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Plan for Air Pollution Research in the Texas Gulf Coast Area

Volume II. Plan for Health Effects Studies

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PLAN FOR AIR POLLUTION RESEARCH IN THE TEXAS GULF COAST AREA
Volume II. Plan For Health Effects Studies

by

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ABSTRACT

In the study reported here, a plan for air pollution research was developed for the Texas Gulf Coast Area. This report is Volume II of a five part series of reports documenting that plan and is specifically directed at presenting a plan for health effects studies.

A panel of three epidemiologists aided by other support staff developed the health effects study plans presented in this report. Available aerometric, health effects, demographic, and meteorologic data as well as other inputs resulting from public meetings were reviewed and considered in development of the plan. Documentation begins with a general assessment of area populations, air quality, and relevant health effects. Questions are addressed which must be answered in accomplishing a plan for health effects studies.

The plan begins with detailed discussion of the general research needs of the area regarding health effects and presents a set of hypotheses which need to be addressed with specific studies. The plan culminates with description of twelve types of studies considered to be most useful in providing definitive answers. Relative priorities, time sequencing, and rough cost estimates are provided with the study descriptions.

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SECTION 1

INTRODUCTION

As part of the Clean Air Act Amendments of 1977, the United States Congress mandated that the Environmental Protection Agency, in cooperation with local groups, plan and execute a research program in the Texas Gulf Coast area to define the air pollution and related health problems. Accordingly, a study has been commissioned by the Agency to develop a plan for a three-year $3,000,000 program. This study, a joint effort of Radian Corporation and Southwest Research Institute, is aimed at the collection and review of information on air pollution and related health effects, and the identification of specific research needs. In particular, the study objective is to define approaches which would best resolve the identified research needs.

The research plan developed under this study has been summarized in a five part series of reports:

Volume I: Plan for Air Quality Studies
Volume II: Plan for Health Effects Studies
Volume III: Summary of Previous Air Quality Studies, and Data
Volume IV: Summary of Previous Health Effects Studies and Data
Volume V: Local Viewpoint on Research Needs

This document is Volume II of that series. It has been prepared following a review of available aerometric, health effects, demographic, and meteorologic data. The assessment included input from several different organizations within the Texas Gulf Coast area. Two public meetings were held in Houston (October 3, 1978 and January 25, 1979) at which the public was invited to make presentations about air pollution and possible health effects of these pollutants. Oral presentations and written documents resulting from these meetings were reviewed and considered in the preparation of this report.

The report is divided into three major sections. Section 1, Introduction, includes information on the composition of the study team and background information regarding area populations, air quality, and relevant health effects. Section 2 contains a set of questions relevant to the design of pertinent research approaches. Section 3 presents a plan for health effects.

A. The Health Effects Study Team

The approach taken in accomplishing this health effects design study has involved the cooperative efforts of three principal groups: a panel of epidemiologists, a principal project team and support staff, and a set of consultants and advisors to the panel and principal staff. (See Table 1). It has been the primary responsibility of the panel of epidemiologists to review existing health, air quality, and demographic data and to draw specific conclusions and recommendations regarding health effects study designs. In

TABLE 1. HEALTH EFFECTS STUDY ORGANIZATION

Panel of Epidemiologists	Organization
Dr. P. A. Buffler, Chairperson	UT School of Public Health, Houston
Dr. D. I. Hammer, Panelist	Rex Hospital, Raleigh, N.C.
Dr. A. H. Holguin, Panelist	UT School of Public Health, Houston
Project Team and Support Staff	
Dr. D. E. Johnson, Technical Director	Southwest Research Institute, Houston
R. J. Prevost, Manager, Health Effects	Southwest Research Institute, Houston
K. T. Kimball, Statistics	Southwest Research Institute, Houston
Dr. J. G. Dobbins, Demography	UT Medical Branch, Galveston
Dr. C. W. Eifler, Biostatistics	UT Medical Branch, Galveston
Dr. D. Reed, Epidemiology	California State Health Dept., Berkeley
Dr. J. R. Goldsmith, Epidemiology	Ben Gurion University, Israel
Health Indicator Advisory Group	
Dr. C. R. Shaw, Carcinogenicity	M. D. Anderson Tumor Institute, Houston
Dr. D. E. Jenkins, Clinical Pulmonary Func.	Baylor College of Medicine, Houston
Dr. T. S. Matney, Mutagenicity	UT Graduate School of Biomedical Sciences, Houston

support of the Panel, the project team has provided input to the Panel, and has worked with them during panel discussions to arrive at the most reasonable approaches to health effects study designs. The project team and Panel have also met with a secondary set of medical advisors regarding specific health indicator parameters (symptomatology, response levels, etc.). The project team has assembled this report under the guidance and direction of the Panel.

The separation of responsibilities between the panel of epidemiologists and the principal project team is of critical importance to this project. Specific study designs and priorities recommended in this report are those proposed by the expert panel of epidemiologists.

B. The Population at Risk

This study is directed toward the population residing in the Texas Gulf Coast Area (TGCA). This area is a highly industrialized urban area in the vicinity of Houston, Texas, including adjacent counties and forms the largest urban and industrial area in the southern United States. As depicted in Figure 1, the ten county coastal area covers a region from Louisiana to the far side of Galveston Bay and includes some 9,538 square miles. In 1970, the population was 2,417,258 persons; one county, Harris, had 70% of this total. A rapid population growth during the last several decades (38% from 1960-1970) has produced a rapidly expanding urban environment and a rapidly changing demographic pattern. This rapid growth has continued since 1970 such that the population of Harris County had an estimated increase of 24% in 1976 as compared to 1970[1]. Net in-migration accounted for 68% of that post census gain. The current TGCA population is estimated to be approximately 3 million persons and is increasing at 4% or 120,000 persons per annum. The ethnic distribution of this population, as estimated from the 1970 census is 79% white (including Spanish), 20% Negro, and less than 1% Other, a category which includes, but is not limited to, American Indian, Chinese, and Japanese. Persons of Spanish language or surname comprise 11% of the population.

All parts of the TGCA lie within boundaries of Standard Metropolitan Statistical Areas (SMSA) as defined by the U.S. Department of Census. The population of the area is therefore primarily an urban and suburban population as opposed to a rural population. In 1970, 74% of the TGCA population lived within the boundaries of six incorporated cities: Houston, Pasadena, Baytown, Galveston, Beaumont, and Port Arthur. In the health effects resource document[2], Volume IV of this series, socioeconomic and demographic data are presented for these cities, including separate statistics for six subregions of the City of Houston. Summary statistics for these areas are presented on the following page. An important item indicated in the table is distance from concentrated manufacturing activities associated with ship channels: the Houston Ship Channel (east Houston to Gulf of Mexico) and the Beaumont Ship Channel (east Beaumont to Gulf of Mexico). The industrialized corridors associated with these two ship channels contain a significant amount of the nation's petrochemical and refining capacity and are potential sources for associated ambient air pollution.

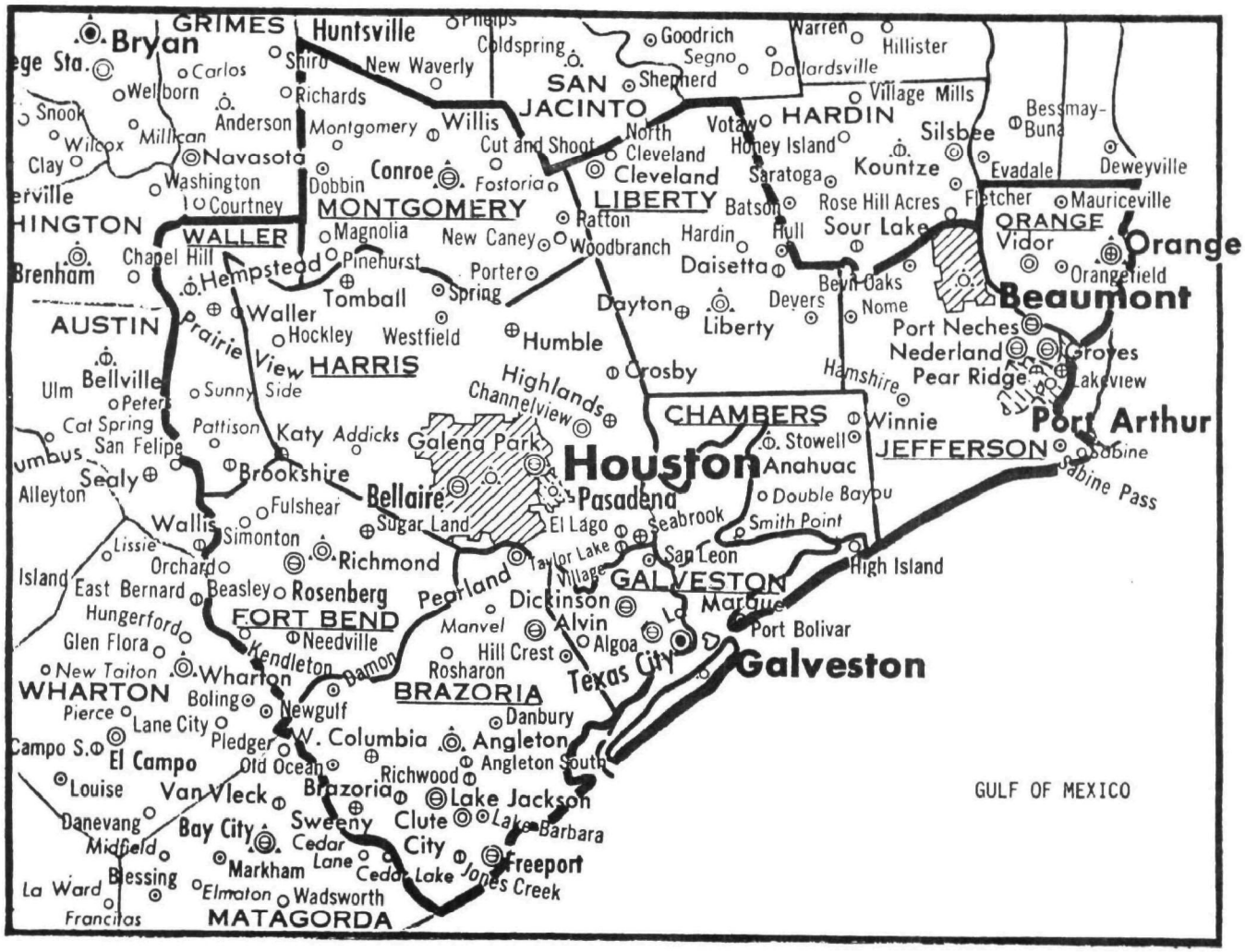

FIGURE 1. The Texas Gulf Coast Area

Urban Subdivision*	1970 Population	% White	% Under 18	Median** Education (Years)	Distance to Ship Channel Industry (Miles
Central Houston	160,483	45	34	9.3	1-7
NE Houston	192,485	55	41	10.2	3-13
NW Houston	188,449	88	37	11.0	6-18
SW Houston	279,654	98	30	13.9	6-22
E. Houston	184,335	90	37	10.0	0-6
Pasadena	102,097	99	39	12.3	0-8
Baytown	43,980	95	39	12.1	0-7
Galveston	61,809	70	32	10.7	7-10
Beaumont	115,919	69	34	11.7	0-12
Port Arthur	57,371	60	34	10.4	0-7
TGCA	2,497,258	79	37	11.9	---

* Urban subdivisions are defined specifically in Reference 2, Section 3.
** Persons 25 years of age and older.

