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IDENTIFICATION SYSTEMS FOR SELECTING CHEMICALS OR CHEMICAL CLASSES AS CANDIDATES FOR EVALUATION

BATTELLE COLUMBUS LABORATORIES

PREPARED FOR
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ABSTRACT

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(1) Identification of chemical hazards to man and his environment
(2) Selecting chemicals not already in use
(3) Assessing potentially hazardous degradation products or synergistic effects
(4) Assessing hazards to plants, animals, and the non-living environment.

Effective combinations of limited scope systems have been assembled by Federal agencies to achieve the chemical identification/assessment/prioritization functions needed for such public concerns as the workplace environment; human health (cancer, child poisoning, birth defects); air, water, and land contamination; and consumer-product hazards. Examination of the operational basis of a number of the individual systems within these combinations suggests that all are variations of a relatively few number of approaches to chemical selection.

A seminar on "Early Warning Systems for Toxic Substances", held in conjunction with this study effort, confirms many of the findings reported herein.

This report has been reviewed by the Office of Toxic Substances, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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This report summarizes the state of the art on systems, either existing or conceptual, that can be used or adapted for use to select, assess, and prioritize chemicals for their health or environmental effects. It is found that, while numerous systems can be identified, none have been formulated with sufficient breadth to permit accomplishing all the functions desired by EPA's Office of Toxic Substances. These functions include:

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SECTION I

CONCLUSIONS

Numerous systems exist which have as their objective the identification of adverse chemical effects on human health and/or the environment. Nearly all have been formulated within a relatively narrow framework of applicability or use; as such, they are not readily adaptable to the needs of EPA's Office of Toxic Substances (OTS). Nevertheless, many of these systems could represent important adjuncts to any OTS efforts to monitor public exposure to various chemicals. For example, many of these systems have well established sensor networks which are valuable early indicators of problem substances.

Existing systems can be classified in several ways. Early in the program it became apparent that a major system class was the information repositories for chemical data - especially toxicity data. These information centers are numerous, frequently provide automated storage and retrieval and generally have a defined albeit limited scope.

Systems other than information centers can be classified with respect to whether their principal function is to identify chemical substances before general exposure of the public and environment occurs (input surveillance), or after such occurs (output surveillance). Each of these types can be further subcategorized into those which basically seek to identify new or unrecognized chemical stressors and those which seek to evaluate the hazard of a recognized stressor.

Systems differ in the manner in which a candidate list of substances for evaluation is identified and comprise (1) systematic literature scanning, (2) licensing, (3) test protocols, (4) expert panels, (5) data base sampling, accumulation, or analysis, (6) incident reports, etc. Conversely, an examination of the design basis of existing systems suggests only a few basic approaches for assessment/prioritization (or categorization) functions. Three of these are the use of experts, a numerical index of measure or hazard, and subjective weighing factors or assigned values for selected parameters felt to be of importance.

Finally, most existing systems are deficient with respect to satisfying OTS's specified needs inthat they generally:

(1) Focus on acute effects rather than long-term (chronic) effects

(2) Have a limited domain of concern

(3) Are not designed to identify hazards from degradation products, synergistic effects or effects on the non-living environment.

SECTION II

RECOMMENDATIONS

The following recommendations are based on the results of this study and the associated seminar.

- Efforts to identify pertinent activities of Federal, State, industrial, and, perhaps, private organizations with needs relating to chemical identification and assessment should continue. For example, chemical firms and their associations, Federal agencies like the Department of Transportation, Atomic Energy Commission, Department of Defense, etc., and organizations privately developing chemical data systems might be examined.
- A comprehensive sensor network should be planned as an essential element of OTS's efforts to identify candidate substances for regulation. To the maximum extent possible this network should be integrated with the well-established networks of other Federal agencies.
- A study should be made of the more important existing information systems and centers to assess, in the context of OTS's needs, (a) the existence of useful data for chemical selection and evaluation, (b) the format and accessibility of the data, and (c) the costs of retrieval (and manipulation) of needed data.
- OTS should seek to interface with current U. S. and foreign efforts to develop computerized chemical data storage and retrieval systems (e.g., RADICAL and ECDIS*) because of the potentially important role such systems could play in identification/assessment efforts.
- A systematic and comprehensive examination should be made of all known chemical, physical, toxicological, economic, environment, etc., parameters (indices) that might find use in identification, assessment, or early warning efforts. Relating such parameters to available data sources should be an essential part of the study.

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*See Appendix E.

SECTION III

INTRODUCTION

Technological advances have resulted in the introduction of large numbers of chemical substances into widespread use.[1] The majority of these are used in ways that are directly or indirectly beneficial to man. Others, like cadmium, mercury, polychlorinated biphenyls, hexachlorobenzene, vinyl chloride, and DDT, have raised serious public concern over their uncontrolled adverse health and environmental effects. Consequently, new approaches are being sought for the identification, assessment, and regulation of chemicals either presently in use or which may be coming into the marketplace.

The Need

The Office of Toxic Substances (OTS), established by EPA in anticipation of legislation for the control of toxic substances,[2] has initiated this study of existing or potential identification/assessment systems that might be adapted as an approach to the problem. The specific questions raised by OTS are the following:

(1) How can a given system select both chemicals and classes of chemicals that are hazardous to man and his environment?

(2) How can a given system preselect chemicals not already in use, before they become widely dispersed and more difficult to control?

(3) How can a system select chemicals based on the potential hazard of their degradation products or their synergistic properties?

(4) How should the system consider hazards to plants, animals, and the nonliving environment?

The need to answer these questions takes on added importance when the magnitude of the problem is considered. On the basis of the Chemical Abstract Service Registry Number System alone, some 2 million chemical entities can be identified. It has been estimated that another 250,000 are added each year, and that several hundred are introduced into commercial use annually. U.S. production of synthetic organic chemicals for various classes of consumer products amounted to nearly 60 million tons in 1969.[1] Federally registered pesticide formulations amount to more than 60,000.[1] The widely diverse uses and disposal of commercially available chemicals and their proliferation into new product lines or formulations further complicate the problem. Furthermore, a plethora of pathways exists by which these chemicals or their degradation products find their way into the environment.

The selection of specific chemicals for regulation, testing for health and/or environmental hazards, or the development of standards for control of exposure levels must be done in most instances with either incomplete, inadequate, or nonexistent data on long- and short-term health and ecosystem effects. To acquire such data on every chemical as an aid to selection is considered much too costly. Costs ranging up to $440,000 for animal toxicity testing of a single chemical have been estimated by the chemical industry.[3] Furthermore, selection without such data might unnecessarily inhibit the commercialization of chemicals of potential benefit to the general society, since their associated risks could not be adequately assessed in the absence of such data.

SECTION IV

STUDY APPROACH

To answer these questions a literature and state-of-the-art search was made to identify systems - either in use or only conceptual - in two general areas of society: health planning (including environmental, occupational, and general health) and environmental management. The term "system" was broadly defined to include not only formalized organizational structures, models, methodologies, but also less formal tools, methods, working groups, etc., which have been conceived, formulated, and applied to the identification, prediction, assessment, or prioritization of chemical substances or effects. A variety of activities comprised the total information gathering effort and these will be briefly described.

Literature Search

A proprietary computerized health information system was utilized to conduct a literature search for identification systems for selecting chemicals or chemical classes as candidates for evaluation. This system incorporates every available major medical bibliographic resource and major medical library information resource including the National Library of Medicine (MEDLINE). In addition, searches of other data bases such as Food and Drug Administration Abstracts, Chemical and Biological Abstracts, American Society of Pharmacists Abstracts, and previously developed information data bases of the Environmental Protection Agency together with the medical information services maintained at The Ohio State University were included. Reference sources included published health periodicals, monographs, published books, proceedings of symposia, and legal periodicals. The indexing system used is compatible with The National Library of Medicine. Terms used for specific indexing are based on health effects.

The comprehensive health-systems information system covers 1940 to 1972, with major emphasis on the last 10 years in predominantly

English language publications. A special search utilizing the TOXLINE data base covers 1965 to 1972. Current inclusions in information systems have a recognized lag of 8 to 10 months behind publication dates.

Other information was obtained from Battelle-Columbus' own resources, especially the Ecology Information and Analysis Center, and a machine search of recent NTIS holdings.

The articles and abstracts compiled from the machine-searched literature were provided in Battelle's Task A report dated October 26, 1973. Of the 300 or so articles identified, approximately 70 were selected as having some particular relevance to this program. A bibliography of these, keyed to a subject index, can be found in Appendix A.

Contacts

Contacts were made by telephone and visits to Federal agencies in acquiring inputs to this study. Appendix B provides a listing of these by agency, section (where known), and individual. The approach generally was to telephone a contact who would either provide on-the-spot information, forward written material for review, or agree to a visit for further discussion. A concurrent seminar effort (see next heading) provided a more expanded range of contacts than would have been possible otherwise.

Seminar

Supplementing this effort was a seminar program on "Early Warning Systems for Toxic Substances" which provided additional insights into the questions raised. This seminar, partially funded as an addendum to this program by OTS (NSF, NIEHS, and Battelle were also cosponsors) is described in detail in a "Task C" report issued separately under this contract. A portion of that report is included as Appendix C. Because the seminar effort was accomplished concurrently with this program, considerable cross-fertilization between the two efforts occurred, thus aiding materially in the formulation of the study results.

The premise of the seminar was that a number of governmental, industrial, and private organizations today are faced with the need, in their sphere of concern, for new approaches to identifying and assessing before-the-fact chemical substances which pose a hazard to man or the environment. Since such efforts must be accomplished within the limitations of finite dollar and manpower resources, a means of assigning priorities to potentially hazardous chemical substances is needed. Furthermore, the priorities must be assigned in most cases on the basis of incomplete or nonexistent data on long-term and low-level toxic effects; risk involved; and related factors. Thus, the seminar was formed to examine the tools which exist for identifying and assessing chemical hazards as well as for alerting the public to these in a controlled manner.

SECTION V

RESULTS

In this study no one system has been found with the capabilities implicitly or explicitly referred to in the four questions raised as the basis of this study. Rather a great many systems have been identified which singly or in combination provide some of the functions desired in the selection of chemicals with respect to their hazards to man and the environment. Nearly all of these do so within a limited domain of concern, i.e., the workplace, the air, water or land environment, an ecosystem, or an aspect of human health (cancer, poisoning, aging, birth defects). From the standpoint of the mission of EPA's Office of Toxic Substances, this diversity of systems represents an asset, one to be capitalized upon in seeking the identification and hazard evaluation of chemicals for which regulatory actions ought to be imposed. Conversely, this same diversity complicates the problem of effectively gaining access to all the data necessary to provide a regulation which properly balances public risk, cost, and benefit.

Tables 1 lists a number of systems which were identified in the course of this study. Most of these were described in the Task A report issued separately under this contract. An expanded version of the Task A descriptive material on the identified systems is included as Appendix D.

It has been found useful to separate the identified systems into two major categories depending upon whether their principal purpose was to identify or evaluate environment or health stressors either prior to general exposure of the public and environment (Category I) or after widespread exposure or use occurs (Category II). The first category was referred to as input surveillance (and assessment) and the latter as output surveillance. Each of these categories can be further subcategorized depending on whether the system activity is primarily related to identifying the existence of a possible health or an environmental stressor. In Table 1 the identified systems are listed with a judgment regarding their appropriate categories as follows:

I. Input Surveillance

A. New Stressor Identification

B. Hazard Assessment of Recognized Stressors

II. Output Surveillance

A. New Stressor Identification

B. Hazard Assessment of Recognized Stressors

One large class of systems identified in this program is the information repositories or data banks, some automated for storage and retrieval, others simply collections assembled in one location. Table 2 lists a number of these selected from an initial list of approximately 650 information centers in the United States.[4] Appendix E contains an expanded description of the data sources of Table 2. The list, not meant to be complete, is divided into groups with or without computerized access and further as primarily chemical, medical, or general sources of information. The listing suggests that considerable amounts of information for chemical identification or assessment purposes is available. The problem is to determine what is available, its form, and its accessibility for identification/assessment purpose. More extensive examination of these type systems was felt beyond the scope of this study.

Efforts under way in the U.S. and Europe to develop new information systems specifically aimed at the problem of toxic substance identification/assessment needs have been identified. Two of these are the (1) RADICAL and (2) ECDIS. Descriptions of these are also included in Appendix E.

Following this summarization of the systems previously identified in the Task A report a number of systems that have chemical identification/assessment as a primary function will be reviewed in more detail. These will be described in the context of their sphere of usage as follows:

- Occupational Health

TABLE 1. IDENTIFICATION/ASSESSMENT SYSTEMS*

System Identifer	Sponsor	Category IA	IB	IIA	IIB
(1) Carcinogen Screening	International Agency for Research Against Cancer		X		X
(2) Animal (Rat) Toxicity Test	Center for Disease Control	X		X	
(3) Short-Term (Hamster) Cancer Test	National Cancer Institute	X			
(4) Biological Materials Surveillance	Bureau of Biologics, Food and Drug Administration	X			
(5) Surveillance of Poisons	National Clearinghouse for Poison Control, Food and Drug Administration		X		
(6) Radiological Product Surveillance	Bureau of Radiological Health, Food and Drug Administration		X		
(7) National Evaluation of X-Ray Trends	Ditto		X		
(8) Biologics Licensing	Department of Health, Education, and Welfare		X		
(9) Drug Surveillance	Bureau of Drugs, Food and Drug Administration		X		X
(10) Chemical Hazard Identification	National Cancer Institute			X	
(11) Poison Control Centers	State Departments of Health			X	
(12) Epidemic Intelligence Service	Center for Disease Control			X	

TABLE 1. IDENTIFICATION/ASSESSMENT SYSTEMS*
(Continued)

System Identifier	Sponsor	Category IA	IB	IIA	IIB
(13) National Electronic Injury Surveillance System	Consumer Product Safety Commission			X	
(14) National Surveillance Network - National Occupational Health Survey	National Institute of Occupational Safety and Health			X	
(15) Toxic Substance List	Ditto			X	X
(16) Prioritization of Workplace Chemicals	"				X
(17) Hazard Evaluation Program	"				X
(18) Walter Reed Disease Forecasting System	U.S. Army				X
(19) Community Health Effects Surveillance Studies	Research Triangle Park, Environmental Protection Agency				X
(20) Cancer Surveillance, Epidemiology and End Results Reporting Program	National Cancer Institute				X
(21) Subclinical Toxicity Survey	Center for Disease Control				X
(22) Technical, Intelligence, and Project Information System	(Conceptual)	X	X		
(23) OVERVIEW System	Ditto		X		X
(24) National Emissions Data System (Air)	Environmental Protection Agency		X		

TABLE 1. IDENTIFICATION/ASSESSMENT SYSTEMS* (Continued)

System Identifier	Sponsor	Category IA	IB	IIA	IIB
(25) General Point Source File (Water)	Environmental Protection Agency		X		
(26) International Decade of Ocean Exploration	National Science Foundation			X	
(27) Marine Resources	National Oceanic and Atmospheric Administration			X	
(28) National Stream Quality Accounting Network	U.S. Geological Survey			X	
(29) International Biological Program	National Science Foundation			X	
(30) SAROAD	Environmental Protection Agency				X
(31) STORET	Ditto				X
(32) Environmental Monitoring	Council on Environmental Quality			X	
(33) National Fuels Surveillance Network	Environmental Protection Agency	X			
(34) Wiswesser Line Notation		X			
(35) Environmental Information System Office	Oak Ridge National Laboratories			X	X
(36) OHM-TADS	Environmental Protection Agency			X	X
(37) National Pesticides Monitoring Program	Interagency		X		X
(38) Priorities for Synthetic Organic Chemicals	Syracuse University Research Corporation				X
(39) Toxicology Information Program	National Library of Medicine		X		X

* Systems are described in Appendix D in the order listed.

TABLE 2. CHEMICAL TOXICITY DATA SOURCES

A. Sources with Automated Storage and Retrieval Facilities

Chemical

Sadtler Research Laboratories, Inc.
American Chemical Society
Columbia University RADICAL System
Commission of the European Communities - ECDIS

Medical

University of Rochester
North Carolina State University
Midwest Research Laboratories
National Library of Medicine
Biological Abstracts

General

The John Crerar Library
Argonne Code Center
Battelle Memorial Institute (Columbus and Northwest)
Atomic Energy Commission - Division of Technical Information Extension
Nuclear Safety Information Center
Pesticides Information Center

B. Other Information Centers

Chemicals

Household Substances Data File, FDA
The Soap and Detergent Association
American Petroleum Institute
Industrial Hygiene Foundation of America, Inc.
Tobacco Literature Service

Medical

National Center for Chronic Disease Control
Army Munitions Command - Toxicological Information Center
New York Academy of Medicine
National Clearinghouse for Poison Control
Pharmaceutical Information Service
Pharmaco-Medical Documentation

TABLE 2. CHEMICAL TOXICITY DATA SOURCES
(Continued)

General
International Association of Water Pollution Research
National Academy of Science-Engineering
World Life Research Institute
Institute for Scientific Information

- General/environmental Health
- Environmental Management.

In this way, the supportive relationship of combinations of systems becomes more apparent, as does the basis for their development. At the same time, the state of the art of existing systems for chemical identification and hazard assessment will be more clearly apparent. Also, a basis for discussing commonalities, differences, and sometimes the distinctiveness among systems will be provided. Finally, the deficiencies of current and proposed systems in relation to OTS's apparent needs - as implied by the four basic questions posed at the outset - will be highlighted.

Occupational Health

In accordance with the Section 20(a)(6) of the Occupational Safety and Health Act of 1970, Public Law 91-596, the National Institute for Occupational Safety and Health (NIOSH) conducts a number of programs which have as their basis the identification and hazard assessment of toxic substances. Among these programs are the following:

- Annual publication of a list of known toxic substances
- Development of a priority listing of toxic substances and physical agents for purposes of criteria document development
- National Surveillance Network - National Occupational Hazard Survey
- In-plant hazard evaluation program
- Computerized retrieval system for chemical data sheets supplied by industry
- Access to medical, mortality, exposure data
- Active participation on the Threshold Limit Value (TLV) Committee of the American Conference of Governmental Industrial Hygienists (ACGIH).

In toto, these programs represent a fairly comprehensive sensor system for identifying chemicals of concern, although the emphasis is on chemicals in the working place.

Toxic Substances List

An annual catalogue of known toxic substances[5] is compiled and is available on tape for computerized searching. The first such list was compiled for publication in June, 1971; this list was revised in 1972 and 1973. The 1973 list contains 11,000 names of chemicals together with 14,000 synonyms. It is anticipated that future revisions will contain 100,000 chemicals with 500,000 chemical descriptions.

A chemical which appears on the list has a documented, potential hazard to man and/or animals. The hazard may be that of lethality, carcinogenicity, teratogenicity, or mutagenicity. No statement concerning the effect on vegetation can be made, nor can any conclusion be drawn from the absence of a chemical from the list.

The information in the lists has been gathered from the literature, from company technical data sheets, from promotional material, and from unpublished sources. The bibliography from which the 1973 list was derived is quite extensive.

Criteria Document Development from Priority Listing of Chemicals

The actual hazard of a chemical, and thus the basis for the establishment of standards for occupational exposure, is developed by NIOSH as a criteria document for the chemical. A criteria document is prepared from a critical evaluation of all published medical, biological, engineering, chemical, and trade data. Professional bias, which may occur in the preparation of the document, is removed by a two-stage advocacy-adversary process.

The criteria document which results from this process is used several ways. First, as a publication, it is a source of information on exposure limits and expected symptoms. Second, as an unbiased compilation of all known data, it serves as the basis for the establishment of regulatory standards.

Candidates for criteria document development consideration are identified from a variety of sources. The various industrial hygiene surveys conducted in the past by NIOSH have served to identify by name a large number of toxic substances and physical agents in widespread industrial use. Additions to the list also came from the several states who participate in the National Surveillance Network (to be described). Further, requests for hazard evaluations and new developments and trends in industry provide items for consideration.

Resources are not available to allow criteria documents to be simultaneously developed on all identified candidates, hence a prioritization scheme[6] was devised to select the most important candidates. The basis for prioritization of the candidate list is NIOSH's evaluation of the potential for health impairment associated with job hazards. NIOSH would like to evaluate job hazards by

(1) Number of workers at risk
(2) Production rates
(3) Trend in use
(4) Severity of effect of exposure
(5) Likelihood of disease resulting from exposure.

As quantification of all the above for each chemical is a large task, NIOSH reduced the above elements to just two

- Expected exposure - based on (1), (2), and (3) above
- Likelihood of disease and severity - based on (4) and (5)

and formed a priority index from the product of these.

Estimates of exposure were obtained from NIOSH surveys and states participating in the National Surveillance Network. These were subjectively adjusted by NIOSH staff when estimates obtained from narrow-based surveys were questioned. The severity rates were obtained by subjective (Delphi) assessment employing some 50 occupational health professionals. The severity rates were rated on an ANSI injury work-lost-days severity scale.

The prioritized 1973 list presents the chemicals by some 17 priority classes. Within each class, the sensitivity of the procedure is not fine enough to allow ranking distinctions to be made. The list for 1973 was truncated at a level where the priority rating system ceased to be sensitive, so that the end result was a list of 471 items. Excluded were substances for which criteria documents have already been developed (e.g., asbestos, beryllium, carbon monoxide, etc.). Not included on the list are the seven items for which criteria documents have already been initiated, nor 14 suspected carcinogens which have been recommended for control by a permit system. These 14 chemicals are:

2-Acetylaminofluorene	N-Nitrosodimethylamine
4-Aminodiphenyl	beta-Propiolactone
Benzidine	Bis(chloromethyl)ether
3,3'-Dichlorobenzidine	Chloromethyl Ether
4-Dimethylaminoazobenzene	4,4'-Methylenebis(2-Chloroaniline)
alpha-Napthylamine	Ethyleneimine
beta-Napthylamine	4-Nitrodiphenyl

National Surveillance Network - National Occupational Hazard Survey

NIOSH is surveying a sample of 10,000 to 15,000 workplaces. Each plant survey consists of a brief interview with the manager followed by a walk-through investigation. A 2-year study will develop basic descriptive information on the working environment in all nonagricultural industries covered under the Occupational Health and Safety Act of 1970. This information will be used to assist in setting priorities for research and compliance, for directing research teams in future investigation efforts, for measuring and to some extent forecasting trends, and for developing criteria for standards which will describe the potential health hazards typical of a particular industry or occupation. All data will be classified, key punched, and stored on magnetic tapes.[23]

Hazard Evaluation Program

At the specific request (written) of employee or employer representatives, NIOSH will perform a field evaluation of the potential toxicity of substances used or found in the workplace. Appropriate literature searching, sampling, analytical and medical testing measures are undertaken on the information and findings are passed along to the employer, U.S. Department of Labor, and the employee's representatives. The emphasis is on acute or short-term incidents, and the results have mostly served to substantiate or negate established criteria rather than provide the basis for new criteria documents.

Retrieval System and Chemical Data Sheets

NIOSH has an established arrangement with industry whereby material safety data sheets, containing data on hazardous products used in workplaces, are supplied voluntarily. These data sheets include these information categories:

(1) Identifiers - Company, product name (trade and generic), and formula
(2) Ingredients - Name, percentage, TLV
(3) Physical Data - Vapor pressure, solubility, color, etc. (9 items)
(4) Fire and Explosion Hazard Data
(5) Reactivity Data - Stability, incompatibility
(6) Health Hazard Data - Ingestion, eye and skin contact, inhalation, effects. etc.
(7) Spill or Leak Procedures
(8) Special Protection Information
(9) Special Precautions

The potential number of such sheets are large. One chemical company has submitted an estimated 6000. Access to the data sheets held in NIOSH files is provided by a computerized retrieval system based upon identifiers for company name, chemical tradename, data sheet I.D. number, and ingredients. NIOSH notes that practically no information is available to them from small companies whose outputs include innumerable products.

