TOTAL
DESCRIPTION Inventory development				
Contract \$	\$ 139,888.00	\$ 39,968.00	19,984.00	\$ 199,840.00
Y-E Funding change by RD (6/26/08)	\$ (39,968.00)	\$ 39,968.00		\$ -
				\$ -
Total, Contract	\$ 99,920.00	\$ 79,936.00	\$ 19,984.00	\$ 199,840.00

Payments to Contractor:

Inv. #	Inv. Date	Ser Per		C/S
1	2/2/2009	VARIOUS	9,961.00	9,961.00 C080589 ✓
2	5/4/2009		15,451.00	15,451.00 C080750 ✓
3	7/31/2009	4/25 - 07/31/09	14,724.00	14,724.00 C090124 ✓

Total, Payments	\$ 40,136.00	\$ -	\$ -	\$ 40,136.00
Balance Available to Pay Contractor	\$ 59,784.00	\$ 79,936.00	\$ 19,984.00	\$ 159,704.00
<i>Balance Must Be Spent By:</i>	<i>6/30/2010</i>	<i>6/30/2011</i>	<i>6/30/2012</i>	

Notes:

Contract Manager: Whitney Leeman

Duplicate

Research Division

Contractor: IRTA

Contract # 07-313

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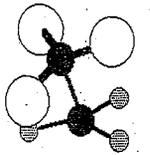
Total, Payments	\$ 40,136.00	\$ -	\$ -	\$ 40,136.00
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Balance Must Be Spent By: 6/30/2010 6/30/2011 6/30/2012

Notes:

Contract Manager: Whitney Leeman



Institute for Research and Technical Assistance
 a nonprofit organization
 230 N. Maryland Ave., Suite 103
 Glendale, CA 91206

1080589

09/07/09 11:00 AM

TO: Air Resources Board
 Research Division, 5th Floor
 P. O. Box 2815
 Sacramento, CA 95812

Attn: Ken Bowers / Emma Plasencia

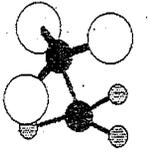
Grant Number 07-813

INVOICE PERIOD	INVOICE NUMBER	IRTA FEDERAL ID NUMBER	DATE SHIPPED
06/10/08-07/30/08 10/28/08-1/31/09	1	95-4253908	February 2, 2009
QUANTITY	DESCRIPTION:	UNIT PRICE	TOTAL
	Work compiled on "Developing a California Inventory for Industrial Applications of Perfluorocarbons, Sulfur Hexafluoride, Hydrofluorocarbons, Nitrogen Trifluoride, Hydrofluoroethers, and Ozone Depleting Substances." Task 1 Literature Review 100% Completed	\$11,068.00	\$11,068.00
Total Invoiced			\$11,068.00
10% Withholding			(\$1,107.00)
TOTAL DUE			\$9,961.00

[Signature]
 Amy A. Blum, Project Administrator

0079 244 400

PAYMENT APPROVED:
[Signature]
 BARTLE CROES, P.E.
 CHIEF, RESEARCH DIVISION
 DATE 3/12/09



Institute for Research and Technical Assistance
 a nonprofit organization
 230 N. Maryland Ave., Suite 103
 Glendale, CA 91206

0080750

1234567890

TO: Air Resources Board
 Research Division, 5th Floor
 P. O. Box 2815
 Sacramento, CA 95812

Grant Number: ~~072318~~

Attn: Ken Bowers / Emma Plasencia

INVOICE PERIOD	INVOICE NUMBER	IRTA FEDERAL ID NUMBER	DATE SHIPPED
02/01/2009 04/24/2009	2	95-4253908	April 24, 2009
QUANTITY	DESCRIPTION:	UNIT PRICE	TOTAL
	Work compiled on "Developing a California Inventory for Industrial Applications of Perfluorocarbons, Sulfur Hexafluoride, Hydrofluorocarbons, Nitrogen Trifluoride, Hydrofluoroethers, and Ozone Depleting Substances."		
	Task 2 Refined Work Plan		
	Principal Investigator K. Wolf	\$100.00	\$8,000.00
	Scientist K. Wolf	\$90.00	\$7,200.00
	Administrator A. Blume	\$40.00	\$800.00
	Other (travel, mail, phone, fax, photography, printing)		\$1,168.00
	Total Invoiced		\$17,168.00
	10% Withholding		(\$1,717.00)
	TOTAL DUE		\$15,451.00

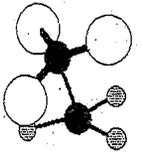
[Signature]
 Anna A. Blume, Project Administrator

PAYMENT APPROVED:

[Signature]
 BART E. CROES, P.E.
 CHIEF, RESEARCH DIVISION

DATE 5/4/09

00071444 0000



**Institute for Research and
Technical Assistance**

a nonprofit organization
230 N. Maryland Ave., Suite 103
Glendale, CA 91206

IRTA

TO: Air Resources Board
Research Division, 5th Floor
P.O. Box 2815
Sacramento, CA 95812
Attn: Ken Bowers / Emma Plasencia

Grant Number: 07-313

INVOICE PERIOD	INVOICE NUMBER	IRTA FEDERAL ID NUMBER	DATE SHIPPED	QUANTITY	DESCRIPTION:	UNIT PRICE	TOTAL
4/25/09 - 7/31/09	3	95-4253908	JULY 31 2009		Work completed on "Developing a California Inventory for Industrial Applications of Perfluorocarbons, Sulfur Hexafluoride, Hydrofluorocarbons; Nitrogen Trifluoride, Hydrofluoroethers, and Ozone Depleting Substances."		
					Task 3 Conduct Discussions/Visits for Targeted Applications		
					Principal Investigator K. Wolf	\$100.00	\$8,000.00
					80 hours	\$90.00	\$7,200.00
					Scientist K. Wolf	\$40.00	\$800.00
					80 hours		\$250.00
					Administrator A. Blume		\$50.00
					20 hours		\$60.00
					Travel		\$16,360.00
					Photocopying and Printing		\$60.00
					Mail, Phone and Fax		\$16,360.00
					Total Invoiced		\$16,360.00
					10% Withholding		(\$1,636.00)
					TOTAL DUE		\$14,724.00

Amy A. Blume, Project Administrator

PAYMENT APPROVED:

BART E. CROES, P.E.

CHIEF, RESEARCH DIVISION

DATE 8/17/09

This invoice has been presented for payment. If you have received this payment in full, please indicate payment later.

PO

Accounting Officer

607-42-0111

STATE OF CALIFORNIA
STANDARD AGREEMENT
 STD 213 (Rev 06/03)

AGREEMENT NUMBER 07-313
REGISTRATION NUMBER

1. This Agreement is entered into between the State Agency and the Contractor named below:

STATE AGENCY'S NAME
 Air Resources Board (State)

CONTRACTOR'S NAME
 The Institute for Research and Technical Assistance (IRTA)



2. The term of this Agreement is: May 01, 2008 through April 30, 2010
 (or upon DGS approval, whichever occurs later) (or 24 months after DGS approval) *KW*

3. The maximum amount of this Agreement is: \$ 199,840 (One Hundred Ninety-Nine Thousand, Eight-Hundred Forty Dollars)

4. The parties agree to comply with the terms and conditions of the following exhibits which are by this reference made a part of the Agreement.

Exhibit A – Scope of Work	1 page
Exhibit A, Attachment 1 – Technical Proposal	53 pages
Exhibit B – Budget Detail and Payment Provisions	1 page
Exhibit B, Attachment 1 – Budget Submittal Form	10 pages
Exhibit C* – *General Terms and Conditions	GTC 307
*Will be included in the contract, by reference to Internet site www.ols.dgs.ca.gov	
Exhibit D – Special Terms and Conditions	2 pages
Exhibit E – Additional Provisions	9 page
Exhibit F – Final Report Format	6 pages

Items shown with an Asterisk (*), are hereby incorporated by reference and made part of this agreement as if attached hereto.
 These documents can be viewed at www.ols.dgs.ca.gov/Standard+Language

IN WITNESS WHEREOF, this Agreement has been executed by the parties hereto.

CONTRACTOR

CONTRACTOR'S NAME (If other than an individual, state whether a corporation, partnership, etc.)
 Institute for Research and Technical Assistance

BY (Authorized Signature)
Katy Wolf
 PRINTED NAME AND TITLE OF PERSON SIGNING
 Katy Wolf, Director

DATE SIGNED (Do not type)
 6/3/08

ADDRESS
 230 N. Maryland Ave., Suite 103, Glendale, CA 91206

STATE OF CALIFORNIA

AGENCY NAME
 Air Resources Board

BY (Authorized Signature)
Socorro Watkins
 PRINTED NAME AND TITLE OF PERSON SIGNING
 Socorro Watkins, Chief, Business Services Branch

DATE SIGNED (Do not type)
 06-03-08

ADDRESS
 P.O. Box 2815, Sacramento, CA 95812

California Department of General Services Use Only



Kyates

Exempt per:

EXHIBIT A
Standard Agreement

SCOPE OF WORK

1. The Institute for Research and Technical Assistance (IRTA) agrees to provide to Air Resources Board (ARB) (type of service) as described in Exhibit A, Attachment 1.
2. The project representatives during the term of this Agreement will be May 01, 2008 through April 30, 2010.

Requesting Agency: ARB	Providing Agency: IRTA
Name: Emma Plasencia	Name: Katy Wolf, Director
Air Resources Board Research Division	
Address: 1001 I Street, P.O. Box 2815 Sacramento, Ca 95812	Address: 230 N. Maryland Ave., Suite 103, Glendale, CA 91206
Phone: (916) 323-1524	Phone: (818) 244-0300
Fax: (916) 322-4357	Fax: (818) 244-0396
Email: eplasenc@arb.ca.gov	Email: kwolf.irta@earthlink.net

The Contract Administrators will be:

Requesting Agency: ARB	Providing Agency: IRTA
Name: Emma Plasencia	Name: Katy Wolf, Director
Section/Unit: Research Division	
Address: 1001 I Street, 5 th Floor Sacramento, CA 95814	Address: 230 N. Maryland Ave., Suite 103, Glendale, CA 91206
Phone: (916) 323-1524	Phone: (818) 244-0300
Fax: (916) 322-4357	Fax: (818) 244-0396
Email: eplasenc@arb.ca.gov	Email: kwolf.irta@earthlink.net

3. Description of Services:

The objectives of the project will be to quantify emissions rates (during production and use), application growth rates, chemical substitution rates, banks, and end-of-life disposal emissions (if applicable) for each high global warming potential (GWP) greenhouse gas (GHG) in each application.

Mitigation strategies, such as emissions reductions associated with chemical substitutes, alternatives, and technology or process changes will be examined in terms of costs and benefits as well as life cycle climate performance (LCCP). The costs and benefits of recovery and/or destruction of high GWP GHGs in each application will be estimated.

Emissions scenarios based on business-as-usual as well as those incorporating various control strategies will be examined in the year 2020 to estimate possible CO₂-equivalent (CO₂E) GHG reductions and the associated costs, based on LCCP.

EXHIBIT A Standard Agreement

The deliverables of the proposed project include a detailed bottom-up inventory for high-GWP GHGs in California by use category, including associated equipment numbers where applicable. The contractor will be required to propose a methodology for generating the inventory that could include data gathering from trade associations as well as surveying the sectors that employ high GWP GHGs in various applications.

BACKGROUND:

With the passage of AB 32, ARB is charged with developing and implementing workplans to enable the State of California to reach its goal of CO₂E GHG emission reductions to 1990 levels by 2020. Originally, the Climate Action Team (CAT) report focused on HFC reduction strategies, but upon further investigation, it has become apparent to ARB's staff that greater global warming potential (GWP) greenhouse gas (GHG) reductions are possible if other, high-GWP GHGs are considered in addition to HFCs.

Roughly 3.75 million metric tons (MMT) CO₂E of SF₆ and 5.4 MMT CO₂E of PFCs were emitted in CA in 2005¹. The 2020 target called for under AB 32 currently requires a reduction of 174 million metric tons relative to BAU, and although high-GWP gas emissions from non-refrigeration/air-conditioning (non-RAC) applications do not account for a large percentage of the total emissions, cost-effective GHG emissions reductions are possible. Additionally, potential emissions from other high-GWP GHGs (besides SF₆ and PFCs) used in non-RAC applications are unknown, but may significantly contribute to overall GHG emissions.

By improving the inventory of high-GWP GHGs used in non-RAC applications, it will be possible to identify cost-effective reduction strategies. Some of the benefits of inventory development and high-GWP GHG emissions abatement include the possibility of establishing a program requiring recovery and reuse/destruction, or an offset program that provides credits for the recovery and destruction of high-GWP GHGs. Such a strategy would not only reduce greenhouse gas emissions but could in some cases provide co-benefits by mitigating emissions of substances that cause stratospheric ozone depletion.

Technical Plan

Task 1: Literature Review

The contractor shall conduct a review of published literature, reports, industry databases, etc., relevant to the topics of historic and current high-GWP GHG production and use, including: inventories, banks, and emissions; high-GWP GHG substitutes and phase-in schedules; alternative gases/processes, improvements in leak-tightness and gas recovery as well as not-in-kind (NIK) technologies; and current end-of-life management practices. The emphasis of the literature review will be on current US practices, and specifically, California practices, where possible. The literature review will also cover current and projected future technologies related to high-GWP GHG production and use, as well as alternative or NIK processes and end-of process or end-of-life (EOL) recovery and destruction.

¹ Numbers from USEPA report "U.S. High-GWP Emissions 1990-2010"; distributed to CA by 2005 population fraction, 12.8 percent. Because of California's semiconductor industry, using the population fraction to distribute national emissions to California might result in underestimation of SF₆ and PFC emissions.

EXHIBIT A Standard Agreement

Deliverable: This task will conclude with a report summarizing the relevant literature. The report will discuss implications for the project's research plan, and shall include a detailed bibliography. The contractor, being familiar with and possibly contributing to, the peer-reviewed literature, shall not expend more than 5 percent of the overall project budget on this task.

The aforementioned report will not be subject to separate review by the ARB's Research Screening Committee. The contractor may treat this report as a draft of an element of the final report of the project. This report should be presented prior to completion of Task 2.

Task 2: Refined Research Plan

The contractor shall present a fully developed research plan describing the necessary steps for the development of a detailed, bottom-up inventory for high-GWP GHG production, use, and banks in California. The determination of the various emissive applications as well as the installed base, and GHG emissions from the applications or installed base will involve a survey instrument to determine the different types and quantities of chemicals used or contained in various equipment types, as well as current installation, lifetime, and disposal practices. Atypical sources such as emissions from landfilled consumer products and stockpiled F-gases, should also be considered and included in the survey to the extent possible.

After applying various emission factors to estimate leak rates in the different life stages of the high-GWP GHGs of interest, the contractor will ultimately provide estimates of emissions and banks (if applicable) in a current year and in the year 2020 under a BAU scenario and under alternative scenarios that describe, at a minimum, the impacts of the following measures on CO₂E emissions over the lifecycles of the chemicals of interest: 1) high-GWP GHG control during production, installation, and lifetime; 2) high-GWP GHG substitutions, recovery, process changes and/or NIK technologies where feasible; and 3) end-of-life management measures including recovery and destruction.

Emissions forecasts will involve estimating future chemical and equipment types, their associated growth rates and lifetimes, as well as containment and recovery/destruction programs in California. The contractor will estimate the errors in the forecasts due to uncertainties in projecting the abovementioned changes.

The contractor will target the following areas in which data are needed for inventory purposes:

- PFC use, banks, and emissions in California
 - Semiconductor manufacturing, fire extinguishing, ODS substitution
 - PFC/PFPE emissions from solvents
- SF₆ use, banks, and emissions in California
 - Semiconductor manufacturing, electric power transmission and distribution
- HFC use, banks, and emissions in California
 - Semiconductor manufacturing, aerosols, fire extinguishing, solvents
- NF₃ use, banks, and emissions in California
 - Semiconductor manufacturing
- HFC-23 emissions from HCFC-22 production

EXHIBIT A Standard Agreement

- HFE use, banks, and emissions in California
 - HFEs have relatively low GWPs, but may be used in large quantities in industrial applications, clothing dry cleaners, and by consumers
- Ozone depleting substance (ODS) banks and emissions in California
 - Stockpiles of Class I and II ODS (which are also high-GWP gases), such CFCs, HCFCs, Halon 1211, 1301, and 2402, carbon tetrachloride, and methyl chloroform, used in the past for solvent cleaning, fire extinguishing and explosion protection (industrial, aviation, military, and other applications)

The results of the inventory will help to determine the most important sectors in terms of overall emissions of high-GWP gases and their reduction potentials.