The population statistics and distances to ship channel industrial areas are of interest to health effects studies. The areas further away from ship channel industry are potentially less exposed to certain air pollutants originating from ship channel sources and could possibly serve as comparison or low exposure areas. Selection of specific areas of possible interest to health effects studies would be dependent upon the specific study design, the characteristics of the ambient air pollution exposure of that population. Some specific study locations of interest to TGCA health effects studies are presented in Figure 2 and discussed in the following section.

C. Air Quality

Two documents prepared by Radian Corporation[3,4] have served this health effects study as the primary sources of background air quality information. The later of those two documents, entitled "Aerometric Research Plan", discusses TGCA ambient air quality. Summary data obtained from that report are presented in Table 2. The research plan for air contaminants, Volume I of this series, is an additional source of air quality data. From these documents and from other data, it has been observed that the air quality of the TGCA is characterized by relatively high levels of ozone, hydrocarbons and particulates. Each of these pollutants have exceeded their respective EPA standards. This table shows data for ten different air monitoring stations covering 1975 to 1977. The highest ozone and hydrocarbon levels were seen at the Parkhurst station which is located northeast of the center of town. The Mae Drive and Clinton stations located east of the center of town near the ship channel had the next highest ozone and hydrocarbons plus the highest levels of particulates. Lower levels of particulates and ozone were measured downtown (MacGregor) and southeast of the city (Fuqua). The Aldine station located northeast of the city further out of town than the Parkhurst station, had intermediate levels of the pollutants.

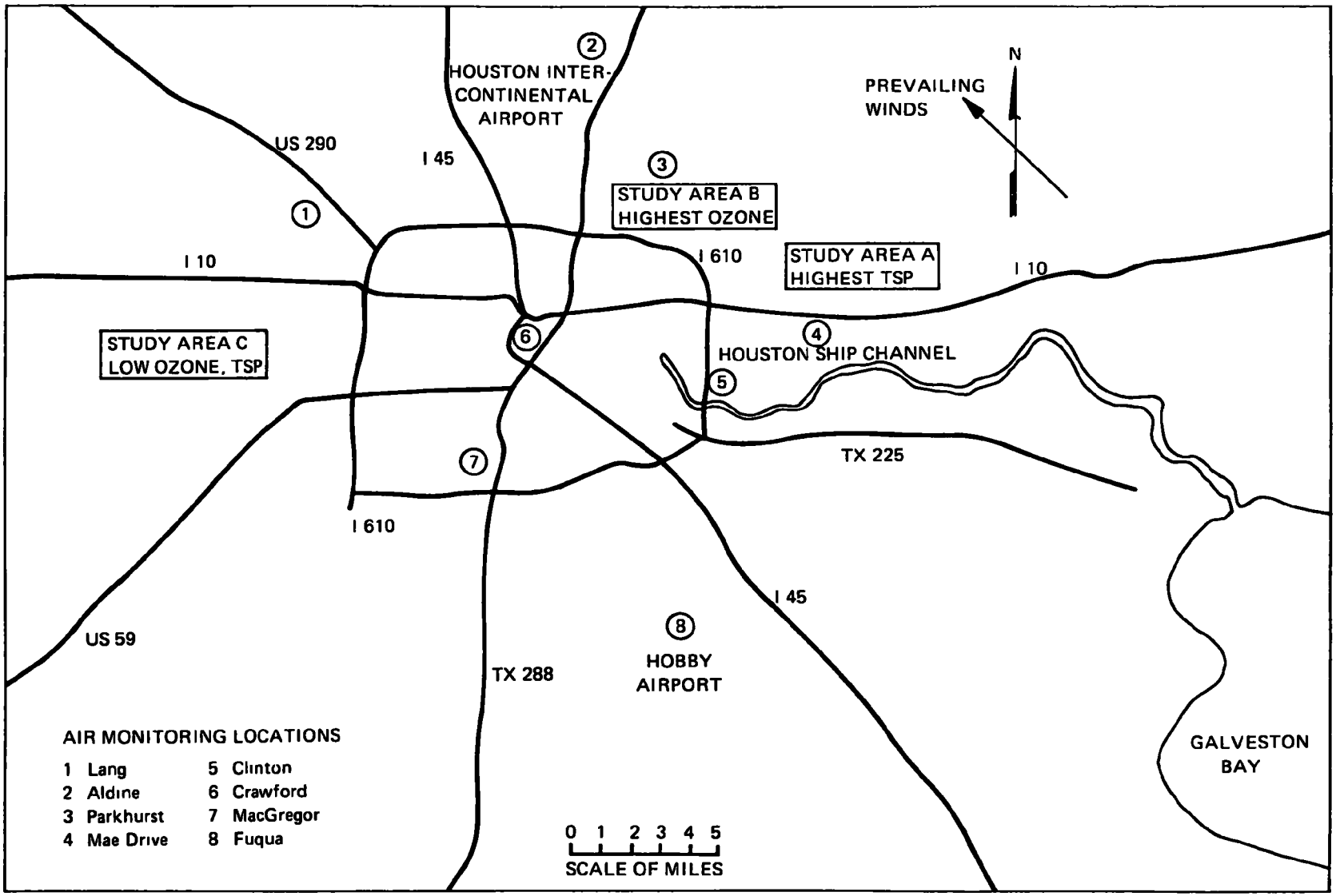

FIGURE 2. Air Monitoring Locations: Harris County, Texas

TABLE 2. SUMMARY OF IMPORTANT AMBIENT AIR MEASUREMENTS FOR THE HOUSTON AREA 1975-1977
(All measurements in parts per million, except TSP in micrograms per cubic meter.)

		Lang (NW)	Aldine (NE)	Parkhurst (NE)	Mae Drive (E)	Clinton (E)	Crawford (CENT)	MacGregor (CENT)	Fuqua (SE)	Texas City	Clute
OZONE											
Maximum Hourly Average	1975	--	0.321	0.267	0.288	0.307	0.254	0.198	0.285	0.222	0.160
	1976	--	0.272	0.286	0.297	0.278	0.223	0.270	0.289	0.225	0.186
	1977	0.256	0.270	0.302	0.222	0.205	0.309	0.254	0.281	0.236	0.185
Number of Hours over .08 ppm	1975	--	251	242	202	214	186	116	255	288	187
	1976	--	397	534	279	518	188	243	289	311	205
	1977	103	322	481	255	224	119	170	281	188	133
Number of Hours over .08 ppm May-Oct Only	1975	--	218	221	180	188	171	96	255	233	145
	1976	--	307	447	232	446	167	219	434	257	152
	1977	88	269	404	224	213	105	129	129	179	84
NITROGEN DIOXIDE											
Maximum Hourly Average	1975	--	0.13	0.13	0.21	0.35	0.41	—	—	0.10	0.09
	1976	--	0.14	--	0.32	0.24	0.29	0.12	—	0.29	0.11
	1977	--	0.11	0.14	0.18	—	0.13	—	—	0.12	0.09
Annual Average	1975	--	0.02	*	0.03	*	*	--	—	0.01	0.01
	1976	--	0.02	—	0.02	*	*	*	—	0.01	0.01
	1977	--	0.02	*	0.03	—	*	—	—	0.02	0.01
NON-METHANE HYDROCARBON											
Highest 6-9 am Average	1975	--	2.1	18.6	3.9	6.3	12.4	--	--	5.4	3.1
	1976	--	3.9	7.0	3.4	10.1	7.6	—	--	3.8	4.5
	1977	--	6.2	15.5	6.1	4.2	10.3	—	--	2.9	6.4
SULFUR DIOXIDE											
Maximum Hourly Average	1975	--	0.11	—	0.20	0.56	0.17	—	--	0.21	0.02
	1976	--	0.01	—	0.12	0.63	0.26	—	—	0.31	0.09
	1977	--	0.01	—	0.11	0.44	—	—	--	0.03	0.02
Maximum 3 Hour Average	1975	--	0.10	--	0.13	0.53	0.14	--	--	0.12	0.01
	1976	--	0.01	—	0.07	0.43	0.19	—	--	0.21	0.03
	1977	--	0.01	—	0.06	0.34	—	--	--	0.02	0.01
Annual Average	1975	--	0.00	—	0.00	*	*	--	--	0.00	0.00
	1976	--	0.00	—	0.00	*	*	--	--	0.00	0.00
	1977	--	0.00	—	0.00	*	--	--	--	0.00	0.00
TOTAL SUSPENDED PARTICULATE											
Maximum 24 Hour Average	1975	149	153	150	204	—	163	149	205	126	180
	1976	227	134	220	198	—	119	175	228	207	185
	1977	273	1041	200	841	334	629	252	240	1203	781
Annual Geometric Mean	1975	57	64	63	82	—	71	62	65	59	74
	1976	60	65	64	90	—	69	53	60	57	71
	1977	62	74	67	91	142	76	53	63	64	89

* Not available at present

Sources: Texas Air Control Board[6]
City of Houston[7]

Levels of ozone in the Houston area are among the highest in the United States with only a few cities measuring higher levels. Ozone is not as high as that seen in Southern California where hourly averages of ozone routinely exceed 0.2 and even 0.3 ppm; in the Texas Gulf Coast area it is rare for an hourly average of 0.3 ppm to occur and hourly averages of 0.2 occur infrequently. The composition of photochemical oxidants in the Houston area may be different from those in Southern California, especially for components that are involved in eye discomfort. In California, additional oxidants implicated for eye discomfort and other health effects included peroxyacyl nitrate, acrolein, peroxy and benzoyl nitrate and aldehydes. Eye discomfort complaints have not been reported in the Texas Gulf Coast area; this may be due to lower exposures of these specific eye irritants. Comparison of the air quality of Houston with that of Southern California is important because much of the health data relative to oxidants has been collected in California.

The high total suspended particulate matter present in the Texas Gulf Coast area may be comprised of smaller particles which may be more important with regard to health effects. Little data are available regarding the percentage of respirable particulates present with the total particulates. Higher levels of particulates are generally seen in urban areas of the north central and north eastern U.S. as well as in the western U.S. Particulates in Houston may be of greater concern than other areas because of the chemical composition of the particulates, especially that of the respirable portion. A relatively high percentage of the particulate emissions in the Houston area is from petrochemical sources located along the Houston ship channel. Little is known regarding the composition of trace inorganic and organic components present with the particulate matter. These unknown chemicals may be associated with certain health problems such as lung cancer, other respiratory diseases, and cardiovascular diseases.

The Houston area greatly exceeds the standard for non-methane hydrocarbons. The levels are similar to those seen in other urban areas the size of Houston. These hydrocarbon levels are relatively high in the Texas Gulf Coast area, especially relative to oxides of nitrogen. There are significant point sources of hydrocarbons, especially along the Houston ship channel which is east of the center of the city of Houston, extending out to and including the city of Baytown. Data from sources such as the Texas Air Control Board indicate that the total emissions of hydrocarbons from point sources have decreased by approximately 40 percent during the last several years; however, the ambient air levels of total non-methane hydrocarbons have not changed appreciably over this time period. Since health effects of hydrocarbon exposures have not been studied, no specific health effects have been attributed to ambient levels of hydrocarbons. Hydrocarbon composition in Houston air is described in the referenced Radian reports[3,4,5]. The presence of aromatic hydrocarbons suggests that there could be some health effects from these pollutants.

