DOCUMENT RESUME

ED 143 354 IR 005 124

AUTHOR Mavor, Anne S.; And Others
TITLE Identification and Preparation of Derivative Information Products Required by Selected Users of Science Information.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE Jan 77
CONTRACT SIS 74-14127
NOTE 138p.; Best copy available

EDRS PRICE MF-$0.83 HC-$7.35 Plus Postage.
DESCRIPTORS Audiovisual Aids; *Curriculum Design; Curriculum Development; Curriculum Guides; Curriculum Research; *Information Needs; *Instructional Programs; Researchers; *Science Curriculum; Science Education; *Science Materials; Science Teachers; Secondary Education; Secondary School Teachers; *Use Studies

ABSTRACT

One area of research with computer-based systems for storage and retrieval of science information is the delivery of knowledge required by users rather than citations to documents which contain the needed knowledge. The purpose of this project was to identify the kinds of derivative information products needed by users of science information and to delineate characteristics of the user and his work which determine how the products should be designed. Identification of derivative information product needs was accomplished through structured interviews with 14 researchers (from three institutions) and 12 teachers (from two school systems) active in environmental science. Product design criteria were determined through case studies with two researchers and two teachers to develop products relative to their current work requirements. Researchers shared a need for eight derivative information products which were grouped into: (1) content related products, (2) method related products, and (3) special data storage and retrieval products. Four of the eight information products described by the high school teachers were similar in structure to those identified by the researchers. Specific derivative information products were prepared for the researchers and teachers by information specialists, according to their needs as determined by the case studies. Materials for teachers were selected to assist in lecture and laboratory preparation and to provide audiovisual presentations for the classroom. Results of the research demonstrated a need for derivative information products which can be prepared by information specialists on the basis of interviews with users. (Author/JAB)

ED143354

IDENTIFICATION AND PREPARATION OF DERIVATIVE INFORMATION PRODUCTS REQUIRED BY SELECTED USERS OF SCIENCE INFORMATION

Anne S. Mavor
W. S. Vaughan, Jr.
J. S. Kidd

Technical Report Prepared Under
University of Maryland Purchase Order W-148894
and
National Science Foundation Grant Number SIS 74-14127

Prepared by:
W/V Associates
3308 Dodge Park Road
Landover, Maryland 20785

January 1977

IR005134

ACKNOWLEDGMENTS

The work described in this report was sponsored by the Information Science Program, Division of Science Information, National Science Foundation. We would like to extend our special thanks to Dr. Edward C. Weiss, Program Director, for his ideas, his encouragement and his continued support.

Project work in the areas of information search and prototype product preparation was heavily contributed to by Judy McDivit and M[illegible] Zackowitz. Miss McDivit, a MLS from the University of Maryland, was responsible for the search associated with the research products. Mrs. Zackowitz of the School of Library and Information Service, University of Maryland, conducted the literature search and participated in product assembly for the high school teacher.

Appreciation is extended to Dr. James B. Carmon and Dr. Edward P. Warren of the Georgia Information Dissemination Center, University of Georgia, and to Dr. Donald J. Hillman, Director, Center for Information Science, Lehigh University, for providing computer searches of selected volumes and files. These searches led to the identification of several useful materials for the research information products.

Finally, we would like to express our thanks to those researchers and teachers who took the time to discuss their work and the information needs and product formats associated with their work.

ABSTRACT

One area of research with computer-based systems for storage and retrieval of science information is the delivery of knowledge required by users rather than citations to documents which contain the needed knowledge. The outputs of these future systems are assumed to be derivative information products whose content and format characteristics match the specific need characteristics of the individual user. The purpose of the present effort was to identify the kinds of derivative information products needed by users of science information, and to delineate some of the characteristics of the user and his work which determine how the product should be designed.

The identification of main categories of derivative information product needs was accomplished through structured interviews with fourteen researchers and twelve teachers active in the field of environmental science. The delineation of product design criteria for individual users was accomplished in case study fashion, working in an on-line mode with two researchers and two teachers to develop specific derivative information products in response to their current work requirements.

Researchers were found to share a common need for eight derivative information products which were grouped into three classes as follows:

- Content Related Products: Variable lists, chemical/physical/behavioral characterization of variables, effects of variables on selected sets of other variables.
- Method Related Products: Descriptions of major methodological approaches, procedural guides, alternative instruments for measurement and analysis.
- Special Data Storage and Retrieval Products: Charts/maps for research site selection, baseline data on selected site.

Four of the eight information products described by the high school teachers were similar in structure to those identified by the researchers. These were variable characterizations, effects of variables on selected sets

of other variables, procedural guides and baseline data. The four other products identified by the high school teachers were lists of local environmental organizations, descriptions of effective teaching methods, characterizations of available laboratory exercises and pollution standards for local streams.

Specific derivative information products were prepared by information specialists with no particular training in the user's field of expertise. The specific design of each product prepared for the two researchers reflected the user's present knowledge of the problem, the decision-task in the overall research process which he needed to resolve, the way in which he structured the variables of concern, and the strategy by which he chose to approach the problem. Type of content presentation depended upon the sophistication or stage of development of the problem area. For well-developed content areas he needed the barest of results summaries as best presented in charts, graphs, tables or figures; for problems in an early stage of development he needed more discursive content, particularly exerpts from Discussion sections of journal articles where the author's ideas are presented about what the results mean.

Product design criteria for the teachers, on the other hand, were based on characteristics of the student population for which the products were intended. Topics were chosen which were most salient to their day-to-day experiences. Only the most well-established facts were needed; presented in the most straight forward manner. As with the researchers, graphic representations of concepts and data were found to be most desirable.

Overall the results of the current work document the need for derivative information products, and demonstrate that highly acceptable products can be prepared by information specialists on the basis of structures determined in task-analysis interviews with the user.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

IDENTIFICATION AND PREPARATION OF DERIVATIVE INFORMATION PRODUCTS REQUIRED BY SELECTED USERS OF SCIENCE INFORMATION

I. INTRODUCTION

A. Rationale

It is generally assumed that the information requirements of scientists as users are not readily satisfied by the information provided by scientists as producers. Formats of journal articles, texts, handbooks and the like are structured to accommodate the details of an experiment, problem area review, data compilation, etc., based on the orientation and perspective of the producer at a given time in the development of the content area of concern. A scientist as user on the other hand, encounters an information requirement in another time and from a unique background of education, experience and expertise. His specific information problem arises in the course of his work as researcher, teacher, advisor to policy decision makers, etc. The information he needs is contained in the scientific literature but is not directly accessible in the form required. He must locate and review a large number of original articles in order to compile information relative to a very limited content area or question. He needs a derivative information product and he typically constructs it himself since the product's usefulness depends upon the interplay of factors best known by him: what he already knows about the content, his approach to the problem solution, the specific task or decision the product is to support, whether he will use it himself or provide it to his students, etc. All of these and potentially other highly individual and time-dependent characteristics of both the scientist-user and the context of his work specify the utility characteristics of the derivative information product. Present information systems retrieve citations and deliver documents to the user; if more were known about the derivative information products he generates from the documents, perhaps future systems could scan and exerpt documents according to the specific characteristics of the individual user's needs.

The current project was undertaken as a beginning effort to empirically document the existence of derivative information products and provide initial answers to the following questions:

- What are the main categories of derivative information products generated by user scientists in research and teaching roles?
- Under what circumstances does the need for derivative products occur in research and teaching activity?
- What criteria guide the design and format of derivative information products?
- Can scientist-information specialist interactions be developed in which derivative information products needed by the scientist can be created by the information specialist?

B. Scope and Conduct

The project participants were a small sample of researchers and teachers working in the environmental sciences. The environmental science area was selected because it provides a common problem context and at the same time involves the use of information from a variety of disciplines. It was felt that a common context would facilitate comparisons between participants while the interdisciplinary nature of the area would provide experience in approaching the literature in several scientific fields such as physics, chemistry, biology, etc. The two job roles of researcher and teacher were selected because scientists in these roles place a high demand on the scientific literature. Additionally, the differences in purposes and perspectives of these two groups were considered as possible sources of variation in information product format requirements. A small sample was used because of the in-depth, exploratory character of the project.

The project was conducted as a two-phase effort. The first phase was devoted to the identification of major catagories of derivative information products either used or desired by researchers and teachers. This was accomplished by a series of in-depth interviews with each participant directed at describing actual practices of creating products from original sources in support of research and teaching related tasks. The second phase involved the development of prototype products based on the characterizations developed in the first phase. The participants in this second phase were two teachers and two researchers. The work required intensive analysis of task needs, elaboration of appropriate product formats from phase one, and the selection and compilation of relevant information into responsive information products. Product creation was accomplished with the assistance of graduate students attending the College of Library and Information Services at the University of Maryland. Completed products were provided to the scientists for review and comment. All products were accompanied by the full set of documents used in product development. Each scientist was asked to examine products for ease of use, for completeness and for appropriateness of organization. One of the major concerns was whether the material included in the products was adequate to the scientists information need or whether this material needed to be supplemented by sections of selected documents which were not included in the products.

II. INFORMATION NEEDS AND PRODUCTS REQUIREMENTS

This section of the report describes the procedures and results associated with the information requirements analysis phase of the project. Specifically, it presents detailed characterizations of the researcher and teacher participants, of the task analysis procedures, of the basic research and teaching tasks, of the information needs associated with each task and of the products required to meet these needs.

A. Researchers

1. Participants and Procedures

Fourteen Ph. D. scientists engaged in problem-oriented environmental research projects were selected as participants. Table 1 shows the institutional affiliation, the specialty and the project area of each researcher. Three institutions are represented in the sample: University of Maryland with six participants, Chesapeake Biological Laboratory with six participants and the Smithsonian Institution with two participants. With regard to areas of specialization, twelve of the fourteen researchers classified themselves in subfields of biology, one in chemical engineering and one in biochemistry. The specific projects being conducted covered a wide range of topics including population dynamics and species competition among paramecia, dietary requirements of blue crab larvae, and patterns of genetic variations in white pines. Some of these projects were conducted in the field and some were conducted in the laboratory. Some involved variable manipulation and others involved variable observation and measurement.

In-depth interviews were held with each researcher for purposes of identifying project-related information needs and the preferred formats for presenting the needed information. These interviews were structured around the tasks performed in conducting a research project. This task approach focused

Table 1. Researcher Participants

Location	Speciality	Project
University of Maryland		
• Zoology Department	Evolutionary Ecologist	Population dynamics and species competition among paramecia.
	Aquatic Ecologist	Distribution patterns of aquatic insects as a function of environmental gradients.
	Behavioral Ecologist	Nature of inter-species competition for food and habitat resources.
	Protozoologist	Taxonomic and morphologic classification of ciliates.
	Neurobiologist	Effects of aspirin and aspirin analogs on cell membrane potential.
• Botany Department	Plant Geneticist	Patterns of genetic variations in white pine and the effects of environmental conditions.
Chesapeake Biological Laboratory	Marine Biologist (3)	• Significance of striped bass spawning ground in upper Potomac River. • Diet of blue crab larvae at various developmental stages. • Effects of dredged spoil dumping on shell fish population. • Environmental requirements for culturing oysters in the laboratory on a large-scale.
	Chemical Engineer	Hydrologic characteristics of the upper Potomac River.
	Physiological Ecologist	Application of electrophoresis to differentiation among black ducks, mallards and hybrids.
	Zooplankton Biologist	Living carbon as a source of food for zooplankton.