The research plan will include a detailed work plan and project schedule.

Deliverable: This task will conclude with the submittal of a refined and revised research plan, work plan and project schedule. The refined research plan, which may integrate the deliverable from Task 1, will be subject to review by the ARB contract manager. The contractor may treat the research plan as a draft of an element of the final report of the project. This deliverable should be submitted prior to completion of Task 3.

Task 3: Survey Instrument Development

The contractor shall design a survey instrument that focuses on estimating high-GWP GHG production, installation, use, banks, and emissions in California. Contractor shall identify and consider for inclusion relevant, validated survey items. Individual interviews will be used to assess the effectiveness of preliminary survey instrument drafts and to identify any difficulties respondents have in answering the questions posed. The contractor shall enlist the advice and review of outside experts during the process of survey development. The survey instrument will be subject to review by an ARB statistician.

Deliverable: This task will conclude with a survey instrument to obtain bottom-up inventory data, as well as a survey pre-test and implementation plan. The survey instrument will have been reviewed by expert, external reviewers, and will also be subject to review by an ARB statistician and the contract manager. The contractor may treat this report as a draft of an element of the final report of the project. This deliverable should be submitted prior to undertaking Task 4.

Task 4: Survey Pilot Test and Report

The contractor shall pilot test the survey design with 100 or more respondents by having respondents complete the questionnaire as they would in the full implementation.

Deliverable: The contractor shall report on the pre-test results and assess, in consultation with the ARB's statistician and contract manager, whether any changes are needed prior to full survey implementation. This report should be presented prior to undertaking Task 5.

EXHIBIT A

Standard Agreement

Task 5: Survey Redesign and Implementation

The contractor shall redesign the survey based on pre-test results, and implement the redesigned survey to obtain no fewer than 1000 completed responses. The numbers of surveys issued for each sector should be weighted by the relative importance of the sector to the extent that it is known, so that more surveys are collected for the most important categories. The survey will be administered to a pre-selected panel designed to be representative of the California population. Survey responses will be compiled into an electronic database, screened for potential errors, and formatted for analysis.

Deliverable: One thousand or more complete, error-free, formatted survey responses. A machine readable file of the completed survey responses shall be submitted in an Excel spreadsheet or other electronic format as determined in discussion with the ARB contract manager. This deliverable should be submitted prior to completion of Task 6.

Task 6: Data Analysis

The contractor shall undertake a detailed, comprehensive analysis of the survey data. Response summaries will be created and reviewed. Areas of concern will be identified, and statistical testing performed as appropriate.

Deliverable: Annotated response summaries, (including number of responses, means, medians, minimums, maximums, standard deviations, and frequencies), will be provided to the ARB contract manager. The contractor may treat this report as a draft of an element of the final report of the project. This report should be presented prior to completion of Task 7.

Task 7: Draft and Final Reports

A draft report shall be prepared by the contractor and submitted to ARB and to outside reviewers for review and comment. The draft report will include discussions, analyses, descriptions of data collected, presentation of research methodology and results for all preceding tasks. The draft report will include a table summarizing the inventory results by chemical type, application, installed base by category including the number of sources, and emissions at various lifecycle stages (production, installation, lifetime, and end-of-life). Also included will be a figure summarizing the BAU emissions and forecasted reductions due to various control strategies in 2020.

A Final Report shall be prepared by the contractor and submitted to ARB. The contractor's work plan shall allow for a period of no less than six months from submittal of the draft report until submittal of the final report. This final report will be subject to formal review by the Research Screening Committee.

Deliverables: Quarterly progress reports, draft, and final reports.

MEETINGS

Prior to beginning the contracted work, the principal investigator and key personnel shall meet with the ARB contract manager and other ARB staff. The meeting location will be at ARB's offices in Sacramento and will cover the overall project plan, details of performing the tasks, the project schedule, and items related to personnel or changes in personnel, and any issues that should be resolved before work can begin.

EXHIBIT A

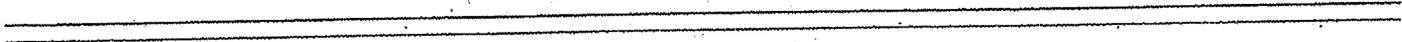
Standard Agreement

The contractor will participate in regular progress meetings with the ARB contract manager and other ARB staff. These meetings will most likely take the form of telephone conferences. The interval between meetings should be no more than quarterly, and may be more frequent as deemed necessary by the ARB contract manager. The contractor should be prepared for open, two-way communication with the ARB contract manager throughout the course of the project.

CONTRACT DELIVERABLES

In addition to the deliverables listed in the technical plan, the contractor will provide quarterly invoices and electronic progress reports. These progress reports will completely discuss the status of the project to date, the progress since the previous progress report, significant problems addressed during the quarter, significant problems to be addressed in the next quarter, and work planned for the next quarter. The quarterly progress report should also quantify the percentage of work accomplished to date and percentage of budget used to date. Finally, the progress report should make a statement about any need to revise the schedule or budget class amounts to reflect changes needed over the existing schedule or budget.

Exhibit A
Attachment 1
Technical Proposal



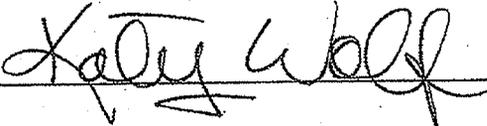
Technical Proposal

**Developing a California Inventory for Industrial Applications of Perfluorocarbons,
Sulfur Hexafluoride, Hydrofluorocarbons, Nitrogen Trifluoride, Hydrofluoroethers
and Ozone Depleting Substances**

Principal Investigator:
Katy Wolf, Ph.D.

Official Authorized to Bind this Proposal:

Name: Katy Wolf, Ph.D.

Signature 

Prepared for:

California Air Resources Board
Research Division
P.O. Box 2815
Sacramento, CA 95812

Prepared by:

Institute for Research and Technical Assistance
230 N. Maryland Ave., Suite 103
Glendale, CA 91206
Contact Person: Katy Wolf
Phone: (818) 244-0300
Fax: (818) 244-0396
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October 12, 2007

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Technical Proposal

STATEMENT OF SIGNIFICANCE

Climate change is recognized by scientists as one of the most challenging issues over the next several decades. Emissions of greenhouse gases (GHGs) will increase substantially over the period. California is the twelfth largest source of GHGs in the world. The state is a major contributor to the problem and is also a leader in addressing environmental issues.

On June 1, 2005, Governor Schwarzenegger signed Executive Order S-3-05 which calls for a reduction of GHG emissions to 2000 levels by 2010, a reduction in GHG emissions to 1990 levels by 2020 and a reduction in GHG emissions to 80 percent below 1990 levels by 2050. In 2006, the California Legislature passed AB 32 which charges the California Air Resources Board (ARB) with developing and implementing a plan for the state of California for reducing GHG emissions to 1990 levels by 2020.

The original focus for GHG emission reductions was on carbon dioxide, methane and, to a smaller extent, hydrofluorocarbons (HFCs). HFCs have been and will be used widely in a number of applications as alternatives to ozone depleting substances (ODSs) that have been or will be phased out over the next several years. ARB has become aware that other substances including perfluorocarbons (PFCs), perfluoropolyethers (PFPEs), sulfur hexafluoride (SF₆), nitrogen trifluoride (NF₃), hydrofluoroethers (HFEs) and ODSs are being used and emitted in various industrial applications. Reductions in emissions of these GHGs may help ARB to meet the requirements of AB 32; the target emission reduction in 2020 is 400 million metric tons (MMT).

The purpose of this proposed project is to focus on certain applications where HFCs, HFEs, PFCs, PFPEs, SF₆, NF₃ and ODSs are used and/or emitted. Although emissions of these materials are lower than emissions of carbon dioxide, their Global Warming Potential (GWP) is much higher on a pound for pound basis. ARB is sponsoring separate projects which focus on GHG emissions from refrigeration and air conditioning and foam applications. The applications that will be addressed here include semiconductor manufacturing, electric power transmission and distribution, fire extinguishing, solvents, aerosols and HCFC production.

IRTA is proposing to provide a detailed bottom-up inventory for the GHGs listed above in California. It will involve quantifying emissions of the gases during production, use and end of life disposal and estimating growth rates in the use of the GHGs in the selected industries. It will also involve identifying substitutes and estimating their penetration in the applications of interest. Methods of reducing or eliminating emissions of the GHGs will also be investigated and the costs, benefits and life cycle climate performance (LCCP) will be estimated. Stockpiles of ODSs will also be estimated. The

results of the project will be used by ARB to evaluate strategies for meeting the 2020 emission limits.

ABSTRACT

The California Air Resources Board (ARB) is charged with developing and implementing a plan to reduce greenhouse gas (GHG) emissions to 1990 levels by 2020. As part of that plan, ARB must estimate the GHG emissions in the state and analyze methods of reducing emissions.

This proposal focuses on estimating the baseline emissions of certain GHGs in seven applications including:

- semiconductor manufacture;
- electric power transmission and distribution;
- fire extinguishing;
- solvents;
- aerosols;
- HCFC-22 production; and
- other.

The GHGs used in these applications are perfluorocarbons (PFCs), perfluoropolyethers (PFPEs), sulfur hexafluoride (SF₆), nitrogen trifluoride (NF₃), hydrofluorocarbons (HFCs), hydrofluoroethers (HFEs) and ozone depleting substances (ODSs). Although absolute emissions of these GHGs are much lower than emissions of carbon dioxide, the Global Warming Potentials (GWPs) of these GHGs are much higher than the GWP of carbon dioxide.

The proposed project described here involves estimating the baseline GHG emissions from the seven applications listed above. The research would include working with trade associations, users, equipment manufacturers and chemical manufacturers to characterize use of the GHGs. It would also include taking into account trends in each application to establish future use of the GHGs or substitute chemicals and practices. In certain of the applications, the GHGs are emitted in the same year they are used; in other applications, the GHGs are "banked" in equipment. Models for each of the applications, taking into account the use and emission characteristics, will be developed to estimate the current and likely future emissions.

The project also involves analyzing methods of reducing or eliminating emissions of GHGs from the target applications. Depending on the application, these methods would include chemical alternatives, process alternatives, use of better equipment, recycling and reuse, better maintenance practices and destruction technologies. The costs, advantages, disadvantages, LCCP and implications or tradeoffs of adopting these methods will be analyzed.

PROJECT OBJECTIVES

The purpose of the proposed project is to develop an inventory of California GHG emissions from certain applications and to analyze methods of reducing or eliminating the emissions. The seven target applications include semiconductor manufacture, electric power transmission and distribution, fire extinguishing, solvents, aerosols, HCFC-22 production and other. The GHGs of interest are PFCs, PFPEs, SF6, NF3, HFCs, HFEs and ODSs.

The first objective of the project is to characterize use of the candidate GHGs in the seven applications. This will involve working with and surveying trade associations, users, producers and equipment manufacturers. In many cases, questionnaires will be distributed to users and, in most cases, visits to facilities using the GHGs will be necessary.

The second objective of the project is to evaluate trends in use of the GHGs in the applications of interest. This will involve contacting and surveying trade associations, users, producers and equipment manufacturers to gather information on practices and their likely penetration.

The third objective is to estimate current and future baseline emissions of the GHGs in the candidate applications. In some cases, the GHGs are emitted in the same year they are used; in other applications, the GHGs are banked during use. Emission models will be developed for each GHG in each application.

The fourth objective is to analyze methods of reducing or eliminating emissions of the GHGs in the target applications. The techniques that would be examined include chemical substitution, process substitution, use of better equipment, use of better operating practices and destruction. The costs, benefits and implications, including LCCP effects, of these methods would be examined and compared.

TECHNICAL PLAN

Background and Research Plan

The GHGs that will be investigated during this project and their applications are summarized in Table 1.

The table indicates that PFCs/PFPEs, SF6, NF3 and HFCs are used in the semiconductor manufacturing process. ARB estimates that the lower bound emissions of SF6 in semiconductor manufacturing in California amounted to 3.75 MMT of carbon dioxide equivalents in 2005 based on a population allocation for the U.S. ARB also estimates that the lower bound emissions of NF3 in semiconductor manufacturing in California at

5.4 MMT of carbon dioxide equivalents. The semiconductor industry also uses PFCs and HFCs for various purposes.

Table 1
Applications of Targeted GHGs

	PFCs/PFPEs	SF6	NF3	HFCs	HFES	ODSs
Semiconductor	X	X	X	X	-	-
Manufacture						
Electric Power	-	X	-	-	-	-
Transmission						
Fire Extinguishing	X	-	-	X	-	X
Solvents	X	-	-	X	X	X
Aerosols	-	-	-	X	X	X
HCFC-22 Pro- duction	-	-	-	X	-	-
Other	X	X	-	-	X	X

Table 1 also indicates that SF6 is used by the electric power industry in transmission and distribution activities.

ODSs were used for many years in fire extinguishing applications. Various fully halogenated brominated ODSs including Halons 1211, 1301 and 2402 were used in portable fire extinguishers and total flooding systems. Some of these materials may still be banked in the systems and they would be available for emission through leaks, during servicing and at system disposal. HFCs are currently used in fire extinguishing applications as replacements for the Halons. PFCs are also used in these applications.

The GHGs in Table 1 currently used in solvent applications include PFCs/PFPEs, HFCs, HFES and ODSs. The ODSs CFC-13 and 1,1,1-trichloroethane (TCA), were historically used in solvent applications and there may remain stockpiles of these materials. HCFC-141b and HCFC-225, both ODSs, are also used in solvent applications.

HFCs are used as propellants in aerosol products of various types. Examples include HFC-152a and HFC-134a. HFCs, HFES and ODSs like HCFC-141b and HCFC-225 are used in aerosol cleaning products as the active ingredient.

HFC-23, a high GWP HFC, is emitted from HCFC-22 production plants.

PFCs/PFPEs, HFCs, HFES and stockpiled ODSs are used in a few other applications. For example, a PFC is used as a quick drying additive in one garment cleaning process. SF6 is also used in a variety of other applications.

Research Methods--Semiconductor Industry

Table 1 indicates that PFCs/PFPEs, SF6, NF3 and HFCs are used by the semiconductor industry. The use, emissions and banks of these materials in California are not available in published information. Although EPA collects industrywide information, it is confidential and does not disaggregate the data for California. Estimates using the California population fraction are not likely to be accurate since California has a disproportionately large semiconductor industry.

IRTA will contact and work with the Semiconductor Industry Association (SIA), which is based in San Jose, California, to collect information on the California industry use, emissions and banks. Through the SIA, IRTA will also arrange visits to two or more semiconductor manufacturing facilities to better characterize use of the GHGs in this industry. IRTA will also work with the SIA to develop a questionnaire for their California members that will focus on their use of the GHGs and their practices involving GHGs. The identity of the facilities could be held confidential by SIA. IRTA will identify semiconductor facilities that are not members of the trade association and either survey them directly or work with SIA to estimate the use and emissions of the GHGs used by the non-members.

IRTA will also try to collect information from SIA or through the questionnaire on the semiconductor industry use of PFCs, HFCs, HFEs and ODSs in cleaning applications. The cleaning information gathered from this process will be considered in conjunction with the information collected from producers, solvent distributors and other solvent users under solvent applications described below.

Industry GHG Use. The semiconductor industry uses fluorinated materials including PFCs, HFCs, SF6 and NF3 for plasma etching and chemical vapor deposition. The PFCs that are commonly used are CF4 and C2F6. The HFC that is commonly used is HFC-23. The GHGs used by the industry have very high 100 year GWPs, ranging from about 6,500 to 11,700.