Carbon monoxide levels are below the EPA standard of 9.0 ppm second highest eight hour average: approximately 5 and 7 ppm in Houston in 1975 and 1977, respectively. Point sources accounted for 60% of carbon monoxide in 1973 according to the emissions data.

Currently, sulfur dioxide levels are relatively low in most areas of the Texas Gulf Coast area with an elevation seen in one area around the Houston ship channel which apparently is associated with several point sources. These levels are low as compared to those seen in some other areas of the United States. Conversion from relatively clean fuels such as natural gas to petroleum fuels and especially high-sulfur coal could significantly increase levels of oxides of sulfur. Some industries in Texas have made conversions to coal at present. If this occurs on a broad scale in Houston, there could be sharp increases in emissions of SO_2 and particulates in the ship channel area and also from electrical power plants located throughout the area.

Oxides of nitrogen are relatively low in the Houston area. Annual averages for Houston range from 0.01 to 0.03 ppm (standard 0.05 ppm) with maximum hourly average ranges of 0.12 to 0.41 ppm. The highest levels are usually seen in the center of Houston. Sources of oxides of nitrogen appear to be from vehicular traffic and from point sources along the ship channel. An increase in burning of dirtier fuels such as petroleum and coal could also lead to significant increases in emissions of oxides of nitrogen. This change could cause other pollutant problems in that it appears that one of the uncommon features of the air pollutant composition in the Houston area is the high total non-methane hydrocarbon to NO_x ratio. It is suggested that the chemical reactions which take place in the atmosphere are NO_x limited; thus significant increases in NO_x may have rather profound changes in levels of other air pollutants such as ozone and other oxidant products.

In the eighth annual report of the Council on Environmental Quality[8], published in 1977, the conditions and trends of air quality for several metropolitan areas in the United States were discussed. It was pointed out that only the South Coast Basin of California, the Houston-Galveston area and the Philadelphia area are likely to be significantly above the ambient ozone standard in 1990. This discussion suggests that the petrochemical industries are responsible for most of the oxidant pollution in the Houston-Galveston area. The report also examines the Pollution Standards Index (PSI) developed by the Federal Interagency Task Force[9]. The PSI index was used to compare the air quality in 20 major metropolitan areas on a uniform basis. Comparison of the PSI values indicated that the Los Angeles area had an index value as the most "unhealthy" area of the United States with nine other cities having unhealthy ratings of 100 or more, but less than 200, days per year. The Houston area was one of these nine areas with a PSI rating of 141 as compared to 318 for Los Angeles.

The Texas Air Control Board presented air quality data for the Houston area in its Biennial Report covering September 1976 to August 1978[10]. The haze problem in Houston was discussed and the need for more information on the exact nature of haze, the chemical reactions which lead to its formation, the effects of high humidity, the relative contributions of automotive and industrial emissions, and its potential health effects were presented.

Pertinent meteorology data for the area included in the aerometric reports [3,4] provided by Radian Corporation are summarized as follows. The prevailing wind direction in the area is from the south to southeast for every month of the year except January in which it is from the north to northwest.

The area has warm temperatures with high relative humidities throughout the year. The area has an annual rainfall of approximately 48 inches and an annual percentage of possible sunshiny days of 57 percent.

The combination of high temperature and high humidities in the TGCA will probably impact health effects studies. It is known that biological response parameters such as performance, pulmonary function, symptomatology and toxicity in experimental animals are significantly impacted by elevated temperatures and humidities. In general elevated temperature and humidity have been associated with increased toxicity. Health effects of air pollutants such as oxidants and particulates have been studied in geographic areas with lower temperatures and lower humidities. The high humidities will affect aerosol formation, transformation and transport. These interactions may be involved in health effects.

Certain conclusions regarding requirements for air monitoring requirements to support health effects studies, can be outlined. Continuous monitoring of some of the criteria pollutants has been underway in the TGCA since about 1973 with little or no air monitoring data prior to this time. Presently, there is continuous monitoring of criteria pollutants by the City of Houston, the Texas Air Control Board and the Environmental Protection Agency. These data would be available and applicable to projected health effects studies provided air monitoring stations were located sufficiently close to study populations. There are several special research efforts on air monitoring that would be useful for health effects studies. Two of these are: (1) The Houston Area Oxidants Study (HAOS) sponsored by the Houston Chamber of Commerce, and (2) The Houston Air Pollution Study (HAPS) sponsored by the EPA.

An extensive air monitoring effort was performed as part of the HAOS effort during the summer of 1977 which provides data to characterize the ambient air in and around the Houston area. Of particular importance are the data for total and respirable suspended particulates and detailed monitoring of individual hydrocarbons. Other measurements included aeroallergens, individual aldehydes, ozone, PAN and other oxidants. Most of this data will be available in a final report in the early part of 1979.

The HAPS program was performed by several EPA contractors to examine aerosols in the Houston area during the summer of 1978. This study included measurements of the quantities of respirable particulates and total particulates as well as detailed chemical characterizations of the organic material associated with the respirable particulates. Some effort has also been planned for measurement of organics not associated with particulate matter through the use of absorbent systems. The analytical methodologies involve gas chromatography combined with mass spectrometry to identify trace organics. Final reports for these studies are scheduled for late 1979.

Even though the criteria pollutants are being monitored at a number of stations in the area on a continuous basis, it is likely that future epidemiology studies will require additional air monitoring stations. These stations

should be located as close to study populations as possible and monitoring both indoors and outdoors near residences may be needed. There is a need to more precisely quantitate the ambient air exposure of individuals. One approach would be through the use of personal air monitoring devices which could be worn by individuals. This approach has not been utilized more because of the large costs involved ($100 plus per monitor) and the generally poor accuracy of the devices. Nonetheless, there is a possibility that with newer technology personal monitors could be utilized for measurements of total particulates and oxidants/ozone to aid in the health effects effort in the TGCA. A pilot study could be done with 20 to 30 selected participants fitted with personal monitors to measure total and respirable suspended particulates and either ozone or total oxidants. The persons would wear these monitors for an 8 to 12-hour exposure period to obtain an integrated time exposure of the two pollutants. This data would then be compared with data from fixed station monitors to determine possible differences. There is a psosibility that real exposures to particulates and ozone of persons that stay indoors at home might be significantly less than that of ambient air exposures because of the reduction of these pollutants going from outdoors to indoors. This is especially true for air conditioned houses in which filters are somewhat effective in reducing particulate matter and ozone.

For health studies related to oxidants/ozone, it is probable that detailed continuous measurements of the following will be needed: ozone, total oxidants, oxides of nitrogen, sulfur dioxide, PAN, aeroallergens, temperature and humidity. Monitoring should be accomplished for the duration of the health study and, in general, needs to accurately describe exposures of participants with monitoring at stations very close to the participants' residences and with combinations of monitoring of individuals and indoor and outdoor monitoring.

For epidemiology studies aimed at aerosols, continuous monitoring for total suspended particulates and respirable particulates would be needed to describe the exposures to participants both indoors as well as outdoors. Size fractionation measurements of particulate matter and detailed chemical characterization of aerosols for both inorganic and trace organic material would be needed on an intermittent basis. The inorganic measurements would include parameters such as trace metals, fluorides, asbestos, nitrates, sulfates, sulfuric acid, and perhaps others. Trace organic measurements should provide the identities and approximate levels of organics that are toxic to man, particularly for those organisms with carcinogenic, mutagenic and teratogenic properties. It might be possible to fractionate the organics and then utilize tissue culture procedures for examination of toxicity to provide a selection of those fractions with the highest toxicity for detailed chemical characterization. The difficulties and costs of these types of measurements would preclude their conduct on a broad scale. Selected samples for peak levels of total particulates should be analyzed.

Retrospective epidemiology studies will require estimates of both previous and current air pollution levels to approximate exposures. Estimates for past exposures could be developed from industrial emissions and production data. These estimates of emissions of various types of materials could be utilized to approximate air quality data historically.

D. Relevant Health Effects

A critical assessment of all the relevant literature for health effects of air pollutants is beyond the scope of this effort. Three recent reviews of the health effects of air pollutants have been published for criteria pollutants. Two of these review articles are Health Effects of Exposure to Low Levels of Regulated Air Pollutants by Ferris[11] and Effects of Air Pollution written by Shy, Goldsmith, Hackney, Lebowitz and Menzell[12]. Each has rather extensive bibliographies plus an assessment of the data for health effects on the criteria pollutants with some idscussion of pollutants associated with aerosols that may be involved in health effects.

A recent review and assessment of the literature for health effects and exposures to sulfur dioxide and particulates in children was published by EPA[13]. This report pointed out the advantages of using children in environmental health studies:

- They are not generally exposed to occupational exposures or tobacco smoking,
- They are less likely to have experienced several different air pollutant exposures related to residential mobility, and
- Acute morbidity would be least likely to be confounded with symptoms of chronic disease.

Attention has also been directed toward those epidemiology studies performed in the Texas Gulf Coast area and to other selected references which report on health effect indicators that may be useful for application in the area. There have been few environmental epidemiology studies performed in the TGCA. Dr. Daniel E. Jenkins of the Baylor School of Medicine conducted a study[14] which collected information regarding the prevalence of respiratory symptoms and abnormal pulmonary function among elementary, junior and senior high school students in two areas of Houston, one with relatively high air pollution near the Houston ship channel and the other with relatively low air pollution in the south central portion of the city. The study indicated a higher prevalence of upper respiratory tract symptoms in the high air pollution versus low pollution area with no differences seen for pulmonary function. The primary air monitoring index was for total suspended particulates as measured by the City of Houston. The monitoring effort was carried out during October-December 1976. A summary brief for this study is provided in Section 4 of the resource document for health effects[2]. A recent study[15] conducted in two Los Angeles communities produced conflicting results: pulmonary function was lower in the high pollution community but respiratory symptoms were reported more frequently by residents of the low pollution community.

A study[16] of selected trace metals in several populations was performed by Southwest Research Institute in 1972 to 1973 in the Houston area in city policemen working downtown, in persons working in covered parking garages and in females living close to major expressways. These three population groups were compared with matched control groups. The results showed that for certain metals such as lead, there were significantly higher levels in blood and hair of persons working in parking garages and on downtown streets. No differences were seen for females near freeways as compared with a control

group of females. A summary brief for this EPA sponsored study is provided in Section 4 of the resource document for health effects[2].

A health effects study[16] was performed as part of the Houston Area Oxidant Study (HAOS) during the summer and fall of 1977 in which health information was collected on persons suffering from allergic asthma, chronic bronchitis and/or pulmonary emphysema. These persons were monitored for prevalence of nasal and respiratory symptoms and a portion were monitored for pulmonary function responses. The data from these health indicators were compared with a broad spectrum of air monitoring data which included ozone, total oxidants, oxides of nitrogen, aeroallergens, total non-methane hydrocarbons, total suspended particulates, total respirable particulates, PAN, formaldehyde, total aldehydes and individual hydrocarbons. The results of this study are to be included in a final report due in February 1979. This effort has significant relevance to the planning document because of its emphasis on a portion of the population believed to be more sensitive to respiratory irritants and on exposure to ozone and total oxidants. A summary brief for this study is provided in Section 4 of the resource document for health effects[2].