Access to Medical Mortality and Exposure Data

Continuing studies of chemical hazards are made by NIOSH's Division of Field Studies and Special Investigation which attempts to tie together environmental, medical, and biometrical (epidemiology and statistics) elements. Five exposure categories established by this group for hazard evaluations include:

- Carcinogens
- Respiratory diseases
- Cardiac disease
- Teratogens/mutagens
- Nerve diseases.

In support of these evaluations the Division contracts with the University of Cincinnati for computerized handling of medical mortality and exposure data. The data file contains these subgroups: (1) identifiers [name, age, occupation, etc.], (2) questionnaire abstraction [health history, job history, etc.], (3) physiological information [urine, blood data, etc.]. NIOSH has found that whereas good and extensive data on chemical exposure and morbidity generally exist, there are few good correlations between exposure and morbidity.

TLV Committee of ACGIH

Threshold limit values (TLV) refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. TLV values are now official federal standards for industrial air.[7] Additions to the TLV list (500-600 substances are now on the list) are made by a 15-member committee of which more than one are currently NIOSH staff members. Appointment to this committee is independent of a member's affiliation. NIOSH cites this involvement with the industrial community as a key mechanism for staying abreast of problem chemicals in the work-place. Much information, not officially obtainable, can be accessed by the informal relationships established over the years between industry and

and this agency. Approximately 1500 ACGIH industrial hygienists serve as a sensor system to feed candidate substances to the 15-member TLV committee. Many more substances appear on the list than NIOSH will ever be capable of putting out criteria documents on for the simple reason that such documents require extensive documentation based on data that are seldom available in the detail required. In essence what exists is a well recognized and accepted (by 35 states) listing of substances whose hazard criteria are developed on the basis of the best professional judgments on available data. The data bases for these judgments are published in a document separate from the TLV listing by ACGIH.

In summary, NIOSH has assembled a number of subsystems which enable them to identify, assess, prioritize, and alert the public to chemical hazards in the workplace. An established sensor system and informed judgments appear to be the major ingredients in the results achieved.

General/Environmental Health

In concentrating its resources on cancer, a leading cause of death in the U.S., the National Cancer Institute (NCI) has developed, spawned, or is supporting a number of systematized and somewhat interrelated approaches for identifying and assessing chemical substances with respect to carcinogenicity. These programs include:

- Survey of Compounds which have been Tested for Carcinogenic Activity (PHS Publication 149)
- Study of Structure-Activity Hazard Assessment of Carcinogens and Mutagens
- Program to Acquire and Analyze Information on Chemicals that Impact on Man and His Environment [formerly the Chemical Hazard Ranking Information System (CHRIS)]
- Cooperative Efforts with the International Agency for Research Against Cancer

- Surveillance, Epidemiology, and End Results Reporting (SEER Program).

The basis of much of NCI's efforts to acquire information of chemical carcinogens is the suspicion that a large percentage of cancer cases are based on chemical rather than biological (e.g., viral) causes.

PHS Publication 149

NCI continues to support (under contract with Tracor JITCO) the extraction, computerization, and publication of updated volumes of this data source entitled "Survey of Compounds Which have been Tested for Carcinogenic Activity". This is probably the most complete collection of data and references on chemical carcinogensis. The contractor retains the hard copy of each article abstracted and referenced since 1961 and makes available a computerized data presentation of the following described characteristics.

Contents. Data and literature references contained in seven volumes of PHS 149:

Original - 1947
Supplement #1 1948 - 1953
#2 1954 - 1960
#3 1961 - 1967
#4 1968 - 1969
#5 1970 - 1971
#6 1972 - 1973.

Format. Literature reference, animal species/strain, route/site of treatment, tumor site, details and duration of experimentation, dosage, chemical compound, CAS Registry numbers, Wiswesser Line Notation, etc.

Accessibility. A master index of the entire series is maintained on tape in offline machine readable form in NCI headquarters in Bethesda, Maryland.

Structure-Activity Hazard Assessment Study

NCI is funding (50 percent) in cooperation with the National Institute of Environmental Health Sciences (NIEHS) a study effort to identify and correlate a relationship between molecular structure and biologic activity for chemical substances. Specifically, a correlation between mutagenicity and carcinogenicity is being sought allowing a structure activity approach to assessing these chemical hazards as opposed to current bioassay techniques. The latter techniques require 2-4 years and the maintenance of secrecy to preclude premature public disclosure prior to full completion of the bioassay period.

Program to Acquire Information on Chemicals

Stanford Research Institute, in a continuing program sponsored by NCI, is developing a system to collect, analyze, and systematize information on the chemical description, production, distribution, and human exposure to carcinogenic chemicals which the public may come into contact with in significant amounts.

Until recently (1973) this program was identified as the CHRIS system (Chemical Hazard Ranking Information System). Dropping of this designator was due to NCI's feeling that "hazard ranking" per se is no longer considered appropriate, i.e., it is not currently considered technically feasible to pursue prediction through structural analyses.[8] It is, however, considered desirable to pursue the potential of hazard identification through structural analyses. Consequently, this program now is proceeding under the title of "A Research Program to Acquire and Analyze Information on Chemicals that Impact on Man and His Environment". In a recent abstract of a paper[9] under this title, the authors described the system as follows:

> "This effort provides information to aid the National Cancer Institute Carcinogenesis Program in selecting chemicals to test to which the U.S. population is exposed. The criteria used by NCI's Chemical Selection Committee for selecting chemicals for carcinogenic testing are:

- The degree of overall human exposure
- Projected new or increased human exposure
- Exposure of subpopulations important to society
- Epidemiological clues (high cancer incidence subpopulations)
- Relation to known carcinogens
- Gaps in knowledge.

The present data base contains information on 3200 chemicals in the following categories:

Intentional food additives	Air pollutants
Pesticide residues in food	Water pollutants
Proprietary drugs	Soaps and detergents
Prescription drugs	Trade sales paints
Cosmetics	

These categories are subdivided into 900 product types representing 18,000 chemical-product combinations.

The data are in computer-readable form and contain the following information:

Product	Each Ingrediment Chemical
Product name	CAS number and name
Quantity available for exposure	Strength (percent) in each product
Exposure routes--oral, dermal, respiratory, and parenteral	Degree of uncertainty associated with quantitative data
Exposure factor by route	References to data sources

In addition to the information on the 3200 chemicals in the above nine exposure categories, a data bank of approximately 25,000 chemicals has been developed which includes many of the substances to which the human population is most likely to be exposed. These chemicals were drawn from eighteen recognized sources of information on such products as cosmetics, food additives, medicinals, etc. For each of the 25,000 chemicals in this data bank, the CAS number, structure, chemical name, and synonyms are stored in computer readable form.

A computerized chemical classification scheme has also been developed that contains 220 nodes or end points. This development has allowed a node assignment to be made for each of the chemicals for which exposure estimates have been made. As additional biological data become available it may eventually be possible to make informed guesses as to a molecule's carcinogenic potential based on such a chemical classification scheme."

International Agency for Research Against Cancer (IARC)

This agency, a spinoff of the World Health Organization based in Lyon, France, is supported by NCI in its efforts to identify chemical carcinogens. It is composed of a group of internationally recognized scientists who:

(1) Receive information on candidate chemicals from many sources including NCI
(2) Evaluate carcinogenic risk to man of chemicals
(3) Publish their conclusions in monograph form.

The basis of this effort is thus a general sensor system to identify candidate substances coupled with expert opinion hazard assessments based on the state-of-available knowledge (testing, chemical, etc., data).

SEER Program

A variety of NCI* programs are concerned with the collection, analysis, and utilization of data on the incidence of cancer, the characteristics of patients and their disease, treatment, and end result. The SEER program[10] integrates a number of data sources (nine registries in U.S. covering 10 percent of population) with the objective of contributing to the assessment of (1) the risk of developing cancer in groups and in individuals and (2) the presence, extent, and probable course of existing cancers. Data collected annually from these sources have permitted long-term trends (approximately 1935 - present) in cancer incidents and mortality to be developed as a function of population groups (sex, age group, etc.), afflicted site (lung, esophagus, etc.), and other factors. This program could serve to identify trends in cancer incidence associated with the impact of changes in the environment and human behavior. It does not specifically relate incidence to chemicals, although clues to chemically based causative agents are possible. For example, Table 3 illustrates an attempt based on SEER data to relate environmental factors to deaths from cancer as a function of the afflicted site.

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* See Appendix D.

TABLE 3. ESTIMATED CANCER DEATHS FOR 1973 (Both Sexes)[10]

Site	Total Deaths	Extent Attributed to Environmental Factors	
Lung	72,000	++++	Tobacco, Asbestos, Air Pollutants, Occupational
Colon-Rectum	47,400	+++	Diet, Other Environmental
Pancreas	19,200	++?	Tobacco, Diet (?)
Leukemia	15,300	+	Radiation, Chemicals
Stomach	14,700	+++	Diet, Other Environmental
Bladder	9,200	+++	Occupational, Tobacco, Diet (?) Other Environmental
Oral Cavity	7,600	++	Tobacco, Chemicals, Diet (?)
Liver (Primary)	7,200	++	Diet, Other Environmental
Esophagus	6,400	++	Environmental
Skin	5,200	++++	Ultraviolet Light, Chemicals, Occupational
Larynx	3,000	+++	Tobacco, Air Pollutants
Total These Sites	207,000	+++	
Other Sites	143,000	+,?	(Includes Hormonal Factors)
TOTAL All Sites	350,000	++	

In summary, NCI's carcinogenesis program has developed both informal and formal systems for identifying and assessing carcinogenic health hazards. Identification appears to rely heavily on three sources: (1) medical experts identified by NCI, (2) systematized searches of the literature for chemical production, use, toxicology and descriptive data, and (3) epidemiological data. Hazard assessments rely on available animal test data, estimates of human exposure, and systematized expert judgment.

Environmental Management

In accordance with air, water, pesticide, and other Federal legislation, the Environmental Protection Agency has underway many programs that involve the systematic identification, evaluation, and prioritization of environmental pollutants, many of which are chemical in nature. Other agencies besides EPA -- Coast Guard, National Science Foundation, USDA, etc. -- either on their own or in collaboration with others -- also have developed systems of interest to this study. A sampling of the more pertinent ones identified will be discussed to illustrate the extent of chemical identification/assessment efforts in this area of concern. These include:

- Systematized approaches to identify hazardous airborne pollutants (EPA)
- Identification/prioritization and data retrieval systems for chemicals spilled into watercourses (EPA)
- Chemical Hazard Ranking Identification System (Coast Guard)
- OHM-TADS, a hazardous material information automated data file (EPA)
- National Pesticide Monitoring Program (Interagency)
- Selection Methodology for Hazardous Solid Wastes (EPA)
- Identification and Assessment of Chemicals Effects on Ecosystems (NSF).

Identification of Airborne Pollutants

The Clean Air Act (amended 1970) requires the EPA Administrator to publish a list of hazardous air pollutants for which emissions standards are to be established. This requirement has resulted in the development by EPA of systematized approaches for identifying such pollutants. To date a listing of 38 pollutants has been generated. Nine of these have had concentration limits in ambient air set and 3 (mercury, beryllium, and asbestos) have been declared hazardous under Section 112 of the Act. Considering the extensive TLV listing by ACGIH (500-600 substances), a continued screening by EPA of potential pollutants is to be expected. One screening basis being pursued by the Control Systems Laboratory (CSL) at NERC/RTP is a precursory listing of "materials of concern"[11] derived from the following four sources:

(1) The current EPA hazardous and ambient air quality listing (nine substances)
(2) A tentative listing of 29 hazardous pollutants by EPA's Office of Air Quality and Planning Standards
(3) 200 airborne contaminants from the NIOSH Toxic Substances List with TLV's of 10 mg/m^3 or less
(4) A list of all known airborne polynuclear aromatic hydrocarbons and other carcinogenic substances.

This list is the first step. Evaluation and prioritization will follow as efforts to identify critical substances for regulatory action proceed.

CSL also has more comprehensive efforts underway to identify emission sources of potentially hazardous pollutants. These efforts will permit a data base to be derived from a methodology for tracing potential harmful airborne pollutants to their industrial source. The method would, conceptually, detail the input of primary and secondary raw materials, intermediate products, and end products for selected industries as shown in Figure 1. Each industry will also be further detailed into processes with air, water, and solid emission points identified.

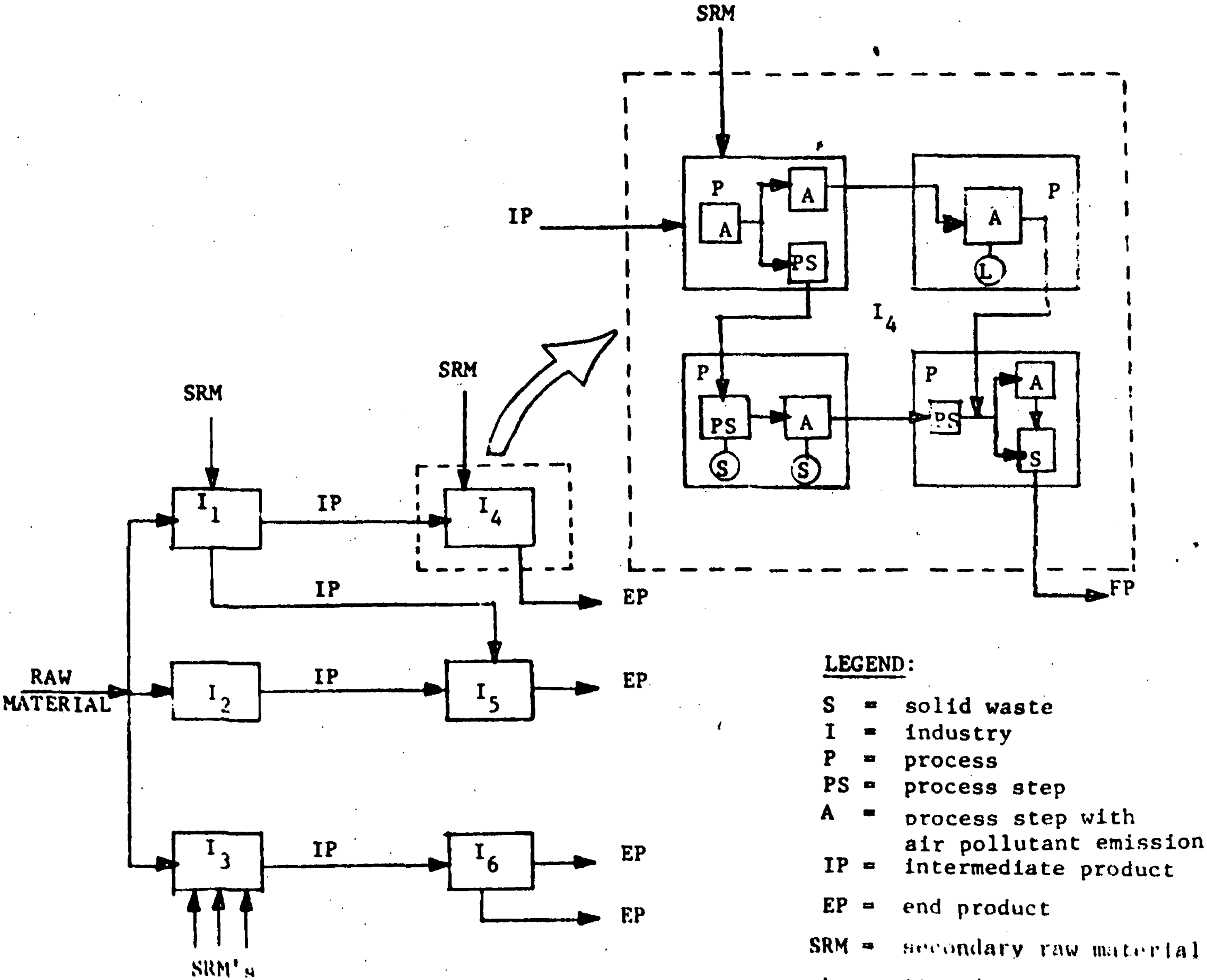

FIGURE 1. GENERALIZED DIAGRAM SHOWING HOW SOURCES OF POTENTIALLY HAZARDOUS POLLUTANTS WILL BE IDENTIFIED BY TRACING THE PROCESSING OF BASIC RAW MATERIALS

Hazardous Water Pollutants

Several agencies are interested in identifying hazardous pollutants entering watercourses. EPA, whose efforts are based on the requirements of the Water Pollution Control Act of 1972 and the Coast Guard (see CHRIS section to follow) are most prominent in such efforts, particularly with respect to episodic-type spills, e.g., these due to accidents and industrial effluents.

EPA, in seeking to satisfy a requirement of 1972 Act (Section 311), is developing criteria for use in designating hazardous waterborne substances which "...pose an imminent and substantial danger to public health or welfare, including but not limited to fish, shellfish, wildlife, shorelines, and beaches." The following sequential criteria are under consideration.[24]

(1) Radioactive - "Any radioactive substance which meets the following inclusive criteria possesses the requisite danger potential to be designated as a hazardous substance:

(a) Half-life = 10 years, and

(b) Bioconcentration factor = 100, and

(c) Radiotoxicity: Radionuclides which, as a result of the energy emitted, the biological effectiveness of the radiation, and the effective half-life in the organism, result in an ICRP concentration limit = 5×10^{-4} microcuries/ml.*

(2) Biologically Concentrated - "Any element or compound other than identified in Criterion 1, which is a biologically concentrated poison showing a concentration factor greater than 1000 and which is produced or handled in excess of research quantities, possesses the requisite

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* Concentration limits for all radionuclides, as recommended by the International Commission on Radiological Protection (ICRP) for continuous 168 hour exposure to the critical organ(s), are published in ICRP Publications 2 (Report of Committee II on Permissible Dose for Internal Radiation) and 6 (Recommendations of the ICRP, as amended and revised 1962).

danger potential to be designated as a hazardous substance. The concentration factor is that value obtained by dividing the net weight concentration of material in the whole organism by the concentration of material in the surrounding waters or in the preceding link in the food chain."

(3) Lethal - "Any element or compound produced in excess of research quantities which is lethal to:

(a) one-half of a test population of aquatic animals in 96 hours or less at a concentration of 1000 parts per million (ppm); or

(b) one-half of a test population of animals in 14 days or less when administered as a single oral dose less than 50 milligrams per kilogram of body weight; or

(c) one-half of a test population of animals in 14 days or less when dermally exposed to less than 200 milligrams per kilogram of body weight for 24 hours; or

(d) one-half of a test population of animals in 14 days or less when exposed to a vapor concentration less than 200 ppm in air for one hour; or

(e) aquatic flora as measured by a 50 percent decrease in cell count, biomass, or photosynthetic ability in 14 days or less at concentrations less than 100 parts per million, possesses sufficient danger potential to be designated as a hazardous substance."

(4) High Oxygen Demand - "Any element or compound stored or transported in tanks or containers containing equal to or greater than 20 metric tons (Approx. 44,000 lbs or 5,000 gal) which can produce a severe stress on the aquatic environment by exerting an oxygen demand greater than 25 percent of its theoretical oxygen demand as measured by

the 5-day biochemical oxygen demand test or its equivalent has the requisite danger potential to be designated as a hazardous substance."

(5) Nuisance Growth Stimulating - "Any element or compound stored or transported in tanks or containers containing, equal to, or greater than 20 metric tons (approximately) 44,000 lbs or 5,000 gal) which can stimulate the growth of nuisance aquatic flora has sufficient danger potential to be designated as a hazardous substance."

A tentative list of designated hazardous materials by these criteria was limited to those materials which have a potential for accidental spillage into water. About 800 chemicals were identified as being potential hazards. Technical documentation of the technique and results is available from GPO.[12]

A study performed for EPA by Battelle in 1970 entitled "Control of Spillage of Hazardous Polluting Substances" identified and prioritized a list of chemicals based on their hazard to the aquatic environment.[13] The list of chemicals to be prioritized was obtained from a previously published list of transported hazardous chemicals. The chemicals were ranked by a deterministic indicator calculated from (1) production and transport volumes by rail, barge, and truck, (2) spill probabilities by transport mode, and (3) critical threshold toxic concentrations. This is represented schematically in Figure 2. The resulting ranking parameter physically represented the volume of water necessary to dilute the annual expected spillage to a safe concentration.

The Analytical Quality Control Laboratory (AQCL) of the EPA's Office of Water Programs contracted the development and maintenance of an Analytical Methodology Information Center (AMIC).[14,15] The Center has six responsibilities namely: (1) acquisition, (2) processing (abstracting and indexing) documents, (3) preparation of a monthly current awareness (abstract) bulletin ("Reviews of Current Literature on Analytical Methodology and Quality Control"), (4) provision of a computerized (on-line interactive) computer system, (5) assisting the Analytical Quality Control Laboratory in its role as a "center of competence" for the Water Resources Scientific

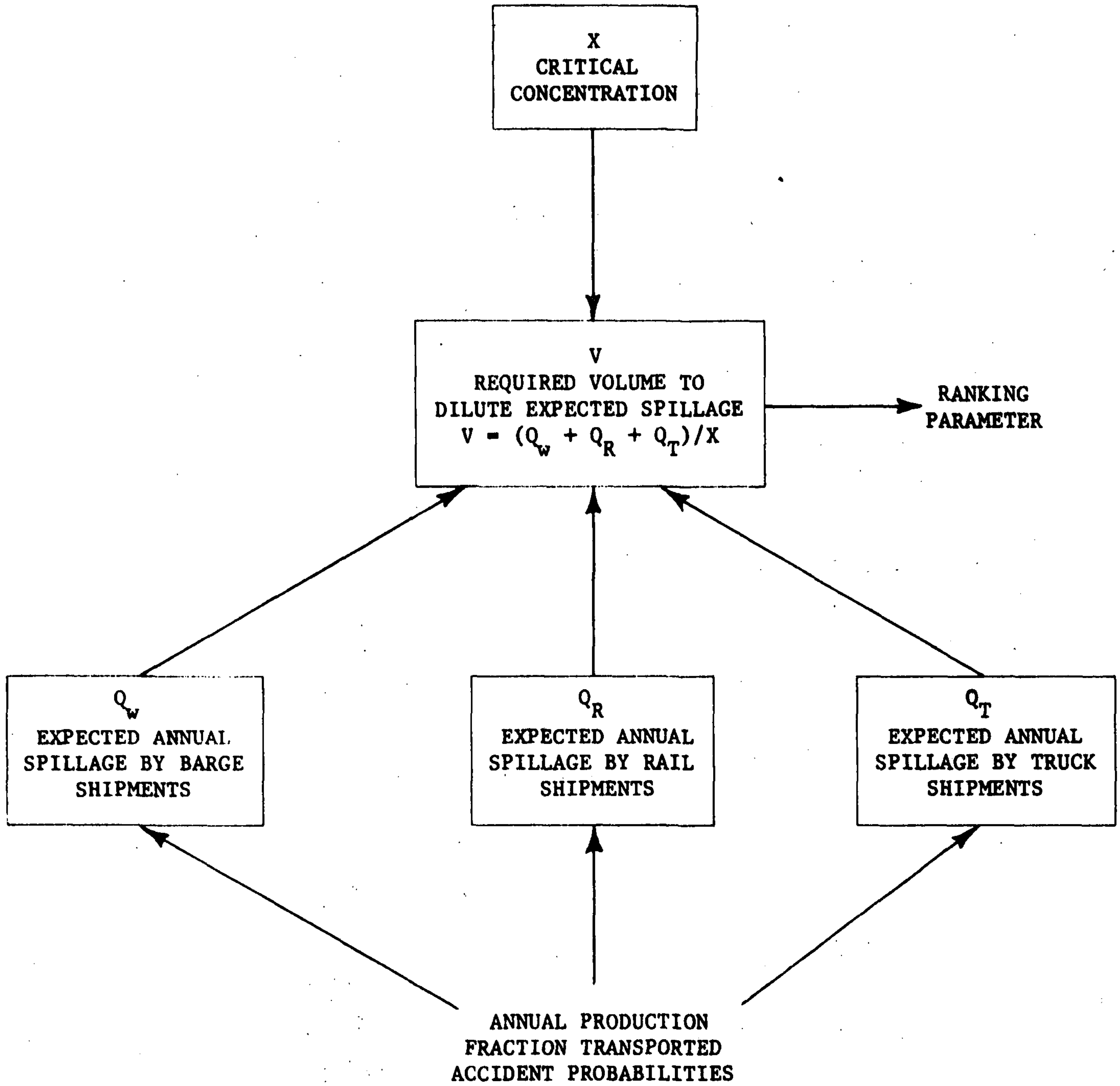


FIGURE 2. GRAPHIC REPRESENTATION OF HAZARDOUS WATERBORNE SUBSTANCES MODEL

Information Center, (6) provision of certain information services.