IRTA staff will visit a few semiconductor facilities to observe and discuss the characteristics of use of the GHGs; this background information will be used to design the questionnaires for this industry. It is important to understand these processes. Since the materials are used for plasma etching and chemical vapor deposition, they are decomposed during use and there may be formation of other GHGs or non-GHGs through decomposition and/or recombination. During the visits and with the assistance of SIA, IRTA will establish a materials balance for the GHGs which includes identification of final products. Adoption of some of the mitigation measures discussed below may alter the mix of final products as well and it is important to take this into account.

Emission Rates. For purposes of analysis, in this application, IRTA will assume that the GHGs used in a particular year and/or their decomposition products are emitted in the

same year. To examine growth rates in this category, IRTA will incorporate trends in use of GHGs and the effects of changing practices.

Methods of Reducing/Eliminating Emissions. EPA identifies several emission reduction methods that could be adopted by existing and new semiconductor manufacturing facilities. These include use of NF3 in place of C2F6 for chemical vapor deposition. Although the GWPs of NF3 and C2F6 are similar, NF3 is more efficient. Etching emission reduction methods include plasma abatement with additive gas, thermal destruction and catalytic destruction. In all cases, it is important to understand the decomposition and recombination characteristics to ensure that GHGs with high GWPs are not generated. Another method of reducing emissions of GHGs is to collect emissions from chemical vapor deposition and etching operations and recycle and reuse them or destroy them. It is not clear that recycle and reuse would be practical because the stream may contain largely decomposition products. Another option for reducing emissions of GHGs is to substitute alternatives with lower or no GWP. The final option for reducing emissions is to optimize the process using detectors and process variation. IRTA will investigate these mitigation methods and others that may arise during the project.

Research Methods--Electric Power Transmission/Distribution

SF6 has a very high 100 year GWP of 23,900. The gas is used as an insulator in electric transmission and distribution equipment. SF6 replaced flammable insulating oils in many insulating applications beginning in the 1950s. Emissions of SF6 occur through leakage, servicing and end of life disposal from gas-insulated circuit breakers and gas-insulated substations. Older equipment generally has a higher leakage rate than newer equipment. EPA estimates emissions of SF6 nationwide but the information cannot be used to estimate California emissions because it is confidential.

IRTA will use one of two possible approaches for this application. With the first approach, IRTA will contact the major electrical utilities in California and request that they assist in estimating SF6 emissions from transmission and distribution. The major utilities in California include:

- Los Angeles Department of Water and Power
- Southern California Edison
- Sacramento Municipal Utility District
- Pacific Gas & Electric
- San Diego Gas & Electric

There are a number of cities in California that generate their own electricity and IRTA will try to identify and contact these municipal utilities as well. Examples of smaller utilities include Burbank Water & Power and the city of Glendale. If data for the smaller utilities in the state cannot be obtained, IRTA will estimate, with the help of the larger

utilities, the likely emissions from the smaller facilities combined based on the proportion of their load distribution and transmission.

It may not be possible to collect good information from the small municipal utilities and the large utilities may want to keep their emissions confidential. In that event, the second approach for estimating the inventory of SF6 would be used. This would involve working through the Electric Power Research Institute (EPRI). IRTA would develop a questionnaire with EPRI and EPRI would distribute it to their members and keep the information provided proprietary. EPRI would also be able to assist in estimating the fraction of the inventory likely to be emitted from non-EPRI member facilities.

Emission Rates. IRTA will model the emissions process by using the EPA approach. This would involve using the current inventory and the banks taking into account leakage, servicing and disposal emissions. It would also involve incorporating growth rates in electricity consumption and the decline in average equipment charge size over time. IRTA will also take into account adoption of any mitigation measures in the model. IRTA would likely adopt the EPA U.S. growth rate of 0.7 percent per year unless the research indicated that the growth rate in California should be different.

Methods of Reducing/Eliminating Emissions. The first option for reducing emissions is to use recycling equipment for reusing the SF6 during maintenance and disposal rather than venting. The second option is to perform leak detection and repair regularly. The third option is to replace older equipment which uses and leaks more SF6 with newer equipment. The fourth option is to use more accurate laser leak detection systems. The fifth option is to replace the SF6 with an alternative that has no or a lower GWP. IRTA will investigate these options during the project and estimate their potential for reducing emissions and/or the GWP of emissions from this source.

Research Methods--Fire Extinguishing

Historically, Halons 1211, 1301 and 2402 were used in fire extinguishing systems in hand held portable fire extinguishers and total flooding systems used to protect computer systems and various types of high value electronic and other equipment. These substances have very high ozone depletion potentials because they contain bromine. Their production has been banned but halons may remain in stockpiles, in fire extinguishers and in total flooding systems in the state. Halons 1211 and 1301 have 100 year GWPs of 1300 and 6900 respectively.

Alternatives that have been adopted in the last several years in fire extinguishing are three HFCs, HFC-227ea, HFC-236fa and HFC-23, and one PFC, CF4. All of these materials have very high GWPs. Some HCFC blends are also used. For portable fire extinguishers, the majority of the market has converted to not-in-kind alternatives like dry powder, carbon dioxide or water. Over the next several years, only two HFCs, HFC-236fa and HFC-227ea, are expected to be used in this sector. The primary material that

has replaced Halon 1301 in total flooding systems is HFC-227ea; HFC-23, HFC-236fa and HFC-125 are also used to some extent. Inert gas systems that contain nitrogen, argon and carbon dioxide are also being used in total flooding systems. Not-in-kind alternatives like powdered aerosols, water sprinklers, water mist systems and foams are also being used to some extent as alternatives to total flooding systems.

The portable fire extinguisher market and the total flooding system market are very different. There is not likely to be one major trade association IRTA could work with to collect all the necessary data. IRTA will work with suppliers of the fire extinguishing agents, fire extinguishers and systems and trade associations like the Fire Suppression Systems Association and the Fire Equipment Manufacturers Association to develop questionnaires. The questionnaires will be used to determine inventory, banked and trend data for California. If California appears to be similar to the national market, IRTA could rely on EPA's model that is based on confidential data to estimate the California inventory based on population or a business metric.

Emission Rates. Emissions of Halons, HCFCs and HFCs in fire extinguishing applications occur through leakage, servicing, inadvertant discharges and discharges during fires. A portion of the GWP is decomposed during a fire and this must be taken into account in the modeling. IRTA may rely on the EPA vintaging model to estimate growth in the industry for California. IRTA will also gather information from system suppliers, the National Fire Protection Association (NFPA) and other knowledgeable industry sources to estimate the mix of technologies likely to be used in the future.

Methods of Reducing/Eliminating Emissions. Many not-in-kind alternatives are already being used in the portable fire extinguishing sector. Such alternatives may be suitable for the entire sector. Certain specialized markets like marine, aviation and military applications may be the only places where HFCs are or need to be used.

For total flooding systems, not-in-kind alternatives like carbon dioxide can be used in some applications, particularly for unoccupied spaces. In occupied spaces, carbon dioxide can be used if alarms and warning systems are used. Other inert gas systems and water mist systems could also be used in some applications.

Research Methods--Solvents

Several of the GHGs listed in Table 1 are used currently or have been used in the past in solvent applications. These include: the Class I ODSs for which production was banned in 1996; Class II ODSs for which production bans were scheduled after 1996; HFCs; HFEs; and PFCs/PFPEs. Because published data are not available for use, emissions or stockpiles of the solvents in California, IRTA will develop questionnaires to estimate the information based on contacts with industry representatives. In some cases, discussions with industry sources, rather than questionnaires, may have to be used to obtain the information. Each of the categories of solvents is discussed below.

Class I ODSs. Solvents are generally emitted in the same year they are used and this will be assumed in this analysis. A major solvent ODS that was used in the past is CFC-113 which was used for electronics cleaning like defluxing printing circuit boards and for various precision cleaning applications. CFC-113 is a gentle cleaner which is compatible with many materials used in making electronics devices. Another major ODS used in solvent applications is TCA which was used primarily for metal cleaning but also was used, to some extent, for defluxing printed circuit boards and in precision cleaning. TCA is a much more aggressive cleaner than CFC-113. Both solvents were used in vapor degreasing and cold cleaning applications. TCA was also used in an extensive range of solvent applications including as a carrier in coatings and adhesives and as a cleanup solvent for coating, adhesive and ink application equipment. Both CFC-113 and TCA were used in dry cleaning and in handwipe cleaning applications. Some companies in California may retain stockpiles of TCA or CFC-113 and may be using the solvents for very limited applications. IRTA will rely on industry sources to determine if companies do still retain stockpiles.

Class II ODSs. When production of CFC-113 and TCA was banned in 1996, some companies converted to various HCFCs including HCFC-141b, HCFC-123 and HCFC-225 for certain types of cleaning applications. HCFC-123 has toxicity problems and it has not been used in solvent application for many years. HCFC-225 production is scheduled to be banned in 2015 because it causes ozone depletion. It is a gentle cleaner like CFC-113 and is used in printed circuit board defluxing and precision cleaning applications. It is expensive so it is not used widely. HCFC-141b is a more aggressive solvent and it was used much more widely than HCFC-225. Production of HCFC-141b was banned in 2003 and EPA restricted its use. Stockpiles of HCFC-141b may remain and the ODS is still used in handwipe and electronics cleaning and, as discussed later, in aerosol cleaning products. Published information on the use and stockpiles is not available. IRTA will rely on discussions with producers, solvent distributors and other industry sources to determine the amount of HCFC-225 used in California and the amount of HCFC-141b used and stockpiled in California. In some cases, questionnaires may be used to obtain the information.

HFC Solvent Use. When CFC-113 and TCA production were banned, some companies converted to blends containing HFC-43-10me and a few different HFEs for printed circuit board defluxing and precision cleaning. These materials are very expensive and are virtually always used in vapor degreasing systems. The solvents have little cleaning capability (even less than CFC-113 or HCFC-225) so they are combined with other solvents wherever they are used. The other solvents they are combined with are classified as VOCs. The South Coast Air Quality Management District (SCAQMD) has stringent VOC regulations on vapor degreasing solvents so when these solvents are used in the South Coast Basin, they are used in airless/airtight degreasers. In other parts of the state, they may be used in open top vapor degreasers. There are no published data on the use of these solvents. To estimate their use in California, IRTA will contact some of the larger

air districts to determine how many permitted systems there are and will contact manufacturers, solvent distributors, other industry sources and some users to estimate the use of the solvents. In some cases, questionnaires will be developed to solicit the information.

PFC/PFPE Solvent Use. Some companies converted from CFC-113 and TCA to PFCs blended with other materials for defluxing printed circuit boards and precision cleaning applications. The PFCs are extremely poor cleaners and are virtually always combined with other materials. EPA restricted the applications where PFCs and PFPEs could be used several years ago because of the chemicals' high GWPs. The types of applications that were allowed included cleaning gyroscopes, electro-mechanical assemblies and direct access devices. IRTA will verify that EPA still allows these uses and will develop questionnaires to estimate the use in California through contacts with manufacturers, solvent suppliers and users.

Trends in Substitution. IRTA will evaluate the trends in substitution for the solvent applications in Table 1. Two HCFCs, HCFC-141b and HCFC-225, are still used in solvent applications but their production has been or will be banned in the future. IRTA will investigate the potential alternatives that might be used in their place.

As an example, consider a company using HCFC-225 for electronics cleaning. When the production ban goes into place in 2015, the company will have to adopt an alternative which could be an HFC or HFE. The HFC or HFE may have a higher GWP than HCFC-225.

Emission Rates. IRTA will estimate the emission rates from this application by taking into account the current inventory and stockpiled GHG solvents. In this category, IRTA will assume that solvents used in a particular year will be emitted during the same year. The estimates will assume a chemical substitution rate based on substitution that is likely to occur and use of more conservative equipment.

Methods of Reducing/Eliminating Emissions. IRTA will investigate methods of reducing emissions in solvent applications of the GHGs. These would include using tighter equipment to limit use and emissions, using non-GHG alternatives and using lower GWP GHG alternatives. Case studies of emission reduction methods and alternatives will be developed. These will include costs, benefits, LCCP implications where appropriate and other impacts of using the emission reduction methods and alternatives.

As an example, consider an HFE or HFC solvent used in precision cleaning applications. SCAQMD requires blends of these solvents used with VOC solvents to use airless/airtight degreasers. This method could also be required for cleaning operations outside SCAQMD. The cost of using an open top versus an airless/airtight degreaser would be compared for the operation and the emission reduction would be estimated. Energy requirements for the two options would also be compared for the LCCP analysis.

As another example, consider an HCFC, an HFE or an HFC used in defluxing printed circuit boards. Alternatives like use of low-solids flux or a water-based cleaner might be viable. Again, case studies for typical operations would be prepared. The cost, energy use, benefits and implications of using the alternatives would be evaluated.

Research Methods--Aerosols

Table 1 indicates that three types of materials--HFCs, HFEs and ODSs--are used in aerosol applications. Three different HFCs, including HFC-134a, HFC-152a and HFC-227ea, are used as propellants in aerosol products. The 100 year GWPs of these products are 1,300, 140 and 2,900 respectively. At least one aerosol packager is considering using HFC-236fa. The types of products where these HFCs are used as propellants include metered dose inhalers, various consumer products and a range of specialty products like electronic equipment dusters, boat horns and tire inflaters.

HFCs, HFEs and ODSs are used in aerosol products as cleaning agents. These cleaners include HFC-43-10me, HFE-7100 and HFE-7200, HCFC-141b and HCFC-225. HFC-245fa may also be used to some extent in solvent products. These high value expensive solvents are generally used in contact cleaners for cleaning energized and non-energized electrical equipment and other high value uses. They are often combined with 1,2-trans dichloroethylene (DCE) to enhance their cleaning capability.

IRTA will estimate the propellant and cleaning agent use of these materials by using the EPA data for the propellants, ARB data for propellants and the cleaning agent and industry contacts. The EPA data are confidential so the use of the propellants for California cannot be disaggregated. It may be reasonable to assume that the fraction used by California can be apportioned based on California's share of the nation's population. ARB's consumer products group collects information on use of various materials including HFC propellants every three years or so to determine the inventory for regulatory purposes. IRTA may be able to rely on the ARB data to estimate the California inventory. This can be compared with the EPA data. If the ARB data are not sufficient, IRTA will develop questionnaires to determine propellant use by packagers.

ARB's Consumer Products group also collects information on the use of solvents in consumer aerosol products. IRTA may be able to rely on the most recent ARB data to estimate the inventory of the HFC, HFE and HCFC solvents. IRTA will also use solvent industry contacts and possibly questionnaires if the ARB information is not sufficient.

Trends in Substitution. Other alternatives are beginning to be used in aerosol contact cleaners. Historically, TCA and CFC-113 were used in these applications. When production was banned, the industry generally converted to HCFC-141b. Production of HCFC-141b has now been banned but inventory may remain and suppliers are still selling HCFC-141b products. In addition to the HFC, HFE and HCFC-225 cleaners, alternatives

suppliers are now offering other cleaners including n-propyl bromide which is a reproductive toxin and perchloroethylene and trichloroethylene which are carcinogens.

Emission Rates. For this category, IRTA will assume that the propellants and the solvents are emitted in the same year they are used. As part of the project, IRTA will estimate the growth rates of the propellants and cleaning agents in aerosol products based on information from industry sources on trends and with input from ARB's consumer products group and industry contacts. IRTA will also investigate emissions from the "heel" in aerosol cans that might be emitted from landfills where spent aerosol cans are sent.

Methods of Reducing/Eliminating Emissions. The HFC propellants in aerosol products can be replaced by alternative propellants including hydrocarbons, dimethyl ether (DME), carbon dioxide and nitrogen. Hydrocarbons and DME are classified as VOCs and ARB may be reluctant to encourage their use as alternatives because of the effort to reduce VOC emissions. IRTA conducted limited testing of various propellants in a project sponsored by ARB to develop and test alternative automotive aerosol cleaning products. IRTA formulated several solvent cleaning products with a carbon dioxide propellant and was impressed with its performance. Many products on the market now contain the propellant and IRTA believes it is a better and lower cost propellant than hydrocarbons. Carbon dioxide is difficult to use as a propellant in water-based products because it can form acid over time. Hydrocarbon propellants, however, can be used successfully in these products.

Propellants in metered dose inhalers (MDI) may be the most difficult to replace. EPA estimates that these products will account for about one-third of all aerosol HFC emissions by 2010. MDIs are used for treating asthma and chronic obstructive pulmonary disease. Alternative propellants in MDIs must be approved by the Food and Drug Administration before they can be used.