A report by the Texas Department of Health and the University of Texas Cancer Center, M.D. Anderson Hospital and Tumor Institute entitled, Impact of Cancer on Texas, published in 1978[18] is important relative to the incidence of certain types of cancer in the Texas Gulf Coast area. This report points out that lung cancer is significantly above the national average in Harris and Galveston Counties and that other forms of cancer such as bladder and liver are higher than the national average. The report concludes that lung cancer is a major public health problem in the state, especially in the Texas Gulf Coast area, with deaths due to lung cancer increasing some 53 percent from 1969 to 1976. Currently, one in four cancer deaths in the state of Texas is due to lung cancer and men account for 79 percent of these.

SECTION 2

DEFINITION OF QUESTIONS

A. Questions to be Answered

Throughout this assessment of research needs consideration has been given to three basic concepts: (1) exposures, (2) populations at risk, and (3) responses. It is the identification of a specific set of these components which defines a research approach. Some important aspects of each of these components which must be considered are listed as follows:

Exposures

- What: criteria and noncriteria pollutants
- What: physical, chemical and biological characteristics
- When: current, past, and future; short/long
- Where: ambient, work place, home, transportation, public buildings

Populations at risk

- Healthy populations and specially sensitive subsets
- Numbers and locations
- Demographic characteristics

Responses

- Recognition of a spectrum of biological responses
- Sensory-visual, smell, test
- Mortality
- Aggravation of existing diseases
- Contribution to formation of diseases

To better organize the review of available data and accomplish the development of study approaches to resolve the research needs in the Texas Gulf Coast area, a set of questions has been formulated which addresses these three basic concepts. The questions were formulated following the study of available aerometric and meteorological data and information about specific health effects studies in the TGCA and a review of possible health problems which appear to be related to exposure to air pollutants. The questions have been structured under three separate headings: (1) Exposures, (2) Populations at risk, and (3) Biological responses.

Exposures

1. What are the air pollutant exposures (current, past and future) to the populations at risk?

2. What will be the effect on air pollutant levels of conversion by a major portion of industry in the TGCA from the burning of relatively clean fuels to dirtier fuels such as coal?

Populations at Risk

1. What populations are at risk to adverse levels of air pollutants?

2. Are there portions of these populations which are more sensitive to air pollutants?

3. What are the approximate numbers and locations of these specially sensitive populations?

Responses

1. What are the health effects responses to the criteria pollutants in this area? Noncriteria pollutants? Current, past and future?

2. What are the important health indicators for evaluation of effects of air pollutants? (Mortality, pulmonary alteration, symptomatology, sensory perception, reproductive changes, behavior, opinions, cancer or cardiovascular effects).

B. Health Effects Study Design

To design a specific health effects study requires the determination of a very specific set of the three major components discussed in the previous section. Three questions must be answered in development of a set of appropriate studies for an area such as the TGCA. These are:

1. What are the logical groupings of the three components which form appropriate and reasonable research approaches?

2. What is the relative importance of the need for information from these groupings?

3. What is the logical sequence for interrelated approaches?

Proper consideration of these questions leads to the development of appropriate specific study designs, and the assignment of priorities regarding effort and time.

To address these questions in development of specific research approaches, the full range of population responses must be considered. These range from death, in the worst case„ to simple psychological stress at the opposite end.

In order of diminishing importance, some of the possible responses are listed below:

- Mortality (cancer, violent deaths, infant mortality, fetal loss)
- Morbidity (chronic obstructive lung disease, birth defects)
- Symptoms (respiratory symptoms, eye or skin irritation)
- Discomfort (headache, general aches and pains)
- Diminished performance (work activities, athletic ability)
- Psychological stress (attitude, concern, odors, visibility)

The ordering of responses in the preceeding list is not always diminishing in the strictest sense, but serves to demonstrate various levels or kinds of response to air pollution. Psychological stress, for example, can possibly lead to serious distress or even death by accident or suicide, but generally it can be expected to occur at the nuisance or diminished performance level. For a given air pollutant, the population at risk generally increases as the severity of response diminishes.

In this document, the general approach to definition of specific health effects studies has been to first, determine specific or general environmental exposures, second, determine important potential health effects related to the exposures and, third, define appropriate populations at risk to be studied. These questions will now be addressed directly in an assessment of the TGCA research needs and the development of a research plan for health effects.

Section 3

RESEARCH PLAN FOR HEALTH EFFECTS

A. Outline of the Plan

A reserach plan for health effects is presented in this section. Research needs are first addressed by taking a comprehensive look at important types and areas of study which would provide needed answers to area problems. After the assessment of research needs, a listing of important hypotheses is made. These hypotheses follow directly from the research needs and address the important questions which need to be answered for the TGCA. Brief descriptions of important health effect study designs are then presented which are considered by the panel of epidemiologists to be most useful in providing definitive answers. For each of the study briefs, priority, time schedule, and sequencing (where appropriate) are addressed. Approximate estimates of the level of effort are given for each study design. A summary of the research plan is then provided to give an overall look at the magnitude and types of studies suggested as high, intermediate, and low priority items. Finally, resources available to perform and support such health effects studies are discussed.

B. Assessment of TGCA Research Needs

The review and assessment of relevant aerometric and health data indicated that there are two primary air pollutants that need to be examined. These are photochemical oxidants and suspended particulates. Sulfur dioxide is not of primary concern but some efforts may be needed, because of possible future alterations in levels of this pollutant. For each of these two major air pollutants, a discussion of the assessment of important health effects, including both short term (acute) and long term (chronic) effects is presented in the following section.

1. Photochemical Oxidants

This air pollutant is significantly elevated in the Texas Gulf Coast area. It appears that elevations will be prevalent for at least the next five years. The levels seen are in violation of the former EPA standard (.08 ppm) for more than 100 days per year. The data base for establishment of a dose-response relationship between ozone and other oxidants and selected health indicators is not adequate. In addition, little information for this relationship is available for the TGCA. As discussed earlier, this area apparently has significant differences in the composition and concentration of oxidants and other air pollutants versus the Los Angeles area where most of the health data were collected. The high humidities and temperatures seen in the TGCA may also affect the dose-response relationship. High humidity combined with elevated temperatures will alter pulmonary function measurements. Also, animal toxicity data clearly show increased toxicity to toxic chemicals with elevated temperature and humidity.

A study should be directed at a vigorously exercising population such as cross-country runners or other types of long distance runners, high school and college track (for runs of 220 yards and above), long distance swimmers in outdoor pools, etc. These vigorously exercising individuals should be examined for evidence of decrements in performance resulting from acute exposures to air pollutants, and for other health effects parameters such as prevalence of certain symptoms, pulmonary function and other physiologic measurements and chromosomal changes. A maximally exercising population represents a population at risk that has a relatively higher pollution exposure than the general population. Persons exercising at 60-80% of their aerobic capacity for 15 to 60 minutes are exposed to as much as 10 times the quantities of air pollutants as sedentary persons. Exercising populations in the TGCA meeting these criteria are present in cross country runners, long distance swimmers (outdoors), long distance runners (training and competitve), track (for the longer races), and bicycling. There is, therefore, a significant population at risk in the study area that is exposed to significantly higher dosages of air pollutants for short time periods.

There is evidence that vigorously exercising persons are at greater risk to exposures of air pollutants currently encountered in ambient air. The primary reason is that for short time periods (usually less than one hour), much larger volumes of air are inhaled thus a higher exposure to air pollutants such as oxidants is encountered.

A study of performance of cross country runners relative to daily level of air pollutants was performed in the Southern California area by Wayne, et al[19]. They found a significant correlation (>0.8) between oxidant levels one hour prior to the race and the percent of team members whose performance did not improve. No relationship was seen between performance and carbon monoxide, nitrogen dioxide nor weather parameters. DeLucia and Adams[20] examined healthy males in a chamber study for effects of ozone with different levels of exercise. They utilized one hour exposures of 0.15 and 0.3 ppm of ozone with the subject at rest and exercised at 25%, 45% and 65% of maximum oxygen uptake. They found altered ventilatory patterns and decreased pulmonary function for maximally exercising persons at levels of ozone of 0.15 and 0.3 ppm. Folinsbee, et al[21] concluded that the effects of ozone are most severe immediately after exercise and that heat stress may modify the overall effect of ozone on pulmonary function. These authors studied the effects of 2 hour exposures to ozone (0.5ppm) to non-smoking healthy males undergoing exercise. From these reports it appears that performance symptomatology and certain pulmonary function parameters are useful indicators of effects of air pollutants.

An RFP issued from the Environmental Protection Agency at Research Triangle Park on cross-country runners in the Texas Gulf Coast area was aimed at studying performance, symptomatology and lung function for home meets. This three year study would provide for an assessment of possible health effects for short term exposures (approximately 15 minutes) to air pollutants. High school cross country meets are held on weekends from September through the first of December in the TGCA. The highest hourly values for ozone occur from May through October in the TGCA. Other pollutants such as oxides of

nitrogen and aerosols are higher during episodes of air stagnation which are more frequent in the summer and fall. The proposed runners study would overlap the end of the expected highest ozone levels. The study should be directed at an assessment of not only ozone, but daily levels of oxides of nitrogen, sulfur dioxide, particulates (total and respirable), and aeroallergens. For an effective assessment of exposures and health responses, a range of air pollutant values is needed. This range should be present in the proposed design.

One of the problems associated with exposures to photochemical oxidants is the question of adaptability of persons to these exposures. The study by Hackney et al.[22] compared four Los Angeles residents with four Canadians who were not accustomed to Los Angeles smog. Each of these persons spent between two and one half and three hours breathing initially clean air and then air with 0.37 ppm of ozone. The blood and lung function of the participants were continually examined for changes. Differences were seen for both groups of people, that is, changes from clean air to ozone exposure; however, the participants from the Los Angeles area showed fewer alterations on the average. It was conlcuded that the differences noted were a result of adaptation to exposure to ozone. Animal studies have indicated that exposure to ozone results in an increase in antioxidant enzyme activity and a proliferation of cells in small airways and air sacs or alveoli of the lungs. This may be an important aspect of exposure to photochemical oxidants.

The effects of ozone and other oxidants on reproduction needs to be considered. This could be accomplished by a prospective environmental epidemiology effort in which a group of pregnant females living in an area with relatively high oxidant levels versus a control area with low oxidant levels are followed over a period of time to include the term of pregnancy and monitored for parameters such as birth defects, fetal loss, fetal size, etc.