Table 1. Researcher Participants (Continued)

Location	Speciality	Project
Smithsonian Institute		
• Rhode River Project	Biochemist	Phosphorus recycling through forests.
• Radiation Biology Laboratory	Environmental Physiologist	Marsh productivity as measured by carbon exchange.

the discussion with the researcher on the step-by-step process of implementing a research project. Each of these steps has a potential for generating the need for information support either to complete that step or to initiate the next step. Two interview guides were developed: one included an outline of task areas and questions related to laboratory manipulation research, the other listed tasks required in field observation projects. (See Appendix A.) Each outline was composed of ten major tasks. Several of the tasks were common to both types of projects. These were:

- Define research problem.
- Select or develop apparatus.
- Select measurement methods
- Collect data
- Analyze data
- Interpret results.
- Report results.

Those tasks that were unique to the field observation projects included characterization of the research environment, selection of specific research site(s) and development of a data collection and sampling plan. The tasks specifically associated with laboratory manipulation projects were identification and description of independent variables, development of experimental design, and maintenance and culturing of organisms in the laboratory.

The first step in each interview was to describe the purpose of the meeting to the researcher. The purpose being to identify information needs and presentation formats associated with the conduct of a research project. The second step involved having the researcher select for discussion a recently completed or on-going project, which required information support at one or more stages. Third, the researcher was asked to review the two interview guides and choose the one which best matched the selected project. The fourth step in the interview process was the step-by-step discussion with the researcher concerning each task, the information needs or questions associated with that task, and the information products either created or desired by the researcher to allow for most efficient use. The average length of these initial interviews was one and one-half to two hours.

The results from the interviews were summarized and the potentially useful information products listed. Structural outlines were then created to characterize each identified product. A second set of interviews was conducted with the researchers to modify and elaborate the product outlines.

2. Results

All of the research projects discussed in the interviews were problem oriented and in most cases the researchers were concerned with applying a familiar methodology to a new content area or to a new set of environmental conditions. The results of the interviews led to the identification of eight information products. Table 2 shows the relationships between information products and research tasks; some of the products were identified as being useful for more than one task. Three of the tasks, develop experimental design, collect data and prepare report, did not require any direct information support for the sample of researcher participants. Development of the experimental design relies on knowledge gained in the accomplishment of other tasks such as selection of variables and selection of methods and, therefore, indirectly draws on the information products supporting those tasks.

Table 2. Research Tasks with Information Products

Research Tasks	Information Products
1. Define Research Problem	• List of variables related to problem area.
2. Describe and Select Variables	• List of variables related to problem area. • Characterizations of variables in terms of physical/chemical/behavioral properties. • Effects of a selected variable on other variables.
3. Characterize Research Environment	• Characterization of variables in terms of physical/chemical/behavioral properties. • Effects of selected variables on other variables.
4. Select Research Site(s)	• Maps and charts specifying topographical information. • Baseline data on selected variables such as rainfall, distribution of biota, etc.
5. Select Research Methods	• Descriptions of major methodological alternatives.
6. Maintain/Culture Sample Organisms	• Procedural guides for sampling, culturing, etc.
7. Select/Develop Apparatus	• Characterizations of alternative instruments for measurement and analysis of selected variables
8. Develop Data Collection and Sampling Plan	• Procedural guides for sampling, culturing, etc.

Table 2. Research Tasks with Information Products (Continued)

Research Tasks	Information Products
9. Analyze and Interpret Data	• Characterization of variables in terms of physical/chemical/behavioral properties. • Effects of selected variables on other variables. • Baseline data on selected variables such as rainfall, distribution of biota, etc. • Descriptions of major methodological alternatives.

Data collection is the implementation of the methodology and procedures. Report preparation is the written presentation of the project and derives indirect support from all information products.

The identified information products fall into three general classes: content-related products, method-related products, and special data storage and presentation products. The specific products in the content class are:

- Lists of variables related to the research problem.
- Characterization of variables in terms of physical/chemical/behavioral properties.
- Effects of selected variables on other variables or variable combinations.

Variable lists were mentioned as desirable by three of the researchers. In all cases these lists were used in the tasks of bounding the problem area and selecting variables to include in the study. One example of this product is a list of marsh plants ordered in terms of abundance in Chesapeake Bay. Another example is a list of environmental factors that could influence growth rates in white pines. Characterization of variables in terms of physical/chemical/behavioral properties was identified as a useful product in the tasks of variable selection and results interpretation by nine researchers. This product can be thought of in terms of a matrix with the rows listing the variables and the columns listing the characteristics. Some specific examples are physical and biological characteristics of trout streams at different elevational gradients; morphological and behavioral characteristics of black ducks, mallards and hybrids; chemical and physical properties of aspirin and aspirin analogs. Variable interactions or the effects of one variable on another was mentioned by five researchers as a product need for two project tasks: selection of variables and interpretation of results. This product is structured to present results summaries from the professional literature primarily in the form of tables and figures. These summaries provide the researcher with a better understanding of the variables under consideration as well as with a basis for comparing data resulting from his/her current research efforts. An example here is the requirement to know more about how environmental conditions affect growth rates in white pines. There were no differences between field and laboratory researchers in their expressed needs for content-related products.

The second class of products, those dealing with methodology and procedures include:

- Descriptions and evaluations of major methodological alternatives for approaching the selected problem area.
- Procedural guides for sampling, transporting, culturing organisms.
- Descriptions of alternative instruments for measurement and analysis.

A description of methodological alternatives for studying a selected content area was identified by four researchers as a useful product. Three of the four researchers wanted this product for purposes of comparing other methodologies with the one chosen in terms of reliability, precision, unit of measurement, etc. The fourth researcher was involved in selecting a methodology to approach the research problem. The need for procedural guides was mentioned by seven of the researchers. These guides would describe the specific procedures and techniques for transporting, maintaining and growing test organisms in the laboratory environment. Some examples of test organisms used in the research projects described are paramecia, aquatic insects, blue crab larvae and oysters. A characterization of alternative instrumentation was needed by six researchers; in all cases the need for this product was linked to field research projects. The primary concern was for description of operational performance and durability under a selected set of environmental conditions such as those existing in a salt marsh, a mountain stream or a large river.

The third class of products deals with special data storage and presentation. They include:

- Charts and maps designed for research site selection.
- Charts and maps designed for baseline data and trend data.

Two researchers indicated a requirement for charts and maps to assist in the selection of a research site. One was interested in topographical features such as vegetation, elevations and roads in the area of mountain streams, the other needed information for selecting a tidal creek as a site to study the characteristics of marsh detritus. Baseline data were mentioned by three researchers. The primary need here was for an historical presentation of information on such variables as biological inventory in a selected area, water quality characteristics or frequency and amount of rainfall. These data were identified as useful in the accomplishment of two tasks: selecting and characterizing a specific research site and interpreting research results obtained at a selected site.

B. Teachers

1. Participants and Procedures

Eleven secondary school teachers and one college professor were selected to participate. Table 3 shows the location, the background, and the course emphasis for each secondary school teacher. These teachers were drawn from two county school systems: Montgomery County and Prince George's County. With regard to educational background, nine had either bachelor or master degrees in biology, one had a bachelor's degree in geology, and one had a master's degree in chemistry. As compared to the researchers, the teachers appear to be less specialized and to have less formal education. The content of the courses offered by these teachers fell into two areas: environmental problems and ecology. The major topics covered under environmental problems included air pollution, water pollution, solid waste disposal and population trends.

The college professor was associated with the University of Maryland and had responsibility for a graduate level course in environmental chemistry. This professor was selected to participate for two reasons: first, to provide a contrast to the secondary school teachers in terms of level of sophistication of needed packages as well as the format of those packages and second, to take advantage of his expressed interest in the development and use of information packages for student learning both at the college and secondary school level. One of his earlier projects was the creation of an environmental chemistry module for use with high school students.

The task analysis methodology discussed in the section on researchers was applied to the in-depth interviews with teachers. An interview guide detailing the seven main teaching tasks was developed. (See Appendix A) These tasks include:

- Selecting objectives.
- Determining course format.
- Selecting topics.

Table 3. Teacher Participants

Location	Background	Course Emphasis
Montgomery County		
• Junior High School	Biologist (BA)	Environmental Problems
• Senior High School	Geologist (BA)	Environmental Problems
	Biologist (MA)	Ecology
	Biologist (MA)	Ecology
Prince George's County		
• Junior High School	Biologist (BA)	Ecology
• Senior High School	Chemist (MS)	Environmental Problems
	Biologist (BA)	Environmental Problems
	Biologist (BA)	Environmental Problems
	Biologist (MA)	Ecology
	Biologist (BA)	Ecology
	Biologist (BA)	Ecology
University of Maryland Chemistry Department	Chemist (Ph.D.)	Environmental Chemistry

- Selecting student reading and projects.
- Preparing lectures/discussion
- Selecting laboratory exercises
- Selecting field exercises

These tasks were identified in a previous study in which the teaching activities of college professors were used as a basis for designing a document retrieval system (Mavor and Vaughan, 1974). Each teacher was asked to describe his/her course activities in each task area and the type and organization of information needed to support those activities. These interviews averaged from one and one-half to two hours in length. Information needs and product characterizations were summarized following the initial set of interviews. A second round of interviews was conducted to modify and elaborate these characterizations.

2. Results – Secondary School Teachers

Results of the interviews led to the following general course descriptions. All secondary school courses were formatted to include lecture, laboratory and field work with the smallest percentage of class time being devoted to formal lectures. Course objectives were of two types: content objectives and process objectives. The content objectives were aimed at students gaining knowledge of key concepts and facts in order to develop an understanding of the environment and the factors that effect environmental balance. The process objectives dealt with students developing skills in applying research methods and techniques. All teachers mentioned both types of objectives; however, some placed more emphasis on content while others focused on process. As mentioned earlier, course topics were in the areas of environmental pollution problems and ecology. For the most part, topic selection was guided by the curriculum. The function of the laboratory was to teach students the use of standard research methods and techniques and to demonstrate, experimentally, principles discussed in the lecture portion of the course. In some cases students were asked to design independent laboratory projects and write a report describing the results. Teachers were interested in insuring that the exercises in the laboratory were integrated with the topics being covered. Each course had a field work component which was designed around monitoring and measuring chemical, physical and biological activities in local streams. This field work was part of a county wide program in both Prince George's and Montgomery Counties. Wherever possible attempts were made to fully integrate the field work with the laboratory and lecture. In one instance, the field effort was used as the core component of the course.

Four of the seven teaching tasks discussed in the interview were identified as requiring information support. These tasks are: select student reading, prepare lectures/discussions, select and prepare laboratory exercises, and select and prepare field exercises. Table 4 shows the eight information products which relate to these tasks. Several of the products described by teachers as useful are similar in structure to those identified by researchers. These products include:

- Characterizations of selected environmental variables in terms of chemical/physical/biological considerations.
- Effects of environmental pollution on plants, animals, humans; interactions of environmental variables.
- Procedural guides for taking and analyzing samples.
- Baseline data on selected variables such as water quality, distribution of biota, etc.