HFC propellants can also be replaced by use of non-aerosol products. Such products include pump sprays, powder formulations, solids and bulk materials used in spray bottles. In the case of MDIs, for example, a small portion of the market can be replaced with dry powder inhalers.

IRTA has tested alternative cleaning products that can replace HCFC-141b, HFC-245fa, HFC-4310me, HFES and HCFC-225 for cleaning non-energized electrical equipment. Water-based cleaners and VOC exempt chemicals with flash points like acetone can be employed for that purpose. IRTA is currently conducting a project, sponsored by EPA, to identify, develop, test and demonstrate not-in-kind alternative cleaners for energized electrical equipment cleaning. The results of that project will provide useful information on alternative cleaning methods.

Research Methods--HCFC-22 Production

Table I indicates that an HFC is emitted from HCFC-22 production facilities. HFC-23 has a 100 year global warming potential of 11,700. The chemical is generated as a byproduct in the HCFC-22 production process which uses chloroform and hydrogen fluoride as feedstocks.

There is one production facility in California, located in El Segundo, that produced HCFC-22 in the past. The facility was converted to HCFC-141b/HCFC-142b production in 1992. Future plans for the facility are not available. Production of HCFC-22, except for use as a feedstock and in equipment manufactured before 2010, will be banned in 2010. IRTA will contact Allied-Signal (now Honeywell) to determine whether the company has any plans for producing HCFC-22 at the El Segundo plant in the future. If the company has no plans to produce HCFC-22 at the plant in the future, IRTA will not evaluate this application further. If the company does plan to produce HCFC-22 in the future, IRTA will further investigate methods of reducing HFC-23 emissions from the facility.

Emission Rates. If HCFC-22 is produced in the El Segundo manufacturing plant, IRTA will estimate the emission rates over time. These rates will take into account mitigation measures that may be implemented at the plant.

Methods of Reducing/Eliminating Emissions. If HCFC-22 is produced in El Segundo, IRTA will evaluate two methods of reducing HFC-23 emissions. These include optimizing the production process and destruction of HFC-23 using thermal or catalytic oxidation. IRTA will determine and compare the costs and benefits of the two options.

Research Methods--Other

IRTA is aware of one additional application where a PFC and an HFE are used. ARB recently adopted a regulation that phases out PERC dry cleaning in 2023. About one-third of the cleaners in the state have already converted to alternative processes. One of these processes that has been adopted by a limited number of textile cleaners is called Pure Dry. It relies on a hydrocarbon to perform the cleaning. Very small amounts of a PFC and an HFE are added to enhance drying and to suppress the flash point of the hydrocarbon. One California dry cleaner claims to still use the Valclene process which relies on CFC-113. Other applications that will be investigated include SF6 use in magnesium production and casting operations, air quality tracer gas studies and face velocity tests for laboratory hoods.

IRTA will investigate these uses and will determine whether there are other uses that merit evaluation. IRTA will estimate emissions from these uses, examine trends in emissions and investigate potential alternatives and/or other control methods.

Project Tasks

This section describes the general tasks that will be conducted during the project for each of the applications where GHGs are used as discussed above. These applications include semiconductor manufacture, electric power transmission, fire extinguishing, solvents, aerosols, HCFC-22 production and other. The final project deliverable will be a detailed bottom-up inventory of the GHGs in the candidate applications and an analysis of the emission reduction methods.

Task 1: Conduct Literature Review. The first task involves conducting a detailed literature review for information related to the project objectives. IRTA will obtain and read papers, reports and databases that pertain to the project aims. The review will focus on historical, current and projected:

- use, emissions, banks and inventories of the GHGs and their applications listed in Table 1;
- trends, including the impact of mitigation measures in the use, emissions, banks and inventories;
- potential chemical, process and product alternatives that could eliminate or reduce the use, emissions or banks of the candidate GHGs;
- mitigation methods for reducing use, emissions or banks of the GHGs;
- information on the LCCP effects, and the health and other environmental effects of alternatives and mitigation methods;
- information on recovery and destruction technologies for the candidate GHGs.

Deliverable: At the completion of Task 1, IRTA will prepare a report that includes a bibliography and summarizes the pertinent literature. Based on the information in the literature, the report will focus on the implications for the research plan.

Task 2: Develop Refined Research Plan. During this task, IRTA will develop a detailed research plan that describes the steps for estimating the inventory, emissions and banks of the GHGs in the applications in Table 1 for California based on the information from the literature review. The refined research plan will include a work plan for the project and a modified schedule for conducting and completing the work.

Deliverable: At the completion of Task 2, IRTA will submit a report to the ARB contract manager. The report will include the results of the literature review conducted in Task 1 and a modified, more detailed work plan for the project and an updated schedule.

Task 3: Develop Survey Instruments. Under this task, IRTA will develop preliminary survey instruments for each of the application areas listed in Table 1 where surveys are practical. IRTA will contact representatives in the industries of focus and collect information on the application areas to develop the draft survey instruments. The drafts will be pre-tested in interviews with knowledgeable industry representatives to gauge the effectiveness of the questions in the draft surveys. Based on input from these expert

sources, the survey will be revised for pilot testing in Task 4 below. IRTA will provide the survey instruments to ARB for review by a statistician.

In some cases, it may not be appropriate to use surveys to determine the information. In these cases, IRTA will use information from knowledgeable industry sources to estimate the information needs. In conjunction with the ARB project manager, IRTA will decide which applications must be handled in this way.

Deliverable: IRTA will provide the survey instruments for each of the application areas in which the GHGs are used to ARB. IRTA will also include a pilot testing and implementation plan.

Task 4: Pilot Test Surveys. During this task, IRTA will pilot test the surveys. The RFP specifies that at least 100 respondents will be asked to complete the surveys. In some of the applications, surveys may not be an appropriate tool to determine the information. ARB and IRTA will decide on the number of surveys that will be pilot tested during the project. The respondents to the pilot testing of the surveys will be asked for their opinions on the survey format, questions and for suggestions on how to improve the surveys.

Deliverable: IRTA will prepare a report on the pilot testing of the surveys and submit it to ARB for review. IRTA will consult with the ARB contract manager and statistician to determine what changes should be made before going forward with the full surveys.

Task 5: Redesign and Implement Surveys: Based on the pilot test results, IRTA will redesign the surveys. IRTA will provide the survey to sources based on the importance of each of the sectors. The industries that use SF6 and PFCs would be heavily represented since emissions and GWPs for these materials are high. The surveys will be administered to a preselected panel that represents the types of California operations that will be surveyed. The responses from the full survey will be compiled into an electronic database, screened for errors and formatted for analysis.

Again, for some applications, it may not be appropriate to use surveys to obtain the information for the inventory. In these cases, IRTA will collect and compile the information that is obtain from knowledgeable industry sources.

Deliverable: IRTA will provide the ARB contract manager with an electronic file of the completed survey responses and the non-survey information. The RFP specifies that 1,000 completed surveys must be used. ARB and IRTA, during the project, may determine that fewer surveys may be adequate.

Task 6: Analyze Data From Surveys. IRTA will analyze and summarize the survey responses and perform statistical testing where appropriate. Statistical tests that would be

conducted as appropriate would include number of responses, means, medians, minimums, maximums, standard deviations and frequencies.

Deliverable: The results of the analysis will be submitted to the ARB contract manager for review and will form a major component of the final report.

Task 7: Prepare Draft and Final Reports. IRTA will prepare a draft final report which will include the findings from all previous tasks. It will contain a summary table detailing the inventory results for the chemicals of interest in their applications. It will also contain a figure showing the baseline emissions and the projected emissions taking into account any mitigation measures. The draft report will be submitted to the ARB contract manager for a six month review. IRTA will incorporate the changes suggested by ARB and issue a final report.

Deliverables: During the project, IRTA will submit electronic quarterly progress reports. IRTA will also submit draft and final project reports.

Data Management Plan

For some of the applications, IRTA may work with trade associations. IRTA will work with these associations to collect data from their members. The trade associations may want to keep the data confidential and IRTA will work out a procedure to have the trade association aggregate the information in a way that keeps it proprietary but, at the same time, puts it in a form useful for the project. All companies in a particular industry are not members of trade associations. In each case where data are collected with trade associations, IRTA will work out a method of estimating the data for companies not included in the original surveys with the trade association.

For some industries, the producers, chemical suppliers and equipment suppliers who provide information may want their identify to remain confidential. In such cases, IRTA will honor the confidentiality of the sources.

Publications Describing Similar Work

- USEPA, U.S. High GWP Emissions 1990-2010: Inventories, Projections and Opportunities for Reductions, EPA 000-F-97-000, June 2001.
 - USEPA, The U.S. Solvent Cleaning Industry and the Transition to Non Ozone Depleting Substances, Prepared by ICF Consulting, 2004.
-

DETAILED WORK PLAN

Anticipated Personnel Work Plan

Figure 1 shows the number of hours each of the IRTA staff people will spend on each task of the proposed project.

PROPOSED PROJECT SCHEDULE

Figure 2 shows the project schedule. The project will require 22 months to complete. The draft project report will be submitted 16 months after project initiation and the final report will be submitted at the end of month 22. This provides ARB staff six months for review of the draft report.

PROJECT MANAGEMENT PLAN

Dr. Katy Wolf will oversee and direct the project. She will also perform the technical research. She will be assisted in the technical work by IRTA's staff scientist. IRTA's administrator will provide assistance to Dr. Wolf and the staff scientist. A detailed resume for Dr. Wolf is included in Appendix A.

RELATED RESEARCH

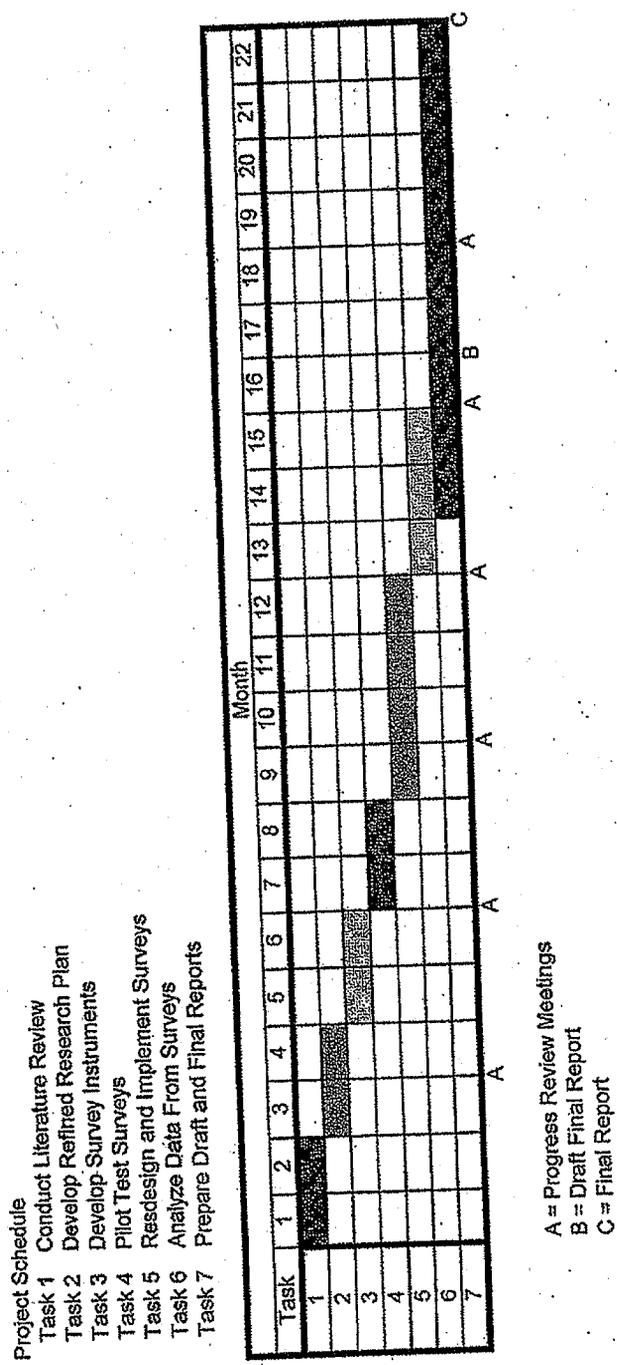
Dr. Katy Wolf, the Project Manager of the proposed project, has more than 30 years of experience in working with ODSs and their alternatives, some of which are GHGs. Dr. Wolf was a researcher at the Rand Corporation for 14 years and, during 11 of those years, her focus was almost exclusively on ODSs and their alternatives. She was involved in developing use, emission and banked inventories for ODSs, evaluating regulatory strategies, investigating alternative chemicals, products and processes and analyzing the performance, advantages, disadvantages and cost of using alternatives. Dr. Wolf worked on many ODS applications including refrigeration and air conditioning, rigid and flexible foams, solvents, halon fire extinguishing and miscellaneous uses. She also worked on CFC production processes. She was part of the U.S. delegation at the first meeting on technologies for ODSs in Rome.

Dr. Wolf continued to work on ODSs and their alternatives after she left the Rand Corporation. At IRTA, Dr. Wolf worked with many companies using ODSs in their processes to assist them in identifying, developing, testing and implementing alternatives. She worked with companies on alternatives in the flexible slabstock foam industry, electronics, metal, precision and aerosol cleaning applications and adhesives applications of Class I and II ODSs. She has also worked on finding alternatives to HCFCs and HFCs in solvent cleaning and aerosol applications.

Figure 1
 Personnel Work Plan

Personnel	Task #	Month												Total Hours By Task										
		1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16	17	18	19	20	21	22
Principal Investigator	1	25																						
	2		40																					
	3			40																				
	4				60																			
	5					40																		
	6							80																
	7								80															
	Subtotal	25	40	40	60	40	80	80	80	80	80	80	80	80	80	80	30	30	0	0	0	0	0	45
Scientist	1	25																						
	2		40																					
	3			40																				
	4				60																			
	5					40																		
	6						80																	
	7							80																
	Subtotal	25	40	40	60	40	80	80	80	80	80	80	80	80	80	30	30	0	0	0	0	0	0	45
Administrator	1	25																						
	2		10																					
	3			10																				
	4				10																			
	5					10																		
	6						10																	
	7							10																
	Subtotal	5	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Grand Total Hours	30	50	50	70	50	160	160	160	160	160	160	160	160	160	110	60	0	0	0	0	0	0	290

Figure 2
 Project Schedule



Over the last four years, IRTA has completed three projects that involved developing and testing alternative automotive aerosol cleaners. During these projects, IRTA tested alternative propellants, including HFC-152a. IRTA is currently conducting a project that focuses on testing and demonstrating alternatives for HCFCs and HFCs in energized and non-energized electrical cleaning. IRTA specializes in finding and evaluating alternatives in solvent applications including:

- dry cleaning
- electronics cleaning
- repair and maintenance cleaning
- brake cleaning
- vapor degreasing
- precision cleaning
- handwipe cleaning
- printing cleanup
- lubricants
- adhesives
- coatings

PUBLICATION LISTS

Dr. Wolf's resume includes a complete list of her publications. Some of the publications that focused on ODSs and their alternatives are listed below.