Another approach for study of the oxidant situation would include panels in which portions of the populations with some type of disease state are monitored for prevalence of symptoms and measurement of pulmonary function over a time period to coincide with the times of expected high oxidants. This is similar to efforts carried out under the HAOS study and other efforts carried out by the Environmental Protection Agency. The panelists would be monitored for health effect indicators such as symptomatology and measurement of pulmonary responses using conventional pulmonary function parameters and perhaps including measurement of small airways resistance. Sensitive populations that could be studied include persons suffering from asthma, bronchitis, emphysema and cardiovascular diseases. Epidemiologic studies have been conducted to evaluate the acute effects of short term exposures to oxidants for persons with asthma, bronchitis and emphysema. Asthmatic children represent an important group of people that are more responsive to respiratory irritants and they have fewer confounding variables than adults. Symptom reporting plus medical, demographic, socioeconomic and personal information will be collected for the children. Pulmonary function measurements may not be useful because asthmatic children have rather variable responses because of their disease and it might be impossible to quantify any small difference, if any, due to daily fluctuations in air pollutants. Adult panels probably should be restricted to

persons with bronchitis and/or emphysema. Asthma in adults is a quite different disease from bronchitis and emphysema. Cigarette smoking is a very concentrated type of air pollution which exerts significant effects, both chronic and acute. An attempt to detect differences due to daily changes in air pollution with wide daily variabilities in exposure to cigarette smoke is difficult and perhaps impossible. It may be, however, that air pollutants are additional factors which aggravate the effects of substances such as cigarette smoke, asbestos, etc. Where possible, nonsmokers should be studied separately from smokers and exsmokers. However, persons with bronchitis and emphysema are likely to be predominantly current and exsmokers, thus exsmokers and nonsmokers could be studied together.

Hyperreactivity measurements may be useful in future studies of respiratory reactions to pollutants. Hyperreactive participants could be isolated during the data analysis and analyzed separately. Hyperreactivity can be measured directly by provocative inhalation of histamine, mecholyl, or carbachol (Golden et al.[23]). These latter measurement techniques are sensitive in detecting alterations in pulmonary changes.

2. Aerosols (Suspended Particulates)

The air pollution situation in the Texas Gulf Coast area is characterized by relatively high levels of total suspended particulates and haze is commonly observed which may be associated with respirable aerosols. Studies should be performed to examine possible health effects related to these aerosols, both chronic and acute effects for populations in and around the ship channel area versus a control population in perhaps the western or northwestern part of Houston.

Populations should be monitored for pulmonary function and symptomatology for prevalence of upper and lower respiratory diseases and chronic respiratory diseases. An area near the Houston ship channel could be selected for relatively high exposures to aerosols (as indicated by high suspended particulate measurements) and another area (west or northwest of the city) with relatively lower levels of aerosols. The area near the ship channel would also have relatively high ozone levels although not the highest in the TGCA. Few measurements are available regarding the respirable portion of particulates for these proposed study areas. As was discussed under the oxidants section, panel studies of persons with asthma, bronchitis and emphysema (children and adults) could be examined for symptomatology (acute effects-short term exposures) and susceptibility to infections (upper and lower respiratory diseases). The latter type study is directed at longer exposures, that is, several months or years. Upper and lower respiratory diseases occur primarily in the winter months while air stagnation episodes usually do not occur in the winter in Houston. The incidence of upper and lower respiratory diseases in children is much higher than in adults.

Other health effect indicators would be mortality and morbidity of cancer of the lung, bladder and liver plus chronic lung diseases such as emphysema and bronchitis. This type of study will have to include rather detailed collection of information regarding the personal habits of the

population to include key elements such as smoking, occupational exposures and previous residences.

Tobacco smoking, especially cigarettes, has been clearly shown to be involved in the etiology of lung cancer, bronchitis and emphysema. Certain occupational exposures have also been implicated in these diseases. Obviously to quantify a possible relationship of these diseases with air pollution in the TGCA will require a very careful accounting for tobacco smoking and occupational exposures. As discussed earlier, Harris County and some of the surrounding counties have a rather higher incidence of lung cancer. The question is the high incidence related to exposures to unknown chemicals from the petrochemical industries in the area. Since lung cancer has a long latency period (20-30 years), the exposures of the population at risk have occurred for time periods for which little or no monitoring information is available, thus rough estimates must be determined.

These studies could be supplemented by measurement of body burdens via examination of human autopsy tissue from different geographic areas, that is, a control area and a high exposure area. Information about occupation, smoking, brief medical history and previous residences will need to be collected from the accidental death cases. The body burden measurements would be made for certain organics and trace metals as an index of exposure. There is also a possibility that animals could be utilized for body burden efforts because of the much shorter life spans of the animals.

Sulfur dioxide is currently not an air pollution problem in the Houston area, but it could become a major air pollutant if dirtier fuels are utilized in industry, particularly coal. It is recommended that, if possible, a background health effects study be conducted relative to sulfur dioxide if it can be associated with a study of particulates. This information could be utilized for comparison with future studies. One area of the Texas Gulf Coast area which has a significantly higher level of SO_2 is in the vicinity of the Houston ship channel.

A battery of rapid biological test procedures to include the Ames test could be used as a type of sentinel system. This would provide for an indication of mutagenetic activity of air pollutants. The system should be operational for several years.

In the proposed studies, it may be necessary to consider the sources of drinking water in the exposed populations. The city of Houston and neighboring communities receive their drinking water generally from two sources, one from underground water which is relatively low in organics and the second from surface water from Lake Houston which tends to have higher levels of organics (trihalomethanes and pesticides). There are research efforts currently underway to monitor toxic organics in water from these two sources and this data should be considered in the design of population studies.

An interesting approach for studying the possible relationship of ambient air pollutants to cancer is through the use of biological test systems. The long latency period in the development of cancer makes it rather difficult

to define a relationship of exposure to air pollutants and development of cancer. Thus monitoring of human populations for cancer is observing effects from a cause perhaps some 20 years previous. A more rapid monitoring system would be advantageous. Such a system has been proposed by a number of investigators and has recently been described in a publication by Commoner[24]. Techniques are described using a battery of cell culture procedures to test particulate matter and urine samples from experimental animals and humans exposed to toxic organic compounds. Dr. T.S. Matney of the University of Texas Graduate School of Biomedical Sciences and a member of the health indicator advisory group of this study has proposed the utilization of a series of biological test procedures including the Ames test. Consideration should be given to use of a battery of tests employing bacteria, plants, animals and human tissue. These studies would involve exposure of specific biological systems to particulates and other pollutants and determination of the specific mutageneticity, carcinogenicity and teratogenicity of the subject pollutants. Dr. Matney has utilized these screening procedures to examine particulate matter present in Houston's ambient air and he found that on certain days, particularly when there was an inversion with a high aerosol level, particulate matter tended to be positive in the screens, but on other days the particulates were negative. Studies could be performed in which particulate matter from several areas was examined using a battery of mutagenic tests on perhaps a daily or weekly basis to determine the presence or absence of potentially carcinogenic materials in the Houston area. Studies could also be performed in which populations were examined for presence of mutagenic materials in their urine samples. These test systems would determine those populations at risk, that is, those with a relatively high exposure to the toxic organics. The test systems might also be utilized to detect those persons most sensitive to these toxic materials. These approaches could add very important pieces of data relative to whether the high particulates and organics present with these particulates may be associated withthe contribution to lung cancer in the area.

In vitro systems have been shown to be positive for substances with known carcinogenic activity in animal studies and to a much lesser extent in people. These tests have also shown negatives which agreed with available data. The tests are often utilized to screen potentially toxic substances for carcinogenic activity. A common scenario is that if the substance is positive in the in vitro tests, then toxicity studies in several animal species would be performed; if negative, the substance would be presumed to be non-carcinogenic and vice versa. The in vitro tests are reported to provide a high degree of accuracy for not reporting "false negatives". An important point for in vitro tests for health effects is to utilize the results of a battery of such tests in combination with epidemiology results to draw conclusions.

Another possibility for the high incidence of lung cancer in the Texas Gulf Coast area is that these elevations may have been associated with exposure to asbestos in the Houston- Galveston area from shipbuilding carried on in the 1940's. To examine this possibility, a case control study could be performed aimed at identifying occupational exposures, specifically employment in shipyard or related activities, smoking history, current and past

residences, and other personal and demographic information. Other types of occupational exposures which may have contributed to these types of cancers include exposures to grain and cotton dust and exposures to pesticides in these operations. A retrospective study would also collect incidence information for other types of diseases in addition to cancer, especially lung diseases. Selection of proper control groups for this study will be extremely important. This can be accomplished several ways such as through random digit dialing or house-to-house surveys.

The panel considers that a systematic review should be accomplished to determine the specific characteristics of existing mortality data systems in the area and to evaluate whether or not a coordinated system would be useful for definition of health problems potentially related to air pollution exposures. A system currently exists for mortality but it lacks many specific characteristics that could make it significantly more useful for application to air pollution studies. An improved system would include information regarding multiple causes of death, migration history, occupation and smoking histories, location of work and work history. Such a system would be useful to describe present conditions in the area especially for future situations when there will be significant changes in the demographic characteristics of the population and in the air pollutants in the area.

3. General

A well-defined opinion survey performed in the TGCA would provide considerable benefits for the Environmental Protection Agency with minimum funds. It could provide information relative to the general population's opinions on their assessment of air pollution in the area, what they think should be done, if anything, about the situation and what they would be willing to do to improve the situation. The survey would collect information regarding opinions for different socioeconomic groups, ethnic groups, different occupations, urban versus rural comparisons and comparisons between the Texas Gulf Coast area and other geographic areas of the United States. Athletes, who represent healthy population, would be surveyed to determine their opinions regarding the effects of air pollution on performance and symptoms such as coughing or headaches after athletic performance. Also, opinions regarding the perception of illnesses within the various groups cited above would be tabulated. Because of the potential usefulness of this information in the design of other portions of a more comprehensive health effects research plan, the opinion survey should be performed as near the beginning of the overall program as possible.

Consideration should be given for the utilization of time series statistical approaches in the examination of data relative to effects of air pollutants on populations. This approach can be used to account for autocorrelation among variables and has been recognized by other investigations as one that potentially can be very useful in the evaluation of effects of air pollutants on people. Autocorrelation is a problem with air variables during episodes of air pollution and for daily health measures which relate strongly from one day to the next.

Chamber studies are important. However, there are enough current chambers in use and it would be wasteful to build another in this area. Population studies should receive high priority because they will help define issues and answer those questions described earlier. One difficulty for any population study for the TGCA is the rapidly changing demographic characteristics of the population. The area is rapidly growing due largely to an influx of new people. This must be considered in the design of population studies.

Air monitoring for several of the health studies should include measurement of the aeroallergens to include ragweed, grass pollen and molds. Air monitoring should also include the measurement of asbestos and fiberglass materials which are related to certain types of cancer.

C. Hypotheses to be Investigated

To be most effective, a health effects research program with limited funding must focus its resources. One very useful technique is to identify hypotheses (unproven statements) which could be tested by experimentation or analysis. Resources should be focused on the testing of those hypotheses which will most contribute to a better understanding of the problem.

Important hypotheses resulting from the assessment of research needs are presented in Table 3. Specific study designs addressing one or more of these hypotheses have been developed, and are presented after the listing of hypotheses.

Hypotheses regarding design of an associated air pollution monitoring program for the TGCA are presented in Volume I of this series of reports.

TABLE 3. HYPOTHESES ON HEALTH EFFECTS

1. Exposures to air pollution levels experienced in some areas of the TGCA causes increased respiratory symptoms and performance decrements in some maximally stressed or exercising healthy persons.

2. The levels of oxidants and suspended particulates experienced in areas of the TGCA can produce an increased frequency of respiratory illnesses and asthma attacks in children with active asthma.