The scope of information contained in the AMIC data base includes the fields represented by the five activities of the AQCL

- Physical and Chemical Methods
- Biological Methods
- Microbiological Methods
- Methods and Performance Evaluation
- Instrument Development

plus these topics of general interest to the AQCL staff

- Special problems related to the analysis of marine samples
- Sample preservation and storage
- Optimizing sampling frequency
- Computer programs for data processing
- Data interpretation
- Water quality criteria, standards, and enforcement
- Quality control
- Development and improvement of specific methods.

Chemical Hazard Ranking Information System

The Coast Guard commissioned A. D. Little, Inc., in 1972 to perform a study on "An Appraisal of the Problem of Handling, Transportation, and Disposal of Toxic and Hazardous Materials".(16) This study focused upon identification, prioritization, and evaluation of information elements as opposed to chemicals. However, the methodology should be of interest to OTS. The result was termed the "Chemical Hazard Ranking Information System" (CHRIS).

The study contains an analysis of information requirements for the five stages of a spillage incident, namely

(1) Detection, evaluation, notification
(2) Containment and countermeasures
(3) Cleanup, disposal
(4) Restoration
(5) Adjudication.

A tentative list containing some 144 perceived information needs was generated (a laundry list). This list was truncated to 78 elements by subjective elimination and aggregation. The list then contained eight major categories

(I) Chemical (16 elements)
(II) Shipping and Carrier (8 elements)
(III) Environment (16 elements)
(IV) Resource (8 elements)
(V) Incident (13 elements)
(VI) Procedures and Background (4 elements)
(VII) Hazard Evaluation (7 elements)
(VIII) Response Model (6 elements)

Nine categories of information users were defined, as were three actions of users and four media by which information could be provided.

Subjective analysis then provided further variables. A score of 0 to 5 was provided as a consequence of a wrong decision by each of the nine users based on each of the 78 information elements. An incremental reduction in the likelihood of the wrong decision by each of the nine users due to the provision of each information element was subjectively assessed. A weighting factor was provided to modify the consequence of each wrong decision by the action of the user. An RCR score (Risk Consequence Reduction) was then computed for each information element -- user pair.

In this manner the information needs of CHRIS were prioritized. It was found, for example, that the top 19 information elements provided a 50 percent reduction in RCR. The most critical information elements for each phase could also be determined with this technique. It should be emphasized, however, that the prioritization is based upon subjective data.

OHM-TADS

Data have been gathered on the physical, chemical, toxicological, and commercial aspects of over 850 hazardous materials and placed in an automated data file. The file, referred to as OHM-TADS, is employed as the technical data source for the EPA Office of Oil and Hazardous Materials and is used by EPA personnel when they are called on to respond to a spill of a hazardous material. The file complements another file (SITREP) which is employed to store data and reports on past spills of hazardous materials.

National Pesticide Monitoring Program

The NPMP consists of an integrated interagency effort to restrict, control, and monitor the pesticides and their decay products in the environment. The program consists of three basic functions.

(1) Criteria - developed by published information, company data, brainstorming

(2) Registration - to control the quantity of pesticides entering the environment

(3) Technical Services - to develop monitoring techniques and to coordinate the efforts of the many environmental monitoring programs currently in existence.

Originally, NPMP was directed toward insecticides, specifically, the chlorinated hydrocarbons, organophosphates, and mercury-containing compounds. After several years of operation its scope was expanded to include polychlorobiphenyls and polychlorodibenzo-p-dioxins.

The generation of the list of chemicals for monitoring is an interesting feature of NPMP activities. Cognizant personnel in Federal agencies are asked to individually compile lists of candidate chemicals, based upon toxicity, quantity, persistence, and, of course, subjective opinion. These lists are merged and condensed (in keeping with the minimum scope of the NPMP) to produce a chemicals monitoring guide. The NPMP board meets once a month and, through a somewhat informal process, decides on list updating. The monitoring agencies participating in NPMP are directed to use this list as a guide, modifying the list as needed to account for local conditions.

Government agencies linked into this effort include: (1) EPA, (2) Department of Agriculture, (3) Department of Interior, (4) Department of Defense, (5) National Science Foundation, (6) Tennessee Valley Authority, (7) Department of Commerce,* and (8) Department of Health, Education, and Welfare.

Identification of Candidate Hazardous Solid Wastes

EPA, in fulfilling the requirements of the Resource Recovery Act of 1970, studied under contract the feasibility of a national system of hazardous waste disposal sites.(17) As a first step it was necessary to identify the nature and quantities of the hazardous wastes to be handled at these sites. In addition to a comprehensive evaluation of toxic and hazardous pure substances, candidate industrial waste substances believed to be hazardous were identified. A scheme for screening these candidates was developed and applied by Battelle. The scheme, shown in a generalized form in Figure 3, employed 11 tests each of which (if positive) served to classify a substance for treatment of a disposal site. These tests were:

- Radioactivity
- Bioconcentration
- Flammability
- Reactivity
- Oral Toxicity
- Inhalation Toxicity
- Dermal Irritation
- Aquatic Toxicity
- Phytotoxicity
- Genetic Changes.

Some 15 classes of wastes were designated as hazardous with a priority for concern.

RANN Programs on Identification/Effects of Trace Contaminants

The National Science Foundation, through its Research Applied to National Needs (RANN) program, supports an "Environmental Aspects of

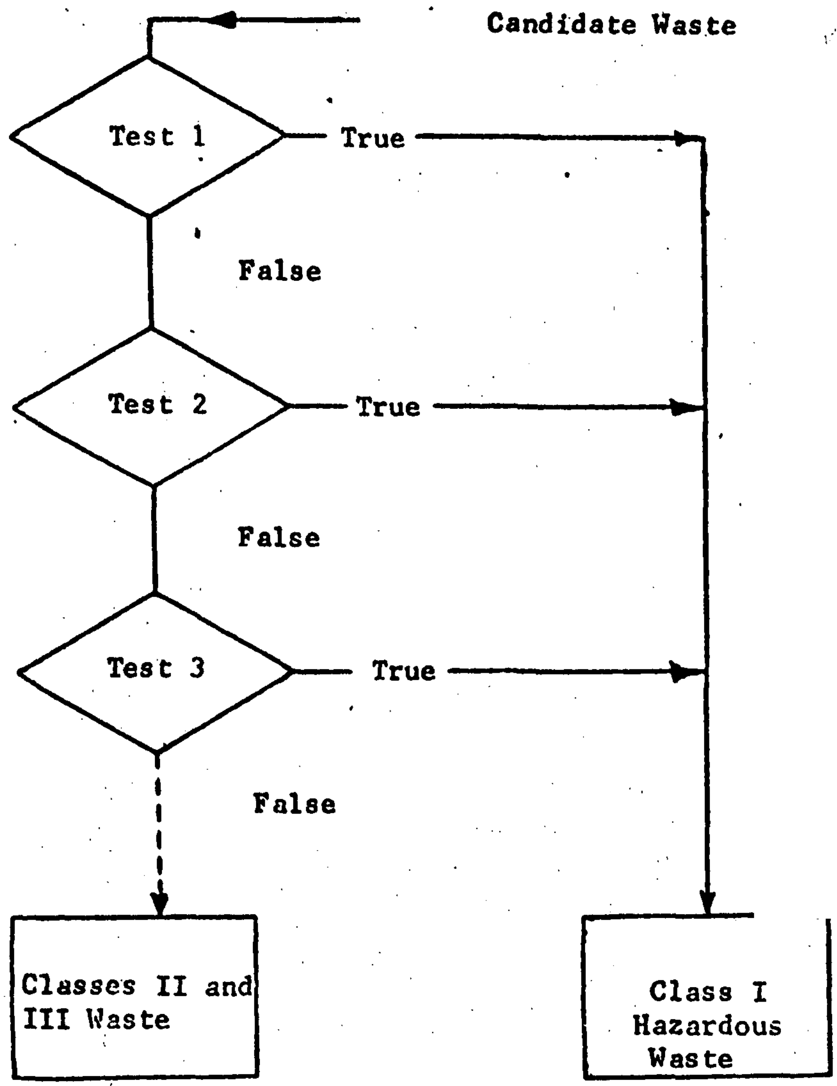


FIGURE 3. GRAPHIC REPRESENTATIVE OF THE HAZARDOUS WASTE DECISION MODEL

Trace Contaminants Program". The Trace Contaminants Program is principally concerned with determining the levels of toxic substances in the environment, assessing the effects of these levels on plants and animals, and relating these findings to assessment.

Trace substances selected in the recent past were considered on the basis of

(1) Intrinsic biological risk
(2) Geographic dispersion
(3) Quantity and persistence in environment
(4) Suspected accumulation technology
(5) Difficulty of avoidance.

Hence the program has recently devoted its resources to lead, mercury, molybdenum, arsenic, cadmium-zinc, and nitrates. Development of a microcosm approach to evaluation of ecosystem effects of chemicals (species eradication, bioaccumulation, etc.), is proposed as part of the continuing program to monitor such substances. Preliminary efforts of this nature have been described.[18]

A parallel NSF program is to be initiated in mid-1974 on synthetic organic chemicals. As the number of these compounds is quite large, NSF will initially support a formal identification/prioritization study to select 100 candidate substances. The preliminary selection will be based upon production levels and extent of dispersion into society and ultimately the environment. A final prioritization will employ parameters relating to dispersal of wastes and effluents, persistence, toxicity, and accumulation in the environment.

Summary

Current governmental programs, growing out of public concern about and legislation on the environment, require the identification and assessment of toxic and hazardous chemicals. Systematic approaches - usually restricted to a single media such as air, water, or land - have been proposed or applied for screening candidate lists of substances. While the utility to OTS of any single approach appears limited, the parameters used and the lists generated are of interest - if for no other reason than that they emphasize the complexity and extent of the toxic substance problem. As these efforts come to fruition, a number of useful data bases ought to become available to OTS.

Health/Environmental Management - CPEHS/OVERVIEW

Two conceptual identification/assessment systems have been formulated in recent studies for Federal agencies. Because of their pertinence to the objectives of this study, they will be described in more detail.

Technical, Intelligence, and Project Information System for CPEHS

Battelle Memorial Institute performed a study in 1970 for the Consumer Protection and Environmental Health Service (CPEHS) entitled "Technical, Intelligence, and Project Information System for the Environmental Health Service".[19] Although CPEHS was disbanded shortly after the study was completed, the objectives of this study were to examine, research, and develop program planning needs within the EHS and to develop a management assistance system for the EHS. Since a well-organized and readily accessible information base is essential to such planning, existing information capabilities and facilities within EHS were surveyed and an environmental health information network was devised. Two model case studies for two environmental stressors, lead and persistent pesticides, were performed to serve as examples during the project and to exercise the elements of the management assistance system.

The reports in this series were:

Volume I - EHS Management Assistance and Planning
Volume II - EHS Information Network Analysis
Volume III - Lead Model Case Study
Volume IV - Pesticides Model Case Study
Volume V - Directory of EHS Information Facilities with Selected Supplementary Resources

The Management Summary from this study is presented in Appendix F. In the discussions which follow, this work will be referred to as the "CPEHS" system.

OVERVIEW

The CPEHS study followed a similar one in 1967 for the U.S. Public Health Service, Office of Environmental Health, entitled "An Overview of Environmental Contaminants".[20] A summary of this report presented in Appendix G. Hereafter the term "OVERVIEW" will be used to refer to this system.

In considering the problem of a system designed to maintain an overview of the public health hazards of chemicals in the environment, the Battelle staff analyzed the nature of the questions which scientific evaluators might have to consider. The following are representative of some of the more important questions:

> What chemicals are of economic importance? In what quantities are they produced? Where are they used? Are they toxic?...in what amounts?...under what conditions? Does a given chemical present a potential public-health hazard? Is this hazard recognized? What changes are taking place in total production?...in the relative use patterns?...as new uses? Of what consequences are these changes to public health? Are there changes in per capita consumption of toxic materials? Are toxic materials accumulating in the environment? Are relatively harmless materials being replaced by more toxic materials?

The broad nature of the OVERVIEW considerations and the depth of knowledge required to properly evaluate possible threats to the environment are immediately evident. Given sufficient time and effort, it would be possible to answer most of the questions posed above for each material of interest. However, in view of the many materials that should be considered and the broad scope of the information required to answer such questions, it was considered mandatory to identify those factors most critical in determining or rating a possible threat. The identification of these factors would, in turn, reduce the total amount of information and data over which surveillance would have to be maintained.

Discussion of CPEHS and OVERVIEW

The CPEHS approach emphasized problem identification, evaluation, and priority setting of potential threats to man and the environment from the perspective of environmental "stressors" - a stressor being defined as a chemical compound or element, biological agent, or physical, social, or psychological condition. OVERVIEW, on the other hand, focused on systematic surveillance of critical indicators to identify potential chemical threats to public health. The approaches to threat or stressor identification, evaluation, and prioritization for each study are worth reviewing.

Identification. The threat identification and evaluation scheme developed for CPEHS was one of three functions of the conceptualized management assistance system. The first function was that of overall environmental health planning, which had as an objective coordinated and comprehensive R&D planning. The second function was to provide assessment of the environmental impacts of technology. The CPEHS final report states...

> "These functions would be complemented by the third function, threat identification and evaluation, which has as its focus the potential threats to man and his environment through intensification or extension of current use patterns of products and services or through the introduction of new chemical, biological, or physical stressors into the environment.
>
> Threat evaluation involves two phases, threat identification and threat assessment. The threat-identification function would be performed by a small group of individuals representing physical, chemical, and biological disciplines. It would be the purpose of this group to question trends or patterns in given industrial, urban, occupational, domestic, and recreational areas and to evaluate in a cursory

> manner the available information that might suggest the possibility of a threat. An Environmental Health Information Network (EHIN) would be used for this purpose. If a possible threat were identified, a threat evaluation mechanism could be set in motion by EHS. Depending upon the magnitude of the potential threat, a center of technical competence may be established."

The threat identification scheme identified in the CPEHS study would appear to be workable under conditions where the total number of potential threats is small, so that the expert group is not overwhelmed. Hence, the scheme might be applicable to the consideration of broad classes of chemicals (pesticides, POMs, etc.) but not to individual chemicals.

OVERVIEW describes a more direct means of identification based upon (1) the fact that current concerns of materials will be reflected in current publications and (2) that the alternative of a direct survey as a means of determining the materials of current concern to environmental-health specialists would be a costly and time-consuming operation. The first approach was tested through the use of the latest available indexes to abstract journals to identify materials causing concern as expressed in the primary journal literature.

The 1964 subject index of Industrial Hygiene Digest, and the 1965 subject index of Public Health Engineering Abstracts were assumed to represent, in part, a compilation of those chemical terms related to materials of significance to environmental public health. Names of elements, compounds, and a few broader terms appearing in these indexes were selected and the number of citations for each was tallied. Other entries such as the use of chemicals for insect control or water treatment were omitted except where there was an established adverse public-health aspect. From this analysis 286 chemicals were recognized during the period 1964 - 1965 as being potential hazards and, therefore, of possible concern.

This approach has a shortcoming in the sense that it is passive. Using this technique identification of a potentially hazardous material will be delayed until the publication of some number of documents, which in turn depends upon the prior arousal of the concern of the scientific community about the potential hazard. Thus, a time delay of several years is introduced during which production and utilization of signficant amounts of the material can occur.

Evaluation. An element of the CPEHS study was the development of a coordinated, agglomerated Environmental Health Information Network (EHIN) which would serve in part as a threat evaluation tool (the threat having been previously identified). Figure 4 presents the scheme of the proposed EHIN. The nomenclature of Figure 4 has the following meanings:

MSIIS - Monitoring, Surveillance, and Intelligence Information System
STIS - Scientific and Technical Information System
PIRS - Project Information Retrieval System
IRIS - Information Resource Identification System
CTC - Centers for Technical Competence.

It should be stressed that EHIN would not have been a capping organization. Rather, it would be a coordinated network of available and proposed resources all of which could be accessed to assure a total and direct assistance of all pertinent resources on any environmental project.

Evaluation of a hazard in the OVERVIEW study would be accomplished by a literature review. In order to maintain surveillance over materials of concern, a list of critical indicators was compiled. Particular emphasis was placed upon rapid evaluation of possible threats to the environment.

Table 4 is a composite list of the critical indicators divided into five major categories. In addition to their role as critical indicators these terms also served as a basis for organizing literature and other communications of direct concern to OVERVIEW.

Based upon several case studies (Hg, V, Ni, fluorocarbons, pulp and paper chemicals) and the critical indicators of Table 4, it was found that a limited, well-defined body of literature should permit a comprehensive surveillance of the contamination of man's environment by chemicals. This list of publications is given in Appendix H under the heading of "Chemistry and Industry".

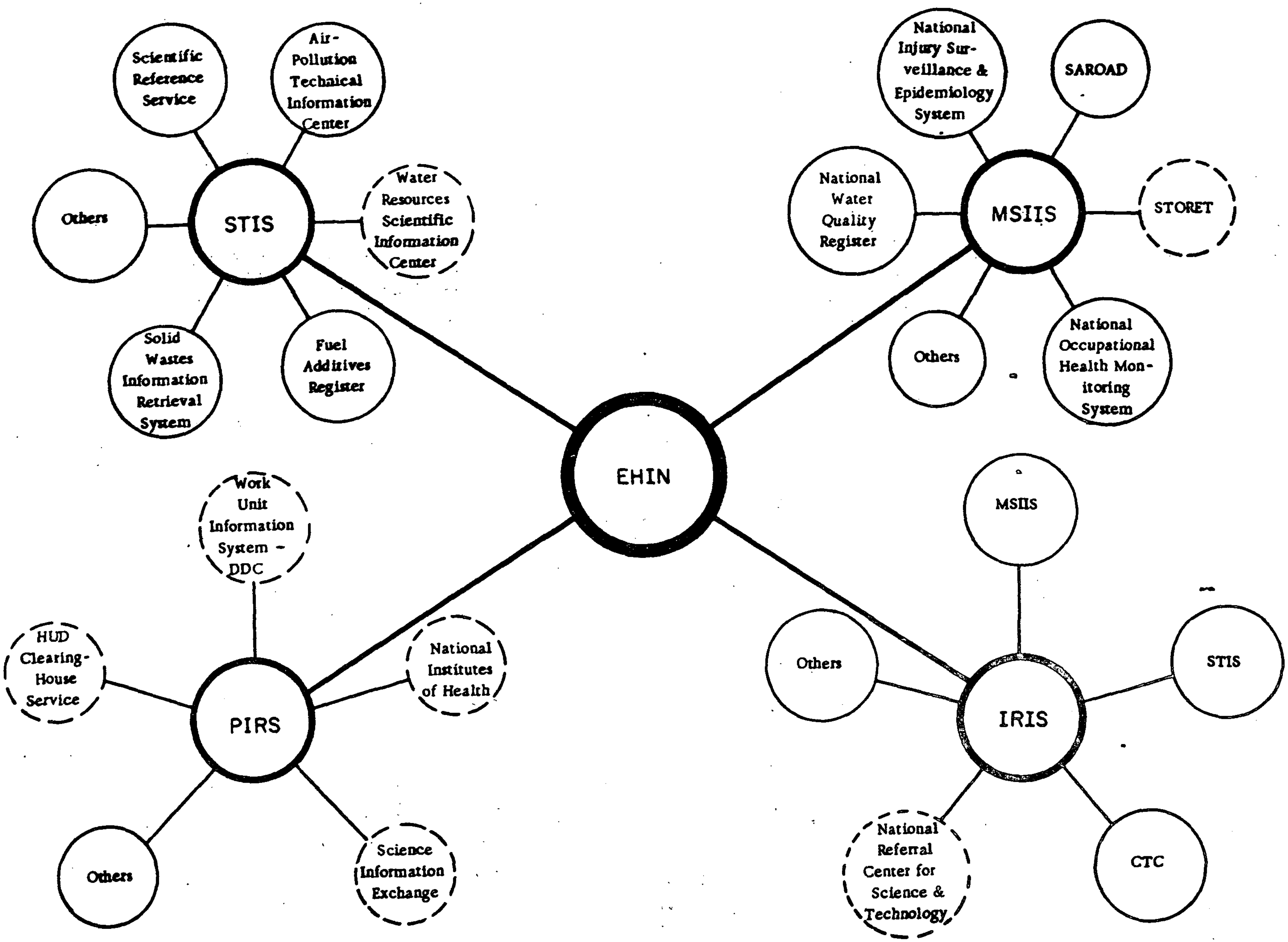


FIGURE 4. THE ENVIRONMENTAL HEALTH INFORMATION NETWORK SHOWN IN THE AGGLOMERATED, COORDINATED CONFIGURATION

TABLE 4. LIST OF CRITICAL INDICATORS

(1) Environmental contamination

- (a) Geographical distribution
- (b) Distribution between soil, water, air, and life
- (c) Biogeochemical cycle of major formulations

(2) Toxicological manifestations

- (a) Physiological interaction with man
- (b) Toxicity level
- (c) Symptomatology
- (d) Epidemiology

(3) Primary production

- (a) Description of processes
- (b) Number and location of plants
- (c) Annual production records
- (d) Distribution by use categories

(4) Secondary-product formulation

- (a) Description of processes
- (b) Number and location of plants
- (c) Capacities and production by end product

(5) End-product distribution and use

- (a) Historical records
- (b) Current annual use data
- (c) Identity and properties of most important formulations
- (d) Industry forecasts

On the other hand, the areas of ecological and toxicological information and the reporting of new pharmacological and biochemical discoveries of possible importance were found to be not so amenable to surveillance. In Table 4, these areas are represented by the critical indicators listed under (1) environmental contamination and (2) toxicological manifestation.

It was found to be virtually impossible to identify and segregate a limited body of primary journals that would permit the maintenance of an adequate overview of these latter areas. New information and data in these areas of "OVERVIEW" concern are diffused throughout English and foreign-language publications. This means that in order to be alert to these events, a broader coverage of United States' and the world's literature, and a greater reliance on abstracting services, has to be maintained than is necessary for "Chemistry and Industry". Accordingly, a limited list of source materials that would permit a reasonable surveillance to be maintained has been developed. This final selection is represented by the remaining six sections of Appendix H.

Appendix H, then, represents a minimal list of publications to be screened and judged to provide a high degree of coverage of the world's literature as related to OVERVIEW concerns. Fourteen principal abstract journals were included to permit surveillance of this body of literature. In addition, applicable "newsletters" were included in this list.

It is estimated that this list of journals, abstracts, and information sources should permit coverage of 70 percent or more of the desired information. Surveillance of this body of literature for the indicators in Table 4 of the chemicals of concern should provide the information necessary for the scientific review of the potential hazard of each chemical.

Prioritization. Only the CPEHS study considered the problem of prioritization. Three basic approaches were examined. One, a relevancy matrix, was based on subjective assignment of an impact level (e.g., A, B, C, or D) to a given problem or stressor for a number of quality of life indices (esthetics, land use, danger to health, etc). A second was the use of a formalized, expert weighting scheme. The third approach considered was a numerical rating index, i.e., a health potential index (HPI).