- "Regulating Chlorofluorocarbon Emissions: Effects on Chemical Production," The Rand Corporation, N-1483-EPA, August 1980.
 - "Technical Options for Reducing Chlorofluorocarbon Emissions," The Rand Corporation, R-2879-EPA, March 1982.
 - "Preliminary Analysis of Alternative Worldwide CFC Production Cap Policies," The Rand Corporation, WD-2473-EPA, December 1984.
 - "Project Use, Emissions, and Banks of Potential Ozone Depleting Substances," The Rand Corporation, N-2282-EPA, January 1986.
 - "Joint Emission Scenarios for Potential Ozone Depleting Substances," The Rand Corporation, N-2282-EPA, January 1986.
 - "Potential Constraints on Cumulative Global Production of Chlorofluorocarbons," The Rand Corporation, R-3400-EPA, May 1986.
 - "Product Uses and Market Trends for Potential Ozone Depleting Substances, 1985-2000," The Rand Corporation, R-3400-EPA, May 1986.
-

- "The Future of CFCs and Source Reduction of Chlorinated Solvents," Waste Minimization Symposium Abstracts, Boeing, Seattle, WA, September 15-17, 1987.
- "Ozone Depletion and the Electronics Industry," Proceedings of the AIChE meeting in San Francisco, CA, November 1989.
- "Ozone Depletion and Chlorinated Solvents," Institute of Environmental Sciences, November/December 1989.
- "Printed Circuit Board Defluxing: Alternatives to Ozone Depleting Substances," in Solvent Substitution, First Annual International Workshop on Solvent Substitution, Phoenix, AZ, December 4-7, 1990.
- "HCFCs: Are They Still Viable in Solvent Applications?" in Second Annual International Workshop on Solvent Substitution, Phoenix, AZ, December 1991.
- "An Analysis of Alternatives to Ozone Depleting Solvents in Cleaning Applications," Pollution Prevention Review, Spring 1992.
- "The Flexible Foam Industry: Options and Tradeoffs in Pollution Prevention," Pollution Prevention Review, Winter 1992.
- "Alternative Cleanroom Solvents," Pollution Prevention Review, Spring 1997.
- "Alternative Adhesive Technologies: Foam Furniture and Bedding Industries, Volume I: Cost and Performance Evaluation," prepared for U.S. EPA, June 2002.
- "Development of Safer Cleaning Alternatives in the Aerospace, Printing and Coating Industries," prepared for EPA, June 2004.
- "Alternatives to Automotive Consumer Products that use Volatile Organic Compounds (VOC) and/or Chlorinated Organic Compound Solvents," prepared for the California Air Resources Board, December 2004.

REFERENCES FOR SIMILAR PROJECTS

IRTA has substantial experience in performing technical projects that focus on finding and evaluating alternatives. IRTA's Director has worked on ODS and GHG alternatives for many years.

References for completed projects similar in technical complexity to the work required in the RFP are listed below.

South Coast Air Quality Management District

21865 E. Copley Drive
Diamond Bar, CA 91765
Lee Lockie
(909) 396-2390

Over the last several years, IRTA has completed projects with SCAQMD that involve:

- developing, testing and demonstrating alternative cleanup materials for lithographic printing
- developing, testing and demonstrating alternative cleanup materials for screen printing
- identifying, testing and demonstrating alternative low-VOC lubricants and rust inhibitors
- identifying, testing and developing alternative low-VOC coating and adhesive application equipment cleaners

Cal/EPA's Department of Toxic Substances Control
1001 I Street
P.O. Box 806
Sacramento, CA 95812
Robert Ludwig
(916) 324-2659

Over the last several years, IRTA has completed projects with DTSC that involve:

- identifying, testing, developing and demonstrating low-VOC, low toxicity alternative thinners and cleanup materials for consumer products
- testing, developing and demonstrating alternatives to consumer product paint strippers
- identifying, developing and testing safer alternative spotting chemical alternatives for the textile cleaning industry
- investigating the hydrocarbon alternative in textile cleaning

U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street, WST-7
San Francisco, CA 94105
John Katz
(415) 972-3283

Over the last several years, IRTA has completed projects with EPA that involve:

- a technology assessment of the alternative cleaners in textile cleaning
- identifying, developing, testing and demonstrating alternatives to VOC emitting and chlorinated paraffin lubricants

Occupational Health Branch
CA. Department of Health Services
850 Marina Bay Parkway
Building P, 3rd Floor
Richmond, CA 94804
Dr. Julia Quint (now retired)
Dr. Quint can be reached at (510) 524-9857

Over the last several years, IRTA completed projects with HESIS that involved:

- analyzing and testing alternatives to five emerging solvents
 - identifying, developing, testing and demonstrating safer alternatives to VOC emitting and chlorinated solvents in automotive aerosol applications
-

Appendix A
Resume for Dr. Katy Wolf

KATHLEEN WOLF

8579 Skyline Drive, Los Angeles, CA 90046
Home: (323) 822-1252/Work: (818) 244-0300

EDUCATION

University of Southern California
Ph.D., Chemical Physics (1980)
San Diego State University
M.S., Physical Chemistry (1972)
University of Washington
B.S., Chemistry (1968)

PROFESSIONAL EXPERIENCE

*Executive Director, Institute for Research and Technical Assistance (IRTA),
Glendale, California, April 1990 - Present*

- Responsible for establishing and managing a nonprofit organization. Aim of IRTA is to help users reduce or eliminate their use of ozone depleting substances, chlorinated and VOC solvents and other pollutants. Involves pollution prevention analysis, field investigation of processes, technical assistance, demonstration and evaluation of new technologies, chemicals and processes. Focuses on general cleaning, precision cleaning, electronics cleaning, handwipe cleaning, film cleaning, printing equipment cleaning, paint stripping, dry cleaning, coatings and adhesives.
 - Developed and distributes quarterly newsletter to more than 1,800 sources.
 - Involved in analysis, evaluation, and demonstration of emerging technologies.
 - Major focus is to analyze cross-media and worker exposure trade-offs. Emphasis is on implementing "best" alternative from overall human health and environmental standpoint.
 - Worked with numerous firms in adopting alternatives to ozone depleting, chlorinated and VOC solvents. Works with chemical manufacturing test labs, formulators and equipment manufacturers to test and analyze new formulations and processes.
 - Arranges and co-sponsors conferences on topical issues.
-

- Identified and analyzed safer alternatives for five toxic chemicals.
 - Identified, developed and tested alternative spotting chemical cleaners for dry cleaning.
 - Identified and tested alternatives to VOC solvents in spray application equipment cleaning and thinners for coatings in industrial and consumer applications.
 - Identified and tested alternatives to VOC solvents in electronics and high technology equipment cleaning applications.
 - Identified, tested and developed alternative low VOC, low toxicity cleanup formulations for screen and lithographic printing.
 - Evaluated alternative lower toxicity dry cleaning technologies.
 - Identified and tested alternative non-methylene chloride strippers for consumer product stripping applications.
 - Identified and tested alternative low- and non-methylene chloride stripping formulations for the furniture stripping industry. Performed testing of high air flow ventilation systems for reducing the risk to workers and community members in the furniture stripping industry.
 - Evaluated and tested alternative low VOC lubricants and rust inhibitors and alternatives to chlorinated paraffin additives in lubricants.
 - Identified, tested and developed alternative low VOC, low toxicity aerosol cleaning alternatives for the auto repair industry. Focus was on alternatives in brake cleaning, engine degreasing, carburetor and fuel injection system cleaning and general purpose cleaning.
 - Evaluated technologies for removing CFCs from refrigerator insulating foam.
 - Performed assessment and managed laboratory analysis of technology for controlling methyl bromide emissions from large scale commodity fumigation operations.
 - Conducted project to test and evaluate water-based cleaning alternatives to chlorinated solvents in 30 Southern California plants. Involved intensive on-site assistance with plants; prepared document
-

on results of cleaning tests and held workshop attended by 80 small/medium sized firms.

- Conducted project sponsored by U.S. EPA to test and demonstrate water-based cleaners in auto repair facilities. Demonstrations involved 18 facilities and 24 tests. Analyzed spent baths and disposal management options. Prepared extensive final report.
- Prepared extensive compendium/analysis of alternatives to chlorinated and ozone depleting solvents in cleaning applications, including handwipe operations, bath cleaning and printed circuit board defluxing. Heavy emphasis on trade-offs of adopting/comparing other dangerous alternatives.
- Conducted analysis of aerospace processes, including handwipe, maskant, coating and paint stripping operations. Focused on methods of reducing use of regulated chemicals.
- Provides technical input to regulators, involved in formulating policies.
- Conducted two projects that involved converting 12 facilities to water-based cleaners for repair and maintenance cleaning. Developed detailed case studies that compared costs of solvent and water-based cleaners.
- Evaluated impact of water-based repair and maintenance cleaning conversion on hazardous waste regulations.
- Held classes for dry cleaners as part of requirement to comply with California Air Toxic Control Measure for Perchloroethylene Dry Cleaning.
- Tested water-based cleaners as alternatives to PERC aerosol brake cleaners in 10 auto repair facilities. Assisted seven facilities in converting to water-based processes and evaluated and compared the costs.
- Extensive public speaking.

Director, Pollution Prevention Center, Santa Monica, California, February 1994 - Present

- Responsible for management and oversight of Center co-sponsored by Southern California Edison, California EPA's Department of Toxic Substances Control, the Santa Barbara County Air Pollution Control District, the South Coast Air Quality Management District, three
-

Southern California Sanitation Districts and the U.S. Environmental Protection Agency Region IX. Center's aim is to assist firms in Southern California in adopting low or non-solvent technologies.

- Conducted demonstrations of UV curable inks for bag printing.
 - Conducted tests and demonstrations for water-based cleaners in brake cleaning.
 - Conducted tests and demonstrations of low-methylene chloride content strippers and ventilation systems in furniture stripping facilities.
 - Conducted extensive project in auto repair industry to assist in conversion from mineral spirits to water-based cleaners.
 - Converted numerous industrial firms from solvent cleaners to water-based cleaners.
 - Worked with POTW Center sponsors and dry cleaning industry to analyze proper disposal methods for separator water.
 - Assisted plating shops in converting from chlorinated solvents to water-based cleaners. Conducted test program at plating facility.
 - Conducted demonstrations and testing in several plants of water-based handwipe solvents.
 - Assisted several aerospace subcontractors in converting to low and non-solvent processes, including paint stripping, coating, maskants and cleaning.
 - Assisted SCAQMD, DTSC and POTWs in outreach effort for repair and maintenance cleaning.
 - Sponsored and arranged workshop on lithographic printing cleanup alternatives.
 - Sponsored and arranged four cleaning conferences on alternatives in cleaning, handwipe and printed circuit board defluxing and two adhesives conferences on non-solvent contact adhesives, and one wood furniture manufacturing conference.
 - Sponsored and arranged two large Expos on repair and maintenance cleaning water-based alternatives. Involved coordinating exhibits.
 - Conducted training for dry cleaners required by the state Airborne Toxic Control Measure.
 - Conducted training for SCAQMD inspectors and small business group on water-based cleaning alternatives. Included visits to firms that have made conversion.
-

Project Manager, Source Reduction Research Partnership (SRRP), Los Angeles, California, February 1987 - April 1990

- Responsible for managing and conducting a unique nonprofit study on source reduction of chlorinated solvents jointly sponsored by the Metropolitan Water District of Southern California and the Environmental Defense Fund. Effort involved field visits to 76 plants. Aim of the study was to estimate the potential for source reduction in firms in the electronics, metal cleaning, dry cleaning, paint stripping, aerosol, adhesive, coatings, flexible foam, textile processing, food processing, pharmaceutical and chemical intermediate industries. These industries account for 90 percent of total chlorinated solvent use. Chlorinated solvents are major contaminants of groundwater and efforts involved identifying methods of preventing future contamination.
- Responsible for technical feasibility and cost analysis of more than two hundred source reduction options in 13 industries using chlorinated solvents. Included evaluation of chemical substitutes, process modification, product substitutes, and control technologies.
- Responsible for coordinating meetings of the SRRP advisory committee. The fifty-four members represented all interested sectors.
- Responsible for interacting with outside groups on the project direction. Included extensive public speaking.

Consultant, The RAND Corporation, Santa Monica, California, February 1987 - 1989

- Responsible for research projects conducted by RAND under the University of California at Los Angeles NSF Engineering Research Center on Hazardous Materials Control. Studies included a technology assessment of cleanup methods for contaminated sites, an evaluation of the impacts of the land disposal ban on the industries that employ chlorinated solvents and an analysis of the influence of waste minimization on future incineration capacity requirements.

Consultant, The UCLA Engineering Research Center, Los Angeles, California, 1988 - 1989

- Responsible for setting up, participating in and conducting innovative workshops on hazardous substances control issues.
- Responsible for leading and conducting a waste minimization project on Small Quantity Generators at Los Angeles International Airport. Four UCLA students worked on the research.

UCLA Extension, Los Angeles, California, December 1987 - Present

- Member of Advisory Committee responsible for setting up and advising the Hazardous Materials Management program.
- Member of Advisory Committee responsible for setting up and advising the Air program.
- Responsible for teaching classes on Technologies for Managing Hazardous Substances, Case Studies of Superfund Cleanups, Special Topics in Hazardous Substances Management, Industrial Processes and Waste Minimization and Advanced Technologies.

Member of National Research Council Committee, March 1987 - 1990

- Responsible for evaluating the utility of mass balance in tracking releases from industrial plants and in measuring progress in waste reduction.

Staff Member, Engineering and Applied Sciences Department, The RAND Corporation, Santa Monica, California, 1976 - February 1987

- Responsible for conducting a study on alternatives to land disposal of chlorinated solvents. Focus was on analyzing appropriate technical alternatives and using parameterized economic model of metal cleaning and dry cleaning industries to evaluate changes in disposal cost.
 - Responsible for an assessment of the dry cleaning industry. Study characterized solvent use, emissions and waste generation for small quantity generators.
 - Responsible for developing a historical data base on chlorinated solvents. Research involved analyzing substitution and life cycle effects on the industries in response to regulation.
-

- Responsible for technical assessment of the chlorofluorocarbon (CFC) industry. This work was part of a series of studies lasting about nine years which focused on CFCs.
- Involved in interdisciplinary studies of the economic impacts of regulation on industries where CFCs and other ozone depleting substances are used and produced. Involved in assessing the implications of regulation on firms' research and development decisions. Particular emphasis was on analyzing and evaluating technical methods for reducing and eliminating use and emissions in solvent, refrigeration and miscellaneous applications of CFCs. Heavy focus on CFC-113 and chlorinated solvent alternatives. Conducted a technical evaluation of the CFC and precursor chemical producing industries. Work involved heavy industry contact, briefings and preparation of documents.
- Responsible for conducting an assessment of worldwide biotechnology research.
- Responsible for analyzing atmospheric and surface water transport and determining the health consequences of substances emitted from coal-fired power plants and coal tar sites. Toxic substances analyzed included beryllium, benzene and a series of coal tar derivatives.
- Responsible for conducting a study on the comparative effects of high and low pressure sodium street lighting on astronomy. The research was a case study that focused on San Diego, California. The city council eventually voted to adopt low pressure lighting to prevent interference with measurements at Palomar Observatory.
- Responsible for determining feasibility of using a carbon dioxide laser to decompose hazardous chlorinated ethanes and ethylenes emitted from industrial plants.

Consultant, Litton Industries, Beverly Hills, California, 1982

- Responsible for analysis of an emission control system for an incinerator.
 - Responsible for examining technologies for destruction of chemical warfare gases.
 - Responsible for identifying future applications of laser chemistry.
-

Research Associate, Chemistry Department, University of Southern California, Los Angeles, California, 1982 - 1983

- Responsible for theoretical calculations on the circular dichroism spectrum of (+) 2-butanol.

Research Assistant, Chemistry Department, University of Southern California, Los Angeles, California, 1977 - 1980

- Responsible for research in Quantum Mechanics, Spectroscopy and Electron Scattering.
- Particular emphasis was on theoretical molecular orbital theory calculations on the ground and excited states of hydrogen fluoride, and the low energy resonance states and core-excited Feshbach states of the hydrogen fluoride negative ion.

Staff Member, Engineering Department, The RAND Corporation, Santa Monica, California, 1973 - 1976

- Responsible for technical feasibility research.
- Involved in studies on materials technology, remote chemical atmospheric sensing and energy conservation. Constructed a data base for energy requirements and conservation potential in nonresidential buildings. Helped develop a forecasting methodology for current and future energy demand in the residential sector of California.

PROFESSIONAL ORGANIZATIONS AND HONORS

Listed in Directory of Physics and Astronomy
Advisory Board, Environmental Quality Management
Recipient of South Coast Air Quality Management District 1997 Clean Air Award
Member of South Coast Air Quality Management District Scientific Review Committee

PUBLICATIONS

"Tert-Butyl Acetate: Safer Alternatives in Cleaning and Thinning Applications," Institute for Research and Technical Assistance, prepared for U.S. EPA, DRAFT, March 2007.

"Low-VOC, Low Toxicity Alternatives for Consumer Product Cleanup and Thinning Solvents," Institute for Research and Technical Assistance, prepared for Cal/EPA's Department of Toxic Substances Control, March 2007.