3. The levels of oxidants and suspended particulates experienced in some areas of the TGCA can produce increased frequency of respiratory symptoms in adults with chronic obstructive respiratory disease.

4. Specific components of suspended particulates from selected areas of the Texas Gulf Coast are genetically active and will produce mutations in mutagenic assay systems.

5. Available bacterial and mammalian mutagenicity test systems can be used effectively in air pollution studies, specifically for characterization of genetic activity of particulates, vapor phase organics and photochemical oxidants.

6. Human and animal cytogenetic techniques can be used effectively in population monitoring for air pollution studies in groups selected from areas within the TGCA experiencing sharp contrasts with respect to ozone, particulate and hydrocarbon exposures.

7. Residential or occupational exposures are associated with the excesses of lung cancer noted in several counties (Galveston, Harris, Jefferson, and Orange) in the Texas Gulf Coast area.

8. Past levels of suspended particulates and specific characteristics of suspended particulates (size, amount of hydrocarbon, composition and genetic activity estimated from present exposures) are associated with cancer patterns described for selected Texas Gulf Coast counties.

9. Body burdens of hydrocarbons in animals and humans resident in areas of high and low pollution relate to hydrocarbon levels found in local air or water sources and relate to incidence of cancer in areas of the TGCA.

10. Chromosomal aberration responses to environmental exposures, specifically exposure to ozone and hydrocarbons, can be measured and specifically related to differences in air pollution experienced in areas of the TGCA with respectively higher and lower exposures.

11. Recent mortality and morbidity patterns in the Texas Gulf Coast area, particularly cancer, fetal and infant mortality and chronic obstructive lung disease, can be related to air pollution levels.

TABLE 3. HYPOTHESES ON HEALTH EFFECTS (Continued)

12. Specific maternal or paternal environmental exposures can be identified for women experiencing early fetal loss (spontaneous abortions prior to 12 weeks).

13. Number and type of chromosomal anomalies present in abortus material from spontaneous abortions prior to 12 weeks can be related to environmental exposures.

D. Proposed Health Effects Studies

The hypotheses described in the previous section can be investigated by collecting appropriate data, and analyzing and interpreting those data with respect to the hypothesis in question. Data collection can involve existing data or data resulting from specific information collected in the field such as clinical testing, biological sampling, questionnaire information, or other observations. Data analysis can be accomplished by statistical analysis, correlation analysis, case studies, mathematical modeling, or other methods.

Brief descriptions have been developed for twelve studies which are thought to be of the types which will be most productive for addressing air pollution related health effects questions in the TGCA. These designs are broad and will require the definition of more detailed experimental plans and protocol before execution. Concepts could be added to each of these designs to enhance the usefulness of the results; on the contrary, many of these study briefs could be subdivided into smaller studies. Priorities have been assigned based on the necessity of addressing the specific health issues and the probability of contribution to a better understanding of air related health effects. A rationale is also presented to document some of the reasons used to justify each priority listed. The study designs, as presented, represent the opinions of this study team regarding the set of studies which would most likely yield definitive and useful answers to TGCA air related health effects questions.

STUDY BRIEF 1.

Performance of Maximally Exercising Healthy Persons in Relation to Texas Gulf Coast Air Pollution Exposure

AMBIENT EXPOSURES

Ozone; hydrocarbons; total suspended particulates; oxides of nitrogen

OBJECTIVE

To determine if exposure to air pollutants in the Texas Gulf Coast Area is associated with increased symptoms and performance decrements in maximally exercising healthy persons.

BACKGROUND

Earlier studies in the Los Angeles basin have shown increased symptoms (eye irritation, cough, chest discomfort) reported by healthy student nurses and decreased performance by high school cross-country track runners to be related to increased levels of photochemical oxidants. These studies have not been replicated despite the need for more studies of the effects of various levels of ozone on healthy stressed adults. There is concern that the photochemical oxidant mix in the Texas Gulf Coast area may be different from that of Los Angeles. Ozone does not cause eye discomfort although it does cause cough and chest discomfort. Maximally exercising healthy persons engaging in aerobic work (running) take in considerably larger doses of ambient air than sedentary persons.

DESIGN

Approximately twenty high school cross-country teams and track teams participating in meets in the Texas Gulf Coast area will be studied for a three-year period. The high school cross-country season is in the fall and the track season is in the spring (April-May). Monthly ozone levels in the TGCA are comparable for the fall (cross-country season) and the spring (track season). The cross-country season usually comprises ten meets. For each runner at each meet, pulse rate and pulmonary function will be determined pre- and post-race and symptom reporting will be determined post-race; race times will be measured for each runner at each meet. Methodologic aspects of this study will be refined during pre-season meet pilot studies. Ambient air pollutants will be measured at meet sites intermittently the day before and the day of each race and continuously at various stations in the area. Race performance times, pre- and post-race pulse and pulmonary function determinations and post-race symptom reporting will be related to ambient pollutant levels and distance of event (220, 440, 880, 1 miles or 3 miles) since distance will enhance dose or exposure.

STUDY BRIEF 1. (Continued)

PRIORITY

High: Ozone is one of the major concerns in the TGCA. Results from a study of healthy stressed or maximally exercising adults may be more generalizable to the area population.

DURATION AND ESTIMATED COST

3 years; $ 750,000.

STUDY BRIEF 2.

Mutagenicity Assay of Air Pollutants in the Texas Gulf Coast Area

AMBIENT EXPOSURES

Total suspended particulates, respirable particulates, ozone, hydrocarbons and vapor phase organics

OBJECTIVES

1. To determine the genetic activity of particulates from selected areas of the Texas Gulf Coast.
2. To characterize the chemical composition of particulates.
3. To evaluate the available bacterial and mammalian mutagenicity test systems for utility in air pollution studies, specifically for characterization of genetic activity of particulates, vapor phase organics and photochemical oxidants.
4. To evaluate human and animal cytogenetic techniques for utility in population monitoring for air pollution studies in groups selected from areas within the TGCA experiencing sharp contrasts with respect to ozone, particulate and hydrocarbon exposures.

BACKGROUND

With the increased concern for chronic health effects of air pollution, especially the possibility of cancer and reproductive wastage, it is important to determine the presence of genetically active compounds in the air mixture and to identify the specific constituents of the air which produce these effects.

DESIGN

Particulate sampling would be done at anticipated peak times in several contrasting areas under varying climatic conditions. These samples would be analyzed for mutagenicity in a bacterial test system using a repair capable strain and selected mammalian cell test systems. Particle size would be accounted for in the sampling methods to obtain a separate sample for respirable particulates. Particulate samples would be analyzed for chemical composition. Air samples from both high and low oxidant (ozone) areas would be analyzed for genetic activity in both bacterial and mammalian cell test systems. Efforts would be directed at identifying both the test system(s) most sensitive to air samples containing mixtures of fairly low levels of ozone and hydrocarbons (particulates) that occur in the ambient air and the system(s) which gives the most specific response to a given pollutant. Important developmental work in this area is being conducted by the Smithville Environmental Carcinogenesis Center of the University of Texas System Cancer Center.

STUDY BRIEF 2. (Continued)

PRIORITY

High: Technology to conduct these studies currently exists and is being used in air pollution studies. Cancer mortality rates, especially lung cancer, apparently are very high in several counties of the TGCA. Difficulty in identifying exposures of 20-30 years earlier that may be related to cancer patterns today makes short term assays like this very important adjunct to environmental cancer studies.

DURATION AND ESTIMATED COST

18 months; $150,000 - $200,000

STUDY BRIEF 3

Evaluation of the Association of Lung Cancer and Air Pollution in the Texas Gulf Coast Area

AMBIENT EXPOSURES

Suspended particulates (1940 to present)

OBJECTIVES

1. To evaluate the association of past levels of suspended particulates and specific characteristics of suspended particulates (size, amount of hydrocarbon, composition and genetic activity estimated from present exposures) to the cancer patterns described for selected Texas Gulf Coast counties.
2. To identify specific residential or occupational exposures associated with the excesses of lung cancer noted in several counties (Galveston, Harris, Jefferson and Orange) in the Texas Gulf Coast area.
3. To determine if any differences exist in the histopathologic distribution for lung cancer cases observed in these counties which may be related to specific environmental exposures.
4. To determine if smoking patterns differ for residents of Texas Gulf Coast Area counties from other Texas or U.S. counties.

BACKGROUND

Although several cancer sites may be identified from morbidity and mortality analyses to be in excess or increasing in the Texas Gulf Coast area, the excess for lung cancer is already fairly well documented for several counties. The continued high frequency for this site would facilitate the conduct of incident (newly diagnosed) observational cohort or case-comparison studies in these selected counties. Because the highest rates of lung cancer mortality have been observed for Galveston, Orange and Jefferson counties, initial field studies should be pursued in these areas. The annual number of newly diagnosed cases for Galveston County is approximately 150 and 300 cases a year for Orange and Jefferson Counties.

DESIGN

The focus of the cancer investigations should be on lung cancer in the apparent high risk counties, specifically counties with a single industry and a fairly non-mobile population. Newly diagnosed cases of lung cancer over two to three year interval would be reported by participating physicians in the counties and the cases interviewed for exposure histories (specifically occupational, residential and smoking). Both a population and a hospital control (two for each case) would be selected and interviewed in the same manner as the cases. Pathology reports and specimens would be obtained and reviewed using a standardized protocol for the histopathologic classification. Environmental analyses would be conducted for regions within the county to include characterization

of particulate exposures and estimation of past exposures (from 1940 to present) using emissions inventories and production data for industries located within the counties. Background information regarding smoking patterns would be obtained from existing sources or studies conducted in other parts of the state or U.S. if available for comparable time period or obtained directly. Data regarding the histopathologic classification of lung cancer cases are available for case series by various means of ascertainment (autopsy, surgical, diagnostic and screening).

PRIORITY

High: Three of the most highly industrialized counties in the TGCA (Orange, Jefferson and Galveston) have excessive lung cancer mortality rates. Industry in these areas is largely chemical and petrochemical and the populations are fairly stable by contrast with Houston. The ability to examine and classify tissue by histopathology will allow comparison with non-industrialized areas and may provide a specific pathologic marker for environmental effects. Mutagenicity assays of current air samples will identify biologic activity of present pollutants. Information regarding mutagenicity will also be utilized when extrapolating backwards from present levels of pollution to estimate levels and characteristics of exposures 20-30 years earlier.

DURATION AND ESTIMATED COST

3 years; $600,000.

STUDY BRIEF 4

Evaluation of Existing Health Data Collection Systems in the TGCA

AMBIENT EXPOSURES

General

OBJECTIVE

To evaluate existing health data collection systems and identify specific information needed for air pollution studies that might be incorporated into these systems to facilitate more efficient and timely population monitoring.

BACKGROUND

Several existing data collection systems are available at the state and local level that could be utilized to evaluate mortality and morbidity patterns in a specific and coordinated fashion. Some efforts in this area are already underway for cancer incidence with the Texas State Cancer Information System (Texas State Department of Health Resources), the Texas Health Atlas (University of Texas School of Public Health) and the Environmental Epidemiology data system of the Lawrence Berkeley Laboratory (University of California). In addition the availability of the National Health Examination Survey tapes for morbidity information at the University of Texas School of Public Health presents an additional data source that should be evaluated for inclusions in some coordinated system.