Characterization of variables and the effects of variables were identified by six teachers as being useful for developing student reading and for preparing lectures. In supporting the task of lecture preparation, these products served two purposes: providing the teacher with new information for his/her understanding and with materials such as charts, tables, and figures that could be used to graphically demonstrate principles to the students. The major concern of the secondary school teachers was to present topics in a way that motivated the students to learn. The sophistication level of the material needed by teachers differed significantly from that required by researchers. Teachers wanted simple explanations accompanied by graphic presentations of selected variables and their effects that would be understandable to high school students; researchers required exhaustive descriptions in these areas as their task was to select variable sets to include in a research project. The third product mentioned by both teachers and researchers was a procedural guide. The four teachers indicating a need for this product were looking for simplified descriptions of field sampling and analysis

Table 4. Teaching Tasks with Information Products

Tasks	Information Products
1. Select Student Reading	• Characterizations of selected environmental variables in terms of chemical/physical/biological considerations • Effects of environmental pollutants on plants, animals, humans; interactions of environmental variables.
2. Prepare Lectures/Discussions	• Characterization of selected environmental variables in terms of chemical/physical/biological considerations. • Effects of environmental pollutants on plants, animals, humans; interactions of environmental variables. • Compilation of local environmental organizations, events, individuals and reports. • Compilation of effective teaching methods.
3. Select and Prepare Laboratory Exercises	• Descriptions of laboratory exercises in terms of purpose, topic, difficulty level, length, etc.
4. Select and Prepare Field Exercises	• Pollution standards for variables being monitored/measured in local streams. • Procedural guides for taking and analyzing samples. • Characterizations of variables in similar field research studies. • Baseline data on selected variables such as water quality, distribution of biota, etc.

procedures. The requirement was for descriptions that could be used directly by students. Researchers needed a product that would present the most sophisticated and precise techniques available. The fourth commonly mentioned product was baseline data on environmental conditions and biological distributions in a selected field research area. The four teachers describing this need were interested in providing students with a general idea of what to expect in the field study area. All mentioned the requirement for simplified keys to assist in the identification of local biota. The researchers' need for environmental baseline data was for use in interpreting research project results.

Four additional products were identified by teachers as being of use in course-related tasks. Two of these provided support for lecture preparation. They were:

- Compilation of local environmental organizations, events, individuals and reports.
- Compilation of effective teaching methods.

The description of local organizations, events, and individuals was described as a need by five teachers. This information would be used to provide students with local examples of topics discussed in class, to plan participation in local events and to identify potential outside speakers on selected topics. The compilation of teaching methods was mentioned by three teachers. These teachers felt that their presentations could be improved if they were aware of methods used effectively by other teachers. Here again, the primary aim was to interest and motivate the student. Another product mentioned was descriptions of laboratory exercises in terms of purpose, topic, difficulty level, equipment needed and length. Five teachers indicated that this type of information would be extremely useful in selecting appropriate experiments. Much time has been used in this selection process to identify experiments that can be performed by high school students in one or two class periods and which rely on equipment that is generally available in high school science departments. The final product, mentioned by four teachers, was a list of pollution standards for variables being measured in the field projects. It was felt that this product would be most useful if it were structured to show the water quality conditions necessary for the survival of aquatic plants and animals.

3. Results - College Professor

The college professor discussed the information needs associated with a graduate level course in environmental chemistry. The purpose of this course was to provide students with an in-depth coverage of environmental chemistry problems. The basic format of the course was a series of lectures on critical environmental problems. These lectures were presented by faculty doing current research in each problem area. Lectures were supplemented by notebooks of materials from the literature describing methods and results.

Three information products were identified:

- Characterization of variables in terms of source, chemical properties, concentrations, etc.
- Effects of variables on plants, animals, humans, weather patterns, etc.
- Descriptions and evaluations of major measurement methodologies.

The first two products, variable characterizations and effects, were mentioned as being useful for both lecture preparation and development of student reading. Descriptions and evaluations of measurement methodologies were discussed in connection with student reading. Although the purpose of these products differed from those identified through researcher interviews, their structure was similar. Additionally, the source of material to be included in the products in both cases was the highly technical journal literature.

III. DEVELOPMENT OF PROTOTYPE INFORMATION PRODUCTS

Phase I activities provided evidence that general categories of derivative information products are needed by scientists in both research and teaching roles. Furthermore, the results suggested that, through a series of information specialist/scientist interviews, specific product requirements could be structured sufficiently to enable the information specialist to prepare a product whose characteristics would match the particular needs of the user scientist.

The objective of Phase II was to substantiate the validity of this proposition through implementation of the process and development of information products for selected user scientists. Accordingly, two researchers, a secondary school teacher and a university professor were enlisted as participants in Phase II activities. In-depth interviews were held with each participant for purposes of describing current tasks and topic areas needing information support. The product outlines developed in the first project phase were used to guide these interviews. Particular emphasis was placed on elaborating the appropriate product outlines in terms of the project or course content. The results of these interviews were summarized and used as the basis for a second round of discussions. These discussions further elaborated and clarified product needs. The four case studies are described here in terms of the scientist's tasks and information products needs, and the information specialist's document search process and product design strategies.

A. Researcher 1

1. Tasks and Product Needs

The first researcher, a biochemist, had just begun a new research project and was involved in the tasks of hypothesis development and variable selection. The general problem area of study was the possibility that herbicides used by farmers were responsible for the increased death rate of higher aquatic plants in the Chesapeake Bay. The needs of this researcher and the information products corresponding to these needs are shown in Table 5. The basic intent of the products was to narrow down the number of potential experimental variables; to obtain information which would assist in selecting those variables most relevant to the problem. Three types of products were identified: Lists of Variables, Characterization of Variables, and Effects of Variables on Other Variables. Lists of variables were required in response to two needs: what chemical compounds are being used by area farmers and what aquatic plants are being affected? A characterization of each of the locally used compounds in terms of degradation over time was

Table 5. Effects of Herbicides on Aquatic Plants: Needs and Information Products

Needs	Products
• What chemical compounds are being used by area farmers?	• List of variables: herbicides used by area farmers rated in terms of volume of usage and increase in usage.
• What is the probability that locally used chemicals are reaching the water?	• Characterization of variables: breakdown of compounds over time due to leaching through soil, sunlight, microorganisms, etc.
• What aquatic plants are being affected?	• List of variables: aquatic plants in the Chesapeake Bay ordered in terms of death rates.
• What is known about the effects of the chemical compounds identified above on the aquatic plants in the Chesapeake Bay.	• Effects of selected variables on other variables: tables, figures, etc., showing the toxic effects of chemical compound sets on aquatic plant sets.

needed to determine which of the compounds had the highest probability of reaching the water. Specific degradation factors mentioned by the researcher were leaching through the soil, sunlight and microorganisms. The requirements for a product dealing with effects and relationships resulted from a need to know about research on the toxicity of selected compounds to aquatic plants in the Chesapeake Bay.

2. Search Process and Product Preparation

The search for materials to be used in compiling the required information products was conducted by a library school graduate (MLS) at the University of Maryland. Two procedures were followed in developing the lists of variables: contacting knowledgeable individuals in the field and reviewing appropriate handbooks. The names of locally used herbicides and the amount of their use in recent years was obtained through an interview with a professor of agronomy at the University of Maryland. This information was not available in the literature. The list of rooted aquatic plants in the Chesapeake Bay was provided by a researcher at the Chesapeake Biological Laboratory who also recommended two reports dealing with the subject.

The search process associated with preparing variable characterizations and describing the effects of one variable on another involved extensive use of the professional journal literature. Six steps were involved in this process.

- Identify relevant bibliographic sources.
- Search bibliographic sources and identify relevant citations.
- Locate and obtain articles.
- Review obtained articles for relevance.
- Analyze relevant articles for author and journal patterns; review references in articles.
- Select extracts and prepare product.

Figure 1 presents the steps and the percentage of time spent in accomplishing each step. Approximately 130 hours were spent by the searcher in completing these steps and in assembling the needed products. The identification of relevant bibliographic sources required 5% of the searcher's time. This step involved selecting the most useful bibliographic tools and ranking them in terms of degree of productivity based on a review of guides to abstracting/indexing services as well as recommendations from on-site librarians and the researcher. The guides to abstracting/indexing services are organized by subject and include brief descriptions of each service in terms of breadth and depth of coverage. Two guides* proved extremely useful in selecting the most highly focused services for accessing the herbicide literature.

Searching the bibliographic sources and identifying relevant citations occupied 20% of the searcher's time. This process represented the first level of screening the literature for relevance to the topic and the researcher's information needs. Key words such as the name of a specific herbicide or a herbicide action were used to enter the abstract indexes. Review of selected abstracts was guided by key words and the way these words related to one another. Emphasis was placed on matching the perspective of the abstracted article with the perspective of the researcher. Weed Abstracts, Biological and Agricultural Index, and Bibliography of Agriculture provided extensive coverage of the literature on the behavior of herbicides. As the searcher moved from one bibliographic tool to the next, increasing redundancy of coverage was experienced. It may be that one or two targeted sources are all that are necessary for identifying key articles in a selected subject area.

Locating and obtaining articles required the use of several libraries at the University of Maryland as well as the National Agricultural Library.

*Abstracting Services, Volume 1: Science and Technology. International Federation of Documentation.

Abstracts and Indexes in Science and Technology. Owen.