"Spotting Chemicals: Alternatives to Perchloroethylene and Trichloroethylene in the Textile Cleaning Industry," Institute for Research and Technical Assistance, prepared for Cal/EPA's Department of Toxic Substances Control, January 2007.

"Automotive Aerosol Cleaning Products: Low-VOC, Low Toxicity Alternatives," Institute for Research and Technical Assistance, prepared for Cal/EPA's Department of Toxic Substances Control and City of Santa Monica, November 2006.

"Assessment, Development and Demonstration of Alternatives for Five Emerging Solvents," Institute for Research and Technical Assistance, prepared for Hazard Evaluation System & Information Service and U.S. EPA, October 2006.

"Assessment, Development and Demonstration of Alternatives to VOC-Emitting Lubricants, Vanishing Oils and Rust Inhibitors," Institute for Research and Technical Assistance, prepared for South Coast Air Quality Management District, August 2006.

"Methylene Chloride Consumer Product Paint Strippers: Low-VOC, Low Toxicity Alternatives," Institute for Research and Technical Assistance, prepared for Cal/EPA's Department of Toxic Substances Control, May 2006.

"Assessment, Development and Demonstration of Low-VOC Materials for Cleaning Ultraviolet and Electron Beam Curable Coatings and Adhesives," Institute for Research and Technical Assistance, prepared for South Coast Air Quality Management District, May 2006.

"Hydrocarbon Technology Alternatives to Perchloroethylene for Dry Cleaning," Institute for Research and Technical Assistance, prepared for Cal/EPA's Department of Toxic Substances Control, December 2005.

"Evaluation of New and Emerging Technologies for Textile Cleaning," Institute for Research and Technical Assistance, prepared for the California Air Resources Board and U.S. EPA, August 2005.

"Alternative Low-VOC, Low Toxicity Cleanup Solvents for the Screen Printing Industry," Institute for Research and Technical Assistance, prepared for Cal/EPA's Department of Toxic Substances Control and U.S. EPA, April 2005.

"Alternatives to Automotive Consumer Products that use Volatile Organic Compounds (VOC) and/or Chlorinated Organic Compound Solvents," Institute for Research and Technical Assistance, prepared for the California Air Resources Board, December 2004.

"Safer Alternatives to Solvent Aerosol Automotive Cleaning Products," Institute for Research and Technical Assistance, prepared for the Department of Health Services Hazard Evaluation System & Information Service, December 2004.

"Alternative Low-VOC, Low Toxicity Cleanup Solvents for the Lithographic Printing Industry," Institute for Research and Technical Assistance, prepared for Cal/EPA's Department of Toxic Substances Control, South Coast Air Quality Management District and U.S. EPA, November 2004.

"Alternatives to VOC Emitting Petroleum Based Lubricants and Chlorinated Paraffin Luricants: Minimizing the Health and Environmental Consequences," Institute for Research and Technical Assistance, prepared for U.S. EPA, November 2004.

"Safer Adhesive and Cleanup Alternatives for Countertop Manufacturing," Institute for Research and Technical Assistance, prepared for Cal/EPA's Department of Toxic Substances Control and U.S. EPA, August 2004.

"Development of Safer Cleaning Alternatives in the Aerospace, Printing and Coating Industries," Institute for Research and Technical Assistance, prepared for U.S. EPA, June 2004.

"Assessment, Development, and Demonstration of Low-VOC cleaning systems for South Coast Air Quality Management District Rule 1171," Institute for Research and Technical Assistance, prepared for South Coast Air Quality Management District, August 2003.

"Assessment, Development, and Demonstration of Low-VOC cleaning systems for South Coast Air Quality Management District Rule 1171, Executive Summary," Institute for Research and Technical Assistance, prepared for South Coast Air Quality Management District, August 2003.

"Furniture Stripping: Tests of Alternative Non-Methylene Chloride Stripping Formulations," Institute for Research and Technical Assistance, prepared for South Coast Air Quality Management District, March 31, 2003.

"Alternative Adhesive Technologies in the Foam Furniture and Bedding Industries," prepared for U.S. EPA, March 2003.

"Alternatives to Perchloroethylene Vapor Degreasing For Plating Operations: Case Study Conversions," Institute for Research and Technical Assistance, prepared for Cal/EPA's Department of Toxic Substances Control, Los Angeles County Sanitation Districts and the City of Los Angeles Bureau of Sanitation, February 2003.

"Furniture Stripping Alternatives Project Testing Protocol," Institute for Research and Technical Assistance, prepared for South Coast Air Quality Management District, November 27, 2002.

"Alternatives to VOC and Toxic Solvents in Batch Loaded Cold Cleaning," Environmental Quality Management, Autumn 2002, p 19.

"Alternatives to Automotive Consumer Products that use Volatile Organic Compounds (VOC) and/or Chlorinated Organic Compound Solvents, Task 1

Plan," Institute for Research and Technical Assistance, prepared for the California Air Resources Board, September 30, 2002.

"Alternatives to Automotive Consumer Products that use Volatile Organic Compounds (VOC) and/or Chlorinated Organic Compound Solvents, Task 3 Interim Report," Institute for Research and Technical Assistance, prepared for the California Air Resources Board, September 15, 2003.

"Alternative Adhesives Technologies: Foam Furniture and Bedding Industries, Volume 1: Cost and Performance Evaluation," prepared for U.S. EPA, June 2002.

"Alternative Adhesives Technologies: Foam Furniture and Bedding Industries, Volume 3: Executive Summary," prepared for U.S. EPA, June 2002.

"Alternatives in Batch Loaded Cold Cleaning: Case Study Conversions," Institute for Research and Technical Assistance, prepared for U.S. EPA, Cal/EPA's Department of Toxic Substances Control, Los Angeles County Sanitation Districts, City of Los Angeles Bureau of Sanitation, Southern California Edison, May 2001.

"Investigation of Technologies to Reduce Emissions of Methylene Chloride From Furniture Stripping Operations, Final Report," Institute for Research and Technical Assistance, prepared for the California Air Resources Board, March 2001.

"Pollution Prevention at a Maquiladora Facility: Tecate Furniture," Institute for Research and Technical Assistance, prepared for the Environmental Health Coalition, February 2001.

"Development of Improved Emission Inventory for Furniture Stripping and Other Uses of Methylene Chloride," Institute for Research and Technical Assistance, prepared for the South Coast Air Quality Management District, June 2000.

"Analysis and Testing of Methods for Reducing the Emissions and Risk from Furniture Stripping Facilities," Institute for Research and Technical

Assistance, prepared for the National Institute for Occupational Safety and Health, March 2000.

"Alternative Cleaning in the Twenty-First Century," Pollution Prevention Review, Winter 2000, p 77.

"Development of Improved Emission Inventory for Furniture Stripping and Other Uses of Methylene Chloride, Project Work Plan," Institute for Research and Technical Assistance, prepared for the South Coast Air Quality Management District, November 5, 1999.

"Evaluation of Low- and Non-VOC Technologies: Application to South Coast Air Quality Management District Cleaning Rules," Institute for Research and Technical Assistance, prepared for South Coast Air Quality Management District, September 1999.

"Evaluation of Low- and Non-VOC Technologies: Application to South Coast Air Quality Management District Cleaning Rules, Executive Summary," Institute for Research and Technical Assistance, prepared for South Coast Air Quality Management District, September 1999.

"Brake Cleaning in Auto Repair Facilities: The Conversion to Water," Institute for Research and Technical Assistance, prepared for U.S. EPA, September 1999.

"Case Studies: Repair and Maintenance Operations Convert to Water-Based Cleaning," Institute for Research and Technical Assistance, published in Pollution Prevention Review, Autumn 1999, p 27.

"Alternatives to Solvents in Cleaning Applications: Case Studies of Small Business Conversions to Water-Based Cleaners," Institute for Research and Technical Assistance, prepared for U.S. EPA, June 1999.

"Water-Based Repair and Maintenance Cleaning: Case Study Conversions," Institute for Research and Technical Assistance, prepared for Southern California Edison, December 18, 1998.

"Water-Based Parts Washer Systems: Case Study Conversions," Institute for Research and Technical Assistance, prepared for U.S. EPA and Santa Barbara County APCD, published by Cal/EPA's Department of Toxic Substances Control, December 11, 1998.

"Switching to Water-Based Cleaners in Repair and Maintenance Parts Cleaning," booklet prepared by the Institute for Research and Technical Assistance in conjunction with Cal/EPA's Department of Toxic Substances Control, City of Los Angeles Bureau of Sanitation, Eastern Municipal Water District, Los Angeles County Sanitation Districts, County Sanitation Districts of Orange County, Santa Barbara County APCD, South Coast AQMD and Southern California Edison, October, 1998.

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EXHIBIT B
Standard Agreement

BUDGET DETAIL AND PAYMENT PROVISIONS

1. Invoicing and Payment

- A. For services satisfactorily rendered, and upon receipt and approval of the invoices, the State agrees to compensate the Contractor for actual expenditures incurred in accordance with Exhibit B, Attachment 1, which is attached hereto and made a part of this Agreement.
- B. Invoices shall include the Agreement Number and shall be submitted in triplicate not more frequently quarterly in arrears to:

Emma Plasencia
Air Resources Board
Research Division
1001 I Street, 5th floor
Sacramento, CA 95814

- C. Contractor, upon written approval by the State's Project Representative, may rebudget funds for a cumulative total of ten (10) percent or \$25,000 whichever is less, between the major budgets categories listed in Exhibit B.
- D. Upon mutual agreement, ARB will give consideration to rebudgeting requests, however, no rebudgeting in excess of ten percent (10%) and no rebudgeting of funds in to the travel category may be performed without the Research Division Chief's approval. The total agreement cost will remain unchanged.

2. Budget Contingency Clause

- A. It is mutually agreed that if the Budget Act of the current year and/or any subsequent years covered under this Agreement does not appropriate sufficient funds for the program, this Agreement shall be of no further force and effect. In this event, the State shall have no liability to pay any funds whatsoever to Contractor or to furnish any other considerations under this Agreement and Contractor shall not be obligated to perform any provisions of this Agreement.
- B. If funding for any fiscal year is reduced or deleted by the Budget Act for purposes of this program, the State shall have the option to either cancel this Agreement with no liability occurring to the State, or offer an agreement amendment to Contractor to reflect the reduced amount.

3. Prompt Payment Clause

Payment will be made in accordance with, and within the time specified in, Government Code Chapter 4.5, commencing with Section 927. Officer or designated representative shall be final.

**Exhibit B
Attachment 1
Budget Submittal Form**

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Budget Submittal Form

This form is supplied for presenting budget detail to the Air Resources Board.

PLEASE TYPE OR PRINT:

Title of Proposal:

Developing a California Inventory for Industrial Applications of Perfluorocarbons, Sulfur Hexafluoride, Hydrofluorocarbons, Nitrogen Trifluoride, Hydrofluoroethers and Ozone Depleting Substances.

Total Budget Requested: \$199,840

Period Covered (months): 22

Business or Institution: Institute for Research and Technical Assistance

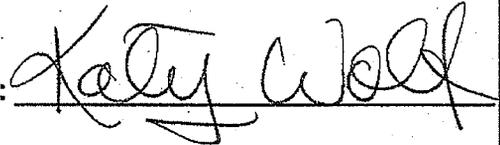
Address: 230 N. Maryland Ave., Suite 103, Glendale, CA 91206

Name of person authorized to bind this bid: Katy Wolf

Title: Director

Phone: 818-244-0300

Signature of person authorized to bind this bid:



Budget Summary

Budget details must be supplied. Use additional pages if necessary.

Direct Costs	
1. Labor & Employee Fringe Benefits	\$ <u>191,550</u>
2. Subcontractor(s)/Consultant(s)	\$ _____
3. Equipment	\$ _____
4. Travel & Subsistence	\$ <u>5,950</u>
5. Electronic Data Processing	\$ _____
6. Photocopying & Printing	\$ <u>1,800</u>
7. Mail, Telephone, and FAX	\$ <u>540</u>
8. Materials & Supplies	\$ _____
9. Analyses	\$ _____
10. Miscellaneous	\$ _____
Total Direct Cost	\$ <u>199,840</u>

Indirect Costs	
11. Overhead	\$ _____
12. General & Administrative Expenses	\$ _____
13. Other Indirect Costs	\$ _____
14. Fee or Profit	\$ _____
Total Indirect Cost	\$ _____

Total Direct and Indirect Cost:
\$ <u>199,840</u>

Budget Detail

I. Direct Costs

1a. Labor Charges

	Individual's Name Cost	Work Title	Est. Hours	Rate/Hour
A.	\$93,500	Principal Investigator	935	\$100
B.		Scientist	935	\$90
C.		Administrator	290	\$40

Subtotal: \$189,250

Dr Wolf will have the overall responsibility of managing the project. She will also perform the technical work of the project. IRTA's Scientist will assist Dr. Wolf in the technical work of the project. IRTA's Administrator will act as the administrator on the project.

1b. Fringe Benefits

	BASE (\$)	RATE (%)	COST
A.			
B.			
C.			

Subtotal:

2. Subcontractors & Consultants

List all subcontractors and consultants. Also submit separate Budget Submittal Form for each subcontractor and consultant.

	Subcontractor or consultant	Cost
A.	NONE	
B.		

Subtotal:

Cost justifications

3. Equipment (itemize)

	Item	Cost
A.		
B.		
C.		

Subtotal:

Cost justifications.

4. Travel and Subsistence (itemize). Use State rates (Attachment 2). NO FOREIGN TRAVEL ALLOWED.

	Description	Cost
A.	Air transportation	\$2,550
B.	Ground transportation	\$3,400
C.	Per Diem or subsistence	
D.	Other	

**Subtotal:
\$5,950**

Cost justifications.

Travel is necessary to visit facilities using GHGs that are the focus of the project.

For air transportation there will be 10 trips to the bay area and Sacramento.

Ground transportation at a rate of \$0.34 per mile for travel to local facilities and estimated travel miles of 10,000.

5. Electronic Data Processing (itemize)

	Description	Cost
A.	Computer usage	
B.		

Subtotal:

Cost justifications.

6. Photocopying & Printing (itemize)

Description of product	Cost
A. Paper	\$600
B. Printing/Toner Cartridges	\$1,200

Subtotal:
\$1,800

Cost justifications.

Paper will be used for reports and correspondence. Printing cost is for reports. Toner cartridges will be purchased for printing with office copiers and printers.

7. Mail, Telephone & FAX (itemize)

Item	Cost
A. Telephone and Fax	\$360
B. Mail	\$2,480
C.	

Subtotal: \$2,840

Cost justifications.

Cost of telephone and fax is estimated at \$150 for Tasks 1 through 6 and \$900 for Task 7, which involves writing the final report. Cost of mail is estimated at \$1000 each for Tasks 4 and 5, which involve surveys and \$168 each for the other Tasks.

8. Materials & Supplies (itemize)

Item	Cost
A.	
B.	
C.	

Subtotal:

Cost justifications.

9. Analyses (itemize)

	Description	Cost
A.		
B.		
C.		
D.		

Subtotal:

Cost justifications.)

10. Miscellaneous (itemize)

	Item	Cost
A.		
B.		
C.		
D.		

Subtotal:

Cost justifications. Justify all costs not included in the categories above. Explain the need for the item and why the cost is reasonable. (Use additional page if necessary.)

Total Direct Cost (add subtotals for categories 1-10): \$199,840

II. Indirect Costs

11. Overhead

	Base (Salaries, total direct costs; etc.) Cost	Rate
A.		
B.		
C.		

Subtotal:

Cost Justifications.

12. General and Administrative Expenses

	Base Cost	Rate
A.		
B.		
C.		

Subtotal:

Cost Justifications.

13. Other Indirect Costs

	Base	Rate	Cost
A.			
B.			
C.			

Subtotal:

Cost Justifications.