The health potential index (HPI) incorporated in a single product the population-at-risk and the severity of the effect at a single point in time, e.g., the present. The value of the HPI was directly related to the availability and accuracy of the input data, especially the toxicological data. If no health effects have been observed from a stressor, or if the concept of a threshold dose for acute symptoms is not valid, then the HPI has little meaning. Many potentially important health effects may be missed with the HPI because missing or negative information cannot be included. Synergisms are also not included. The HPI, however, represents a rapid means of evaluating the health components of environmental problems. The fact that one is forced to state the potential explicitly is a step toward rigorous and defensible priority setting.

The health potential index is based upon the assumption that the chronic exposure to a stressor can be expressed as the ratio of the body burden of the stressor (in concentration units) to the threshold body burden (in concentration units) at which acute effects are observed. The weighting factor for the acute effect was arbitrarily defined as unity; chronic effects were by definition less than unity. The health potential index is a combination of the population-at-risk and the severity index. Separation of the population into two groups based upon body burdens should have been done in a reasonable manner for each stressor. As defined, the HPI represents the current status. To provide further information to the decision maker, the health index should be followed by a plus if, in the judgment of the expert, the index will increase with time over the planning horizon; and with a minus if it is decreasing, or a zero if no change is expected. The health potential index for a stressor, s, was defined as

$$HPI_s = (N_a S_a)_s + \Sigma_j (N_{C_j} S_{C_j})_s \quad ,$$

where

N_a = number of people exhibiting acute symptoms

S_a = severity indicator for acute effect = 1

N_{C_j} = number of people with body burden of the stressor at concentration C_j

S_{C_j} = severity indicator at body burden $C_j = \dfrac{C_j}{C_{threshold,\ acute}}$.

It is seen that three separate ranking schemes were proposed to EHS. The first two relied upon variations of the "wise man" approach, i.e., a consensus of experts, to determine priorities for R&D planning. The third ranked specific problems by the application of an objective deterministic indicator (HPI).

Summary

In summary, both the CPEHS and OVERVIEW studies have addressed the questions of identification and evaluation of environmental hazards, and the CPEHS study provides insight into the prioritization problem. Both studies conclude that an information network is an essential aspect of any planned system, in one case utilizing a subset of published information, and in the other utilizing a variety of monitoring, surveillance, and technical information centers.

Discussion of Results

A large number of systems (including information systems) exist which are predicated on the identification, assessment, and prioritization needs of specific, mission-oriented organizations. While systems used by governmental agencies in the health and environmental areas were emphasized in this program, there are probably as many industrial and private systems that could be identified. For example, it became apparent during the early warning seminar that even public-interest groups, such as the Center for Science in the Public Interest, function as a system for alerting the public to the hazards of toxic substances by contributing their members, as sensors of potential problem substances, to an active study-assessment effort. The larger industrial chemical firms undoubtedly have internal systems for the identification and assessment of new chemical hazards. (It is believed that these are the subject of at least one other OTS study.)

A sufficient number of system types has been identified in this program to provide convincing evidence that

(1) No system exists which in itself will accomplish all the selection and assessment functions for toxic chemicals implied in the question posed by OTS. A few provide some of these functions in limited areas, such as carcinogenic, workplace, or environmental hazards. A basis for adapting these to include all functions (such as assessing synergistic effects) is not readily apparent.

(2) While many additional systems could be identified through continued search efforts, these would turn out to provide essentially the same general functions as those reported in this study. In general, these functions include surveillance, surveying, monitoring, screening, reporting, sampling, testing, data compilation, or manipulation, etc., for identification, assessment, or prioritzation purposes.

The evidence for the first item should be apparent from the systems described in preceding sections. Further examination of some underlying commonalities and differences between the various system-methodologies tends to support the latter statement.

Commonalities/Differences

In searching the systems of Appendix D for an existing methodology applicable to the four questions posed by OTS, some underlying commonalities of methodology were recognized. For example, the scope of the existing systems directed at chemicals is without exception more specific than the perceived needs of OTS. Existing systems have their scope limited by:

(1) class of chemicals

(2) the source of chemicals

(3) the transport media leading to exposure, and/or

(4) the affected species.

In addition, existing systems focus implicitly upon acute rather than chronic effects, due mainly to the orientation of published literature towards acute effects. Thus, while the systems identified might be recognized as partial solutions to OTS' needs, the expansion of the scope of any existing system is obviously not easily accomplished.

Another area of commonality lies within the goals of existing systems. Almost every system studied has as a basic goal the determination of a potentially hazardous subset of chemicals or chemical classes from a larger list of candidates. This process may be accomplished in a single step, or a hierarchy of steps may be employed, with each step again consisting of the determination of a potentially more hazardous subset.

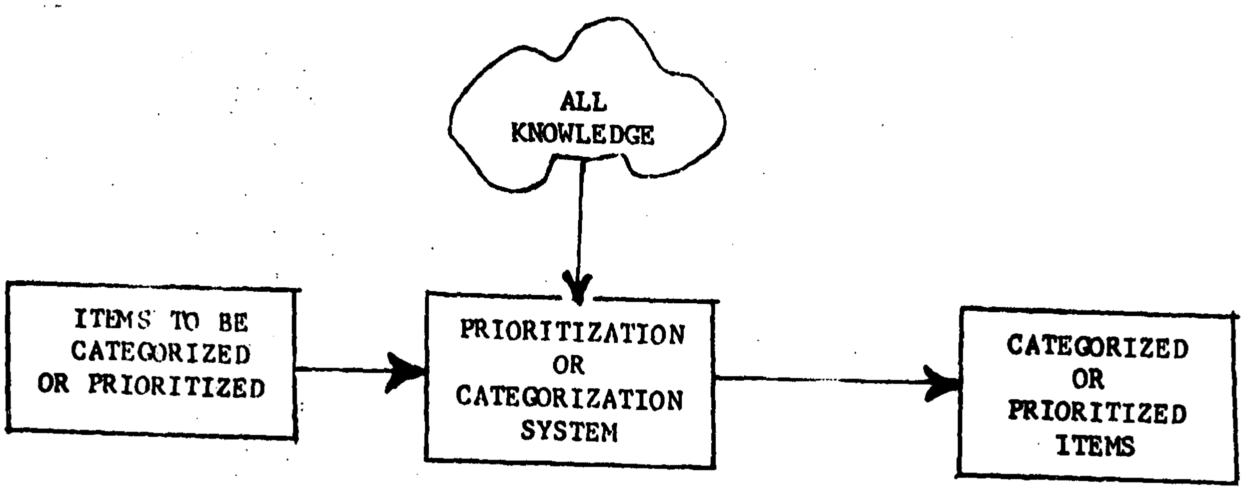
Each step may be viewed as a process in which information is gathered for the list of chemical candidates and combined in some manner to produce an assessment of the estimated hazard on a univariate scale. The utilization of judgment to provide a true/false answer to the question of hazard is an example of the combination/assessment process.

The first step does not have a preceding step to provide a candidate list. Many existing systems have developed sensor networks to generate the chemicals on the original candidate list. One frequently employed sensor network for existing systems is the use of the literature, i.e., either monitoring the raw literature or condensations of literature. The NIOSH Toxic Substances List,[5] for example, relies upon Chemical Abstracts as a source of chemical names and information. Further information needed for the list is obtained from the open literature. Some systems studied, however, relied upon previously published candidate lists, hence the first step had been previously accomplished for these systems. Another example of a sensor network for the generation of an original candidate list, typified by the approach used by the National Pesticide Monitoring Program, was the collected judgment of professionals, queried and resolved by the Delphi technique. This approach is feasible when the candidate list is relatively small.

Some sensor networks are monitoring networks in the real environment. The NIESS system (Appendix D) of the Consumer Product Safety Commission, for example, generates its candidate list for hazards from hospital emergency room reports. This approach is useful when a direct, measurable cause-effect result can be observed after the fact.

After their sensor networks establish candidate lists of chemicals, existing systems determine a potentially hazardous subset of chemicals through a single or repeated application of information collection and decision-making. The large number of sources of chemical information was referred to earlier (Table 2).

After the information is collected, existing systems manipulate the information to form a design basis by which prioritization/classification decisions can be made. A general framework has been structured which expresses the design basis of most existing prioritization systems. This general basic system for prioritization or categorization accepts from the universe of knowledge a small subset of information. This information subset is then processed and combined to produce categories or priorities. Graphically, the process is as follows.



To design or adapt a prioritization/categorization system, it is necessary to specify

(1) The subset of information to be used by the system

(2) The algorithm by which the subset of information will be manipulated and combined.

Examination of the existing systems suggest three approaches to the design of a prioritization/categorization algorithm

(1) The "wise man" approach, a subjective design where the system framework is established on the basis of perceived needs and an assessment of available resources. The National Pesticide Monitoring Program, and many contemporary systems appear to have been formulated this way.

(2) The "index" approach, a design based upon a specific ranking parameter formed algebraically and/or logically from other data. This would be exemplified by a system for ranking hazardous waterborne substances by the volume of water necessary to dilute expected annual spillage to a safe or limiting concentration.

(3) The "optimized" approach, designs wherein the parameters are selected for producing categories or priority ranking on the basis of assigned values and weightings. This was the technique employed in the Coast Guard's Chemical Hazard Ranking Information System (CHRIS).

These approaches can be exemplified by reference to a few of the existing systems.

"Wise Man Approach". A classic example of the "wise man" approach is given by the National Pesticide Monitoring Program.* Its list of pesticides of concern was constructed via a collective set of opinions, based on toxicity, quantity, and persistence.

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* See Appendix D.

Index Approach. An index can be constructed by two methods. In a stochastic construction, statistical techniques are used to derive indices from a wide variety of data or observations. A large amount of data are generally required for the stochastic approach. The deterministic construction identifies or deduces (subjectively) relevant indices from the area of concern. The indices may be algebraic and/or logical combinations of data. Frequently an index may have a physical meaning.

Stochastic Index. In 1971, Synectics Corporation[25] developed a system for allocating priorites to industrial waste treatment R&D projects. In this study, three priority indicators were derived by the stochastic technique from existing, implicit EPA priorities.

Each of the indicators was derived by the utilization of past Federal funding to provide rank order as a dependent variable. The independent variables for the three indices (location, constituent, and industry) are presented in Table 5. A statistical technique was used to derive the three indices from the gathered data. These indices were then utilized to prioritize future EPA expenditures by state and by industry.

The scheme presented by Synectics typifies the construction of a stochastic index to perform prioritization. The data utilized to construct the index, however, (Federally funded) must be viewed as subjective data representing at best a consensus opinion of experts.

Deterministic Index. Many examples of deterministic indices are available. Such an indicator was proposed in the CPEHS study in which a conceptual system was derived to examine research and development program planning needs, and to develop a management assistance program. The prioritization scheme of the study is based on a deterministic index.

As the study did not have the data to perform priority ranking, and such data would not be available to CPEHS for several years after implementation, the ranking was never performed. An intermediate alternative method was proposed, however. This was in essence a "wise man" approach, utilizing value judgments from experts.

TABLE 5. INDEPENDENT VARIABLES FOR STOCHASTIC INDICES IN EPA PRIORITIZATION OF FUNDING

Locational (State as Case)	Effluent Constituent (State as Case)	Industrial Volume (SIC 2 digit code as Case)
Industrial Waste Water Volume	Effluent Volume	Industrial Effluent Volume
Population	State Standard	Water Use
Valve added by Manufacturer	Economic Effects	Value added by Manufacture
Annual Runoff	EPA Regional Standard	Employment
Water Area	Public Notice	Number of States with Plants
Population Density	Low Concentration Limit	Total Plants
Industrial Water Use	High Concentration Limit	Plants using >20 mgy
	Relative Cost of Removal	

Other examples of deterministic indicators are available. These include

(1) A water hazard ranking scheme which utilizes volume transported, accident probabilities, and critical concentrations to provide a rank based upon the expected volume of water polluted to the critical concentration annually[13]

(2) A solid waste hazard screening system which classifies a material as very hazardous if the material meets any one of eleven criteria. This is an example of a logical (as opposed to algebraic) indicator[17]

(3) An air hazard ranking scheme[21] analogous to (1) above, but including stationary sources. Stationary sources produced an index based upon a record of accidents with arbitrary scoring, while mobile sources produced an index analogous to (1) above, but with considerations of volatility and hazard ratings. The two indices were combined logarithmetically to produce a hazard ranking index, for accidental air pollution episodes.

(4) The Office of Water Programs has developed a list of hazardous substances based upon a logical deterministic index. Data considered includes half-life, bioconcentration, radiotoxicity, lethality (in aqueous, oral, dermal, or vaporous), oxygen demand, and nuisance aquatic growth stimulation.[22]

(5) Each year NIOSH provides a priority list for Criteria Development for Toxic Substances and Physical Agents.[5]

"Optimized" Approach. The Coast Guard CHRIS system described earlier[16] is an example of the "optimized" approach. The study contains an analysis of information requirements for an accidental spillage incident. The prioritization of the information needs demonstrated that 19 of the 144 perceived needs satisfied 50 percent of the total need.

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APPENDIX A -1

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APPENDIX A

BIBLIOGRAPHY OF MACHINE-SEARCHED LITERATURE

Subject Index

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APPENDIX B-1

<u>CONTACTS FOR INFORMATION GATHERING PURPOSES</u>

B-1

TABLE B-1. CONTACTS FOR INFORMATION GATHERING PURPOSES

Agency/Unit	Persons	Type of Contact		
		Telephone	Correspondence	Visit
(1) National Cancer Institute				
a. Carcinogen Bioassay and Program Resources Branch	Dr. Sidney Siegel	X	X	X
b. Biometry Branch	Dr. James L. Murray	X	X	
(2) Center for Disease Control				
a. Toxicology Program	Dr. William Barthel			X
b. NIOSH - Cincinnati, Ohio				
1. Director of Programs	Dr. Bobby F. Craft	X	X	X
2. Industrial Hygiene Services	Mr. Thomas Anania			X
	Mr. Richard Lewis			X
3. Hazard Evaluation Section	Mr. Jerry Flesch			X
4. Medical Investigation Branch	Dr. William Parnes			X
5. Division of Laboratories and Criteria Development	Mr. William Kelly			X
6. Toxicology Branch	Dr. Lewis Trent			X
	Mr. William Wagner			X
	Dr. Xintaras			X
c. NIOSH - Rockville, Maryland				
1. Priority Evaluation Branch	Mr. Richard James	X		X
2. Office of Research and Standards Development	Mr. Vern Rose			X

TABLE B-1. CONTACTS FOR INFORMATION GATHERING PURPOSES
(Continued)

Agency/Unit	Persons	Type of Contact		
		Telephone	Correspondence	Visit
(3) Food and Drug Administration				
a. Bureau of Drugs	Mr. Henry Vernhulst	X		X
b. Division of Electronic Products	Dr. Roger H. Schneider	X		X
	Dr. Robert L. Elder	X		
c. Bureau of Biologics	Mr. Lawrence Stern	X		X
d. Bureau of Foods	Dr. Fischbach	X		
e. Division of Toxicology	Dr. W. G. Flamm	X	X	
(4) National Center for Toxicological Research	Dr. John M. Clayton	X	X	
(5) Consumer Product Safety Commission				
a. Bureau of Product Safety	Dr. John Locke	X	X	X
	Mr. Theodore Woronka	X		X
(6) Department of the Army				
a. Walter Reed Army Medical Center	Dr. Anne C. Fred	X	X	
(7) National Heart and Lung Institute	Dr. C. J. M. Lentant	X	X	
(8) Bureau of Veterinary Medicine				
a. Division of Compliance	Mr. Friedlander	X		
(9) National Institute of Allergy and Infectious Diseases	Dr. Frank Neva	X		
(10) Stanford Research Institute	Mr. Arthur A. McGee	X	X	X
	Mr. Stephen Brown			X

TABLE B-1. CONTACTS FOR INFORMATION GATHERING PURPOSES
(Continued)

Agency/Unit	Persons	Type of Contact: Telephone	Correspondence	Visit
(11) National Science Foundation				
a. RANN Trace Contaminants Program	Dr. Robert Rabin	X		X
(12) New York University Medical Center	Dr. Norton Nelson	X		
(13) National Research Council	Dr. Ralph Wands	X	X	X
(14) National Academy of Sciences				
a. Environmental Studies Board	Mr. J. Charles Baummer, Jr.	X		
(15) Oak Ridge National Laboratories Toxic Materials Information Center	Mrs. Emily Copenhaver			X
(16) National Institute of Environmental Health Sciences	Dr. Douglas Lee	X		
	Dr. Otto Bessey	X		X
(17) Environmental Protection Agency				
a. Office of Toxic Substances	Mrs. Benigna Carroll	X		X
b. Office of Pesticides Programs	Dr. Robert O'Brien	X		
c. NERC-RTP	Dr. Anthony Colucci	X	X	
	Dr. Gordon Hueter	X	X	
	Dr. Douglas Hammer	X		
	Dr. Harry Landon	X		
d. NERC-Las Vegas	Dr. Edward Schuck	X		X

TABLE B-1. CONTACTS FOR INFORMATION GATHERING PURPOSES
(Continued)

Agency/Unit	Persons	Type of Contact: Telephone	Correspondence	Visit
e. Office of Air Programs, SAROAD	Mr. Gerry Akland	X		
f. Office of Water Programs	Mr. Alan Wastler	X		
	Mr. Jerry Tempchin	X		
	Mr. Bob Worn	X		
(18) Department of Agriculture				
a. Agricultural Research Service	Mr. Milt Schechter	X	X	
b. Forest Service	Mr. R. Keith Arnold	X		
(19) Department of Commerce				
a. NOAA	Dr. Richard E. Hollgren	X		
b. NOAA-MARMAP	Mr. Howard Schuck	X		
(20) Department of the Interior				
a. Geological Survey	Mr. Ernest L. Hendricks	X		
1. National Stream Quality Accounting Network	Mr. R. H. Langford	X		
b. Bureau of Land Management	Mr. Paul Howard	X		
c. Bureau of Mines	Mr. Joseph Corgan	X		
d. Bureau of Reclamation	Mr. Elwood A. Seaman	X		
e. Office of Water Resources Research	Mr. Raymond A. Jensen	X		
(21) International Joint Commission - United States and Canada	Mr. Eugene W. Weber	X		

TABLE B-1. CONTACTS FOR INFORMATION GATHERING PURPOSES
(Continued)

Agency/Unit	Persons	Type of Contact: Telephone	Correspondence	Visit
(22) National Aeronautics and Space Administration				
a. Earth Observation Programs	Dr. John N. DeNoyer	X		
(23) National Science Foundation				
a. International Decade of Ocean Exploration	Mr. Feenan D. Jennings	X		
(24) Smithsonian Institute				
a. Office of Environmental Sciences	Mr. William Eilers	X		
b. Center for Short-Lived Phenomena	Mr. Robert A. Citron	X		

APPENDIX C - 1

SEMINAR ON EARLY WARNING SYSTEMS FOR TOXIC SUBSTANCES

APPENDIX C-1-a

SEMINAR ON EARLY WARNING SYSTEMS FOR TOXIC SUBSTANCES

INTRODUCTION

This appendix summarizes the activities and results of a seminar on "Early Warning Systems for Toxic Substances" held January 30 - February 1, 1974, at Battelle's Seattle Research Center in Seattle, Washington. The seminar was funded jointly by Battelle, EPA's Office of Toxic Substances, the National Science Foundation, and the National Institute of Environmental Health Sciences.

The relationship of this seminar to the current program (Contract 68-01-2108) was described in the Battelle-Columbus proposal of June 1, 1973, in response to RFP WA-73-R337. At that time, it was noted that the suggestion for a seminar on early warning methodologies for toxic and hazardous pollutants had been put forth internally at Battelle and that such a seminar might provide a good forum for critiquing some of the systems to be identified.

Battelle's motivation for organizing a seminar on this topic had its roots in two major programs[1,2] conducted for HEW from 1967-1970. Both of these programs examined approaches for identification, assessment, priority setting, and the alerting of the public to health and environmental stressors due to toxic substances and other conditions. Consequently, it was with considerable enthusiasm and interest that this effort was undertaken. OTS' decision in November, 1973, to partially fund the seminar was most welcome, and from that point on EPA's inputs were a continuing part of the planning of the seminar.

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(1) Lutz, G. A., et al., "Design of an Overview System for Evaluating the Public Health Hazards of Chemicals in the Environment", USPHS Contract DA-86-66-165 (1967).

(2) Morrison, D. L., Levin, A. A., et al., "Technical, Intelligence, and Project Information System for the Environmental Health Service", Vol. I-V, HEW Contract CPS 69-005 (1970).

DESCRIPTION OF SEMINAR

Objectives and Scope

Many governmental, industrial, and private organizations today have either goals or legal requirements to regulate, limit, or control the short- and long-term exposure of man and the environment to substances which have or are likely to have an adverse impact. The number of candidate substances is quite large, and new ones regularly come into existence and commercial use. A need exists to identify, from among the candidates, those substances which constitute the more significant hazards so that the allocation of limited resources for their control and study can be made in a rational manner.

The seminar focus then was on (1) approaches, methodologies, or systems--conceptual or currently operational--applicable to the early identification, assessment, and prioritization of toxic substances; and (2) discussion of the problem of providing adequate early warning in the absence of data on the health or environmental impact of many substances in question. Early warning was defined at the outset as having these aspects:

(1) The identification of hazards associated with chemicals now in use, before such usage increases the level of hazard;

(2) The identification of hazards likely to be presented by the incorporation of an existing commercial chemical into a new product-line or use category

(3) The identification of potential hazards associated with new chemicals at a reasonably early point in the laboratory--pilot scale--commercialization sequence.

Thus, the objective of the seminar was to elucidate and critically examine the tools that exist for identifying and assessing a priori toxic or hazardous substances and to assess their practicality for the early warning need.

Format

The seminar comprised three discrete and distinct sessions held on three successive days. Each session was a combination of formal papers, a panel discussion, and time for the airing of viewpoints, comments, questions and answers, etc., for all participants. The seminar program and timetable are included at the end of this appendix. A brief summary of each session follows.

Session I. Effects, Legislation, and Incidents

This session was designed to examine the extent of the toxic substance problem in terms of (1) health and environmental effects, (2) the basis of and need for legislation, and (3) early warning needs. A panel discussion on institutional perspectives was held with the intention of displaying the varying viewpoints of the participants towards the need for early warning, its definition, and the toxic substance problem in general.

Session II. Early Warning System Elements

This session attempted to focus on concepts, approaches, existing tools, needs, and other considerations related to the establishment of an early warning system. As a framework in identifying appropriate speakers, three conceptual elements of an early warning system were defined for examination: (1) identification of chemicals or classes of chemicals as candidates for evaluation; (2) assessment of short- and long-term health or environmental hazards, cost benefit tradeoffs, etc., as a step in selecting substances for emphasis in testing, development of control measures, regulation, etc.; and (3) alerting the public to identified hazards in a controlled manner. A panel discussion was held to summarize what the various speakers said relative to these three elements and supplement this information with thoughts from the participants at large.

Session III. Early Warning Systems/Subsystems

The intention of this session was to present information about a few actual or conceptual systems which have some of the early warning aspects reviewed in Session II. A final closing panel discussion was designed to raise the questions (1) where do we go from here, (2) what are some of the R&D needs, and (3) how can an early warning system be implemented?

Participants

About 65 persons participated in the seminar. Among those represented were (1) U. S. government agencies--NCI, AEC-ORNL, NSF, EPA, NIEHS, NIOSH, FDA, DOD; (2) Canada--Environmental Protection Service, Environmental Health Centre, Brock University; (3) industry--Dow, DuPont, Monsanto, Eastman, Esso, Hercules, Cyanamid; (4) universities--Columbia Oregon State, Utah, Colorado State, Washington, New York University Medical Center; (5) research institutes--Battelle, Stanford, Syracuse, NAS; and (6) a public interest group--Center for Science in the Public Interest. Thus, the participants represented a fair cross-section of the institutions concerned with the problem.