Identify Most Useful Bibliographic Tools - 5%

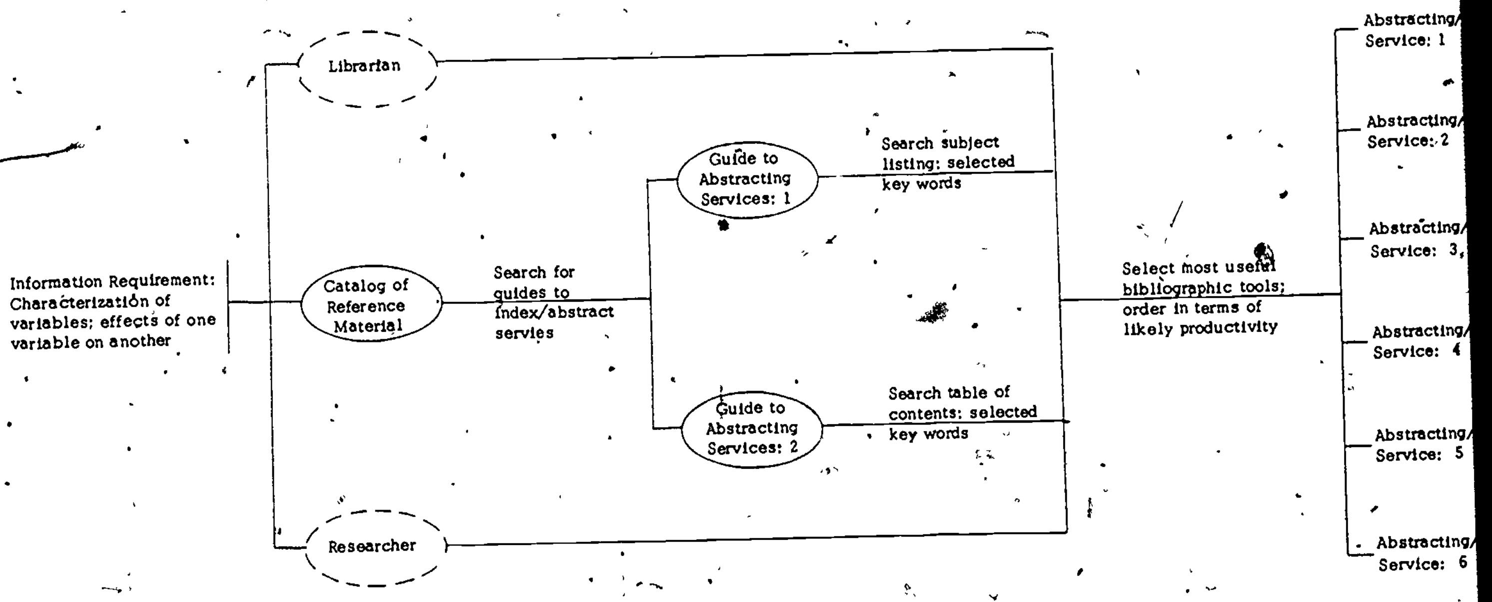
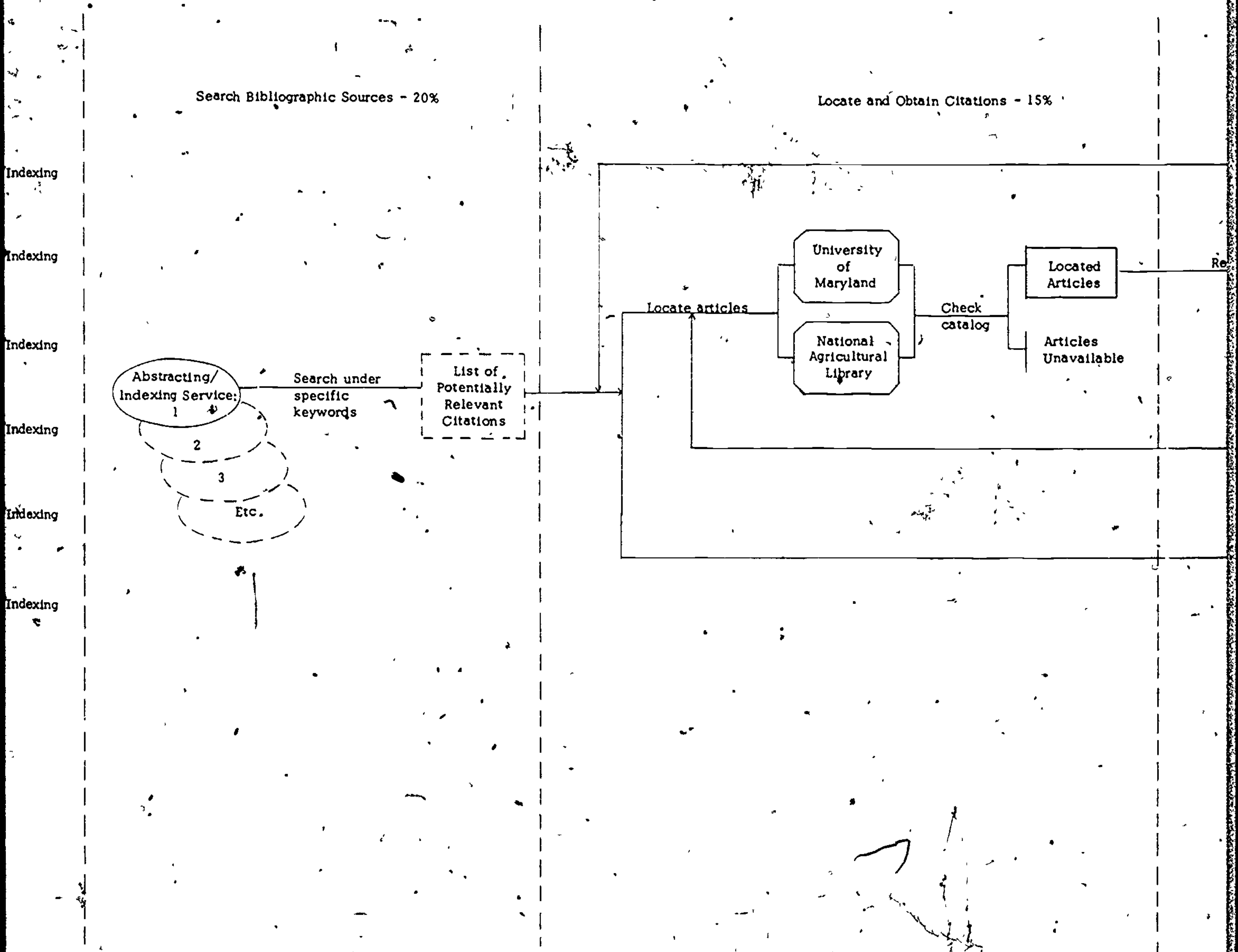
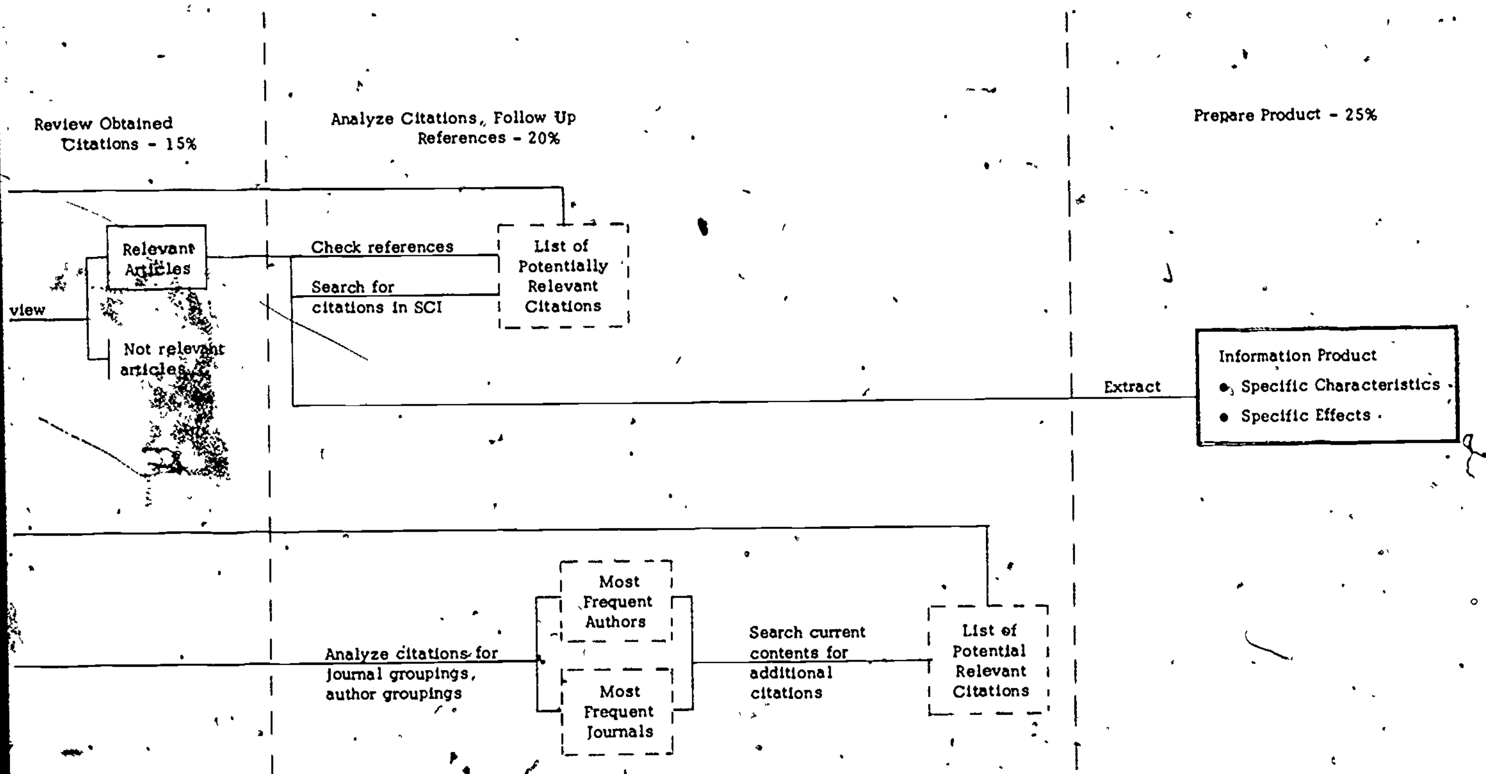


Figure 1. Search Process for Developing Research Products


Search Bibliographic Sources - 20%
Locate and Obtain Citations - 15%
Indexing
Indexing
Indexing
Indexing
Indexing
Indexing
Abstracting/ Indexing Service: 1
2
3
Etc.
Search under specific keywords
List of Potentially Relevant Citations
Locate articles
University of Maryland
National Agricultural Library
Check catalog
Located Articles
Articles Unavailable
Re



Review Obtained Citations - 15%
Analyze Citations, Follow Up References - 20%
Prepare Product - 25%
Relevant Articles
Not relevant articles
view
Check references
Search for citations in SCI
List of Potentially Relevant Citations
Extract
Information Product
• Specific Characteristics
• Specific Effects
Analyze citations for journal groupings, author groupings
Most Frequent Authors
Most Frequent Journals
Search current contents for additional citations
List of Potential Relevant Citations

This step, which required 15% of the searcher's time, involved identifying the location of journal volumes, selecting the appropriate article(s) from those volumes and obtaining needed hard copies. A second level of screening was accomplished at this stage in the search process; some citations that were identified as relevant from abstracts were rejected upon a cursory inspection of the articles.

A detailed review of selected articles represented the third level of screening. This screening required 15% of the searcher's time and included categorization of articles into sub-groupings to address specific researcher questions and examination of article sections for possible extraction and inclusion in the final product. Some articles were weeded out during this process because they were too general, redundant with other articles or not directly relevant to the topic. Approximately 80% of the hard copy articles were evaluated as relevant and non-redundant; of the remaining 20%, half were redundant and half were irrelevant.

The next step in the search process involved analyzing relevant articles for clues to additional useful literature. There were three separate analyses in this process. The first required checking the lists of references in each relevant article for earlier work which might contribute to meeting the researcher's information needs. The second involved searching forward in time by making use of the Science Citation Index to identify those articles that cite the key articles already retrieved. The third analysis was the determination of author or journal patterns of the relevant articles. That is, certain authors and journals were represented with greater frequency than others. Where journal patterns existed, further searching was done in tables of contents of recent journal issues. This analysis was of particular value for the literature on herbicides where 70% of the relevant articles were found in three journals. All citations selected through these analyses were located, obtained and reviewed for relevance and possible contribution to the final information product. The percentage of time spent by the searcher in accomplishing this step was 20%.

The final step in the search process-product development chain was the extraction and organization of material from relevant articles into coherent product sections. Here decisions were made as to the information necessary to adequately meet the researcher's needs. This step required 25% of the researcher's time.

3. Prototype Products

Four prototype information products were preared for the researcher. The process of extracting needed information from collected documents and articles and the organization of these extracts into information products required approximately 35 hours.