14. Fee or Profit, if applicable (give details)

	Base Not Applicable	Rate	Cost

Total Indirect Cost (Add categories 11-14):

Total Project Cost: \$199,840

III. Cost By Task

Cost By Task					
Task	Labor	Travel	Photocopying and Printing	Mail, Phone and Fax	Total
1	\$9,900	\$850	\$150	\$168	\$11,068
2	\$16,000	\$850	\$150	\$168	\$17,168
3	\$23,600	\$850	\$150	\$168	\$24,768
4	\$16,800	\$850	\$150	\$1,000	\$18,800
5	\$64,000	\$850	\$150	\$1,000	\$66,000
6	\$30,300	\$850	\$150	\$168	\$31,468
7	\$28,650	\$850	\$900	\$168	\$30,568
Total	\$189,250	\$5,950	\$1,800	\$2,840	\$199,840

EXHIBIT D

Standard Agreement

SPECIAL TERMS AND CONDITIONS

1. Excise Tax

The State of California is exempt from federal excise taxes, and no payment will be made for any taxes levied on employees' wages. The State will pay for any applicable State of California or local sales or use taxes on the services rendered or equipment or parts supplied pursuant to this Agreement. California may pay any applicable sales and use tax imposed by another state.

2. Settlement of Disputes

- A. In the event of a dispute, Contractor shall file a "Notice of Dispute" with ARB within ten (10) days of discovery of the problem. Within ten (10) days, the ARB shall meet with the Contractor and Project Representative for purposes of resolving the dispute.
- B. Any dispute concerning a question of fact arising under the terms of this Agreement which is not disposed of within a reasonable period of time by Contractor and State employees normally responsible for the administration of this Agreement shall be brought to the attention of the Executive Officer or designated representative of each organization for resolution. The decision of the State Executive Officer or designated representative shall be final.
- C. In the event of a dispute, the language contained within this Agreement shall prevail over any other language including that of the proposal.
- D. The existence of a dispute not fully resolved shall not delay Contractor to continue with the responsibilities under this Agreement which is not affected by the dispute.

3. Potential Subcontractors

Nothing contained in this Agreement or otherwise, shall create any contractual relation between the State and any subcontractors, and no subcontract shall relieve the Contractor of his responsibilities and obligations hereunder. The Contractor agrees to be as fully responsible to the State for the acts and omissions of its subcontractors and of persons either directly or indirectly employed by any of them as it is for the acts and omissions of persons directly employed by the Contractor. The Contractor's obligation to pay its subcontractors is an independent obligation from the State's obligation to make payments to the Contractor. As a result, the State shall have no obligation to pay or to enforce the payment of any moneys to any subcontractor.

Contractor shall not subcontract any services under this Agreement without prior approval of the State.

4. Stop Work Order

State reserves the right to issue an order to stop work in the event that a dispute should arise, or in the event that State gives Contractor a notice that the Agreement will be terminated. The stop-work order will be in effect until the dispute has been resolved or the Agreement has been terminated.

EXHIBIT D
Standard Agreement

5. Termination

- A. In addition to the rights under Exhibit C of the Standard Agreement, State reserves the right to terminate this Agreement at its sole discretion at any time upon thirty (30) days prior written notice to Contractor.
- B. In the case of early termination, Contractor shall submit an invoice in triplicate and a report in triplicate covering services to termination date, following the invoice and progress report requirements of this Agreement. A copy and description of any data collected up to termination date shall also be provided to State.
- C. Upon receipt of the invoice, progress report, and data, a final payment will be made to Contractor. This payment shall be for all State-approved, actually-incurred costs that in the opinion of State are justified, and shall include labor, and materials purchased or utilized (including all non-cancellable commitments) to termination date, and pro rata indirect costs as specified in the proposal budget.

6. Amendments

ARB reserves the right to amend this agreement for additional time and/or additional funding.

EXHIBIT E Standard Agreement

ADDITIONAL PROVISIONS

1. DVBE Audit

Contractor agrees that the State or its delegate will have the right to review, obtain, and copy all records pertaining to Contractor's compliance with the Disabled Veteran Business Enterprise (DVBE) requirements as contained in Public Contract Code sections 10115 et. seq. Contractor agrees to provide State or its delegate with any relevant information requested and shall permit State or its delegate access to its premises, upon reasonable notice, during normal business hours for the purposes of interviewing employees and inspecting and copying such books, records, accounts, and other material that may be relevant to a matter under investigation for the purpose of determining compliance with the DVBE requirements. Contractor further agrees to maintain such records for a period of three years after final payment under this Agreement.

2. Federal Funding

- A. It is mutually understood between the parties that this Agreement may have been written before ascertaining the availability of congressional appropriation of funds, for the mutual benefit of both parties in order to avoid program and fiscal delays which would occur if the Agreement were executed after that determination was made.
- B. This Agreement is valid and enforceable only if sufficient funds are made available to State by the United States Government for the fiscal year(s) covered by this Agreement for the purposes of this program. In addition, this Agreement is subject to any additional restrictions, limitations, or conditions enacted by the Congress or any statute enacted by the congress which may affect the provisions, terms, or funding of this Agreement in any manner.
- C. It is mutually agreed that if Congress does not appropriate sufficient funds for this Agreement, this Agreement shall be amended to reflect any reduction of funds.
- D. The State has the option to cancel this Agreement under the 30-day cancellation clause or to amend the agreement to reflect any reduction of funds.
- E. The Contractor shall comply with the Single Audit Act and the reporting requirements set forth in OMB Circular A-133.
- F. Funds provided under this Agreement shall not be used for payment of salaries to individual consultants retained by the Contractor or any subcontractors in excess of the rate for Level 4, Federal Executive Schedule. The limit expressed does not include transportation and subsistence costs for necessary travel for work required under Agreement.
- G. The Contractor warrants by execution of this Agreement, that no person or selling agency has been employed or retained to solicit or secure this Agreement upon agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide

EXHIBIT E Standard Agreement

established commercial or selling agencies maintained by the Contractor for the purpose of securing business. For breach or violation of this warranty, the State shall, in addition to other remedies provided by law, have the right to annul this Agreement without liability, paying only for the value of the work actually performed, or otherwise recover the full amount of such commission, percentage, brokerage, or contingent fee.

3. Travel & Per Diem

- A. Any reimbursement for necessary travel and per diem shall be at rates not to exceed those amounts paid to State of California employees as set forth by Department of Personal Administration rules and regulations, or verification supplied that indicates such rates are not available to Contractor.
- B. No travel outside the State of California shall be reimbursed unless prior written authorization is obtained from State.

4. Evaluation of Contractor

Performance of the Contractor under this Agreement will be evaluated. The evaluation shall be prepared on Contract/Contractor Evaluation Sheet (STD 4), and maintained in the Agreement file. For consultant agreements over \$5,000, a copy of any negative evaluations will be sent to the Department of General Services, Office of Legal Services.

5. Progress Payments

In computing the amount of any progress payment, the State shall determine what Contractor has earned during the period for which payment is being made on the basis of the Agreement terms, but shall retain out of such earnings, an amount equal to 10 percent thereof, pending satisfactory completion of the entire agreement. However, if the Agreement consists of the performance of separate and distinct tasks, then any funds so withheld with regard to a particular task may be paid upon completion of that task.

6. Computer Software

Contractor certifies that it has appropriate systems and controls in place to ensure that State funds will not be used in the performance of this contract for the acquisition, operation or maintenance of computer software in violation of copyright laws.

7. Meetings

- A. Initial meeting. Before work on the contract begins, Contractor will meet with the State's Project Representative and other staff to discuss the overall plan, details of performing the tasks, the project schedule, items related to personnel or changes in personnel, and any issues that may need to be resolved before work can begin.
- B. Progress review meetings. Contractor and appropriate members of his or her staff will meet with the State's Project Representative at monthly intervals to discuss the progress of the project. This meeting may be conducted by phone, if appropriate.

EXHIBIT E Standard Agreement

- C. Technical Seminar The Contractor will present the results of the project to ARB staff and a possible webcast at a seminar at ARB facilities in Sacramento or El Monte.

8. Reports and Data Compilations

- A. With respect to each invoice period, Contractor shall forward to the Project Representative an electronic copy of the progress report and mail one copy of the progress report with each invoice. (Do not use Express Mail.) When e-mailing the progress report, the "subject line" should state the contract number and the billing period. Each progress report will begin with the following disclaimer:

The statements and conclusions in this report are those of the Contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

- B. Each progress report will also include:
1. A brief narrative account of project tasks completed or partially completed since the last progress report.
 2. A brief discussion of problems encountered during the reporting period and how they were or are proposed to be resolved.
 3. A brief discussion of work planned, by project task, before the next progress report.
 4. A graph showing allocation of the budget and amount used to date for each task.
 5. A graph showing percent of completion for each task.
- C. If the project is behind schedule, the progress report must contain an explanation of reasons and how Contractor plans to resume the schedule.
- D. Six months prior to contract termination date, Contractor will deliver to State twenty (20) bound copies of a draft final report for review by ARB staff. The reports may be stapled or spiral bound, depending on size. The draft final report will conform to Exhibit F.
- E. Within forty-five (45) days of receipt of State's comments on the draft final report, Contractor will deliver to the State's Project Representative two (2) copies of the final report incorporating all reasonable alterations and additions requested by State and the Research Screening Committee. Upon approval of the amended final report by the State's Project Representative, Contractor will within two (2) weeks, deliver to State two (2) camera-ready **UNBOUND** originals and a final report incorporating all final alterations and additions. The final report will conform to the Contract Final Report Format, Exhibit F.
- F. Together with the final report, Contractor will deliver a copy of the report on diskette, using Microsoft Word 6.0 (or newer) and a set of all data compilations as specified by the ARB Project Representative.

EXHIBIT E

Standard Agreement

G. Contractor's obligation under this Agreement shall be deemed discharged only upon submittal to and acceptance by the State of the final report, report diskette, and all required data compilations.

H. No reports, professional papers, information, inventions, improvements, discoveries, or data obtained, prepared, assembled, or developed by Contractor pursuant to this Agreement shall be released or made available, except to ARB, without prior written approval of State while the Agreement is in force. State's consent shall not be unreasonably withheld.

9. Priority Hiring Considerations

Contractor shall give priority consideration in filling vacancies in positions funded by this Agreement to qualified recipients of aid under Welfare and Institutions Code Section 11200.

10. Forced, Convict, and Indentured Labor

No foreign-made equipment, materials, or supplies furnished to State pursuant to this Agreement may be produced in whole or in part by forced labor, convict labor, or indentured labor. By submitting a proposal to State, Contractor agrees to comply with this provision of the Agreement.

11. Sole Proprietor (If agreement is with a sole proprietor)

If signing this Agreement as a sole proprietor, Contractor certifies they are not an alien that is ineligible for state and local benefits, as defined in Subtitle B of the Personal Responsibility and Work Opportunity Act (8 USC 1601, et. seq.)

12. Insurance (Hazardous activities)

A. Contractor shall furnish to State a certificate of insurance stating that liability insurance of not less than \$1,000,000 per occurrence for bodily injury and property damage liability combined is presently in effect for Contractor.

A. Contractor agrees that the bodily injury liability insurance herein provided for shall be in effect at all times during the term of this Agreement. In the event said insurance coverage expires at any time or times during the term of this Agreement, Contractor agrees to provide, at least thirty (30) days before said expiration date, a new certificate of insurance evidencing insurance coverage as provided for herein for not less than the remainder of the term of the Agreement or for a period of not less than one year. New certificates of insurance are subject to the approval of the Department of General Services, and Contractor agrees that no work or services shall be performed prior to such approval. The State may, in addition to any other remedies it may have, terminate this Agreement on the occurrence of such event.

The Certificate of Insurance must include the following provisions:

1. The insurer will not cancel the insured's coverage without thirty (30) days prior written notice to State; and
2. The State of California, its officers, agents, employees and servants are included as additional insured, but only insofar as the operations under this Agreement are concerned.

EXHIBIT E Standard Agreement

13. Copyrightable Materials

- A. ARB reserves the right to any copyrightable materials developed under this Agreement: Upon acceptance of the copyrightable materials developed under this Agreement, and payment of the sums then due under the terms of the Agreement, ARB shall have the sole and exclusive right, title, and interest (including trade secret and copyright interests) in the copyrightable materials. Contractor and his or her subcontractors hereby assign(s) all rights, title, and interest (including trade secret and copyright interest) in any copyrightable materials developed under this Agreement to ARB.
- B. ARB, at its discretion, may grant a nonexclusive and paid-up license to Contractor and his or her subcontractors to use said copyrightable materials. Contractor and his or her subcontractors agrees to cooperate with and assist ARB to apply for and to execute any applications and/or assignments reasonably necessary to obtain any patent, copyright, trademark, or other statutory protection for all copyrightable materials.
- C. Contractor and his or her subcontractors shall not disclose any copyrightable materials, any of the deliverables thereof, or any portion thereof, to any other organization or person without the written consent of ARB.
- D. Contractor and his or her subcontractors shall not use the copyrightable materials, any of the deliverables thereof, or any portion thereof, in any other work performed by this Agreement subject to any license granted without the written consent of ARB.
- E. Contractor's obligations under this provision shall survive the expiration or termination of this Agreement.

14. Confidentiality

It is expressly understood and agreed that information Contractor receives from State in performing its obligations under this Agreement may be deemed confidential by State. Therefore, Contractor agrees to:

- A. Observe complete confidentiality with respect to such information, including without limitation, agreeing not to disclose or otherwise permit access to such information by any person or entity in any manner whatsoever.
- B. Ensure that Contractor's employees, agents, representatives, and independent contractors are informed of the confidential nature of such information and ensure by agreement or otherwise that they are prohibited from copying or revealing, for any purpose whatsoever, the contents of such information or any part thereof, or from taking any action otherwise prohibited under this section.
- C. Not use such information or any part thereof in the performance of services to others or for the benefit of others in any form whatsoever whether gratuitously or for valuable consideration, except as permitted under this Agreement.
- B. Notify State promptly and in writing of the circumstances surrounding any possession, use or knowledge of such information or any part thereof by any person other than those authorized by this paragraph.

EXHIBIT E Standard Agreement

15. Patent Provisions

A. Definitions

1. "Invention" means any discovery or product of creative imagination, thought, mental synthesis, or purposeful experimentation conceived or first reduced to practice in the course of or under this Agreement. The term "invention" includes, but is not limited to, any art, method, process, device, machine, manufacture, design, or composition of matter, or any new and useful improvement or application thereof, or any variety of plant, that is or may be patentable under the patent laws of the United States of America.
2. "Agreement" means any legally enforceable agreement, covenant, compact grant, or other arrangement or subcontract setting forth terms and conditions to do or not to do something and entered into by or for the benefit of the State where a purpose of the agreement is the conduct of experimental, developmental, or research work.
3. "Subcontract" means an agreement under or subordinate to a previous or prime agreement, including this Agreement.
4. "Subcontractor" means an individual or firm that contract with Contractor to perform part or all of the prime Contractor's work under this Agreement.
5. "To bring to the point of practical application" means to manufacture in the case of a composition or product, to practice in the case of a process, or to operate in the case of a machine, device, or system and, in each case, under such conditions as to establish that the invention is being worked, operated, or utilized, and that its benefits are reasonably accessible to the public.

B. Rights Granted to the State

Contractor agrees to grant to State all right, title, and interest in and to each invention discovered, conceived, or first reduced to practical application during performance of this Agreement, subject to the reservation of a non-exclusive paid-up worldwide license to Contractor.

C. Invention Disclosures and Reports

With respect to each invention, Contractor shall furnish to ARB:

1. A written disclosure of each invention within six (6) months after conception or first actual reduction to practice, whichever occurs first under this Agreement, sufficiently complete in technical detail to convey to one skilled in the art to which the invention pertains a clear understanding to the nature, purpose, and operation, and the physical, chemical, and electrical characteristics of the invention;
2. A final report listing all inventions, including all those previously disclosed, or certifying that there are no inventions prior to final payment under this contract.

EXHIBIT E Standard Agreement

3. Information in writing, as soon as is practicable, of the date and identity of any public use, sale, or publication of any such invention made by or known to Contractor, or of any contemplated publication by Contractor;
4. Upon request, such duly executed instruments and other papers as deemed by ARB necessary to vest in State the rights granted it under this patent provision and to enable State

to apply for and prosecute any patent application in any country covering such invention where State has the right under this patent provision to file such application; and upon request, an irrevocable power of attorney to inspect and make copies of any United States patent application filed by or on behalf of Contractor. This demand may also be made under subdivision 8.