DESIGN

The available data collection and information systems in the TGCA will be reviewed for inclusion of specific content related to air pollution health effects. Potential sources of available data will be identified as well as a mechanism(s) to coordinate methods of data collection and analysis.

PRIORITY

High: There is need for background data (incidence, prevalence, disability) to assess impact of conditions associated with air pollution and to design and conduct more specific studies. Review of descriptive data will generate additional hypotheses to be tested.

DURATION AND ESTIMATED COST

1 year; $150,000.

STUDY BRIEF 5.

Respiratory Illnesses and Asthma Attacks in Children with a History of Asthma Related to Ozone and Total Suspended Particulate Exposure

AMBIENT EXPOSURES

Suspended particulates, ozone, and other pollutants

OBJECTIVE

To determine if children with active asthma exposed to oxidant/total suspended particulate air pollution report an increased frequency of acute respiratory illnesses and asthma attacks than similar children not so exposed.

BACKGROUND

Asthma in children is different than adult asthma and quite heterogeneous. Asthma prevalence in the general population ranges from 2 to 5 percent. Relatively few studies of air pollution and asthmatic children have been done, yet children (and adults) so afflicted are affected markedly by air pollution with both an increased frequency of asthma attacks and an increased frequency of acute respiratory diseases.

DESIGN

Children with a history of active asthma from an area with higher/lower oxidant total suspended particulate exposure will be recruited. Initial health questionnaire and quarterly pulmonary function tests will be accomplished. Participants will be followed for one/two year(s) with weekly or biweekly questionnaires on the frequency of acute upper and lower respiratory disease attacks. The frequency of asthma attacks, the use of asthma medications, the frequency of physician attended illness, the frequency of Emergency Department visits and the frequency of hospitalizations for asthma will be monitored. This study permits distinction between medically attended and medically unattended respiratory illnesses and asthma attacks and should be considered a pilot project representing a major contribution to the study of air pollution and chronic respiratory disease in children.

PRIORITY

High to Intermediate: The association of air pollutants with the increased risk of acute respiratory disease, especially among children, is an important issue and an issue which will become even more important with a possible increase in SO_2 emissions.

DURATION AND ESTIMATED COST

2 years; $350,000.

STUDY BRIEF 6.

Body Burden Studies in Human and Animal Populations of the Texas Gulf Coast Area

AMBIENT EXPOSURES

Air pollutants shown to be genetically active through mutagenetic assay

OBJECTIVES

To determine the body burden of hydrocarbons in animals and humans resident in areas of high and low pollution using autopsy data

BACKGROUND

Measurement of pollutants in body burdens (blood, urine, hair, feces, soft tissue, bone) has been utilized to estimate exposures and accumulation. This approach has been very useful in describing relatively longer term exposures to various air pollutants. Exposures of hydrocarbons to marine organisms via body burden measurements has been performed for several years but the approach has not been applied to animal or people studies. Analytical techniques are available for these measurements, especially the high boiling aromatic compounds.

DESIGN

Human body burden studies would be designed to complement the mutagenicity assay of air samples in areas with the greatest contrast for the compounds identified to be genetically active. The extent of absorption and degree of exposure to hydrocarbons experienced by longterm residents in these areas would be assessed by analyzing the amount stored in body fat using available autopsy material. An animal model using domestic animals (pets) may be more efficient for these analyses since domestic animals have a shorter life span and more restricted range.

PRIORITY

Intermediate: This study is sequential to mutagenetic assay. Useful in assessing lifetime exposure to hydrocarbons among longterm residents since exposure to some of these compounds is associated with increased cancer rates.

DURATION AND ESTIMATED COST

18 months; $150,000 - $200,000.

STUDY BRIEF 7.

Analysis of Mortality and Morbidity Patterns in the Texas Gulf Coast Area

AMBIENT EXPOSURES

General

OBJECTIVES

1. To determine background rates (mortality, incidence, prevalence), time trends and environmental and demographic correlates of cancer, chronic obstructive lung disease and reproductive wastage in the TGCA.
2. To analyze recent mortality and morbidity patterns in the Texas Gulf Coast area with particular reference to cancer, fetal and infant mortality and chronic obstructive lung disease.

BACKGROUND

Excesses of cancer, specifically lung cancer, have been noted for several counties in the Texas Gulf Coast area. The persistence of these trends in the counties noted (Galveston, Harris, Orange and Jefferson) and the possible environmental and demographic factors associated with these rates have not been adequately documented.

DESIGN

This study would include detailed analytic studies of cancer and reproductive wastage in the Texas Gulf Coast area. Chronic obstructive lung disease would be included in these analyses to evaluate both acute and chronic effects. Information regarding background rates, time trends and environmental and demographic associations would be obtained. Such information is essential for the development of specific case-control prevalence, panel or prospective studies to test hypotheses generated from the descriptive studies. All counties in the designated Texas Gulf Coast area would be included in the morbidity and mortality analyses (cancer, reproductive wastage, chronic obstructive lung disease). Specific urban industrialized and non-industrialized areas within the Texas Gulf Coast area would be selected for studies of acute morbidity of chronic obstructive lung disease and related diagnoses, utilizing hospital discharge diagnostic summaries,outpatient visits or insurance data for several days for each month throughout a 12 month period. Mortality, demographic and air quality data available for all U.S. Counties from the Lawrence Berkeley Laboratory would be analyzed by county and when possible by census tract for the TGCA. The availability of data from the Houston Influenza Watch program at Baylor would facilitate an evaluation of the variation in viral disease patterns with variations in air pollution. School absenteeism and the use of a "sentinel class" for illness reporting will be considered in conjunction with the analysis of data provided by the Influenza Watch program. Data tapes from the National Center for Health Statistics (Health Examination Survey) will be analyzed for Texas and the TGCA to identify prevalence of selected acute and chronic conditions by geographic area or population group.

STUDY BRIEF 7. (Continued)

PRIORITY

Intermediate: This study is sequential to evaluation of existing data collection systems. It would be useful to determine specific background rates which may relate specifically to air pollution.

DURATION AND ESTIMATED COST

2 years; $400,000.

STUDY BRIEF 8.

Symptom Reporting and Pulmonary Function in Adults with Emphysema/Chronic Bronchitis Exposed to Texas Gulf Coast Air Pollution

AMBIENT EXPOSURES

Ozone, particulates, and other pollutants

OBJECTIVES

To determine if adults with chronic bronchitis or emphysema exposed to oxidants and suspended particulate air pollution report an increased frequency of symptoms on days with higher pollution.

BACKGROUND

Studies of air pollution episodes in Donora, Pa. and London, England have shown that persons with chronic lung disease (asthma, emphysema, bronchitis) were much more affected by high pollutant levels when compared to healthy adults. Exposure response relationships for lower levels of ambient pollutants are not yet completely delineated. Furthermore, current pollutant exposures probably differ from the historical air pollution episodes. It is important to know what effects current pollutant levels have upon persons with chronic bronchitis and emphysema because they represent about 7% of the adult population. Response to air pollutants has been shown to be different among asthmatics compared to persons with extremely impaired respiratory function, i.e. chronic bronchitis and emphysema.

DESIGN

A group of 200-250 adults (age approximately 40-60 years) with a history of chronic obstructive lung disease, excluding asthmatics, will be monitored for an eight month period for symptoms and pulmonary function testing. Panelists will be recruited from an area in the TCCA with relatively high levels of ozone (Northeast). Diagnosis of illness should be confirmed by clinical examination. Current smokers should be excluded from the panel. Symptoms should be recorded daily and collected bi-weekly. Pulmonary function tests will be performed twice weekly with a two week interval of daily tests. Health indicators will be examined relative to daily levels of several air pollutants (as a minimum ozone, total oxidants, PAN, NO_2, TSP, RSP, SO_2, and aeroallergens).

PRIORITY

Intermediate - Low: Results may not be unambiguous. Numerous studies of respiratory symptoms and pulmonary function of healthy and chronically ill persons have been done and the results have been inconsistent. In many instances the reporting of symptoms is not related to decrements in pulmonary functioning or to levels of air pollutants, but may be due to other differences between

STUDY BRIEF 8. (Continued)

persons from the high and low pollution areas being compared.

DURATION AND ESTIMATED COST

1 year; $350,000.

STUDY BRIEF 9.

Public Opinion and Environmental Pollution in the Texas Gulf Coast Area

AMBIENT EXPOSURES

Criteria and noncriteria pollutants

OBJECTIVES

To systematically study public opinion regarding possible immediate and longer-term effects of environmental pollution on their health and well being.

BACKGROUND

Public opinion is a major determinant of public policy yet its systematic study with regard to environmental pollution is usually ignored; infrequent, earlier studies have shown that people readily perceive and complain about nuisance and annoyance aspects of ambient pollution, e.g., alterations in visibility, odors, soiling and acute irritation symptoms; much less is known about their concern and awareness of the possible long-term effects of pollution exposure; little is known about the general population's opinion and knowledge regarding the major sources and effects of environmental pollution in a given area; current concerns about limited energy, alternative energy sources, and population growth would be well served by systematic, thoughtful, representative surveys of public opinion areas with varying growth and pollution.

DESIGN

Approximately 5,000 families would be surveyed once in a house-to-house survey using an appropriately designed questionnaire administered by specially trained interviewers during a six-month period; sampling parameters will include pertinent, representative socioeconomic, demographic, occupational and geographic characteristics; questionnaire information would include environmental opinions regarding sources, health effects and economic costs, age, sex, race/ethnic group, education, occupation, socioeconomic status, number of persons in household, cigarette smoking habit, prevalence of chronic illness, duration of residence in area and previous area of residence; the survey results will provide useful scientific information as well as one reasonable basis for determining public policy.

PRIORITY

Intermediate - Low: How pollution problem and nuisance aspects of pollution are perceived by residents of TGCA is important to know, but not as important as determination of specific health effects.

DURATION AND ESTIMATED COST

6 months; $50,000.

STUDY BRIEF 10.

Cytogenetic Studies in Human Populations of the Texas Gulf Coast Area

AMBIENT EXPOSURES

Air pollutants shown to be genetically active through mutagenetic assay

OBJECTIVES

To determine the specificity of type, number and timing of chromosomal aberration responses to environmental exposures, specifically exposure to ozone and hydrocarbons.

BACKGROUND

Human cytogenetic monitoring has been utilized in radiation studies and in populations highly exposed to cytotoxic agents (patients on chemotherapy or persons occupationally exposed to chemical mutagens). Results have not been consistent and appear to be highly dependent on technique (both handling of specimens and scoring procedures) as well as the high proportion of nonspecific responses reflected as simple or transient chromosomal breaks. If complex anomalies, specifically decentrics,which appear to be the most objective response, are utilized and standardized protocols are followed, this technique may be extremely useful in population monitoring and should be evaluated.

DESIGN

Human cytogenetic studies should be designed to complement the mutagenicity assay of air samples in areas with the sharpest contrast for the compounds identified to be genetically active. A cross-section of long-term residents (all ages) in areas of high and low pollution would be examined to identify the number and type of chromosomal aberrations in circulating lymphocytes by age. The resulting age distributions of complex chromosomal breaks or anomalies could be compared for the two or more areas.