RESULTS

It is not possible to adequately assess the results of a seminar like this from the viewpoint of one or a few participants. Nevertheless, it is Battelle's belief that the seminar was highly successful in achieving the desired aim of examining in a public forum the tools and viewpoints that exist relative to the need for early warning. A good many issues regarding the need for workability and practicality of early warning were raised. At the risk of misstating the real consensus of the seminar's participants, a few comments which may reflect the results of three days of discussion will be attempted.

(1) On the need for and nature of an eventual early warning system--a good case, indeed a good definition of early warning beyond that stated as a premise for the seminar for development of a single comprehensive early warning system was not made. Rather it was pointed out that quite a number of institutional programs are in existence today which serve to alert the public to toxic substance hazards. These include: (1) public interest groups, such as the Center for Science in the Public Interest; (2) systematic assessment programs such as those carried out by the

National Cancer Institute, and based on the accumulation and examination of data regarding human exposure, chemical toxicity, and epidemiology; and (3) the Consumer Product Safety Commission's Surveillance of product related hazards (including chemicals) via their NEISS* program. Consequently, early warning is more likely to be achieved through a variety of integrated approaches, systems, and institutional responses to specific needs. There are questions as to who the users of such a system might be as well as what kind of agency should operate it (regulatory, advisory, etc.)

(2) On the availability and access to data for chemical hazard assessment--there are many reservoirs of available data on toxicity, persistence, production, use patterns, and environmental health hazards. Numerous data banks are in existence and a number are being developed. On the other hand, gaps in data-needs exist, e.g., there is a dearth of information on long-term, low-level effects of chemicals. The problem for the available data is gaining access within the time-frame of need. The notion that industry is sitting on a mountain of data needed for early warning or toxic substance assessments was disputed. The problem seems to be more of not knowing precisely what data are needed or necessary, thus making blanket requests for the turnover of industry's data unrealistic. Industry associations may be a vehicle for the interfacing of public needs with industrial proprietary data. The cost of generating comprehensive long- and short-term toxicological data on new substances is an issue with industry. A stepwise approach related to level of introduction into use or use category seems needed.

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* National Electronic Injury Surveillance System

(3) On toxic substance legislation--it is not a matter of "if" but of "when". Pending energy legislation appears to be delaying progress on the Toxic Substance Control Act.

(4) On alerting the public--there is general agreement that it is essential to prevent premature arousal of the public to possible hazards. The role of the public interest group in this regard is sensitive. Forcing premature decisions (banning) which may have to be reversed later can affect public confidence in future warnings.

(5) On risk-benefit-costs--theoretical approaches to assessing these tradeoffs exist, but their practical application is difficult, especially with respect to longer-term quantification. There seems little doubt that assessment of these factors should be a part of early warning efforts.

SEMINAR

ON

EARLY WARNING SYSTEMS FOR TOXIC SUBSTANCES

Cosponsored by

BATTELLE MEMORIAL INSTITUTE
ENVIRONMENTAL PROTECTION AGENCY—
OFFICE OF TOXIC SUBSTANCES
NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES
NATIONAL SCIENCE FOUNDATION

January 30 — February 1, 1974

BATTELLE'S SEATTLE RESEARCH CENTER
4000 Northeast 41st Street
Seattle, Washington 98105

PROGRAM

Tuesday — January 29, 1974

7:00- 9:00 Registration and Mixer at the Center

Wednesday — January 30, 1974

8:30- 9:00 Registration at the Center

9:00 Welcome, T.W. Ambrose, Battelle's Seattle Research Center

9:05 Introductory Remarks, Mr. Frank Butrico, Battelle Memorial Institute

9:15 Keynote, Dr. Norton Nelson, New York University Medical Center

SESSION I EFFECTS, LEGISLATION, AND INCIDENTS
Chairman Farley Fisher, Office of Toxic Substances, Environmental Protection Agency

9:45 Session Chairman's Comments

9:50 Human Health Aspects — Anthony Colucci and Paul Brubaker, NERC-Research Triangle Park, Environmental Protection Agency

10:20 Coffee Break

10:50 Environmental Aspects — John Fortesque, Brock University, Canada

11:20 Legislation and Laws — Michael B. Brownlee, U.S. Senate Commerce Committee Staff

12:00 LUNCH

1:00 An Incident of Industrially Related Toxic Peripheral Neuropathy—Bobby F. Craft, National Institute of Occupational Safety and Health

1:30 An Industry's Experience — Elmer P. Wheeler, Monsanto Company

2:00 Coffee Break

2:20 Panel Discussion on Institutional Perspectives of Early Warning—Chairman Otto Bessey, National Institute of Environmental Health Sciences

Thursday — January 31, 1974

SESSION II EARLY WARNING SYSTEM ELEMENTS
Chairman Ronald S. Goor, National Science Foundation

9:00 Session Chairman's Comments

9:05 General System Requirements—Benigna S. Carroll, Environmental Protection Agency

9:35 Establishing Priorities for Synthetic Organic Chemicals—Philip H. Howard, Syracuse University Research Corporation

10:05 Proposed International Registry on Potentially Toxic Chemicals—Cyrus Levinthal, Columbia University
10:35 Coffee Break
10:55 Model Ecosystems and Toxic Substances—Robert L. Metcalf, University of Illinois
11:25 Anticipating Hazards of Low Level Exposure to Toxic Substances—Cyrus Levinthal, Columbia University
11:55 Methods for Detection of Teratogenic Agents—Thomas H. Shepard, A. Fantel, T. Regimbal, University of Washington
12:30 LUNCH
1:30 Environmental Health Criteria and Monitoring Programs of the World Health Organization—F. Gordon Hueter, Environmental Protection Agency
2:00 Should Assessment Include Cost-Benefit Tradeoffs—Dennis P. Tihansky and Harold V. Kibby, Environmental Protection Agency
2:30 Problems with Early Warning Systems for Toxic Materials—W. Fulkerson, Oak Ridge National Laboratories
3:00 Coffee Break
3:20 Panel Discussion on Early Warning System Elements—Chairman John L. Buckley, Environmental Protection Agency
5:30 SOCIAL HOUR
6:30 BANQUET—Speaker, Glenn L. Schweitzer, Director, Office of Toxic Substances, Environmental Protection Agency

Friday — February 1, 1974

SESSION III EARLY WARNING SYSTEMS/SUBSYSTEMS
Chairman James E. Flinn, Battelle's Columbus Laboratories

9:00 Session Chairman's Comments
9:05 Review of Health/Environment Systems with Potential Early Warning Applications—Theodore J. Thomas and James E. Flinn, Battelle's Columbus Laboratories
9:35 Program to Acquire and Analyze Information on Chemicals Impacting Man and Environment—Arthur A. McGee and Kirtland E. McCaleb, Stanford Research Institute
10:05 NCI Program of Cancer Surveillance, Epidemiology, and End Results Reporting (SEER Program)—James E. Murray, National Cancer Institute, Department of Health, Education, and Welfare
10:35 Coffee Break
10:55 Environmental Impact of Chemicals—Robert J. Moolenaar, Dow Chemical Company
11:25 Environmental Stressor Matrix System for Early Warning David L. Morrison, Battelle's Columbus Laboratories
11:55 Public Interest Methods for Assessing Chemicals—Albert Fritsch, Center for Science in the Public Interest
12:30 LUNCH
1:30 Panel Discussion on the Concept of Early Warning, Existing Systems, Research Needs, and Implementation—Chairman David L. Morrison, Battelle's Columbus Laboratories
4:00 ADJOURN

APPENDIX D - 1

IDENTIFICATION/ASSESSMENT SYSTEMS

APPENDIX D-1-a

IDENTIFICATION/ASSESSMENT SYSTEMS

Those systems identified during this study are listed here with respect to the following general classification scheme:

I. Input Surveillance
   A. New Stressor Identification
   B. Hazard Assessment of Recognized Stressors

II. Output Surveillance
   A. New Stressor Identification
   B. Hazard Assessment of Recognized Stressors

The systems described are listed in the same order as given earlier in Table 1.

(1) Carcinogen Screening (IB, IIB)

The International Agency for Research Against Cancer, based in Lyon, France, is a spin-off of the World Health Organization. It is a periodic meeting of a group of internationally recognized scientists who (1) receive information from many sources including the National Cancer Institute's Carcinogenesis Program, (2) evaluate the carcinogenic risk of chemicals to man, and (3) publish their conclusions in the form of a monograph.

(2) Annual (RAT) Toxicity Testing (IA, IIA)

A major animal test approach used by the Center for Disease Control, Atlanta, is called the LD50 Rat Feed Process. This process was worked out by Thomas Gaines (currently with the Food and Drug Administration in Pine Bluff, Arkansas). The LD50 is the amount of a particular toxic substance needed for half of the test rats to die. Three approaches apply the LD50 concept. One approach identifies the acute single dosage required to cause the LD50 effect. Another approach administers subacute dosages repeatedly over a period of time to assess the chronic disease impact of the toxin. A third approach observes breeding and examines the offspring.

(3) Short-Term (Hamster) Cancer Test (IA)

Dr. Joseph A. DiPaolo and his colleagues at the National Cancer Institute are working on a process for testing substances that will take about two weeks, compared to two to four years taken by current methods. The process involves the injection of test substances into pregnant hamsters, thus exposing the embryos to both the chemical and its metabolic by-products. After two weeks, embryonic cells are examined under a microscope for cancerous transformations.

(4) Biological Materials Surveillance (IA, IIB)

The Bureau of Biologics of the Food and Drug Administration maintains surveillance of all experimental biological materials under study for potential commercial use.

(5) Surveillance of Poisons (IB)

The National Clearinghouse reviews advertising in a wide assortment of trade journals in search of products for which they have no information. If such a product is discovered, they follow up with the manufacturer.

(6) Radiological Product Surveillance (IB)

The Division of Electronic Products, Bureau of Radiological Health, Food and Drug Administration, maintains the Radiological Health Regulations. About two regulations are added each year. In addition, they are responsible for surveillance of compliance as described below.

The manufacturer must affix a label, the design of which is approved by the Bureau of Radiological Health, to the product stating that the product complies with Radiological Health Regulations. He cannot introduce the product into commerce without this label. He cannot attach this label until he has provided the Bureau a complete description of the quality control and product testing program for that product. The Bureau judges the completeness of the report. Public Law 90-602 specifies criminal and civil penalties for noncompliance.

The Bureau receives data from State Health Departments having Radiological Health Groups whenever questionable products are discovered. The Bureau tests products in its own laboratories for compliance with regulations and does exploratory testing of products for which they have reason to believe there is a requirement for a regulation.

Manufacturers must provide the Bureau with a written report on every new model and must provide an annual summary of the results of his testing program.

(7) National Evaluation of X-ray Trends (IB)

The NEXT system amounts to a surveillance of X-ray trends by State Health Departments. A conference of Federal and state officials called the Conference of Radiation Control Program Directors organized the NEXT Tast Force. The NEXT Task Force developed a testing and reporting format that has been superimposed on the state testing programs. The Bureau of Radiological Health maintains a data base derived from the NEXT system reports. This data base is available to the states for comparison of results among states and for the evaluation of trends over time.

(8) Biologics Licensing (IB)

The Bureau of Biologics of the Food and Drug Administration is responsible for setting standards for the production and testing of biological products and for the surveillance of compliance to the regulations they publish.

Following Bureau of Biologics review, the Department of Health, Education, and Welfare issues licenses for the manufacturing establishment and for the product.

(9) Drug Surveillance (IB, IIB)

The Bureau of Drugs of the Food and Drug Administration provides surveillance of products prior to marketing through regulations requiring manufacturers to submit a "notice of intent" to market a new drug. The manufacturer is required to test the product in accordance with regulations prior to marketing.

(10) Chemical Hazard Identification (IIA)

Originally, the National Cancer Institute contracted with Stanford Research Institute for a program called Chemical Hazard Ranking Information System (CHRIS). Though the project initially was described as "hazard ranking", this is no longer considered appropriate. It is not currently considered technically feasible to pursue prediction through structural analysis. Nevertheless, it is considered desirable to pursue the potential of hazard identification through structural analysis. Consequently, the program has been renamed A Research Program to Acquire and Analyze Information on Chemicals that Impact on Man and His Environment.

The process of chemical selection currently used in the SRI program is described as follows. SRI first identifies chemicals now in use within the following nine categories: (1) intentional food additives, (2) pesticide residues in food, (3) proprietary drugs, (4) prescription drugs, (5) cosmetics, (6) air pollutants, (7) water pollutants, (8) soaps and detergents, and (9) trade sales paints. After the chemicals have been identified, the products containing those chemicals are identified. Then the means of man's exposure is established in terms of the four kinds of exposure: (1) dermal contact, (2) oral contact, (3) inhalation, and (4) any other. Finally, a "sum of exposure" is defined. This information then is presented to the Chemical Selection Committee of the NCI Carcinogenesis Program. The role of this committee is to gather information on chemicals and identify candidates for bioassay. The committee bases its decision on a three-stage dossier. The dossier approach is used to provide a rational progression of information selection to the formal bioassay program.

(11) Poison Control Centers (IIA)

The National Clearinghouse for Poison Control in the FDA Bureau of Drugs serves as a communication depot for Poison Control Centers in state departments of health.

When the ingestion of a questionable substance has been reported to a state Poison Control Center, the state Center (1) responds by providing information regarding the substance and the appropriate treatment (if known) and (2) sends a punch card report to the National Clearinghouse. The information then is transferred from card to tape and is stored off-line with 24-hour retrieval capability.

The National Clearinghouse provides the following related services:

(1) Publishes "Poison Control Statistics" annually. This publication is used primarily by Federal government agencies.

(2) Publishes a bimonthly bulletin reporting poison experiences. This is circulated to approximately 3000 organizations including industry, hospitals, poison Control Centers, and professional groups.

(3) Prints and distributes a 5 x 8 information card on each substance for the state Poison Control Center's manual files.

(12) Epidemic Intelligence Service (IIA)

The Center for Disease Control is made up of a number of bureaus, one of which is the Bureau of Epidemiology. The Epidemic Intelligence Service is a component of this bureau. EIS officers are assigned to each state. Their job is to follow up unusual incidences of infections or toxic illness to determine cause and assess the impact on the community.

(13) National Electronic Injury Surveillance System (IIA)

NEISS is in the Bureau of Product Safety of the Consumer Product Safety Commission. A paper dated February 27, 1973, titled "Identifying

Product Safety Priorities" by John W. Locke, Acting Executive Director of the Consumer Product Safety Commission, describes NEISS. Following is an attempt to extract the key factors in NEISS from that paper.

NEISS is a system for establishing priorities for initiating governmental efforts to eliminate product hazards. It is a decision model utilizing a whole series of factors, some of which are

- Frequency of injury,
- Severity of injury,
- Exposure (degree to which consumer comes in contact with product),
- Citizen willingness to incur risk,
- The likely success of a standard in reducing hazards,
- The cost of reducing the hazard,
- The cost of injuries, and
- Citizen concern.

(14) National Surveillance Network - National Occupational Health Survey (IIB)

NIOSH is surveying a sample of 10,000 to 15,000 work places. Each plant survey consists of a brief interview with the manager followed by a walk-through investigation. A 2-year study will develop basic descriptive information on the working environment in all nonagricultural industries covered under the Occupational Health and Safety Act of 1970. This information will be used to assist in setting priorities for research and compliance, for directing research teams in future investigation efforts, for measuring and to some extent forecasting trends, and for developing criteria for standards which will describe the potential health hazards typical of a particular industry or occupation. All data will be classified, key punched, and stored on magnetic tapes.

(15) Toxic Substance List (IIA, IIB)

The Occupational Safety and Health Act of 1970 (Public Laws 91-596) requires NIOSH to publish an annual list of toxic substances. The 1973 edition contains 25,000 listings of chemical substances, including 11,000 names of different chemicals with applicable toxic dose information and 14,000 additional listings consisting of synonym and codes taken largely from ACS Chemical Abstract Service (CAS) listings.

It is the purpose of this publication to identify all known toxic substances which may exist in our environment and to provide pertinent data on the toxic effects from known doses entering the body by any route described. Data included are the:

(1) Chemical substance's prime name
(2) CAS registry number
(3) Molecular weight and formula
(4) Synonyms
(5) Wiswesser line notation
(6) Toxic dose data, including
 a. Qualifying toxic dose
 b. Route of exposure
 c. Species exposed
 d. Description of exposure
 e. Units of dose measurement
 f. Notations descriptive of toxicology
(7) Cited reference
(8) U. S. occupational standards
(9) NIOSH criteria documents

(16) Prioritization of Work Place Chemicals (IIB)

A methodology has been developed by NIOSH to prioritize a candidate list of substances for which criteria documents might be developed. The candidate list is assembled from a variety of sources, plant surveys, new industrial trends, the National Surveillance Network, etc.

The prioritized 1973 list presents the chemicals by some 17 priority classes. Within each class, the sensitivity of the procedure is not fine enough to allow ranking distinctions to be made. The list for 1973 was truncated at a level where the priority rating system ceased to be sensitive so the end result was a list of 471 items. Excluded were substances for which criteria documents have already been developed (e.g., asbestos, beryllium, CO, etc.). Not included on the list are the seven items for which criteria documents have already been initiated, nor 14 suspected carcinogens which have been recommended for control by a permit system.

(17) Hazard Evaluation Program (IIB)

Section 20(a)(6) of the Occupational Safety and Health Act of 1970 charges the Department of Health, Education, and Welfare with the responsibility for evaluating the potential toxicity of materials used or found in the workplace, upon receipt of written requests by employers and employee representatives. HEW's National Institute for Occupational Safety and Health (NIOSH) is the agency which provides these on-site toxicity determinations. While these activities are the responsibility of the Division of Technical Services, several other Institute Divisions and programs contribute at various stages to the overall program. Coordination of on-site toxicity determinations is handled by the Division of Technical Services' Hazard Evaluation Services Branch in Cincinnati and supported by regional industrial hygienists. This hazard evaluation service is provided at no cost to the party making the request.

The request, along with the packet of technical information, is sent to a NIOSH regional industrial hygienist who then contacts plant management and employee representatives to schedule an initial field visit. Employee representatives requesting such evaluations may have their names held confidential if they so desire. An observational survey of the workplace is conducted with these representatives to elucidate the extent of the problem and to determine the number and type of environmental samples to be collected. Employee interviews are conducted to identify adverse symptomatology experienced by the workers. Findings from the survey are reported to headquarters and a strategy developed for the environmental-medical evaluation. Sampling, analytical, and medical tests are derived and conducted by NIOSH to determine the concentration of substances found and the potentially toxic effects to affected employees. Study results are assessed, and a final determination made.

Affected employees are notified of the determination. A full report of the study including recommendations for controlling observed hazards, if appropriate, is sent to the employer, employee representatives, and the U. S. Department of Labor.

Health Hazard Evaluation reports will be utilized in developing new standards where toxic substances are found but for which no standards exist. Information derived from health hazard evaluations will also be used in assessment of the validity of existing standards.

(18) Walter Reed Disease Forecasting System (IIB)

The Walter Reed Army Institute of Research has undertaken the organization of information on certain diseases to estimate their potentials for man. The potential is the estimated number of cases of a disease per 1,000 (one thousand) man-days in a particular terrain.

Their mechanism for arriving at the estimates for threats of specific disease entities is called a Disease Forecasting System. It is composed of two parts:

(1) Disease Information System

(2) Disease Forecasting System.

These are mutually interactive.

The Disease Information System facilitates the transition from information in documents to concepts of disease potentials. Like other information systems, it associates data with sources (extracts with documents). This differs from systems of abstracts in that abstracts condense and shrink an article around its ideas. In their system, the extracts dissect the data and save those data applicable to arriving at an estimate of the number of cases of the specific disease entity per 1,000 man-days exposure to particular place and time.

The logic of this system is based on the idea that diseases can be defined as biologic phenomena, so that all influences on each biologic phenomenon are influences on the dynamics of that disease and thus its risk factor.

Pertinent data for this system include observed occurrence in man and animals (reported cases, prevalence, and incidence); the animal populations involved in each disease entity (biologic phenomenon), the climactic, topographic, hydrologic, vegetational, chemical, and other factors influencing these populations. A device for integrating the effects of multiple factors has been developed to make general estimates of disease-risk based on world data for the influential factors.

There are some 25,000 extracts on eight different diseases currently in the computer.

(19) Community Health Effects Surveillance Studies (IIB)

The CHESS system observes the correlation between the presence of pollutants and incidence of disease through the use of a mailing questionnaire. This system is administered by the Human Studies Laboratory at Research Triangle Park, North Carolina, for the Environmental Protection Agency.

(20) Cancer Surveillance, Epidemiology and End Results Reporting (IIB)

The SEER program was developed for the National Cancer Institute. Dr. Marvin Schneiderman may be contacted for more information. The following statement describing SEER was provided by the National Cancer Institute.

"The SEER program provides information on trends in the incidence of various forms of cancer in the United States, variation in the occurrence of cancer among different population groups and in different geographic areas, changes in diagnostic and treatment practices and the associated end results in the general run of cancer patients. Data are obtained from a selected number of population-based cancer registries that provide uniform information on a continuing basis and participate in ad hoc studies designed to identify and assess etiologic and prognostic factors."

The following list of essential characteristics has been provided by the National Cancer Institute in describing the population-based tumor registry. The tumor registry is described as . . .

"A reporting system designed to obtain information on every newly diagnosed case of cancer (except non-melanotic skin cancer) and on every death with cancer, among members of a defined population (usually one to three million people). The cooperation of every general hospital and of the state office of vital statistics is necessary to assure completeness of reporting.

"The goal is to produce reliable and timely data on the incidence of cancer among the residents of the area to provide information on changes over time and on variation in the occurrence of cancer among subgroups of the population. All, or a majority of the hospitals, participate in a patient follow-up system to provide information on end results, i.e., the relationship of the characteristics of the patient, the nature of the tumor, extent of disease at diagnosis, and treatment to patient survival.

"The collected data are utilized to identify issues that warrant investigation through special studies which may be carried out within a single geographic area or as a collaborative project by two or more areas."

(21) Subclinical Toxicity Survey (IIB)

The CDC in Atlanta is developing a subclinical toxicity survey process for predicting the effect of stressors through correlation with steroids and metaboloids in urine.

(22) Technical, Intelligence, and Project Information System (IA, IB)

This is a conceptual system derived in a study for HEW to examine research and development program planning needs within the now disbanded Environmental Health Service (EHS) and to develop a management assistance system for the EHS. Problem identification from the perspective of environmental stressors and priority setting were determined to be important functions to be performed in the planning cycle. No single method for planning and priority setting was found to be totally applicable to the mix of complex problems encountered by EHS. Continuation of categorical planning activities was recommended to serve as the foundation for the development of an integrated planning system based upon quantitative assessments of the impact of technology upon man and his environment. Full implementation of the integrated planning system requires the availability of a hierarchy of mathematical models for the assessments.

Demonstration of the integrated planning system concept was provided through case studies for lead and DDT, and for lead, a preliminary identification of elements to be included in a partial program plan was made.

The concept of urgency as a means to establish priorities for EHS was investigated. The urgency consists of the people affected, the severity of the effect, and the rate of change of these quantities with time. Where data on these quantities are not available, a simpler index based upon number of people affected and severity may be used as a cursory estimate of priority.

An investigation also was made of existing EHS information resources including monitoring and surveillance activities. A directory of EHS information facilities and selected supplementary resources was prepared. An environmental health information network was devised which would provide EHS ready access to technical, project, and monitoring information.