D. Licenses Granted by Contractor to Others Subject to State's Rights

Contractor recognizes that State may contract for property or services with respect to which the vendor may be liable to Contractor for royalties for the use of an invention on account of such a contract. Contractor further recognizes that it is the policy of State not to pay, in connection with its agreements, charges for use of patents in which the State holds title. In recognition of this policy, Contractor agrees to participate in and make appropriate arrangements for the exclusion of such charges from such agreements or for the refund of amounts received by Contractor with respect to any such charges not so excluded.

E. Subcontracts

1. Contractor shall, unless otherwise authorized or directed by State, include a patent rights clause containing all the terms of this patent provision in any subcontract hereunder where the purpose of the subcontract is the conduct of experimental, developmental, or research work. In the event of refusal by a subcontractor to accept this patent provision, Contractor:
 - a. shall promptly submit a written report to the State setting forth the subcontractor's reasons for such refusal or the reasons Contractor is of the opinion that the inclusion of this clause would be unacceptable, and other pertinent information that may expedite disposition of this matter; and
 - b. shall not proceed with the subcontract without the written authorization of State.
2. Contractor shall not, in any subcontract or by using such a subcontract as consideration thereof, acquire any rights to inventions for his/her own use (as distinguished from such rights as may be required solely to fulfill his/her agreement obligations to State in the performance of this Agreement).
3. Contractor, at the earliest practicable date, shall also notify State in writing of any subcontract containing a patent rights clause, furnish to State a copy of such subcontract, and notify State when such subcontract is completed. It is understood that State is a third party beneficiary of any subcontract clause granting rights to State in inventions, and Contractor hereby assigns to State all the rights that Contractor would have to enforce the subcontractor's obligations for the benefit of State with respect to inventions. Contractor

EXHIBIT E Standard Agreement

shall not be obligated to enforce the agreements of any subcontractor to State with regard to inventions.

F. Right to Disclose Inventions

State may duplicate and disclose reports and disclosures of inventions required to be furnished by Contractor pursuant to this patent provision.

G. Forfeiture of Rights in Unreported Inventions

Contractor shall forfeit to State all rights in any invention which Contractor fails to report to State, at or prior to the time Contractor (1) files or causes to be filed a United States or foreign application thereon, or (2) submits the final report required by 3., B of this patent provision, whichever is later, provided that Contractor shall not forfeit rights in an invention if (a) contending that the invention is not an invention, s/he nevertheless reports the invention and all the facts pertinent to Contractor's contention to State, the time specified in 3. A above, or (b) Contractor establishes that the failure to report was due entirely to causes beyond Contractor's control and without Contractor's fault or negligence. Contractor shall be deemed to hold any such forfeited invention and the patent applications and patent pertaining thereto, in trust for State pending written assignment of the invention. The right accruing to State under this paragraph shall be in addition to and shall not supersede any other rights State may have in relation to unreported inventions.

H. Examination of Records Relating to Inventions

State shall, until the expiration of three years after final payment under this agreement, have the right to examine any books, records, documents, and other supporting data of Contractor that State shall reasonably deem directly pertinent to the discovery or identification of inventions or to compliance by Contractor with the requirements of this patent provision.

16. Equipment Provisions

A. Equipment is defined as movable articles of nonexpendable property that meet the following requirements:

1. Have a normal useful life (including extended life due to repairs) of at least one year;
2. Have a unit acquisition cost of at least \$5,000 for other than land and structures (for example, identical assets costing \$3,000 each for a \$12,000 total would not meet the requirements); and
3. Be used to conduct work under this contract, and/or
4. Any and all EDP equipment used to conduct work under this contract.

B. The cost of equipment includes the purchase price plus all costs to acquire, install, and prepare equipment for its intended use.

C. The ARB reserves the right to purchase total equipment whose cost is greater than \$25,000 and any and all EDP equipment for this contract, through the State procurement process.

EXHIBIT E
Standard Agreement

Contractor's proposed cost of this equipment will be deducted from the total amount payable to the Contractor.

- D. In the event Contractor purchases with ARB funds, procures, uses, or otherwise takes possession of equipment owned by ARB to perform work under this contract, title to such equipment shall remain with ARB and such equipment shall become ARB's equipment upon delivery thereof into Contractor's control or possession.
- E. Contractor shall obtain written approval from ARB prior to the purchase of equipment that is not specifically identified and listed in the approval budget and which is valued at more than \$1,000. The contract funding shall be adjusted for any equipment or supplies furnished by ARB.
- F. The ARB reserves the right to full and adequate access to ARB equipment.
- G. The Contractor shall maintain and administer a program for the utilization, maintenance, repair, protection, and preservation of ARB equipment, whether acquired from the ARB or purchased with ARB funds from a third party, so as to assure its full availability and usefulness for performance of this contract or as long as this equipment remains in the control or possession of the Contractor. The Contractor will install upon each item of equipment a tag identifying the equipment as belonging to the ARB and will maintain location records of all equipment. The Contractor shall take steps to comply with all appropriate directions or instructions that the ARB may prescribe for the protection of ARB equipment.
- H. The Contractor shall provide to ARB, with the final invoice, a final equipment inventory. The final invoice shall contain an itemization of equipment purchased with ARB funds or procured through the State procurement process, including the type of equipment, manufacturer, serial number, and cost. All ARB equipment shall be returned to the ARB in full operating condition upon termination of this contract, unless ARB approves a different disposition in writing. Disposition of the equipment shall be in accordance with the instructions from ARB, to be issued after receipt of the final inventory.

EXHIBIT F Standard Agreement

FINAL REPORT FORMAT

The contract Final Report (Report) is as important to the contract as the research itself. The Report is a record of the project and its results, and is used in several ways. Therefore, the Report must be well organized and contain certain specific information. This Appendix outlines the requirements that must be met when producing the Report.

Note: In partial fulfillment of the Final Report requirements, the Contractor shall submit a copy of the Report on a CD in PDF format and in a word-processing format, preferably in Word - Version 6.0 or later. This is in addition to the submission of any paper copies required. The diskette shall be clearly labeled with the contract title, ARB contract number, the words "Final Report", and the date the report was submitted.

Legibility. Each page of the approved Final Report must be legible and camera-ready.

Binding. The draft Report, including its appendices, must be either spiral bound or stapled, depending on size. The revised Report and its appendices should be spiral bound, except for two unbound, camera-ready originals.

Cover. Do not supply a cover for the Report. The ARB will provide its standard cover.

One-sided vs. two-sided. To conserve paper, both the draft Report and the revised Report, except for the unbound camera-ready copies, should be printed on both sides of the page. **The unbound camera-ready copies must be printed on only one side of the page.**

Title. The title of the Report should exactly duplicate the title of the contract unless a change is approved in writing by the Project Representative.

Spacing. In order to conserve paper, copying costs, and postage, please use single or one-line (1) spacing.

Page size. All pages should be of standard size (8 1/2" x 11") to allow for photo-reproduction.

Large tables or figures. Foldout or photo-reduced tables or figures are not acceptable because they cannot be readily reproduced. Large tables and figures should be presented on consecutive 8 1/2" x 11" pages, each page containing one portion of the larger chart.

Color. Color presentations are not acceptable; printing shall be black on white only.

Corporate identification. Do not include corporate identification on any page of the Final Report, except the title page.

Unit notation. Measurements in the Reports should be expressed in metric units. However, for the convenience of engineers and other scientists accustomed to using the British system, values may be given in British units as well in parentheses after the value in metric units. The expression of measurements in both systems is especially encouraged for engineering reports.

Section order. The Report should contain the following sections, in the order listed below:

EXHIBIT F Standard Agreement

Title page
Disclaimer
Acknowledgments
Table of Contents
List of Figures
List of Tables
Abstract
Executive Summary
Body of Report
References
List of inventions reported and copyrighted materials produced
Glossary of Terms, Abbreviations, and Symbols
Appendices

Page numbering. Beginning with the body of the Report, pages shall be numbered consecutively beginning with "1", including all appendices and attachments. Pages preceding the body of the Report shall be numbered consecutively, in ascending order, with small Roman numerals.

Title page. The title page should include, at a minimum, the contract number, contract title, name of the principal investigator, contractor organization, date, and this statement: "Prepared for the California Air Resources Board and the California Environmental Protection Agency"

Disclaimer. A page dedicated to this statement must follow the Title Page:

The statements and conclusions in this Report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

Acknowledgments. Only this section should contain acknowledgments of key personnel and organizations that were associated with the project. The last paragraph of the acknowledgments must read as follows:

This Report was submitted in fulfillment of [ARB contract number and project title] by [contractor organization] under the [partial] sponsorship of the California Air Resources Board. Work was completed as of [date].

Table of Contents. This should list all the sections, chapters, and appendices, together with their page numbers. Check for completeness and correct reference to pages in the Report.

List of Figures. This list is optional if there are fewer than five illustrations.

List of Tables. This list is optional if there are fewer than five tables.

Abstract. The abstract should tell the reader, in non-technical terms, the purpose and scope of the work undertaken, describe the work performed, and present the results obtained and conclusions. The purpose of the abstract is to provide the reader with useful information and a means of determining whether the complete document should be obtained for study. The length of the abstract should be no

EXHIBIT F Standard Agreement

more than about 200 words. Only those concepts that are addressed in the executive summary should be included in the abstract.

Example of an abstract:

A recently developed ground-based instrument, employing light detecting and ranging (lidar) technology, was evaluated and found to accurately measure ozone concentrations at altitudes of up to 3,000 meters. The novel approach used in this study provides true vertical distributions of ozone concentrations aloft and better temporal coverage of these distributions than other, more common methods, such as those using aircraft and ozone sonde (balloon) techniques. The ozone and aerosol measurements from this study, in conjunction with temperature and wind measurements, will provide a better characterization of atmospheric conditions aloft and the processes involved in the formation of unhealthy ozone concentrations than can be achieved with traditional ground-based monitors.

Executive Summary. The function of the executive summary is to inform the reader about the important aspects of the work that was done, permitting the reader to understand the research without reading the entire Report. It should state the objectives of the research and briefly describe the experimental methodology [ies] used, results, conclusions, and recommendations for further study. All of the concepts brought out in the abstract should be expanded upon in the Executive Summary. Conversely, the Executive Summary should not contain concepts that are not expanded upon in the body of the Report.

The Executive Summary will be used in several applications as written; therefore, please observe the style considerations discussed below.

Limit the Executive Summary to two pages, single spaced.

Use narrative form. Use a style and vocabulary level comparable to that in Scientific American or the New York Times.

Do not list contract tasks in lieu of discussing the methodology.

Discuss the results rather than listing them.

Avoid jargon.

Define technical terms.

Use passive voice if active voice is awkward.

Avoid the temptation to lump separate topics together in one sentence to cut down on length.

The Executive Summary should contain four sections: Background, Methods, Results, and Conclusions, described below.

THE BACKGROUND SECTION. For the Background, provide a one-paragraph discussion of the reasons the research was needed. Relate the research to the Board's regulatory functions, such as establishing ambient air quality standards for the protection of human health, crops, and ecosystems; the improvement and updating of emissions inventories; and the development of air pollution control strategies.

EXHIBIT F Standard Agreement

THE METHODS SECTION. At the beginning of the Methods section, state what was done in general, in one or two sentences.

The methodology should be described in general, non-technical terms, unless the purpose of the research was to develop a new methodology or demonstrate a new apparatus or technique. Even in those cases, technical aspects of the methodology should be kept to the minimum necessary for understanding the project. Use terminology with which the reader is likely to be familiar. If it is necessary to use technical terms, define them. Details, such as names of manufacturers and statistical analysis techniques, should be omitted.

Specify when and where the study was performed, if it is important in interpreting the results.

The findings should not be mentioned in the Methods section.

THE RESULTS SECTION. The Results section should be a single paragraph in which the main findings are cited and their significance briefly discussed. The results should be presented as a narrative, not a list. This section must include a discussion of the implications of the work for the Board's relevant regulatory programs.

THE CONCLUSIONS SECTION. The Conclusions section should be a single short paragraph in which the results are related to the background, objectives, and methods. Again, this should be presented as a narrative rather than a list. Include a short discussion of recommendations for further study, adhering to the guidelines for the Recommendations section in the body of the Report.

Body of Report. The body of the Report should contain the details of the research, divided into the following sections:

INTRODUCTION. Clearly identify the scope and purpose of the project. Provide a general background of the project. Explicitly state the assumptions of the study.

Clearly describe the hypothesis or problem the research was designed to address. Discuss previous related work and provide a brief review of the relevant literature on the topic.

MATERIALS AND METHODS. Describe the various phases of the project, the theoretical approach to the solution of the problem being addressed, and limitations to the work. Describe the design and construction phases of the project, materials, equipment, instrumentation, and methodology. Describe quality assurance and quality control procedures used. Describe the experimental or evaluation phase of the project.

RESULTS. Present the results in an orderly and coherent sequence. Describe statistical procedures used and their assumptions. Discuss information presented in tables, figures and graphs. The titles and heading of tables, graphs, and figures, should be understandable without reference to the text. Include all necessary explanatory footnotes. Clearly indicate the measurement units used.

DISCUSSION. Interpret the data in the context of the original hypothesis or problem. Does the data support the hypothesis or provide solutions to the research problem? If appropriate, discuss how the results compare to data from similar or related studies. What are the implications of the findings?

EXHIBIT F Standard Agreement

Identify innovations or development of new techniques or processes. If appropriate, discuss cost projections and economic analyses.

SUMMARY AND CONCLUSIONS. This is the most important part of the Report because it is the section that will probably be read most frequently. This section should begin with a clear, concise statement of what, why, and how the project was done. Major results and conclusions of the study should then be presented, using clear, concise statements. Make sure the conclusions reached are fully supported by the results of the study. Do not overstate or over interpret the results. It may be useful to itemize Secondary results and conclusions. A simple table or graph may be used to illustrate.

RECOMMENDATIONS. Use clear, concise statements to recommend (if appropriate) future research that is a reasonable progression of the study and can be supported by the results and discussion.

References. Use a consistent style to fully cite work referenced throughout the Report and references to closely related work, background material, and publications that offer additional information on aspects of the work. Please list these together in a separate section, following the body of the Report. If the Report is lengthy, you may list the references at the end of each chapter.

List of inventions reported and publications produced. If any inventions have been reported, or publications or pending publications have been produced as a result of the project, the titles, authors, journals or magazines, and identifying numbers that will assist in locating such information should be included in this section.

Glossary of terms, abbreviations, and symbols. When more than five of these items are used in the text of the Report, prepare a complete listing with explanations and definitions. It is expected that every abbreviation and symbol will be written out at its first appearance in the Report, with the abbreviation or symbol following in parentheses [i.e., carbon dioxide (CO₂)]. Symbols listed in table and figure legends need not be listed in the Glossary.

Appendices. Related or additional material that is too bulky or detailed to include within the discussion portion of the Report shall be placed in appendices. If a Report has only one appendix, it should be entitled "APPENDIX". If a Report has more than one appendix, each should be designated with a capital letter (APPENDIX A, APPENDIX B). If the appendices are too large for inclusion in the Report, they should be collated, following the binding requirements for the Report, as a separate document. The Project Representative will determine whether appendices are to be included in the Report or treated separately. Page numbers of appendices included in the Report should continue the page numbering of the Report body. Pages of separated appendices should be numbered consecutively, beginning at "1".

EXHIBIT F Standard Agreement

ADDITIONAL PROVISIONS

1. Reports and Data Compilations

- A. With respect to each invoice period, IRTA shall forward to the ARB Contract Administrator one (1) copy of the progress report along with each invoice. (Do not use Express Mail.) When e-mailing the progress report, the "subject line" should state the contract number and the billing period. Each progress report will begin with the following disclaimer:

The statements and conclusions in this report are those of the Contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

- B. Each progress report will also include:

1. A brief narrative account of project tasks completed or partially completed since the last progress report;
2. A brief discussion of problems encountered during the reporting period and how they were or are proposed to be resolved; and
3. A graph showing allocation of the budget and amount used to date.

- C. IRTA's obligation under this Agreement shall be deemed discharged only upon submittal to ARB of quarterly progress reports along with data submission.