PRIORITY

LOW: This study is sequential to mutagenicity assay. Technologic and methodologic problems still to be overcome before this technique can be successfully utilized in field studies of low level exposures.

DURATION AND ESTIMATED COST

18 months; $200,000.

STUDY BRIEF 11.

Study of Reproductive Wastage Due to Air Pollution in the Texas Gulf Coast Area

AMBIENT EXPOSURES

Photochemical oxidants, hydrocarbons

OBJECTIVES

1. To determine if specific chromosomal anomalies are associated with environmental exposures.
2. To identify numbers and types of chromosomal anomalies present in abortus material from spontaneous abortions of less than 12 weeks gestation.
3. To determine if early fetal loss (spontaneous abortion prior to 12 weeks) is associated with specific maternal or paternal environmental exposures.
4. To determine if the distribution of chromosomal anomalies identified in the TGCA case series differs from that observed in other areas of the United States where studies of this type are underway.

BACKGROUND

The association of chromosomal anomalies with spontaneous abortion and the association of specific anomalies with environmental exposures provide a potential population monitoring mechanism for a more specific evaluation of causal mechanisms in reproductive wastage.

DESIGN

A series of approximately 3,000 women in the Houston area planning to become pregnant would be recruited through the obstetrical gynecologic services of participating hospitals or private practices. Women enrolled in the study would be interviewed to determine residence, smoking, employment, husband's employment and other aspects of environmental exposure; and would be instructed how to detect and report early signs of pregnancy. They would be tested for pregnancy as soon as possible. Resulting pregnancies would be monitored. Specimens would be obtained by or from women experiencing spontaneous abortions. Cytogenetic analyses would be performed on the specimens obtained. It is estimated that 1500 pregnancies would result from a sample of 3000 women over a two-year period. If all the fetal losses of less than 12 weeks gestation that can be detected are ascertained, approximately 450 fetal losses would be identified and available for study. The rate of chromosomal anomaly for spontaneous abortions has been observed to be extremely high (50-60%) and even higher in spontaneous abortions of short gestation. A study of this type would require at least 3 years to conduct and would entail extensive laboratory costs as well as costs associated with field activities (recruitment, interviewing and followup of study sample).

STUDY BRIEF 11 (Continued)

PRIORITY

Low: This study is sequential to mortality and morbidity analyses. The study approach would be much more specific in terms of evaluating exposure effects on the developing fetus than the statistical treatment of historical data. However, this type of study requires fairly sophisticated cytogenetics support and, as a study approach, is just now being evaluated in New York City (Columbia University).

DURATION AND ESTIMATED COST

3 years; $600,000.

STUDY BRIEF 12.

Hazard Assessment of Increased Emissions in the TGCA due to Projected Uses of Alternate Fuels, Particularly Coal

AMBIENT EXPOSURES

Sulfur Dioxide, Particulates, Oxides of Nitorgen

BACKGROUND

Relatively clean fuels such as natural gas and low-sulfur petroleum are the predominant energy source at present in the TGCA. Accordingly, sulfur dioxide levels are relatively low in all areas of the TGCA; exceptions to this are several areas associated with specific point sources. There is concern regarding possible increases in emission of certain pollutants such as sulfur dioxide, particulates, oxides of nitrogen, and possibly others due to the possibility of conversion to coal, especially high-sulfur coal. If broad scale conversion to coal occurs in the TGCA, there could be sharply increased emissions of these pollutants in the ship channel industrial areas and also from the electrical power plants located throughout the area. These increases could sharply impact the ambient levels.

DESIGN

This is a paper study to analyze the possible impact of increased use of alternative energy sources. It would involve projections of the energy requirements and the specific energy sources for these requirements over the next ten years. An assessment of existing and projected control technologies would accompany the projections of energy consumption. Analyses would be made regarding the expected levels of pollutants such as sulfur dioxide, particulates, and oxides of nitrogen, the populations exposed to these levels, and the populations most-at-risk to determine the degree of severity of this problem.

PRIORITY

Low: Plans to convert to alternative sources are presently uncertain in the TGCA. Large scale use of alternative energy sources does not present a significant air pollution problem at present. Any such problems may not occur at all or may be avoided for many years into the future.

DURATION AND ESTIMATED COST

1 year; $150,000 - $200,000.

E. Summary of the Plan

The study briefs presented in the previous section collectively form the basis of an integrated research plan for health effects. Taken as presented the preliminary cost estimates total to a sum greater than the three million dollars budgeted for air pollution and health effects during the current three year TGCA program. Though all of the studies presented are considered important, the assignment of priorities has been made to better focus on those studies considered most important and most probable to produce tangible results. A summary of these priorities and estimated costs is presented in Table 4.

Air quality measurements would be required to support the health effects studies outlined here. A summary of the general types of air quality measurements needed for this support is presented in Table 5. The frequency of measurements is divided into three categories: hourly, 24 hour and intermittent. The hourly and 24-hour samples should be available on a daily basis. The intermittent samples (or analyses) should be accomplished at intermittent intervals during a given period of study.

The research plan for air contaminants presented in Volume I[5] of this series presents objectives which differ from the specific needs for support of health effects studies, but there are considerable interactions in the proposed studies. The following proposed projects from Volume I have applicability to understanding possible health effects in the TGCA: 1.3, 1.6, 1.7, 1.8, 1.9, 1.10, 1.11, 1.13, 1.15, 1.16, 1.19, 1.24, 1.29, 2.3, 2.4, 2.5, 2.15, 2.17, 2.18, 2.23, 2.24, 2.27, 3.3.

Those efforts directed at the characterization and identification of sources and transport of aerosols are very important to the health effects needs. The plans proposed in Volume I also include an effort to identify compounds with known or suspected carcinogenic and mutagenic activity present in ambient air of the TGCA.

F. Resources for Performance and Support of Health Effects Studies in the TGCA

The types of health effects studies considered and recommended in this report require extensive capabilities for proper performance. This spectrum of capabilities includes population recruitment and sampling, biological, microbiological, chemical, and clinical laboratories, air monitoring, statistical and computational facilities, access to existing data sources, and others. A listing of some of the principal resources available for application to these types of health studies is presented in Table 6.

Table 4. Summary of Research Priorities

Study Brief	Short Title	Ambient Exposures	Priority*	Estimated Cost		
1	Maximally Exercising	O_3, HC, TSP, NOX	1	$750,000		
2	Mutagenicity Studies	TSP, RSP, O_3, HC	1	200,000		
3	Lung Cancer Study	Suspended Particulates	1	600,000		
4	Health Data System	General	1	150,000		
5	Respiratory Illness	TSP, RSP, O_3	1-2		350,000	
6	Body Burden Studies	Organics, HC	2		150,000	
7	Mortality and Morbidity	General	2		400,000	
8	Adult Symptom Reporting	O_3, TSP, RSP	2-3			350,000
9	Public Opinion	Criteria Pollutants	2-3			50,000
10	Cytogenetic Studies	Organics, HC	3			200,000
11	Reproductive Wastage	O_3, TOX, HC	3			600,000
12	Hazard Assessment	SO_2, TSP, NOX	3			200,000
Total - High Priority				$1,700,000		
Intermediate Priority					900,000	
Low Priority						1,400,000
Total for all Priorities						$4,000,000

*1 = High Priority
2 = Intermediate Priority
3 = Low Priority

TABLE 5. SUMMARY OF AIR QUALITY MEASUREMENTS REQUIRED FOR HEALTH EFFECTS STUDIES

Air Quality Parameter	Frequency of Measurements
Ozone	Hourly
TOX	Hourly
Oxides of Nitrogen	Hourly
SO_2	Hourly
PAN	Hourly
TSP	24-hr sample
RSP	24-hr sample
Aeroallergens	24-hr sample
Size Fractionation of Particulates	Intermittently
Chemical Analyses of Particulates*	Intermittently
Mutagenic Assay of Particulates**	Intermittently
Individual hydrocarbons with emphasis on aldehydes, benzene, and toluene	Intermittently

*Chemical analysis for the following compounds:

Sulfate	Lead
Nitrates	Cadmium
Fluorides	Arsenic
Asbestos	Mercury

High molecular weight polynuclear aromatics (such as benzo-α-pyrene)

**Mutagenic assay utilizing a battery of tests:

Ames test (both repair capable and repair deficient strains)

Chemical mutagenesis and carcinogenesis tests (plants, animals, human tissue)

Chemical teratogenesis tests (animals)

TABLE 6. AVAILABLE RESOURCES FOR SUPPORT OF TGCA HEALTH EFFECTS STUDIES

Organization	Type of Support
Baylor College of Medicine, Houston	Pulmonary physiology, spirometry laboratory, virus watch program
Beaumont Chamber of Commerce	Population, health, and economic data
Department of Health, City of Houston	Health statistics, air pollution monitoring, air pollution data from previous years
EPA Regional and District Offices	Air pollution data, previous support of air/health studies
Galveston Chamber of Commerce	Population, health, and economic data
Gulf Universities Research Consortium, Galveston	Population estimates, economic, demographic, and environmental data
Houston Allergy Clinic	Resident allergists, allergy patients
Houston Chamber of Commerce	Population and economic data, previous support of air/health studies
Houston-Galveston Area Council	Transportation and air quality control strategies, population estimates, health statistics
Houston Independent School District	Students, attendance and other records, previous support of air and health studies
Lamar University, Beaumont	Environmental sciences dept.
Lawrence Berkeley Laboratory, University of California, Berkeley	Mortality, demographic and air quality data for U.S. counties
Radian Corporation, Austin	Air monitoring, environmental engineering
Research Statistics, Inc., Houston	Statistical and epidemiologic consultation

TABLE 6. AVAILABLE RESOURCES FOR SUPPORT OF TGCA HEALTH EFFECTS STUDIES (Cont.)

Rice University, Houston	Environmental Sciences Dept.
San Jacinto Lung Association, Houston	Previous support of air/health studies
South East Texas Regional Planning Commission, Beaumont	Population estimates, health statistics
Southwest Center for Urban Research Center for Health Planning, Houston	Health statistics, health planning data
Southwest Research Institute, Houston	Conduction of air/health studies and air pollution monitoring
Texas Air Control Board	Air pollution data, previous support of air/health studies
Texas Southern University, Houston	Environmental and health related departments
Texas State Department of Human Resources	Mortality and morbidity data
University of Houston	Environmental and health related departments
UT Health Sciences Center at Houston, School of Public Health, Graduate School of Biomedical Sciences	Resident epidemiologists, biostatisticians, toxicologists, environmental health faculty, community medicine, clinical faculty
UT Medical Branch, Galveston	Cancer Center, Departments of PM and CH
UT System Cancer Center, Houston UT Carcinogenesis Center, Smithville	Health statistics, environmental mutagenesis and carcinogenesis laboratories

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16 ABSTRACT

In response to Congressional mandates, the U. S. Environmental Protection Agency will conduct an extensive study of air pollution related problems in the Texas Gulf Coast Area. As an initial effort, EPA awarded a contract to review the existing technical information and record the local viewpoint on air pollution problems in the area, define research needs, and design experimental studies addressed to these needs. Results are presented in 5 volumes. Volume II describes and discusses a research plan for health effects studies.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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