(23) Overview System (IB, IIB)

This conceptual study derives from a study derives from a study made to develop a mechanism that would allow the Public Health Service to maintain an active overview of chemical contaminants that are now, or likely to be, present in the environment. A system design study verified the mechanism utilizing an overview information center to provide the necessary hazards-identification, evaluation, and alerting system. Specific attention was given to the contamination potentials of mercury, vanadium, nickle, fluorocarbons, and pulp and paper production.

(24) National Air Emissions Data System (IB)

The Office of Air Programs, EPA, maintains the National Emissions Data System. The NEDS represents an attempt to collect, store, and have retrieval capability for all emission data in the country. The system is composed of several data files:

(1) Point source
(2) Area source
(3) Federal facilities source
(4) Emission factor
(5) Hazardous pollutants source
(6) Geographical ID
(7) Control equipment ID
(8) IPP (Implementation Planning Programs) process identification
(9) Population data.

Information for all point and area sources are stored and can be retrieved by the following kinds of programs:

(1) Nationwide inventory programs - outputs data so that point and area source emissions may be reported by source classification and geographical area

(2) IPP modeling conversion program - selects data elements from the source files to be used for modeling and places the data in an acceptable format for IPP programs

(3) Area source gridding programs - appropriations area source emissions to grids for IPP modeling

(4) Trend/projection analysis programs - utilize existing data to ascertain trends on projections of emissions by source and geographic area.

(25) General Point Source Water File (IB)

The General Point Source File which is maintained by the Office of Water Programs, EPA, represents a comprehensive information system to record all point sources and discharging facilities in the water environment. It is being prepared for early 1973 and will have the capability to perform many varied analyses. Map location indicators are being included in the system, and ultimately, discharges will be related to ambient water quality.

(26) International Decade of Ocean Exploration (AII)*

The National Science Foundation represents the United States in the International Decade of Ocean Exploration Program. The IDOE program is part of the United States' contribution to the Long-Term and Expanded Program of Oceanic Exploration and Research (LEPOR). The program is designed to support oceanographic research efforts that will contribute to a better understanding of the total ocean environment on the part of both U.S. interest and other nations of the world.

The objectives of the IDOE program are:

(1) Determine the quality of the ocean environment through accelerated scientific observations of the ocean's natural state

(2) Evaluate the impact of man's activity on that environment

(3) Establish a scientific basis for corrective actions necessary to preserve the ocean environment

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*Environment Reporter, The Bureau of National Affairs, Inc., Washington, D.C., 1973.

(4) Provide the scientific basis needed to improve environmental forecasting

(5) Assess the sea floor for its resource potential

(6) Provide the basic scientific knowledge of biological processes necessary to the intelligent utilization of living marine resources

(7) Improve the scientific framework necessary to reach sound international agreements on man's uses of the oceans and the resources located therein.

The program is carried out by universities and nonprofit institutions, industries, and government agency laboratories.

(27) Marine Resources (IIA)*

The Marine Resource Monitoring, Assessment and Prediction program (MARMAP) provides for continuing research studies to develop a program plan, specialized equipment, and expertise required to (1) understand the biological characteristics requirements of living marine resources; (2) provide Federal and state regulatory agencies with baseline inventories and structural analyses of communities of marine organisms; (3) determine levels of various contaminants in the marine environment in order to set water quality standards and assess the results of industrial and other pollutants entering the marine environment; and (4) develop a public service program under state-federal partnership for the management of commercial and sport fisheries in the grants-in-aid program. NOAA plans to expand research for comprehensive assessment of living marine resources on a continuing basis; operation and maintenance of vessels concerned with biological investigations, such as engine, hull, and structure repairs; conducting basic ecological studies and effects of environmental alteration on marine organisms; grants-in-aid to states to assist in the federal-state partnership in commercial and sport fishery management; environmental impact analysis of water resources; and an analysis of the overall requirements of an aquaculture system.

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*Environment Reporter, The Bureau of National Affairs, Inc., Washington, D.C., 1973.

(28) National Stream Quality Accounting Network (IIA)

The Geological Survey maintains a National Stream Quality Accounting Network. The NSQAN is collecting and analyzing water supply, quality, and quality data to provide a gross estimate (for Level I accounting network) of water resources. The kinds of information being reviewed relate to:

(1) Specific conductance
(2) Temperature
(3) Bacteriology
(4) Dissolved solids
(5) Turbidity
(6) Potassium
(7) Sodium
(8) Phosphorus
(9) Nitrates
(10) Dissolved Oxygen
(11) Mercury
(12) Cadmium
(13) Lead
(14) Arsenic
(15) Organics.

(29) International Biological Program (AII)*

The International Biological Program (IBP) has as its worldwide theme "The Biological Basis of Productivity and Human Welfare". The U.S. response to the central theme of IBP has taken the form of multi-investigator integrated research projects to develop a good understanding of how total ecosystems operate. The overall goal is to understand more clearly the interrelationships within and among ecosystems, by providing bases for predicting the consequences of environmental stress, whether man-made or natural, and enhancing the ability to better manage natural resources.

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*Environment Reporter, The Bureau of National Affairs, Inc., Washington, D.C., 1973.

The new dimension added by IBP is the integrated attack on complex ecological systems by teams of investigators representing a variety of disciplines. A major objective is to achieve a fuller understanding of the processes and rates of nutrient cycling, water movement, energy flow, and population dynamics in natural and man-dominated ecosystems that can be obtained by individual investigators working independently.

The IBP effort, in part, includes deciduous forest, coniferous forest, grassland, desert, tundra, and tropical forest. These studies are designed to provide basic information which will be useful for solving problems of biological production, resource management, and environmental quality. The goals of these studies are to establish a scientific base for programs to function, relate the derived principles to characteristics of ecosystems, and develop and refine a generalized adaptable simulation model for use in planning studies for new development projects.

Each of the IBP biomestudies is attempting to elucidate the characteristics of an ecosystem; the processes covering transfer of matter and energy among components, and the controlling variables; to ascertain the response to natural and man-induced stresses appropriate to each biome; to understand the land-water interactions characteristic of each biome; and to synthesize the results of these and other studies into predictive models of temporal and spatial variation, stability, and other ecosystem characteristics necessary for resource management in each biome.

(30) SAROAD (IIB)

SAROAD (Storage and Retrieval of Aerometric Data) is the data-handling system adopted by the Environmental Protection Agency Office of Air Programs.

SAROAD consists of a set of standard formats for recording validated measurements for different pollutants and associated meteorological observations with various averaging times and a set of standard codes for identifying pollutants, site locations, and methods of sampling and analysis. At its inception, SAROAD entailed six basic forms: a single form for identifying site location and five data forms. In several years of use, state and local agencies have suggested improvements to the site form and several of the data forms.

The aerometric data are stored within NADB, The National Aerometric Data Bank.

(31) STORET (IIB)

The Office of Water Programs of EPA maintains a Storage and Retrieval (STORET) system for water quality data. STORET, developed in 1964, is programmed to perform statistical summations of data as well as retrieve raw data. It is based in Washington, D.C., with approximately 200 consoles located throughout the country. The data are provided to the system by Federal, state, local, and private users covering approximately 102,000 stations. If the code for the data is known, the information is retrievable. The system assembles and identifies data according to a River Mile Index, which is constructed on the basis of the stream configuration of the watersheds from the headwaters to the ocean. It also identifies data stations by latitude, longitude, and political boundaries.

(32) Environmental Monitoring (IA)

The Council on Environmental Quality has been assigned duties and responsibilities under Public Laws 91-190 and 91-224 and Executive Orders 11507 and 11514. These duties and responsibilities require the council to prepare an annual environmental quality report; prepare recommendations to the President on policies for improving environmental quality; analyze conditions and trends in the quality of the environment; conduct investigations relating to the environment; appraise the effect of federal programs and activities on environmental quality; evaluate the effects of technology; recommend to the President and to Federal agencies priorities in environmental programs; promote the development and use of indices and monitoring systems; advise and assist the President and agencies in achieving international environmental cooperation--under the foreign policy guidance of the Department of State; and review the implementation of Executive Order 11507 and, from time to time, report to the President thereon.

The CEQ funds contract studies to develop indicators of environmental quality covering land use, water and air pollution, recreation, pesticides, and wildlife. One such study, performed in 1971 by MITRE Corporation, presented a design concept for a system to monitor the nation's environment. It described a proposed set of approximately 110 environmental indices and indicators and identified major data gaps in current monitoring programs which must be reduced to allow for routine computation of the indices. The system concept featured maximal exploitation of existing monitoring resources for collection of environmental data. An analysis of alternatives for computing environmental indices identified advantages and disadvantages of centralized versus decentralized processing configurations.

(33) National Fuels Surveillance Network (IA)

The combustion of petroleum based fuel in motor vehicles represents an important emission source of both particulate and gaseous pollutants to the environment. The potential health hazard associated with the combustion products from fuels and fuel additives was recognized in the Clean Air Act as amended in 1970, Section 211, which empowers the Environmental Protection Agency (EPA) to require manufacturers of fuels and fuel additives to register their products. As an integral part of this program, EPA established a National Fuels Surveillance Network (NFSN) in 1972 for the collection and analysis of fuels and fuel additives throughout the country.

The NFSN collects gasoline and other fuels through the 10 Regional Offices of the Environmental Protection Agency. Physical, chemical, and trace element analytical determinations are made on the collected fuel samples to detect components which may present an air pollution hazard or poison exhaust catalytic control devices now under development.

(34) Wiswesser Line Notation (IA)

As demonstrated within the Task A report, a chemical may be identified in several fashions, including structured notation, common name, and chemical formula. A deep need exists for a compact notation for complex compounds. Such a notation should also support structure-activity studies.

These needs may be fulfilled by Wiswesser line notation. This notation allows for a unique mapping from structure notation to a line formula.

As an example, aspirin has the chemical formula of $CH_3COOC_6H_4COOH$. The Wiswesser notation is 1VOR BVQ. Toluene, which has the chemical formula $C_6H_5CH_3$, is simple 1R in Wiswesser.

(35) Environmental Information System Office (IIA, IIB)

The ORNL has organized an Environmental Information System Office (EISO) to develop the information activities of environmental research projects. To do this, EISO has developed several information data bases which contain abstracts of relevant publications and activities. The following list represents the major data bases:

(1) Mercury
(2) Ecological sciences information center
(3) Solid waste data base
(4) Environmental mutagen information center
(5) Material resources and recycling

(6) Regional modeling
(7) Energy data base
(8) Toxic materials
(9) Deciduous forest biome 1972 subproject
(10) Heavy metals
(11) Environmental plutonium data base
(12) Thermal effects
(13) Radionuclide cycling in soils and plants.

(36) OHM-TADS (IB, IIB)

Data has been gathered on the physical, chemical, toxicological, and commercial aspects of over 850 hazardous materials and placed in an automated data file. The file, referred to as OHM-TADS, is employed as the technical data source for the EPA Office of Oil and Hazardous Materials and is used by EPA personnel when they are called on to respond to a spill of a hazardous material. The file complements the SITREP file which is employed to store data and reports on past spills of hazardous materials.

(37) National Pesticides Monitoring Program (IB, IIB)

The MPMP consists of an integrated interagency effort to restrict, control, and monitor the pesticides and their decay products in the environment. The program consists of three basic functions:

(1) Criteria--developed by published information, company data, brainstorming
(2) Registration--to control the quality of pesticides entering the environment
(3) Technical Services--to develop monitoring techniques and to coordinate the efforts of the many environmental monitoring programs currently in existence.

(38) Prioritization of Synthetic Organic Chemicals (IIB)

Dr. Philip Howard, Syracuse University Research Corporation, has examined approaches for establishing priorities for synthetic organic chemicals which impact adversely on the environment. In a recent paper* and in private communications, he has suggested the following information categories would provide the parameters needed for determination of environmental hazard: (1) chemistry and chemical structure, (2) exposure in terms of production quantities and use categories, (3) toxicity, and (4) environmental stability. Conceptual in nature, this systematic approach is workable only for substances where adequate data are available, e.g., in the case of a commercially produced substance.

(39) Toxicology Information Program (IB, IIB)

The Toxicology Information Program was organized at the National Library of Medicine in 1967, following recommendations in a 1966 Presidential Science Advisory Committee report on the "Handling of Toxicological Information". It has two overall objectives: to create automated toxicology data banks using data from the scientific literature and the files of collaborating government, industrial, and academic organizations; and to establish toxicology information services for the scientific community.

In order to fulfill the latter objective, the Toxicology Information Program sponsors the production of review articles on topics of special current interest in toxicology, with particular emphasis on environmental toxicology. Recognized experts submit proposals for writing such reviews; these proposals are evaluated and ranked in order of importance by the Toxicology Study Section of the National Institutes of Health. The preparation of the actual article is funded by a contract between the author and the Toxicology Information Response Center (TIRC) at the Oak Ridge National Laboratory. This center is affiliated with, and wholly

* Howard, P.H., "Establishing Environmental Priorities for Synthetic Organic Chemicals: Focusing on the Next PCB's", paper presented at Seminar on Early Warning Systems for Toxic Substances at Battelle's Seattle Research Center, January 30 - February 1, 1974.

funded by, the Library's Toxicology Information Program. Completed manuscripts are then submitted, in the usual manner, to the editor of Environmental Health Perspectives.

The Toxicology Information Program has also devised two other modes of disseminating toxicology information to the scientific community: (1) TIRC performs literature searches in toxicology, on demand, a partial cost recovery fee of $50 being charged for each search; (2) the Toxicology Information Program operates an on-line, interactive toxicology information retrieval service called TOXLINE, provided via a nationwide communications network. It gives users access on their own terminals to citations, abstracts, keywords, and index terms for some 250,000 journal articles in toxicology and related fields from 1965 to the present.

APPENDIX E-1

CHEMICAL INFORMATION SYSTEMS AND CENTERS

APPENDIX E-1-a

CHEMICAL INFORMATION SYSTEMS AND CENTERS*

SADTLER RESEARCH LABORATORIES, INC.(1,2,3)**

3316 Garden Street
Philadelphia, Pennsylvania 19104
Tel: (215) 382-7800

Toxicology-Related Interests: Reference spectra for biochemicals (infrared and ultraviolet), surface active agents (including detergents), pharmaceuticals (infrared and ultraviolet), monomers and polymers (including adhesives), agricultural chemicals (infrared), and industrial solvents.

Holdings: Books, periodicals, and reprints, primarily related to the area of analytical chemistry; a large and up-to-date collection (80,000 entries) of infrared, ultraviolet, and nuclear magnetic resonance spectra.

Publications: Sadtler Standard Infrared, Ultra Violet, ATR, and Nuclear Magnetic Resonance spectra, and DTA thermograms (available for sale on microfilm, magnetic computer tapes, or in printed volumes).

AMERICAN CHEMICAL SOCIETY(1,3)

Chemical Abstracts Service
The Ohio State University
2041 North College Road
Columbus, Ohio 43210
Tel: (614) 293-5022 Library 293-6356

Toxicology-Related Interests: Inorganic and organic chemicals; lethal dose drug studies; food toxicology; pesticides; chemical hazards and safety; forensic analysis; venoms; antigens; toxicons; air and water pollution.

Holdings: The Chemical Abstracts Service library has about 12,000 chemical and chemical engineering journals from 100 countries and patents issued by 25 countries, all regularly monitored in the preparation of Chemical Abstracts.

Publications: Chemical Abstracts; Basic Journal Abstracts; CA Condensates; Chemical-Biological Activities; Polymer Science and Technology; Ring Index; SOCMA Handbook of Commercial Organic Chemical Names; Steroid Conjugates.

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* Refer to Table 2 in report; also Reference 4, page 59.

**Accessibility and cost code where this information is known:
1 = on-site public use of facilities; 2 = information services for a fee;
3 = answers to inquiries; 4 = information services for free.

RADICAL SYSTEM

Professor Cyrus Levinthal
Columbia University
New York, New York 10025

The RADICAL System (Retrieval And DIsplay of ChemicALs) is an information retrieval system specifically designed to handle data relating to chemical compounds. It is designed to produce information similar to that contained in the NIOSH Toxic Substance List, while allowing computer aided searches for specific criterion or combinations of criteria. The system is designed but is not fully operational.

EUROPEAN ENVIRONMENTAL CHEMICALS DATA AND INFORMATION SYSTEM (ECDIS)

Dr. Mitro Boni
Commission of the European Communities
Ispra (Varese) Italy

This system is intended to be a "data bank on environmental chemicals", generated through close relationship to existing information centers in member states of the "Commission of the European Communities". A pilot program is in operation in Ispra, Italy, which employs Professor Levinthal's (Columbia University - see RADICAL System) data base and a local retrieval system with the acronym SIMAS. The file contains physical data, manufacturers, toxicity data, and structure information on some 1500 chlorinated aromatic compounds. The compounds were taken from the U.S. Tariff Comission and CRC Handbook for Chemistry and Physics.

The goal of this pilot study is the development of a data base applicable to the problems resulting from the large-scale production of synthetic chemicals.

UNIVERSITY OF ROCHESTER[1,3,4]

Department of Pharmacology
University of Rochester Medical Center
260 Crittenden Blvd.
Rochester, New York 14620
Tel: (716) 275-3141

Toxicology-Related Interests: Clinical toxicology; chemical accidentogenesis; chemical ingredients of commercial products; toxicity of chemical ingredients; toxicity rating of general formulations (sample formulas); prevention of pediatric poisonings by study of mineral and vitamin deficiencies (possible cause of pica).

Holdings: Over 50,000 cross-indexed documented tradename items filed by tradename, chemical ingredients, use, and manufacturer; large collection of related reference data; 10,000 reports; books, periodicals.

Publications: Clinical Toxicology of Commercial Products; monthly bulletins.

NORTH CAROLINA STATE UNIVERSITY [1,2,3]

Institute of Biological Sciences
School of Agriculture and Life Sciences
North Carolina State University
Box 5306
Raleigh, North Carolina 27607
Tel: (919) 755-2665

Toxicology-Related Interests: Molecular toxicology; basic biological mechanism reactions in toxicology on a molecular level; biological significance of pesticidal residues in soils, plants, and streams.

Holdings: The central North Carolina State University Library holds most of the periodicals and books pertinent to this area of work.

Publications: Tobacco Abstracts; journal articles; annual report.

MIDWEST RESEARCH INSTITUTE [1,2,3]

425 Volker Boulevard
Kansas City, Missouri 64110
Tel: (816) 561-0202

Toxicology-Related Interests: Toxicities of chemicals, including pharmaceuticals, cosmetics, food additives, and agricultural and industrial chemicals, toxic effects on reproduction; teratogenicity; tumorigenicity and cocarcinogenicity; interactions of chemicals; biochemical effects and mode of toxic action; factors affecting toxicity; drug metabolizing enzymes; absorption; distribution, excretion, and metabolism; pollution and pollution mechanisms; analytical methods.

Holdings: 7000 books; 800 periodical titles; 8000 reports. The Institute is situated adjacent to Linda Hall Library of Science and Technology, which has 370,000 books and receives 11,000 serials and 250,000 reports published in 36 languages.

Publications: Books, reports, bibliographies, periodicals, abstracts, indexes, directories.

NATIONAL LIBRARY OF MEDICINE[1,3,4]

8600 Rockville Pike
Bethesda, Maryland 20014
Tel: (301) 656-4000

Toxicology-Related Interests: Drug-induced abnormalities; drug allergies; drug reactions; poisoning; toxins, venoms; chemicals; drugs; analytical, diagnostic, and therapeutic technics and equipment; medicine, biological sciences; disease; general toxicology; pharmacology.

Holdings: Over 1,300,000 books, journals, theses, pamphlets, prints, microfilms, and other audiovisual materials. (The Library collects material exhaustively in some 40 biomedical subject areas and, to a lesser degree, in a number of related areas such as general chemistry, physics, zoology, botany, psychology, and instrumentation.) The History of Medicine collection numbers more than 60,000 volumes, including over 500 titles published before 1501.

Publications: Index Medicus; Cumulated Index Medicus; Toxicity Bibliography; Medical Subject Headings; National Library of Medicine Current Catalog; Bibliography of Medical Reviews; List of Journals Indexed in Index Medicus.

BIOSCIENCES INFORMATION SERVICE OF BIOLOGICAL ABSTRACTS[2]

2100 Arch Street
Philadelphia, Pennsylvania 19103
Tel: (215) 568-4016

Toxicology-Related Interests: Pharmacological toxicology; pharmacology; industrial toxicology; veterinary toxicology; food residues, additives, and preservatives; poisons in psychopathology; addiction; antidotes; carcinogens; toxicity of chemotherapeutic and neoplastic agents; teratogens; pesticides; environmental pollution; ecological poisons; mutegenic agents; toxins of microbial origin; toxic effects of radiation; toxic diseases; allergic responses.

Holdings: Journals, abstracts, magnetic tapes, microfilm, bibliographic references.

Publications: Biological Abstracts; BioResearch Index; Abstracts of Mycology.

THE JOHN CRERAR LIBRARY[1,2]

35 West 33d Street
Chicago, Illinois 60616
Tel: (312) 225-2526

Toxicology-Related Interests: All branches of science, including toxicology, pharmacology, medicine, botany, chemistry, and nuclear science.

Holdings: Over one million volumes and pamphlets, and current subscriptions to more than 13,000 periodicals and serial publications, devoted exclusively to science, technology, and medicine. The Library has a complete collection of reports from the U.S. Atomic Energy Commission and the National Aeronautics and Space Administration, a partial collection of U.S. Department of Defense unclassified reports, and selected reports of other U.S. Government agencies.

Publications: Leukemia Abstract; bibliographies; pamphlets describing the Library's services.

ARGONNE NATIONAL LABORATORY[3]

Argonne Code Center
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439
Tel: (312) 739-7711 Ext. 4365 or 4366

Toxicology-Related Interests: Computer programs for radiological safety analysis (atmospheric diffusion, potential doses from radioactive fission products).

Holdings: 291 program packages and 120 ENEA (European Nuclear Energy Agency) program packages containing source decks, object decks, sample problems, and documentation and/or data libraries required to make the program usable at another installation.

Publications: Compilations of program abstracts describing each computer program currently available in the Center library (ANL-7411); a collection of bench-mark problems prepared by the Mathematics and Computation Division of the American Nuclear Society (ANL-7416); bibliographies of relevant computer programs.

BATTELLE MEMORIAL INSTITUTE (2,3)

Pacific Northwest Laboratories
Post Office Box 999
Richland, Washington 99352
Tel: (509) 942-111 Ext. 3611

Toxicology-Related Interests: Anesthetics; carcinogens; aerosols; cigarettes; virology; particles; radioactive chemicals; analytical methods; blood abnormality; cancer; teratism; pollution; absorption; injection; inhalation; emphysema.

Holdings: 25,000 books; 1000 periodicals; 50,000 reports.

BATTELLE MEMORIAL INSTITUTE (2,3)

Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Tel: (614) 299-3151

Toxicology-Related Interests: Biochemistry; biophysics; carcinogenesis; chemistry; drug screening; endocrinology; immunology; microbiology; natural products; pathology; pharmacology; toxicology; animal physiology; tissues and tissue culture.

Holdings: 115,000 bound volumes; 3000 periodical titles; 50,000 reports. The holdings include extensive collections of scientific and technical literature of Eastern Europe and the U.S.S.R.

Publications: Science Policy Bulletin.

ATOMIC ENERGY COMMISSION (2,3)

Division of Technical Information Extension
Post Office Box 62
Oak Ridge, Tennessee 37830
Tel: (615) 483-4352

Toxicology-Related Interests: Metabolism, physiology, and toxicology of radioisotopes, actinide elements, and fission product elements.

Holdings: The master collection of AEC and AEC-contractor technical reports; related reports from other U.S. Government agencies and their contractors; reports from all countries actively engaged in atomic energy research and development; English translations of atomic energy literature in foreign languages; engineering drawings and specifications.