The two variable lists were the easiest and least time consuming to prepare. These lists of locally-used herbicides and aquatic plants in the Chesapeake Bay were primarily developed through interviews with experts. Appendix B shows some example pages from these lists. The list of locally used herbicides contained 13 compounds ordered in terms of amount of use. Type of use, trade name and manufacturer were also included. The list of aquatic plants presented 15 rooted aquatic plant species ordered by abundance and characterized by rate of decrease in recent years. Additionally, this list identified those plants known to be food sources for water fowl. Both of these lists assisted the researcher and the information searcher in the initial bounding of the research problem and in narrowing down the herbicides and plants to further learn about through a review of the literature.

The variable characterization focused on the leaching and degradation behavior of locally used herbicides. This product was integrated with the product dealing with variable effects because the effects information logically followed the variable characterization information; i.e., what is the nature of the herbicide and how does it affect aquatic plants. Product preparation required extensive use of the professional journal literature.

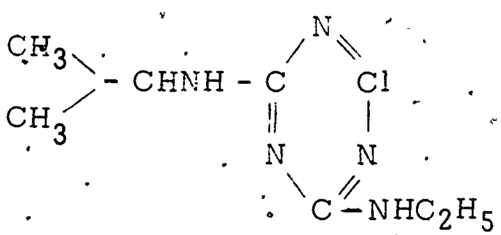
Information in the literature was available on 11 of the 13 herbicides included on the original list. Some herbicides had been researched extensively while others received little experimental treatment. The range of product pages per herbicide was 9 to 49 with a mean of 23 pages. Within each herbicide section the available information was categorized as follows:

- Mode of action against weeds
- Characteristics in the soil: toxicity related behavior
  - Adsorption by soil
  - Absorption by crop plants
  - Leaching (penetration)
  - Lateral movement (rainfall)
  - Decomposition by sunlight
  - Decomposition by microbial activity
- Persistance in water
- Effects on aquatic plants.

In the subsection on characteristics in the soil, the information was further divided by the characteristics of the soil which affect actions of the herbicide. Some of these characteristics include temperature, moisture content, cation exchange capacity, percent clay content, percent organic content and amount of soluable phosphor. The materials compiled on each herbicide were preceded by a summary sheet describing the chemical compound and the effects of microorganisms, sunlight and leaching through the soil. Table 6 provides an example of such a summary sheet. The final product developed on the herbicide problem was a matrix showing the articles published on each aquatic plant/herbicide combination. The rows of the matrix contained the 13 herbicides, the columns listed 12 aquatic plants. This product is shown in Appendix C.

Table 6. Information Product Outline Characterization of Herbicides

Herbicides: Atrazine

Time History of Chemical Change				
Chemical Compounds Used by Area Farmers in Herbicides	Effects of Microorganisms	Effects of Sunlight	Effects of Leaching Through Soil	Other Effects
Atrazine 2-chloro-4-ethylamine)-6-(isopropylamino)-s-triazine 	Significant residues may remain in soil for over a year (Herbicide Handbook) Half life at 15°C = 6 mos. 30°C = 2 mos. (Hague and Freed)	Not significant under normal conditions (Herbicide Handbook)	Leaching limited, normally not found below the upper foot of soil. Readily adsorbed on muck or clay, desorption occurs readily. Solubility in water at 27°C = 33 ppmw (Herbicide Handbook) Rf value: silt loam = .35 fg silty clay loam = .47 f sandy loam = .89b (Helling and Turner)	Vapor pressure mm Hg $10°C = 5.7 \times 10^{-8}$ $20°C = 3.0 \times 10^{-7}$ $30°C = 1.4 \times 10^{-6}$ $50°C = 2.3 \times 10^{-5}$ (Herbicide Handbook)

The procedure for selecting extracts to include in these products involved two steps. The first step was to determine the key contribution of each article to fulfilling the researcher's needs. In most cases this involved identifying a condensed representation of experimental results such as tables, figures and graphs. The second step was to determine the amount of textual material required to interpret the graphic material. Several strategies were used in performing this second step. Some product sections were prepared with only figures and tables, some included abstracts, some presented selected text from Results, Methods and Discussion sections of the journal article. It was felt that these variations would provide the researcher with a range of formats from which to choose the most efficient for transmitting the needed information. Appendix D provides an example of an information product which includes minimal textual material in support of graphic presentations of results. The information compaction of the products ranged from 10 to 1 to 4 to 1. That is, the amount of material presented in the full text hard copies was reduced a fourth to a tenth in assembling the information products. The various formats were reviewed by the researcher to determine the most usable and efficient presentation for acquiring needed knowledge. The researcher selected the format which included tables and figures with a minimum of textual elaboration.

The products represented significant expansions of the researcher's knowledge in the selected problem area. Through the literature review and product development processes, several additional variables related to the problem were identified and elaborated. When the question of local herbicides was first raised the researcher was aware of one aquatic plant, two herbicides, and three mechanisms of herbicide degradation. The search process identified 15 aquatic plants, 13 herbicides, 6 degradation mechanisms, and 6 soil characteristics which interact with or affect the degradation process. Additionally, the researcher was provided with organized sets of results characterizing each herbicide and its known effects on aquatic plants.

B. Researcher 2

1. Tasks and Products

The second researcher, a cell biologist, was interested in studying the possible effects of food additives on cells and organs and relating these to the effects of additives on behavior. The idea that food additives might influence behavior was proposed by the Nutrition Foundation in a report suggesting a link between artificial food additives and hyperkinetic behavior in children. The first task of the researcher was to select a set of additives to be explored experimentally in the laboratory. Figure 2 shows the information needs associated with this project task and the products identified as being responsive. Since the researcher was initially interested in examining the chemicals in additives which impact on behavior, it was decided to start with a product which compiled information on the relationship between hyperkinesis and diet. If specific additives were identified in this literature then these additives would be further described in terms of their chemical and physical structure and of their known effects on cells, organs and systems. If specific additives were not identified as linking to hyperkinesis then the strategy was to develop a list of colorings, flavorings and preservatives, to select those which were salicylate-related and to describe both the properties and effects of these. Based on his prior experiments the researcher assigned high priority to salicylates as potential sources of cell effects. An additional product needed by the researcher was a characterization of the behavioral and physiological correlates of hyperkinesis. The purpose of this product was to delineate the various behaviors and physiological values which distinguish hyperkinetic from normal individuals. These distinguishing factors could be used as comparisons with the laboratory results obtained in the planned project. As with the first researcher, all three types of content-related information products were identified: variable lists, variable characterizations, and variable effects.

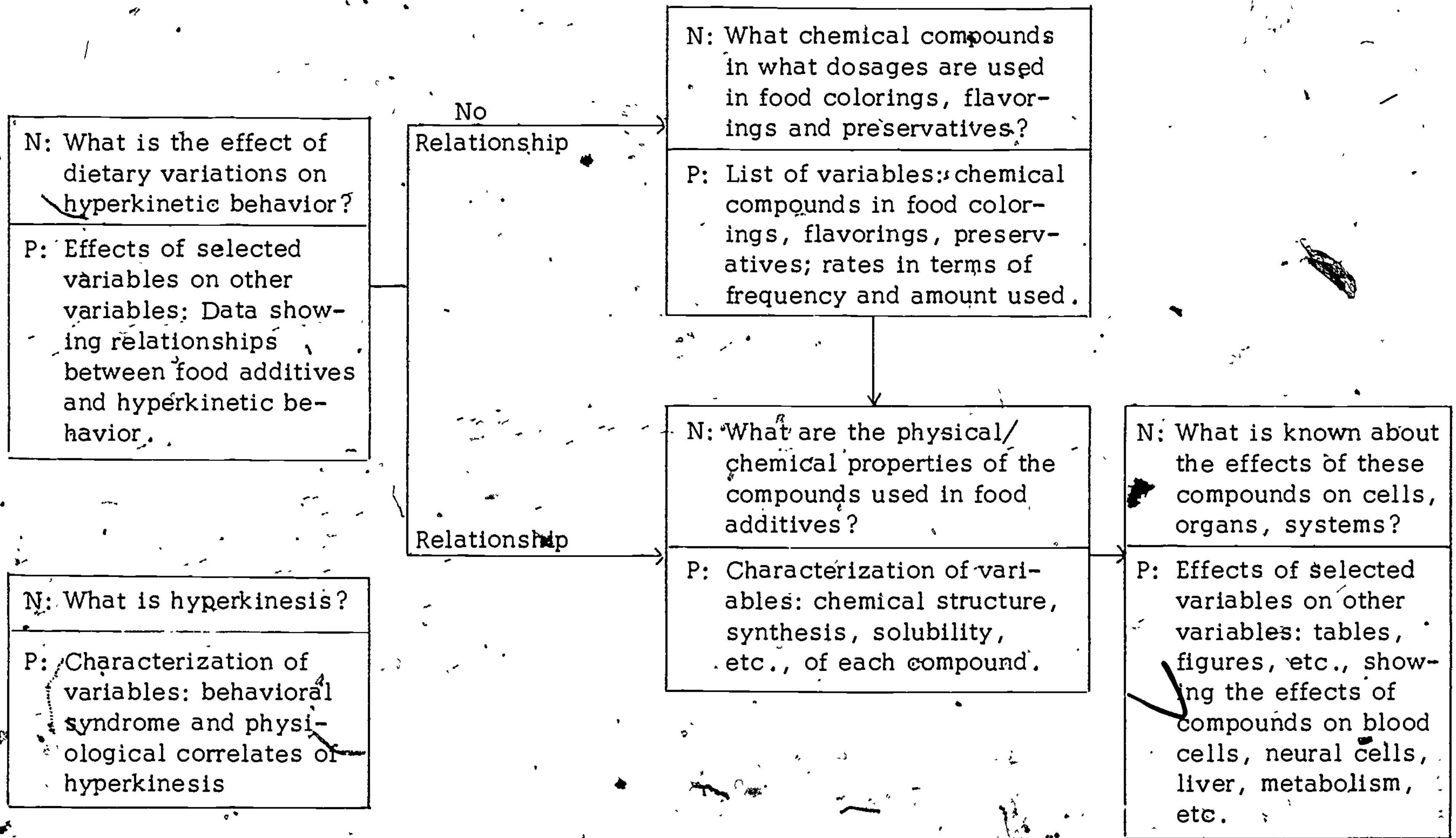


Figure 2. Food Additives and Their Effects, Needs and Product Development Strategy

2. Search Process and Product Preparation

The search for materials to be used in information product development was accomplished by a library school graduate (MLS) at the University of Maryland. The process used to prepare the variable characterizations and effects products on both hyperkinesis and food additives relied principally on the professional journal literature. The search steps and the percentage of searcher time devoted to accomplishing each step were similar to that described for the first researcher. These steps were:

- Identify relevant bibliographic sources (5%).
- Search bibliographic sources and identify relevant citations (20%).
- Locate and obtain articles (15%).
- Review obtained articles for relevance (15%).
- Analyze relevant articles for author and journal patterns; review references in articles (20%).
- Select extracts and prepare product (25%).