Publications: Nuclear Science Abstracts; Technical Progress Reviews; Abstracts of Limited Distribution Reports.

NUCLEAR SAFETY INFORMATION CENTER

Oak Ridge National Laboratory
Post Office Box Y
Oak Ridge, Tennessee 37830
Tel: (615) 483-8611 Ext. 7253

Toxicology-Related Interests: Radioactive chemicals; heavy metals; contamination by radioactivity; beryllium.

Holdings: Reference file, indexed in depth, of information in the above areas; documents on nuclear safety, such as reactor safety analysis reports.

Publications: Nuclear Safety; bibliographies; state-of-the-art reports.

PESTICIDES INFORMATION CENTER

National Agricultural Library
U.S. Department of Agriculture
Beltsville, Maryland 20705
Tel: (202) 388-3434

Toxicology-Related Interests: Pest control (biological, chemical, cultural, ecological, mechanical, and integrated methods); pests (insects, nematodes, parasites, weeds, etc.) affecting plants, animals, man, and natural resources.

Holdings: Computer-based data bank containing data from 20,000 periodical articles for the period 1960-1966 and from 1100-1500 articles every two weeks since January, 1967; International Tree Disease Register (INTREDIS) on magnetic tape; Herbicides Data File on magnetic tape.

Publications: Pesticides Documentation Bulletin; special bibliographies.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Food and Drug Administration
Office of Product Safety
Division of Hazardous Substances, Household Substances Data File
Room 5844, FB-8
Washington, D.C. 20204
Tel: (202) 963-5571

Toxicology-Related Interests: Toxicology of primary chemical substances which may be potentially hazardous.

Holdings: Several thousand laboratory reports, 5000 to 8000 books and journals, 500 research and/or development reports, 400 clinical reports.

THE SOAP AND DETERGENT ASSOCIATION (1,3,4)

485 Madison Avenue
New York, New York 10022
Tel: (212) 751-6080

Toxicology-Related Interests: Detergents; soaps; glycerine; fatty acids; water pollution (product residues); household chemicals; cleaning agents; surface-active agents.

Holdings: Books, journals, abstract literature, bibliographies, pamphlets, clippings, research data.

Publications: Division newsletters; Water in the News; Scientific and Technical Reports.

AMERICAN PETROLEUM INSTITUTE (1,3,4)

Time-Life Building
1271 Avenue of the Americas
New York, New York 10020
Tel: (212) 586-4200 Ext. 288 (Library)

Toxicology-Related Interests: Aromatic petroleum naphtha; benzene; butadiene; copper naphthenate; crude oil; cyclohexane; gasoline; kerosene; naphthalene; naphthenic acids; styrene; sulfur dioxide; sulfuric acid; toluene; xylene.

Holdings: The Institute's main library, located at the New York office, has about 3500 books, 14,000 bound journals, 15,000 reports, 300 bound API publications, and various pamphlets and papers.

Publications: Toxicological Reviews; Proceedings of API; Drilling and Production Practice; API Abstracts of Refining Patents and API Abstracts of Refining Literature; Index of Papers Sponsored by Division of Production; Petroleum Facts and Figures; Weekly Statistical Bulletin; Annual Statistical Review.

INDUSTRIAL HYGIENE FOUNDATION OF AMERICA, INC.[2]

5231 Centre Avenue
Pittsburgh, Pennsylvania 15232
Tel: (412) 687-2100

Toxicology-Related Interests: The health conservation of all occupational employees and improvement of work environment. Development of health-conservation programs in industry. Environmental health research.

Holdings: 130 journal titles, 2000 books, 40,000 abstracts in Industrial Hygiene Digest.

Publications: Publishes Industrial Hygiene Digest and Index, Transactions of the IHF Annual Meetings, annual reports, books, publication lists, technical bulletins.

TOBACCO LITERATURE SERVICE[1,2,3]

205 D. H. Hill Library
North Carolina State University
Raleigh, North Carolina 27607
Tel: (919) 755-2836 or 755-2837

Toxicology-Related Interests: Tobacco, including chemical and physical properties, diseases (general, bacterial, flowering plants, fungus, nematodes, virus), insects, physiology, and biochemistry.

Holdings: 31,000 abstracts; 248 reprints. The Tobacco Literature Service uses the collections of the D. H. Hill Library at the University, which has 426,375 volumes, 1,520 maps, 205,185 microprints and microcards, 45,171 microfiche, 3,683 microfilm reels, 10,300 pamphlets and newspaper clippings, 29,640 bound and 400,000 unbound Federal and State documents, and 16,000 periodical titles.

Publications: Tobacco Abstracts; Tobacco Reprints Series.

NATIONAL CENTER FOR CHRONIC DISEASE CONTROL[1,3]

National Clearinghouse for Smoking and Health
Parklawn Building, Room 11-A-45
5600 Fishers Lane
Rockville, Maryland 20852
Tel: (301) 443-1374

Toxicology-Related Interests: Biomedical evidence linking smoking (tobacco) to health, including published and unpublished items and information on research in progress.

Holdings: Over 12,000 items, including books, articles, unpublished papers, etc. (collection centers on the period from the late 1950's to date).

Publications: Smoking and Health Bibliographical Bulletin; Smoking and Health Bibliography; Directqr of Ongoing Research in Smoking and Health; Health Consequences of Smoking, a Public Health Service Review; various brochures, films, filmstrips, etc.

ARMY MUNITIONS COMMAND (3,4)

Research Laboratories
Industry Liaison Office
Toxicological Information Center
Edgewood Arsenal, Maryland 21010
Tel: (301) 671-2503

Toxicology-Related Interests: Toxicology; biochemistry; pharmacology; physiology.

Holdings: 300,000 reference-abstract cards and about 100 brochures on chemical compounds.

Publications: Reports, critical reviews.

NEW YORK ACADEMY OF MEDICINE (1,2,3)

Two East 103d Street
New York, New York 10029
Tel: (212) 876-8200

Toxicology-Related Interests: Drugs; drug habituation; narcotics; legal medicine; legal chemistry; industrial medicine; allergy; insecticides; pathology.

Holdings: 380,000 bound monographs and journals; 200,000 pamphlets and other items, including Government documents, portraits, and manuscripts.

Publications: Bulletin of the New York Academy of Medicine; History of Medicine Series; descriptive brochures of the library; accessions list.

NATIONAL CLEARINGHOUSE FOR POISON CONTROL CENTERS (4)

Crystal Plaza #5
2211 Jefferson Davis Highway
Arlington, Virginia 20204
Tel: (703) 557-2226

Toxicology-Related Interests: Poisoning from household products and drugs or medicines; antidotes and recommended treatment; ingredients of drugs and hazardous household products.

Holdings: Thousands of poison reports. Data on antidotes and ingredients of new products are supplied by more than 200 manufacturers of drugs and household products.

Publications: Bulletin of the National Clearinghouse for Poison Control Centers; Director of Poison Control Centers.

PHARMACEUTICAL INFORMATION SERVICE (3,4)

Philadelphia College of Pharmacy and Science
43d Street and Kingsessing Avenue
Philadelphia, Pennsylvania 19104
Tel: (215) 386-5800

Toxicology-Related Interests: Toxicity and adverse effects of drugs; poisonous plants; pharmaceutical, pharmacological, and clinical aspects of drugs; foreign drug products and their U.S. equivalents.

Holdings: 15,000-card index listing information about drugs.

PHARMACO-MEDICAL DOCUMENTATION (2,3)

Post Office Box 401
Chatham, New Jersey 07928
Tel: (201) 635-9582 or 635-9644

Toxicology-Related Interests: Drugs; pesticides; all biologically-active compounds and substances.

Holdings: Books, periodicals, reports.

Publications: Unlisted Drugs; Unlisted Drugs on Cards; indexes, bibliographies, reports, critical reviews.

INTERNATIONAL ASSOCIATION OF WATER POLLUTION RESEARCH[2,3]

c/o Mr. Robert Canham
Secretary, U.S. National Committee IAWPR
3900 Wisconsin Avenue, N.W.
Washington, D.C. 20016

Toxicology-Related Interests: Water pollution research; acute and chronic effects of water pollution on aquatic biota.

Publications: Water Research; Proceedings of International Conference on Water Pollution Research.

NATIONAL ACADEMY OF SCIENCES - NATIONAL ACADEMY OF ENGINEERING - NATIONAL RESEARCH COUNCIL[3,4]

Advisory Center on Toxicology
Division of Chemistry and Chemical Technology
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418
Tel: (202) 961-1380

Toxicology-Related Interests: General toxicology; toxicology of commercial products; toxicology of pollutants.

Holdings: Various data from governmental, industrial, and academic sources; books, periodicals, reports.

Publications: Reports.

WORLD LIFE RESEARCH INSTITUTE[2]

International Biotoxicological Center
23000 Grand Terrace Road
Colton, California 92324
Tel: (714) 825-4773 or 783-0077

Toxicology-Related Interests: Marine biotoxicology; phytotoxicology; venomous reptiles, amphibians, and arthropods.

Holdings: Extensive collection on biotoxicology, including data from ancient civilizations and in all major languages of the world; extensive files of unpublished documents covering such areas as China, tropical South America, and tropical Africa.

Publications: Poisonous and Venomous Marine Animals of the World; bibliographies, books, reviews.

INSTITUTE FOR SCIENTIFIC INFORMATION (2)

325 Chestnut Street
Philadelphia, Pennsylvania 19106
Tel: (215) 923-3300

Toxicology-Related Interests: Worldwide scientific and technical literature, including biological, medical, and agricultural sciences; chemistry; pharmacology; and nuclear physics.

Holdings: 250 journals plus a large basic reference collection. The Institute's combined services annually cover some 400,000 current items published in over 3000 source journals.

Publications: Current Contents Life Sciences; Current Contents Physical Sciences; Current Contents Chemical Sciences; Current Contents Education; Current Contents Behavioral, Social, and Management Sciences; Index Chemicus; Encyclopedia Chimica Internationalis; Permuterm Subject Index; Science Citation Index; International Directory of Research and Development Scientists; reports, articles, state-of-the-art reviews.

APPENDIX F-1

MANAGEMENT SUMMARY FROM CPEHS STUDY

APPENDIX F.1.a

MANAGEMENT SUMMARY FROM CPEHS STUDY*

Implicit in the charge to EHS to establish a better understanding of the ecological system through consolidation of existing knowledge and the acquisition of new knowledge is its R&D function. This particular study is addressed to the concepts embodied in the development and implementation of a comprehensive R&D and program planning capability for EHS. Because the mission of EHS represents a new approach to improving man's environment, i.e., considering man and his total ecosystem, a comprehensive system for planning and action must evolve over a period of several years rather than be implemented immediately. The multidisciplinary and multiechelon nature of environmental programs also influences the rate at which comprehensive planning and action can be achieved. In this study the kinds of components needed were identified and means for their implementation are recommended.

Since man is continuously subjected to stresses from many sources in his environment, it is convenient to plan in terms of environmental stressors. The environmental stressor is that chemical compound or element, biological agent, or physical, social, or psychological condition, reduced to its simplest terms, that has a resultant effect upon man. Within the man-total environment concept, the source(s) of the stressor, the path(s) through which it is transported, the receptor(s) of the stressor, and the ultimate effect(s) upon man must be considered. The chain from source to effect is termed the pollution chain and the source-transport path-receptor portion of it will be referred to as the subenvironment. While actions can be taken to treat the effects of stressors, the solution to environmental problems and the improvement of the quality of man's environment lies at the stressor base. Removal of the cause of an environmental health problem requires elimination or control of a stressor which may transcend many compartments in the environment.

Problem identification from the perspective of environmental stressors is the first important function that EHS must perform in its R&D planning cycle. Once the problems have been identified, some order of priority must be adopted for their detailed examination and solution. Intuitively, those problems that have the greatest impact upon man within the broad EHS mission should receive primary attention. In practice, this involves the application of a value system that includes health, bioenvironmental, and nonhealth factors. Given the rank ordering of problems, it is then necessary for EHS to develop plans to solve these problems which most effectively use the funds available. This encompasses the ability of EHS and its components to state the objectives and planning assumptions pertaining to each of the problems, to list and evaluate alternative means to accomplish the objectives, and to select an optimum mix of alternatives to form an action program.

*Morrison, D. L., et al., "Technical, Intelligence, and Project Information System for the Environmental Health Service", Vol. I-V, HEW Contract CPS 69-005 (1970).

No single method for planning and priority setting was found to be totally applicable to the mix of complex problems encountered by EHS. Rather, the current categorical planning activities should serve as the foundation for the development of an integrated planning system based upon quantitative assessments of the impact of technology upon man and his environment. Full implementation of the integrated planning system will require the availability of comprehensive mathematical models to make the assessments and the development of selection or decision criteria based upon the quality of life. A hierarchical modeling approach has been outlined in this study which can take full advantage of submodels developed as a part of on-going research programs of EHS. Although there appears to be a consensus of the attributes of the quality of life, there is presently no good measurement of some of these indicators and no acceptable means to intercompare health, nonhealth, economic, and ecologic impacts. Efforts to develop a value system and metrics for it are required. Until these are available, judgment must be used on the comparability of values in the planning process.

The concept of urgency as a means to establish priorities within the environmental health field was examined. For a given stressor or stressor-subenvironment combination, the urgency to act consists of the number of people affected, the severity of the effect, and the rate of change of each of these quantities with time. Where data on these quantities are not readily available, a simpler index based upon the number of people affected and the severity of the effect may be used as a cursory estimate of priority.

Improvements to categorical planning within EHS can be made through the application of explicit methods to evaluate projects. The objectives of EHS should be decomposed into a hierarchy of successively more specific objectives to which specific projects can be related. Each alternative can then be evaluated with respect to the objective, cost, and other external restraints, and a quantitative performance measure can be assigned to the project. The ultimate goal is to achieve a planning system that minimizes strictly subjective inputs and provides quantitative measures of performance of listed alternatives to the decision maker.

A well-organized information base is essential to supply inputs to the planning process. Existing EHS information resources, including the monitoring and surveillance activities, were investigated. A survey was conducted of the documentation systems and libraries to determine their operational characteristics as related to an information network.

The results of this survey, including a limited number of external information resources, are contained in a separate volume entitled "Directory of Information Sources for the Environmental Health Service".

Additional data were obtained through limited personal and telephone interviews at all levels of EHS and its Administrations and through study of EHS documentation.

On the basis of the study, the establishment of an Environmental Health Information Network (EHIN) has been structured, incorporating the existing information and data sources, and also new resources such as the Information Resource Identification System (IRIS) and the Project Information Retrieval System (PIRS).

In structuring the proposed EHIN, it is recognized that other agencies of the Federal Government have established information and data bases which relate to EHS responsibilities. Mechanisms for interfacing and utilizing these resources are suggested. Further, it is recognized that an operational EHIN, structured as a result of this study, may not be immediately achievable. Rather, EHIN represents a concept which EHS should build toward as it is able in order to assist in constantly strengthening its role in protecting man's environment.

Very little analytical response (e.g., state-of-the-art reports, technical compilations, data or design handbooks, and direct answers to technical inquiry) can be expected from the present information resources, both within EHS and outside EHS. EHS should establish Centers of Technical Competence (Information Analysis Centers) for various high-priority threat areas in order to provide the needed analytical capability. In addition, there is a lack of accurate, documented information relative to the identification of sensitive population groups, to the determination of the number of people currently and potentially affected by a stressor, and to the nature and severity of the effect. This represents an information gap which should be filled on a selective basis. Accepted thesaurus building rules should be enforced in all EHS information activities in order to establish some compatibility of the various thesauri in terms of cross-reference techniques and similar devices. Growth of special-purpose information systems, however, should not be stifled by the creation of a unified vocabulary.

Necessary information resources and capabilities for effective analysis and evaluation of threats are so great in magnitude and variety that they cannot be concentrated within any single agency. To cope effectively with the complexities of today's environmental problems, a wide variety of information resources should be utilized. Various facilities probably can justify, and should have, a stand-alone computer capability in addition to access to the central computer facility, primarily for data processing and research purposes. However, with regard to information systems, every effort should be made to strive for compatibility of operations. The computer facility provided for EHS administrative operations, including information storage and retrieval operations, should equal or exceed the capability of the equipment currently employed by the central computer facility, if that facility cannot be made available to EHS.

The specific elements of the management-assistance system recommended to provide support to the R&D and program planning functions and to provide scientific, technical, intelligence, and project information are:

(1) Overview Environmental Health Planning (OEHP)
(2) Inpact Assessment
(3) Threat Identification and Evaluation
(4) Environmental Health Information Network.

The objective of the overview environmental health planning function is to provide coordinated and comprehensive planning in the man-centered ecosystem. OEHP represents a series of steps undertaken at the Service level with the assistance and support of the components of EHS and outside contractors. The activities to be performed as a part of OEHP are to develop problem statements, obtain stressor matrix input, establish decision criteria, construct a relevancy matrix, establish weights of decision criteria, obtain a rank ordering of problems, and determine problem assignments. The final plan is to be reviewed by EHS and the program selection is to be made. A high rate of professional staff effort is required to launch OEHP and would involve 15 people the first year and 17 the second. The level of effort by professionals the third and fourth years are 8 and 6 man-years per year, respectively. The program should continue at 6 man-years per year effort. This activity could be conducted entirely within EHS, entirely by outside contractors, or by a combination of EHS staff and contractors. After the third year, the sole use of EHS staff is recommended.

Assessment of the impact of technology upon man and his environment is important to provide EHS management evaluations upon which policies can be established, planning can be performed, and actions can be implemented. The impact-assessment function would include the collection and development of mathematical models, the analysis of interactions between stressors, and the assessment of the impact of a stressor or combination of stressors on man and various sectors of his environment. If the assessment function is to be limited to EHS needs only, a minimum level of effort by senior professional staff of 3-1/2 man-years per year is recommended. Approximately 1 man-year per year of computer programming support is also required. This activity could be performed within EHS. However, since the level of effort to meet the demands for assessments fluctuates, contract support would be recommended. The assessment function could also be broadened to serve other elements of government and industry. A Center of Technical Competence for Assessment Technology could be established. Since its mission would be broader, a larger staff would be required and would include 4-1/2 to 5 senior professionals, 2 junior professionals, 2 computer programmers, and secretarial support. Operation of the center by a contractor is recommended to accommodate fluctuating work loads efficiently.

The third component of the management-assistance system would be directed at the identification and evaluation of potential threats to man and his environment through intensification or extension of current use patterns of products and services or through the introduction of new chemical, biological, or physical stressors into the environment. The threat-identification function could be performed by a small group of individuals representing physical, chemical, and biological disciplines. Trends or patterns in industrial, urban, occupational, domestic, and recreational areas would be examined to determine whether potential threats existed. If potential threats were identified, detailed evaluations would be made. This latter function could be combined with the previous function for the evaluation phase. The minimum level of effort that would be required on a continuing basis for the threat-identification aspects would be 3 to 5 man-years per year, assuming that EHIN were operational. This identification function could be performed within EHS, but complementary assistance by outside contractors or consultants who may be more closely attuned to trends in the areas noted would be desirable.

The following recommendations are made for the establishment of an Environmental Health Information Network (EHIN):

(a) The network should be a coordinated network consisting of a Project Information Retrieval System (PIRS), a Monitoring, Surveillance, and Intelligence Information System (MSIIS), and a Scientific and Technical Information System (STIS), supplemented by an Information Resources Identification System (IRIS).

(1) PIRS should be a centralized system, operating within EHS. The early establishment of PIRS is urged and should include:

a. Inventory all current and past internal projects.

b. Inventory all current and past external contracts and grants.

c. Inventory all results (reports) produced to date, both internally and by contract and grant. For all future projects, at least one copy of each report should be sent to this facility.

d. Organize the above in such a manner as to make them both accessible and useful to the entire EHS community including EHS management, EHS operational levels, and EHS contractors.

(2) IRIS should be a relatively small operation, maintaining an inventory of information resources and providing switching and referral service both for the use of the entire staff and for referral of other agencies desiring information to the proper portion of the EHIN network. Implementation of IRIS should begin as soon as practicable.

(3) MSIIS and STIS should each remain a federation of centers in a coordinated network structure. Each center or activity should report to the highest authority consistent with its mission, scope, and user audience.

(b) Within the EHS headquarters element, a Director of EHIN should be appointed to represent and to coordinate the interests of the network, not only at the EHS level, but also in interagency and other Federal activities.

(c) The Director of EHIN should be assisted by an Advisory Council composed of the coordinating managers of PIRS, MSIIS, and STIS plus five representatives from the operating levels. The Advisory Council would assure the vitality of the network, determine network requirements for equipment, and recommend establishment, consolidation, or disestablishment of activities within the network.

(d) The Director of EHIN and his Advisory Council should investigate the extent to which information resources dealing with program assistance, training, and demonstration and testing should be established and incorporated into the network.

Structuring of an environmental thesaurus oriented to the needs of EHS should begin. It is strongly urged that the thesaurus be based upon actual content of projects and reports (and eventually S&T literature), rather than be constructed by a conference of experts. While the latter is possible, it is expensive and may result in generalized decisions which may or may not be of practical value in actual practice. Further, it is almost certain that many vocabulary terms of real value to the user S&T community will be missed by such a conference and will need to be integrated at later stages.

Two model case studies were undertaken for the environmental stressors lead and persistent pesticides to investigate and develop the operational plan and staffing table described above. The effectiveness of the system was tested by the case studies, and areas of improvement were detected. Examples of the type of information on environmental stressors that are currently available were provided and the R&D efforts needed to obtain additional data to eliminate or control the hazards from lead in the environment were explored in a preliminary manner. By selecting a specific stressor for study, mathematical modeling, priority rating, and the environmental stressor matrix concepts which were evolved as a part of the overall management-assistance system could be demonstrated and evaluated. Both model case studies also represented a comprehensive review of the environmental aspects of the stressors. The salient features of the two model case studies are described below.

Lead usually occurs as either sulfide ores (galena, PbS) or oxide or carbonate ores (anglesite, $PbSO_4$, and cerussite, $PbCO_3$). Minerals of iron, zinc, silver, copper, gold, cadmium, antimony, arsenic, bismuth, and others may be associated, in varying proportions, in lead ore deposits. The average grade of lead ores mined contains between 3.0 and 8.0 percent lead. Mining, smelting and refining, secondary recovery, and imports are the four main sources of lead in this country. In 1969, mine production of recoverable lead was approximately 500,000 (short tons), with Missouri accounting for 350,000 tons and Idaho 65,000 tons. Mine production in the U. S. during the last ten (10) years has exceeded 250,000 tons annually. The 1969 U. S. supply from mining, primary refining, secondary smelters, and recovery from copper-based scrap amounted to about 1,540,000 tons. During the last decade, the U. S. supply annually has been near or beyond 1,000,000 tons. Extending this rationale to the domestic lead consumption of primary, secondary, imports, and lead in lead ore entering directly into the manufacture of lead pigment and salts, a figure of 1,333,000 tons is obtained for 1969. These figures suggest that even though only a small percentage of lead may enter the environment from the production and consumption cycle, a certain background level of lead would be expected.

An examination of the use pattern for 1969 and the immediate years preceding indicates how lead is added to the environment. Although there have been fluctuations in quantities in the use categories reported, no major changes in the categories themselves have been reported during the last decade. That is, the major uses of lead during 1969 continued to be (in decreasing order) in the production of storage batteries and accessories, gasoline antiknock additives (mostly tetraethyllead), red lead and litharge pigments, ammunition, solder, cable covering, and calking lead. An inspection of the materials requirements and manufacturing processes for the lead-acid storage batteries, e.g., preparation of pasted plates, preparation and assembly of grids, and particle size distribution and grinding of lead oxides revealed cases of lead intoxication in 66 battery-based industries in Pennsylvania. The use of old battery cases for fuel and the resulting lead-containing ash also were identified as environmental hazards of air and soil.