The three most useful bibiliographic tools were Chemical Abstracts, Biological Abstracts and Index Medicus. The citations identified through these sources were obtained at the National Library of Medicine and at the various University of Maryland libraries. A review and screening of retrieved articles resulted in the evaluation that approximately 90% of the articles contained information that was relevant. Of these, 15% presented redundant material. Most of this redundancy was in the information dealing with the behavioral and physiological correlates of hyperkinetic behavior, Here decisions were made to include those articles providing the most complete and clearest coverage of the topic area. The use of citations in relevant articles proved extremely useful in identifying additional relevant material for each product. The analysis of journals containing relevant materials showed that 40% of the articles on food colors were published in two journals whereas no particular pattern emerged on the topics of behavioral and physiological correlates of hyperkinesis. The entire search and product preparation process required 270 hours.

3. Prototype Products

The first information package developed for the researcher was 128 pages in length and contained two products. The first was a characterization of hyperkinesis, the second focused on the possible links between hyperkinesis and diet. The characterization of hyperkinesis was divided into two sections: Behavioral Correlates of Hyperkinesis and Physiological Correlates of Hyperkinesis. The section on behavioral correlates included descriptions of behavior and results of experiments comparing hyperkinetic and normal behavior in a variety of situations. The material on physiological correlates was divided into several subsections such as genetic, biochemical, pre-natal, etc. These data were useful to the researcher in identifying specific behavior patterns and physiological values. The product dealing with the possible relationship between hyperkinetic behavior and diet included subsections on additives, nutrition and vitamins. Although an extensive literature review was conducted, very little useful information was found on this topic. The information that was located showed no clear links between specific additives or food categories and hyperkinesis; however, there was some indication that those additives containing salicylates might have some influence on this type of behavior. The product did not serve the purpose of identifying specific additives to be pursued experimentally but it did suggest that the presence of salicylates might be important.

The next step was to develop a list of colorings, flavorings and preservatives. This list, compiled from handbooks, contained certified and non-certified food colors accompanied by color index numbers, artificial food flavorings, and preservatives. Because the number of food additives is in excess of 3,000, the researcher was asked to review the list and make selections for further characterization. His choices narrowed the number of food colorings to 24, the number of flavorings to 25 and the number of preservatives to 5 (see

Appendix B). Many of these additives contained salicylates. Further information was obtained on each of these compounds in terms of frequency of use in foods, amounts used and where obtained. Table 7 provides an example of this type of listing. This material was used by the researcher to further narrow the list of variables considered for study. Those with the greatest use in foods could be considered as most profitable candates for first experiments.

The two major guides used in selecting additives for additional characterizations were the quantity of use and the relationship to salicylates. These characterizations included a description of chemical and physical properties. Table 8 shows an example of the characterization of a selected food color in terms of physical and chemical properties, chemical structure and methods of synthesis. All information presented in this table was obtained from handbooks. The results were used by the researcher to determine which compounds should further be elaborated through a literature review on effects.

Effects products were prepared on three colorings: Red #3, Red #40 and Yellow #5. These products contained an average of 50 pages each. The major sections were:

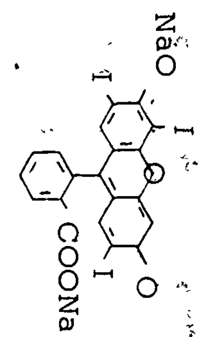
- Toxicity studies
- Metabolism
- Skin and local tissue
- Blood
- Thyroid gland
- Reproductive organs.

All products contained a variety of formats ranging from graphic presentations to large sections of text. The information compaction ratios varied between 7 to 1 to 4 to 1 from original articles to material presented in the products. The process of extraction and organization of relevant information into product required approximately 65 hours. A review of the various formats by the researcher led to the evaluation that graphic presentations of the data were of most use when supplemented by excerpts from discussion sections which presented the author's interpretation of results.

Table 7. Chemical Compounds in Food Additives

Colorings	Common Compounds	Frequency of Use in Foods	Amounts Used	Where Obtained (from whom, cost)
Red #3	Erythrosine FD&C Red #3 C.I. #45430 Sodium (or potassium) salt of 2', 4', 5', 7' -tetraiodofluorescein (ideosine) Xanthene dye Introduced 1907	In order of frequency of use: Pharmaceuticals, candy and confections, bakery goods, dessert powders, sausage, maraschino cherries, cereals, beverages, cosmetics, snak foods, ice cream and dairy, meat inks (Food Colors)	ADI = 0 - 1.25 Estimated ingestion per day = 1.88mg/day/capita (Food Colors)	Dye Specialist Division of Specialty Chemicals, Allied Chemical Corporation, P.O. Box 1087R, Morristown, N.J. 17960

Table 8. Properties of Common Compounds in Food Additives

Compounds	Physical Properties	Chemical Properties	Chemical Structure	How Synthesized
Erythrosine	Solubility: g/100 ml. Water = 9 25% EROH = 8 Glycerin = 20 Propylene glycol = 20 Veg. oil = insoluble (Food Colors) Soluble in alcohol absorption maximum in water = $524m_u$ (Merck Index)	Molecular weight: 879.92 Formula: $C_{20}H_6I_4Na_2O_5$ C = 27.30% H = 0.69% I = 57.70% Na = 5.23% O = 9.09% LD_{50} i.p. in rats (Merck Index	 (Merck Index)	Dolinsky and Jones article (1951: Gilliard, et. al., German patent 108,838 (1899)

G. Secondary School Teacher

1. Tasks and Product Needs

The high school teacher selected to participate in prototype product development was responsible for an environmental problems course offered to junior and senior level students. This course focused on the chemistry of air, water and solid waste pollution. The teacher's primary concern was the development of student interest and motivation to learn. One method used for gaining this interest was the presentation of specific practical problems which related to the types of pollution covered in the course. Basically, these practical problems were the vehicles for teaching students about chemistry and pollution. It was felt that information products were needed to assist in the development and presentation of selected problems. There are three course preparation tasks involved in developing a problem area for presentation: select and provide student reading, prepare lectures and discussions, prepare laboratory exercises. The specific information products required in support of these tasks are:

- Characterization of selected environmental variables in terms of chemical/physical/biological considerations.
- Effects of environmental pollutants on plants, animals, humans.
- Compilation of local environmental organizations, events, individuals dealing with the selected problem area.
- Compilation of laboratory exercises relating to selected problem areas described in terms of purpose, difficulty level, length, equipment needed, etc.

All of these products were prepared and integrated into one information package for each of the two practical problem areas selected. The two problems were automobile exhaust and air pollution, and solid waste disposal methods as a source of pollution. The next section will present a discussion of the search processes required to develop these package elements.

2. Search Process and Product Preparation

The search for materials to be used in preparing the products was carried out by a graduate student at the University of Maryland who was working towards a Master's Degree in Library Science. The search process, as shown in Figure 2, differs somewhat from the steps followed for developing the researcher information products. These procedural differences are due to the differences in level of information required by the two groups of users. The researchers needed exhaustive coverage of the professional journal literature, the teachers needed simplified explanations of scientific findings. The five basic steps in the search procedure were:

- Search bibliographic sources and identify relevant citations.
- Locate and obtain materials.
- Review obtained materials for relevance.
- Analyze relevant articles for magazine patterns; review references in books, articles, technical reports.
- Select extracts and prepare product.

The search process and product development work required 250 hours. Table 9 compares process steps and searcher time allocation for researcher and teacher products. For the high school level products there appeared to be no need to perform the step of identifying the most useful bibliographic tools. This was because the abstracting and indexing services which serve as guides to the professional journal literature were not included in the search strategy. The searching of bibliographic sources to identify relevant citations occupied approximately 25% of the searcher's time. The specific sources included card catalogs, indexes to government reports such as ERIC, and the Reader's Guide to the Periodical Literature. Vertical files recommended by the librarian were also searched. These files contained many valuable experiments as well as useful guides to audio-visual materials. The searcher found that the card catalogs and indexes were better arranged for identifying relevant material on solid waste disposal than on automobile emissions.

Table 9. Time Allocation Comparisons in Search Process-Product Preparation for Researchers and High-School Teachers

Process Steps	Time Allocation	
	Researcher	Teacher
• Identify relevant bibliographic sources	5%	-
• Search bibliographic sources and identify relevant citations	20%	25%
• Locate and obtain materials	15%	15%
• Review obtained material for relevance	15%	25%
• Analyze relevant articles for author and journal patterns; review references in articles	20%	10%
• Select extracts and prepare product	25%	25%

Most of the information on the automobile problem was in publications dealing with the general question of air pollution. This search of bibliographic sources continued in parallel with other process steps. As materials were collected and reviewed more possible search terms were identified as means for entering the bibliographic sources for additional relevant citations.

Locating and obtaining identified materials required 15% of the searcher's time. This step involved going to various libraries, searching the stacks and vertical files, generally reviewing tables of contents for relevant sections and obtaining copies. Some screening was done at this stage to eliminate materials that were not related to the topic. Written requests were needed for obtaining many of the government documents.

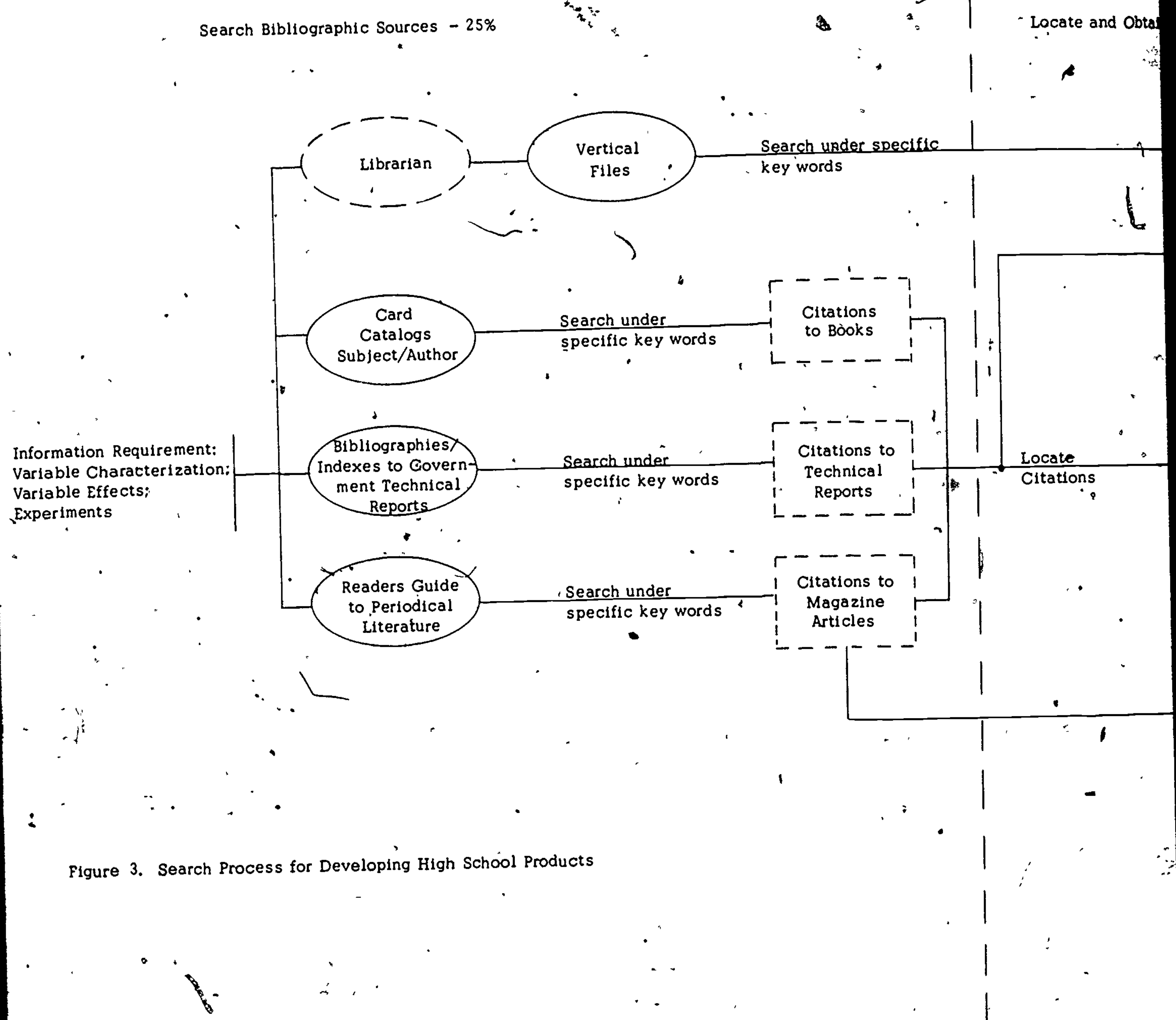
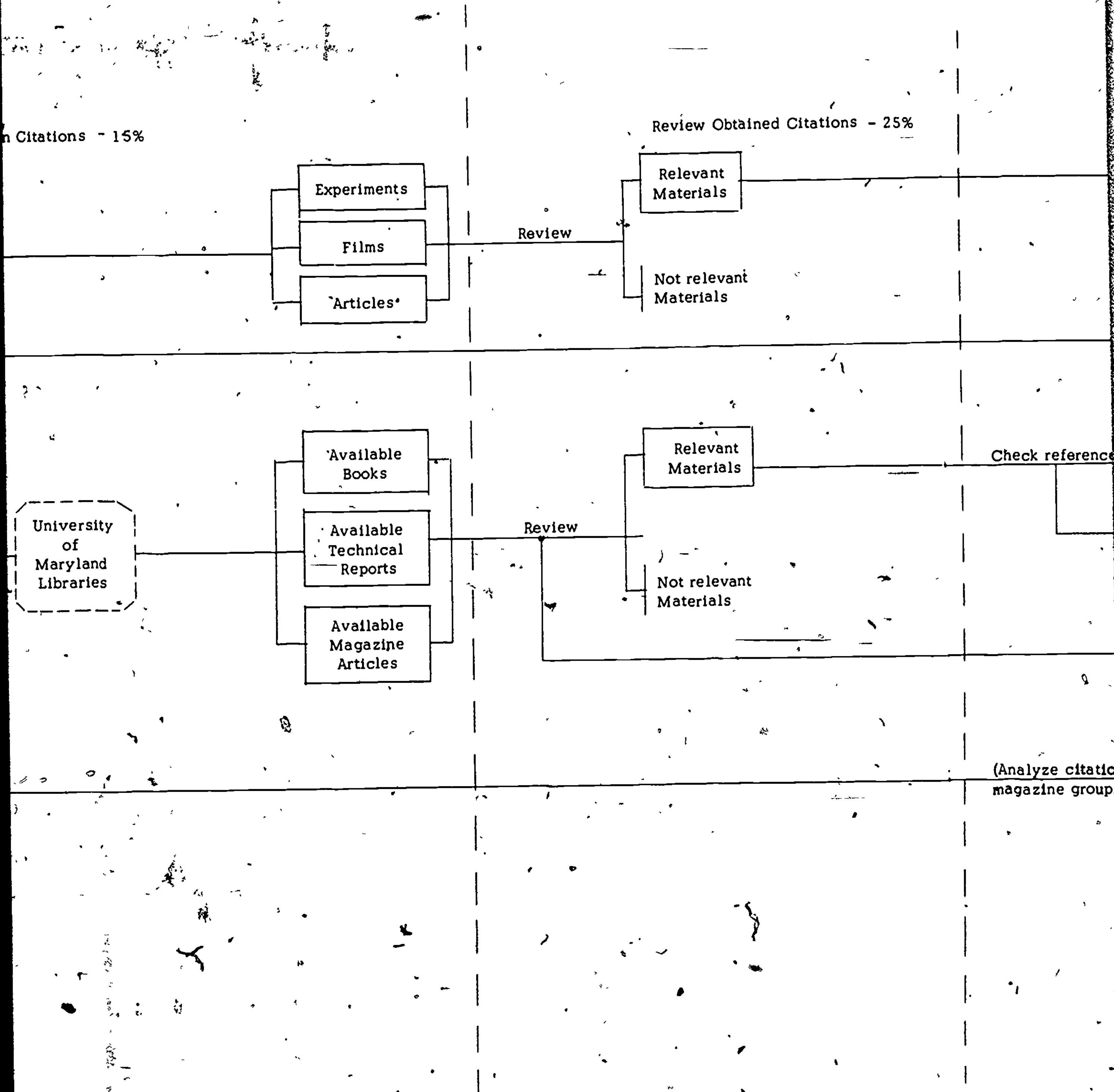
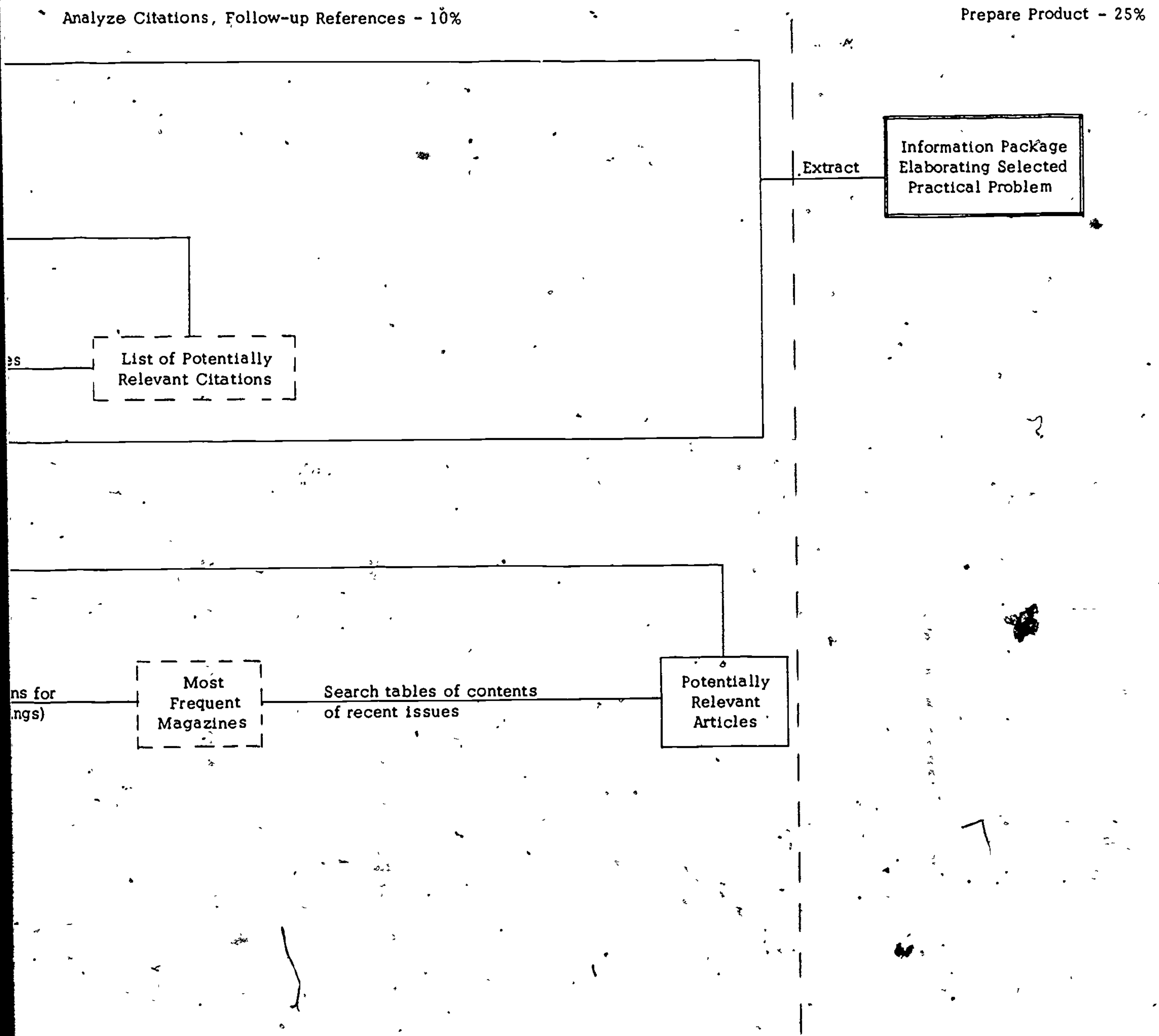


Figure 3. Search Process for Developing High School Products


n Citations - 15%
Review Obtained Citations - 25%
Experiments
Films
Articles
Review
Relevant Materials
Not relevant Materials
University of Maryland Libraries
Available Books
Available Technical Reports
Available Magazine Articles
Review
Relevant Materials
Not relevant Materials
Check referenc
(Analyze citatio
magazine group


Analyze Citations, Follow-up References - 10%
Prepare Product - 25%
Extract
Information Package
Elaborating Selected
Practical Problem
List of Potentially
Relevant Citations
Most
Frequent
Magazines
Search tables of contents
of recent issues
Potentially
Relevant
Articles

Reviewing obtained materials involved a detailed screening process. Because of the text book level of treatment of the selected topic areas there was much redundancy in the material. That is, several book sections or magazine articles provided similar discussion of the same topic. The problem was in selecting material which presented the desired concepts most efficiently and clearly. This redundancy question was not a problem in the review of journal literature for the researchers. The review of materials for the high school level products involved 25% of the searcher's time as compared to 15% for research-related products.

Examining relevant material for clues to additional useful material included two types of analysis. The first analysis was a review of reference lists included by authors. These lists contained many useful citations which were located and evaluated for inclusion in the product. The second analysis was a determination of patterns for magazine titles which contained the highest frequency of relevant articles. Two magazines were identified as providing the best level of coverage: The Science Teacher and School Science and Mathematics. Review of recent issues resulted in additional articles. These magazines also included book reviews which led to the identification of potentially useful titles. Performance of this step required 10% of the searcher's time as compared to 20% for researcher products. This difference is due to the more extensive follow-up procedures in identifying additionally relevant materials to be included in the research support products such as searches in Current Contents and the Science Citation Index.

The last step was the extraction of material and the organization of those extracts into final product sections. As with the researcher products this process involved 25% of the searcher's time. The details of the extraction process and the structure of the information product are discussed in the following section.

3. Prototype Products

Assembly of the two information packages required approximately 50 hours. Information for both packages was organized into four general sections: Problem Description, Problem Source, Problem Impact, and Problem Solutions and Costs. These sections were designed to provide teachers and students with a detailed and clear description of the problem scope, the cause of the problem, the implications of the problem and alternatives for solving the problem. Materials were selected to assist teachers in lecture and laboratory preparation, to provide audiovisual presentations for the classroom and to offer a range of student reading.