Examination of the use pattern of leaded gasoline additives tetraethyllead (TEL) and lesser amounts of tetramethyllead (TML) indicated that leaded fuels continue to be a major source of environmental lead. Each gallon of today's gasoline contains on the average of 2 to 3 grams of lead (maximum of 4 grams), which adds up to approximately 540 million pounds of lead consumed, according to gasoline sales. An estimated two-thirds of the lead exits through the exhaust, and about half of the exhausted lead becomes airborne, that is, each year about 180 million pounds of lead swirls into the atmosphere. Analysis of atmospheric precipitation samples of lead and other metals collected by a nationwide network of 32 stations throughout the U. S. indicated that the concentration of lead in precipitation correlated with the amount of gasoline consumed in the area in which the sample was collected. The above two investigations suggest that leaded gasolines contribute notably to the environmental (soil and water) burden. Red lead and litharge-based paints were identified as an environmental hazard during shipscrapping because of the high temperatures involved in burning off (volatilizing) the spent paint.

Further exploration of the lead-pigment use pattern brought to light the ban on the use of lead pigments in indoor paints. More important, however, it revealed the many instances of pediatric plumbism (pica) in substandard housing areas of our eastern cities, e.g., New York, Baltimore, Cleveland, and Chicago. Factors such as the elimination of lead paint from walls, continuous education and enforcement activities of the city health department, efforts of local pediatric services, establishment of comprehensive health care clinics for children in the susceptible age living in high risk areas, family planning, and an improved social climate have resulted in a drop of almost 50 percent (286 to 141) in pediatric plumbism in Baltimore during two consecutive 3-year periods (1964 to 1966, and 1966 to 1969).

As Chisolm points out, these corrective measures deserve attention when it is realized that total treatment costs for an institutionalized child suffering from severe permanent brain damage may cost approximately $250,000 during a 60-year period.

An examination of the methods of obtaining lead and the diverse uses of lead suggested that the effects of lead on man may be exercised through contact, inhalation, and ingestion. In order to determine stressor → source → transport → path → effect (on man) relationship, an environmental stressor matrix was formulated for lead. The stressor matrix approach appears sufficiently flexible to collect and display information to define the effects that any stressor may exercise, since it permits specification of the medium, the compartment, the portal of entry, target site of action, consequences, and control.

Lead is very slowly absorbed from environmental sources, e.g., soil, water, food, and air, but the gradual accumulation of the element in the body is the basis for progressive toxicity. It was formerly believed that considerable amounts of lead could gain access to the body percutaneously, but this has been refuted; instead, inhalation and ingestion are the two main routes of entry. The average man ingests about 5 mg/yr from drinking water, 100 mg/yr from his diet, and about 15 mg/yr through respiration. Generally, health authorities agree that lead concentration in respired air should be below 150 $\mu g/m^3$ and tetraethyllead (TEL) should be below 50 $\mu g/m^3$. Concentration of lead in ambient air may vary from approximately 0.01 $\mu g/m^3$ to 50 $\mu g/m^3$ (the latter in air along heavily traveled highways).

Although the principal site of lead in the body is the skeleton, many other soft tissues, e.g., brain, lung, heart, liver, kidney, spleen, and muscle have been found to contain 20 to 120 μg of lead/100 g fresh tissue. Teeth are confirmed to have a higher concentration of lead than any of the bones, and the average lead concentration increases with age, e.g., <10 years ca 17 $\mu g/g$ of ash and 50 to 60 years ca 116 $\mu g/g$ of ash. Blood has shown the following lead distribution: erythrocytes 24 μg/100 g, and plasma 1.5 μg/100 g. Blood-lead levels approaching 50 μg/100 g of blood warrant therapy in order to avoid the central nervous system CNS syndrome of adult or pediatric plumbism. Lead is normally found in hair in higher concentrations (on a weight-per-weight basis) than in any other tissue. The determination of lead in scalp hair is a valuable aid in diagnosing chronic or mild intoxication, using atomic absorption spectroscopy. In the distribution of lead in fetal tissues, lead seems to pass from the mother through the placenta to the fetus at the expense of blood.

The average individual is in lead balance, and the body burden of lead is established early in life and does not change appreciably through the life span. Feces and urine excretions, perspiration, and miscellaneous processes, in decreasing order, help to maintain balance. Lead is primarily excreted by the bowel as unabsorbed lead (90 percent), with urinary excretion being about 10 percent of the amount ingested. The amount of lead in the feces is practically equivalent to that obtained through food and lead intake, plus the unresolved portion secreted into the alimentary tract in the biliary, digestive, and mucous secretions.

Both acute and chronic lead poisoning have been recognized in children and adults. Acute intoxication results from the ingestion of metallic lead, soluble lead compounds, and lipophylic compounds (TML and TEL). Symptoms include leg cramps, muscle weakness, coma, impairment of renal function, depression, and death. A syndrome identical with chronic intoxication may develop if sufficient lead is retained after acute plumbism. Chronic intoxication consists of three types: gastrointestinal or abdominal, neuromuscular, and the central nervous system (CNS) syndrome. These may occur separately or in combination. The neuromuscular and CNS syndromes result from intense exposure to lead, whereas the abdominal syndrome tends to result from a slow and insidious developing intoxication. The CNS syndrome has been termed lead encephalopathy and is the most serious manifestation of lead poisoning in children. Blood-lead levels above 50 μg/100 g of blood and a lead concentration in hair of 42 to 975 μg/g suggest chronic plumbism. It occurs rarely in adults and then only following massive exposure to lead fumes or TEL.

Interference by lead in the biosynthetic pathway for the formation of heme may result in encephalopathy. Diagnostic techniques for lead intoxication in children include urinary coproporphyrin, serum delta-aminolevulinic acid, lead in hair, whole blood, X-rays of bone, and urinalysis. Combinations of 2, 3-dimercaptopropanol (BAL), ethylenediaminetetracetic acid (EDTA), and edathamil calcium disodium are recommended for treatment of childhood plumbism. Plumbism in adults generally can be detected by blood and urine analyses, determination of delta-aminolevulinic acid (ALA), and urinary coproporphyrin assay. Blood-lead values above 80 μg/100 ml and urinary lead values above 20 μg/100 ml are indicative of active plumbism and require immediate therapy. Adult plumbism, which results primarily from inorganic and TEL intoxication, is treated with EDTA-type chelating agents or penicillinamine.

An appraisal was made of the costs associated with acute lead poisoning of children to determine whether the effects on an environmental stressor upon man could be translated into pecuniary values. Cost estimates were developed for long-term treatment of patients suffering brain damage as children from lead poisoning. The lifetime costs for care and treatment were estimated to be $200,000 to $250,000 for each individual and the annual incidence of children suffering permanent brain damage in the U. S. was estimated at 1,900. Translation of effects of environmental stressors into monetary units appears feasible for stressors such as lead if there are acute exposures. No satisfactory method of handling costs associated with chronic exposures was found in this limited study.

A mathematical model was developed to represent the environmental transport of the stressor lead from several sources with the subsequent intake of lead by man. In particular, the submodels for airborne transport of lead and the lead in the body were developed. The model developed for the airborne transport of lead is used to calculate the airborne concentrations of lead in the atmosphere due to emissions of lead from several sources. The predicted output is for an average steady-state airborne lead concentration, as the model was not developed to predict time-varying airborne lead concentrations.

The submodel, which represents the flow of lead into, within, and out of an individual, was developed in order to predict the distribution and quantity of lead in several body organs. Since measurement of the blood-lead level of an individual is a clinical method of investigating the effect of lead on an individual, the blood-lead levels due to several modes of intake of lead, including inhalation of various concentrations of airborne lead and ingestion of normal and above normal amounts of lead, were calculated.

The lead model study indicates that environmental sources of lead constitute a major source of lead intake, and lead in the ambient air may not contribute materially to the body burden of lead. Considerable information concerning the toxicology of pediatric and adult plumbism was appraised. The biochemical, clinical, metabolic, diagnostic, and therapeutic parameters of plumbism have been discussed.

In this model case study, the stressor lead was investigated specifically. The relative importance of lead compared with other stressors was not evaluated. Thus, the following recommendations are made to implement environmental health criteria concerning lead, based only upon this model case study for lead without the relative importance of lead to other stressors being determined at this time:

(1) Conduct research to determine the chronic effects of lead in the atmosphere on health. To date, definitive information on the effects of airborne lead on health has not been obtained.

(2) Lead overexposure can change certain biochemical functions, but techniques have not been developed to employ these changes for biological monitoring. For example, further studies on ALA metabolism could lead to the development of a technique for detecting subtle biochemical changes caused by intake of lead either by inhalation or ingestion. This ALA screening should be developed so that elevated ALA levels would indicate recent intake of higher than normal quantities of lead.

(3) Research should be conducted to develop more effective therapeutic agents for plumbism, as some chelating agents may produce more harmful effects than the stressor itself. This is extremely important in pica therapy and massive overdoses of lead in industry.

(4) Reexamine the effect of shifting technology in the utilization of lead, e.g., the large-scale use of lead storage batteries in electric cars. Conceivably, this could lead to a reduction in the environmental burden of lead from gasoline additives. The advantages and disadvantages of this shift should be explored from an environmental health point of view and second-order or higher-order factors should be evaluated.

(5) Synergistic effects. Before the environmental character of lead can be finalized, there is need to determine possible synergistic effects of other stressors. For example, oxides of sulfur, nitrogen, and metals that comprise the environmental burden need to be investigated.

The severity of the health and associated economic effects from the ingestion of lead-based paints by children having pica has been recognized. Several large cities have screening programs under way to detect high levels of lead in children. In addition to the several recommendations pertaining to research programs for the stressor lead, the elimination of ingestion of lead by ghetto children having pica is highly desirable, as this mode of intake was shown by the preliminary lead model to yield body-lead concentrations as compared with other modes of intake. Programs should be initiated to locate and remove lead-based paints from ghetto houses and screen all children who may be expected to have elevated lead body burdens.

The preliminary mathematical model developed for this model test case for the stressor lead can be used to quantitatively investigate some of the previous recommendations and as a tool for R&D planning. The model should eventually be developed into a more comprehensive detailed model which will require better data than are available at the present time. Some of these data are:

(a) Chemical forms of lead inhaled and ingested

(b) Assimilation of lead upon entering the body

(c) Elimination rates by body organs

(d) Particle size distribution of inhaled lead

(e) Emission rates of lead sources

(f) Meteorological data, specifically in mining, reclamation, and manufacturing areas.

Because of numerous technical difficulties, DDT was found to be the most reasonable model compound for study. This decision was dictated primarily because of paucity of data regarding environmental effects of other classes of pesticides. DDT is useful because it has been in widespread use longer than any other material and has demonstrated a wide interaction with all of the potential transport pathways for man-made chemicals in the environment. Because it was necessary to restrict the study to DDT, one major conclusion is obvious: sufficient information is not now available about the quantitative mechanisms of redistribution of pesticides in the environment. Specifically, major deficiencies exist in the aerial transport and uptake of pesticides by man, the environmental reservoirs of pesticide storage, the chronic effects of pesticides upon man and wildlife (from the molecular view rather than simply mortality estimates), and the ultimate fate of pesticides.

In the pesticide study it was useful to divide human exposures into two major pathways. The first, the direct pathway, deals with the direct uptake from primary sources of pesticide release. Primary sources were manufacture and application. Human exposure was by inhalation. Dermal uptake and ingestion are secondary features. Accidental poisonings remained about the same even though the frequency of application and the acute toxicity of the new pesticides has increased. These trends suggest that a very credible job of education is being done at the industrial level. Since most of the victims of death from accidental poisoning were children, further reductions could be made by reduction of the total toxicant contents of the home package to below the child lethal dose, where possible, and elimination of those chemicals that cannot be used within the safety margin (e.g., substitution of carbamates and pyrethrians for organophosphate insecticides). Prescription and dispensing pesticides by trained professionals would also reduce accidental deaths. Aerial application accounts for the largest number of deaths and either elimination or control of this method appears worth study.

The second pathway, the indirect pathway, involves human exposure by translocation through the air, water, or food. While more complicated to consider and model, the indirect pathway involves the total biosphere. The general population of the U. S. is exposed by this means. Serious conflicts exist in the data as to which indirect pathway leads to the major store of pesticides in man. On a worldwide basis, the persistent pesticide content of man is remarkably constant. Within the U. S. there are, however, significant racial and geographic differences. Such differences are difficult to explain if food is the major transport pathway to man. The southern population and the southern negro have greater levels of pesticides than the northern equivalent populations. On the basis of this, together with some indirect evidence from residues in animals, it is likely that only 50 percent of the body burden is from food; the remainder may come from inhalation of insecticide aerosols or dust laden with insecticides. If these observations are correct, then control of the human burden of pesticides by control of food residues, as is now practiced, is at best only partially effective.

There is, at present, no evidence to attribute a direct shortening of human life from pesticide exposure. There are suggestions that large amounts of pesticides will increase the frequency of certain tumors in animals. Whether or not pesticides induce cancers in man cannot be settled at present, because there appears to be a dose dependence in cancer induction. Whether tumors or cancers in man can be induced at the low levels presently in foods is not known. These studies suffered from the relatively small numbers of all toxicological experiments and the short term of exposure.

In any event, man is not the animal in the environment most sensitive to pesticides. Animals of the aquatic environment are particularly sensitive because the translocation pathways are highly conservatory of persistent compounds. Persistent compounds become concentrated rather than diluted as residues pass up the food chain. Fish and birds are inherently more sensitive to pesticides than mammals. Fish appear to lack the basic microsomal oxidase enzyme systems, found in all mammals, which detoxify many pesticides. Birds appear to be very sensitive to the steroidal hormone mimicking effects of the chlorinated hydrocarbons. Hormonal effects in man are not known.

Only the soil system appears to be a "safe" repository for pesticides. Conversion to nontoxic metabolites can also be promoted in the soil by anaerobic conditions. The aquatic ecosystem can be protected from pesticides by modifications of agriculture practice to ensure that pesticides are retained and degraded within the soil system. Little hazard to man through the ground water exists.

Finally, while it is possible to model crudely the distribution of DDT in the environment and to suggest ways to reduce the environmental burden of DDT, these efforts will have little direct effect on human health. Advances in protection for aquatic birds and fish can be accomplished. This study suggests that regulation of pesticides on the basis of their hazard to human health is less important than regulation on the basis of their hazard to wildlife. Human health will most likely be improved rather than degraded by emphasis on wildlife, since regulations based upon harmful effects to wildlife will inevitably reduce human exposure. This does not mean that careful evaluation of pesticides for human health hazards is unnecessary. On the contrary, more information is needed. This study suggests that the rate of application and hence long-term residual levels in the environment are best regulated with more concern to wild-life survival. The margin of safety between levels evoking chronic effects in man and environmental levels will increase by this procedure. Man will hence be "safer".

APPENDIX G - 1

SUMMARY FROM OVERVIEW STUDY

APPENDIX G-1a

SUMMARY FROM OVERVIEW STUDY*

The need for "an early warning system" or "overview of environmental contaminants" has been expressed recently by members of Congress and various committees studying environmental health problems. However, the Bureau of Disease Prevention and Environmental Control recognized this need over a year ago when it initiated, with Battelle-Columbus, the design for an overview system that would assist in maintaining a continuous surveillance of chemical contaminants in the environment. The needs for such a system are many. The continued and rapid growth of industrial use and production of chemicals poses uncertain risks and hazards to the general public. In addition, there exists a critical need for evaluating the state of knowledge of the interaction of chemicals with man's environment to predict significant and hazardous conditions, as well as changes in future levels of contamination from the presently available state of knowledge. The extent and degree of these hazards are largely unknown. The data that are derived from such a system will also be helpful to the Bureau in establishing priorities for intramural and extramural research and training programs and in the setting of standards and controls and initiation of control measures.

To assess properly the difficulties and problems that would confront a surveillance program, as well as to provide data on the operation of such a system, five specific chemicals or groups of industry were selected mutually by the Battelle investigating team and the United States Public Health Service. These five, including mercury, nickel, vanadium, fluorocarbons, and the chemicals involved with the pulp and paper industry, were treated as urgent surveillance problems.

The results of the case studies were derived from data collected by Battelle staff during travel and discussion with key scientists in specific disciplines, interviews with appropriate staff members of governmental agencies, and analysis of operations of existing and contemplated information centers and of existing governmental and private laboratories engaged predominantly in environmental-health activities. In addition, Battelle's information analysis staff utilized available information sources, including those referred to above, for its analysis of the literature dealing with specific tasks.

The studies revealed potentially hazardous situations. For example, the report on mercury showed a substantial increase in recent quantities of mercury used in the electrolytic production of chlorine. Significant quantities of mercury are released to the environment each year which apparently cannot be traced and which to date cannot be accounted for. There exists a striking lack of fundamental information on national levels of mercury in our air, water, and food.

The study of vanadium showed a significantly increased usage of volatile compounds of vanadium in industrial applications.

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* Lutz, G. A., et al., "Design of an OVERVIEW System for Evaluating the Public Health Hazards of Chemicals in the Environment", USPHS Contract DA-86-66-165 (1967).

The nickel study raised the question of possible chronic effects of small quantities of nickel in food from the use of large quantities of nickel equipment in food processing and the demonstrated transfer of some nickel to food during processing.

A need was demonstrated for the establishment of the environmental fate of fluorocarbons used in aerosols and refrigerants and for the toxicological characteristics of combustion products of fluoroplastics.

Finally, a review of current analysis information on the chemical processes employed by the pulp and paper industry demonstrated the need for surveillance of the atmospheric pollutants resulting from increased use of kraft pulping operations, for toxicological data on paper modified with additives, and for the identification of combustion products of paper and paperboard fortified with additives currently in use.

Through experience developed in dealing with these groups of potential contaminants, information needs were found to fall into predictable categories:

(1) Chemical production

(2) Secondary-product formulation

(3) Pattern of chemical usage

(4) Chemical toxicology and pharmacology

(5) Environmental health hazards.

Based on experience derived from these studies and from the national resources available in information, skills, and competencies to this program, Battelle has designed a system of continuous surveillance of chemical threats to environmental health.

Four separate features were recognized as essential to an Overview Center to provide the necessary functions defined by a surveillance and early alarm role:

(1) It must possess a good scientific library and information-handling capabilities and professional and clerical staff knowledgeable and experienced in information-analysis methods.

(2) It must possess ready and convenient access to a sufficiently large pool of scientific competence to facilitate the rapid preparation of responses to specific queries.

(3) An organizational solution must be presented for the integration of the widely scattered and often unrelated pockets of information and competencies residing in federal, state, and local agencies and with the individual scientists whether in the academic, private, or governmental sectors of environmental-health research.

(4) It must possess to a strong degree the characteristics of immediacy combined with the ability to tap the required skills whenever necessary, to marshal appropriate skills to the level demanded by the urgency of the current problem, and to deliver in-depth competence on demand. This requires the managerial ability to fuse all the required functions necessary for an Overview Center into a viable, functional operation, focused strictly upon its mission-oriented objectives.

It was found that 70 percent, or more, of the desired information relative to changes in the level of contamination of our environment by chemicals (together with relevant information from the fields of ecology, physiology, toxicology, and public health) could be obtained from a preliminary surveillance of 61 key publications and 12 industrial and governmental contacts. It is estimated that this preliminary surveillance (including information acquisition and processing and technical surveillance) will require 27 professional man-months. Approximately 38 professional man-months of effort would then be required to identify and evaluate "hot" leads on possible threats to public health due to chemicals in the environment. It was estimated that up to 24 in-depth case studies per year (involving approximately 85 man-months of effort) of critical hazards should be undertaken in the overview program. The total program for a comprehensive overview of chemical threats to environmental health is judged to require 187 professional man-months of effort plus consultant assistance. This total includes project management and information support activities in addition to those mentioned above.

Battelle recommends, therefore, that an Overview Center be established within an existing institutional structure possessing the qualifications necessary to provide both the information-analysis specialities and a significant multidisciplinary block of professional scientists to immediately provide an internal core for such a Center.

An office, established and staffed by personnel of the Bureau of Disease Prevention and Environmental Control, would provide continuous and intimate relationship to the Overview Center, permit the Bureau staff to immediately establish information and research priorities, and establish and maintain an integrated national network of skills and expertise which could participate both in the evaluation of potential threats to human health and in contributing research efforts toward their solution.

The report identifies the necessary components of the Center itself, as well as specific recommendations for the Bureau of Disease Prevention and Environmental Control's participation in the integration of appropriate skills and resources into the Overview Center.

Finally, the report deals with the requirements, costs, and recommended methods of operation of the total Overview Program, following the successsful completion of the period of preliminary pilot phase of the recommended operation. A continuation of the present program at Battelle would provide access to Battelle staff in the initiation of the final Center following the pilot phase already defined.

APPENDIX H-1

NEWSLETTERS, PERIODICALS, AND OTHER PUBLICATIONS PERTINENT TO THE OVERVIEW PROGRAM

APPENDIX H-1-a

NEWSLETTERS, PERIODICALS, AND OTHER PUBLICATIONS PERTINENT TO THE OVERVIEW PROGRAM

The following publications should have been reviewed regularly to obtain information on environmental hazards that were pertinent to OVERVIEW. These publications are identified under seven categories as follows

Chemistry and Industry

Chemical and Engineering News
Chemical Week
Chemical Engineering
Gaylor's Survey
Search
Bureau of Mines bulletins, circulars, and yearbooks
Modern Plastics
Ceramic Industry
Hydrocarbon Processing
Paper Trade Journal
Chemical Abstracts

Public Health and Epidemiology

Today's Health
Medical World News
New England Journal of Medicine
American Journal Public Health
World Health
United States Public Health Service publications
American Journal of Epidemiology

<u>Public Health and Epidemiology (Continued)</u>

Index Medicus
Biological Abstracts
Public Health Engineering Abstracts
Excerpta Medica - Public Health, Social Medicine and Hygiene

<u>Industrial Hygiene and Occupational Medicine</u>

Occupational Health Newsletter
Environmental Health Letter
Industrial Hygiene Digest
Industrial Hygiene Review
Journal of Occupational Medicine
Archives of Industrial Health
Index Medicus
Biological Abstracts
American Industrial Hygiene
Association abstracts
Air Pollution Control Abstracts
Water Pollution Abstracts

<u>Toxicology</u>

Drug News
Toxicology and Applied Pharmacology
Journal of Pharmacology and Experimental Therapeutics
Food and Cosmetic Toxicology
Archives of Environmental Health
National Clearinghouse for Poison Control Center Bulletins

Toxicology (Continued)

Archives of Industrial Health
Bulletin of Environmental Contamination and Toxicology
Journal of Forensic Sciences
Index Medicus
Chemical Abstracts
Biological Abstracts
Biological and Agricultural Index
Pharmaceutical Abstracts
Industrial Hygiene Digest
International Abstracts of the Biological Sciences
Excerpta Medica - Pharmacology and Toxicology

Environmental Health

Environmental Health Newsletter
Occupational Health Newsletter
Archives of Environmental Health
Environmental Health Research
Bulletin of Environmental Contamination and Toxicology
Index Medicus
Biological Abstracts
Chemical Abstracts
Public Health Engineering Abstracts
Air Pollution Control Association Abstract
Water Pollution Abstracts

Pollution - Air, Water, Waste Control

Air/Water Reports
Environmental Health Newsletter
Water Newsletter
Journal of the Water Pollution Control Association
Air Pollution Foundation Report
Bulletin of Environmental Contamination and Toxicology
Water and Sewage Works
Water Pollution Research
Journal of Sanitary Engineering
Water Resources Research
Biotechnology and Engineering
Environmental Engineering, Quarterly
Air Pollution Control Association Abstracts
Water Pollution Abstracts
Chemical Abstracts
Engineering Index
Applied Science and Technology

Ecology (Animal and Plant Epidemiology)

Ecology
Ecological Monographs
Journal of Ecology
Journal of Animal Ecology
Journal of Applied Ecology
Biological Abstracts