Table 10 shows the information needs and products associated with each package section on the problem of the automobile and its contribution to air pollution. The completed package consisted of 210 pages. The Problem Description section included three products which were integrated to provide needed information on the characteristics of exhaust components and the contribution of these emissions to air pollution problems. This section was divided into subsections based on each exhaust component. These subsections are:

- Identification of Pollution Sources and Air Pollution Standards
- Carbon Monoxide
- Nitrogen Oxides and Photochemical Smog
- Hydrocarbons
- Sulfur Dioxide
- Lead
- Aldehydes

Each subsection included variable characterizations and experiments for identifying each variable. The variable characterizations involved descriptions of chemical properties, behaviors, and amounts of pollution contributed by the automobile versus other sources. These characterizations were mainly in the form of tables and figures supplemented by brief excerpts. Selection

Table 10. Information Package: The Automobile and Air Pollution

Package Section	Needs	Products
Problem Description	• How do automobiles contribute to air pollution? • What are the components of automobile exhaust emissions and what are their characteristics? • What percentage of air pollution in urban areas is a result of automobile emissions?	• Characterization of variables: amounts, chemical properties, behaviors of exhaust emission components. • Experiments/demonstrations to identify exhaust components. • Local organizations, individuals working in the problem area.
Problem Source	• What is the chemical composition of gasoline? • How does the internal combustion engine process gasoline to create emissions?	• Characterization of variables: chemical properties of gasoline and how processed by internal combustion engine. • Experiments/demonstrations to measure chemical composition of gasoline.
Problem Impact	• What is the effect of each exhaust emission component on plants, animals, material, human health?	• Variable effects: results of studies showing impact of each component. • Experiments/demonstrations showing how each component effect plants, animals, etc..
Problem Solutions and Costs	• What are the alternatives to the internal combustion engine? • What are the cost/effectiveness characteristics of these solutions	• Characterization of variables: types of emissions from alternative engines, costs of alternatives to driver, manufacturer. • Variable effects: impact of emissions from each alternative on plants, animals, etc. • Local organizations/individuals involved in solution alternatives

of materials was based on clarity of presentation. The experiments for identifying each exhaust component were graded in terms of difficulty level and equipment needed. These experiments follow directly behind the variable characterizations in each subsection. Appendix E shows the subsection developed for carbon monoxide. A list of local individuals and organizations working in the problem area was included at the end of the section. The purpose of this list was to provide teachers with local contacts and potential speakers.

The second major section of the information package was concerned with problem source and dealt with questions of gasoline composition and the internal combustion process. The searcher was unable to find much material in these areas that was at the appropriate level of sophistication. Most of the characterizations of gasoline and internal combustion were highly technical. One simplified description, however, was located and included in the product. This description provides diagrams and textual descriptions of each step in the internal combustion process. A useful film was also identified.

The section on Problem Impacts was divided into subsections by exhaust component as follows:

- General Impact of Air Pollution
- Effects of Carbon Monoxide
- Effects of Nitrogen Oxides
- Effects of Hydrocarbons
- Effects of Sulfur Oxides
- Effects of Lead

Each subsection included tables and figures showing the impact of various levels of each chemical on plants, animals, materials, and human health. In some instances sections of articles describing effects on health were also included. Following each discussion of effects were experiments which demonstrated those effects in the laboratory. Appendix E shows an example subsection.

The final section of the package was devoted to Problem Solutions and Costs. This section contained variable characterizations and effects for alternative solutions in three categories. These are:

- Emission Control Devices
- Alternative Fuels
- Alternative Engine Configurations.

The variable characterizations described each alternative in terms of chemical emissions and in terms of the costs to the driver and the manufacturer associated with adopting that alternative. Variable effects included the impact of each alternative on the environment. The material used in creating these products were diagrams, tables, brief written descriptions, recommended films and lists of organizations involved in research on solution alternatives. An example from this section is shown in Appendix E.

Table 11 shows the needs and products which are associated with the information package on solid waste disposal methods. It can be seen from this table that the package sections and corresponding products have the same structure as those discussed for the package on the automobile as a source of pollution. The primary difference between the two packages is that the solid waste disposal package contains fewer graphics and more written description. This difference is a function of the nature of the literature generated about the two problems; there was far more quantitative information available on the automobile and its emissions. The organization of the solid waste disposal package is as follows:

- Problem Description
  - Composition of solid waste
  - Collection of waste
  - Disposal of waste as a source of pollution

Table 11. Information Package: Solid Waste Disposal Methods As A Source of Pollution

Package Section	Needs	Products
Problem Description	• What is solid waste and how much is there? • What are the problems with collection and disposal? • What forms of pollution are a result of various disposal methods?	• Variable characterizations: amounts and types of solid waste; disposal problems and pollution. • Experiments/demonstrations to identify pollution caused by disposal techniques. • Local organizations/individuals working in problem area.
Problem Source	• What are the disposal procedures which cause pollution? • What packaging materials create a solid waste problem and why?	• Variable characterizations: description of packaging materials and procedures for disposing of these materials. • Experiments/demonstrations of how disposal cause pollution.
Problem Impact	• What are the effects of solid waste on the environment? • What are the effects of pollutants from disposal processes on plants, animals, humans?	• Variable effects: results show impact of pollutants. • Experiments/demonstrations of pollution effects on plants, animals, etc.
Problem Solutions and Costs	• What are the alternatives to existing methods of solid waste disposal.	• Variable characterizations: descriptions of each alternative and its cost. • Variable effects: impact of alternative on the environment. • Local organizations/individuals working on alternative.

- Problem Source: Disposal Methods and Packaging
  - Dumps and how they are operated
  - Landfill techniques
  - Incineration processes
  - Packaging that is not disposable.
- Problem Impact
  - The effects of collection methods on employees
  - The effects of pollution caused by each disposal method on plants, animals, humans
- Problem Solutions and Costs
  - Alternatives to existing collection methods
  - Modification of incineration procedures
  - Creating fuel from solid waste
  - Resource recovery and recycling
  - Creating disposable packaging.

Each subsection in Problem Description, Problem Source and Problem Impact included descriptive material composed of a series of extracts from a wide range of sources. Where possible these descriptions were followed by laboratory exercises. As with the automobile package, all experiments were graded in terms of level of difficulty and equipment availability. The section on Problem Solutions and Costs did not contain any experiments. Descriptions of useful films and tapes were presented in each major section. These descriptions included abstracts, costs and rental instructions. The total package was composed of 140 pages.

Both packages were reviewed by three high school teachers and one junior high school teacher. All indicated that the material was organized and presented in a logical fashion, and that the coverage was complete, clear and at the appropriate level of sophistication both for teacher preparation and direct student use.

D. College Professor

1. Tasks and Products

The college professor was interested in compiling information from the literature to supplement and support lectures on selected topics in environmental chemistry. Two topics were chosen for information product development: Trace Metals in the Chesapeake Bay; Urban and Stratospheric Ozone. Table 12 shows the needs and products associated with these topic areas. It can be seen from this table that the needs and products follow the same format in each topic area. The need was for variable characterizations which describe sources, concentrations and behavior of the variables and for variable effects products which provide data on the impact or influence of each variable.

2. Search Process and Product Preparation

The search for materials was conducted by a graduate student in the School of Library and Information Service at the University of Maryland.

Table 12. Environmental Chemistry Course: Needs and Information Products

Needs	Products
• What are the sources, concentrations, mobilities and sinks of trace metals in the Chesapeake Bay? • What are the biological effects of the trace metals?	• Variable characterizations: sources, concentrations and behaviors of each trace metal. • Variable effects: tables, figures, showing toxicity levels of each trace metal for various biota.
• What are the sources, concentrations, mobilities of urban ozone; stratospheric ozone? • What are the effects of various concentrations of ozone?	• Variable characterizations: sources, concentrations, behavior of ozone. • Variable effects: data on ozone and its influence on weather.

Approximately 100 hours were required to identify, locate, obtain and extract the needed information for the products. The major sources of information used in characterizing the sources, mobility, concentrations and sinks of trace metals in the Chesapeake Bay were regional technical reports sponsored by the Environmental Protection Agency and the Office of Water Resources. The professional journal literature, for the most part, did not provide information on this local question. The product on the toxicity of trace metals included material from both the technical and the professional literature.

The search for materials on the characteristics and effects of urban and stratospheric ozone was based on the professional journal literature. The process steps and the proportion of time spent in accomplishing each step were similar to those used in creating the research information packages. (See Figure 1, page 27.) The most useful bibliographic source was Chemical Abstracts. All citations identified as relevant through this source were located, reviewed, analyzed as keys to additional relevant material, and extracted into appropriate package sections.

3. Prototype Products

The characterization of trace metals and the effects of various concentrations of these metals on biota was integrated into one information package. This package was designed primarily for student use as a supplement to information provided through lectures. The organization of material was by major river or Bay area such as Susquehanna River, Baltimore Harbor, etc. Within each river the information obtained was divided into sources, concentrations, mobilities, and sinks. The material on effects was included as a separate section. Most of the information presented in the products was in the form of tables, figures and maps. Some examples of these data presentations are shown in Appendix F. The total package was 80 pages in length.

All material characterizing and describing the effects of urban ozone was integrated into one package. The material on stratospheric ozone and its role in weather modification formed another package. Both packages were organized by the major sections of sources, transportability characteristics and effects. Here, again, the focus was on data and its interpretation. The presentation formats were similar to those used in the research products. Each of these packages consisted of approximately 75 pages.

IV. SUMMARY AND CONCLUSIONS

The results of the project showed that both researchers and teachers in the Environmental Sciences do require derivative information products of several kinds, both content and method oriented. These product requirements are in response to specific task-related needs. The differences in research and teaching tasks provide some interesting contrasts with regard to structure, level of sophistication and durability of needed information products.

Research product needs arise in a context of specific task-related decisions which the researcher must resolve. In the case studies, both researchers had formulated general hypotheses: i.e., some herbicide related compounds are responsible for the decline of aquatic plants; some food additive-related compounds promote hyperkinetic behavior in children. Each researcher needed derivative information products in order to progress toward the design of specific experimental efforts. The general purpose of the products in each case was to reveal the more promising alternatives and/or to remove some number of alternatives from further consideration.

Specific structure of a required product is highly individualistic, reflecting the researcher's background and knowledge of the problem area. For example, the researcher with the herbicide problem was a chemist and preferred to attack the problem from the toxicity characteristics of the locally-used herbicides; a botanist given the same research problem preferred to begin with a review of the vulnerability characteristics of the local aquatic plants.

Product requirements parallel the researcher's strategy of approach to the problem. For example, the researcher with the food additive-hyperkinesis problem started with a product need based on the hyperkinesis-diet literature. The strategy being one of efficiency: if the product revealed patterns of diet-hyperkinetic behavior, the diet components could be analyzed for common additives, and the researcher would have quickly identified the most promising chemical compounds for experimentation. In the present case, the information product revealed no high-confidence relationships; the status of the diet-behavior research literature did not provide a basis for strong conclusions of the kind needed for the researcher to proceed. Consequently, the researcher's next step was to review lists of food additives, characterized by chemical structure, for the presence of compounds which had established effects on more fundamental physiological processes at the cell and organ level.

Teacher product needs arise in the context of tasks such as lecture preparation and reading selection. In performing these tasks the teacher is concerned with organizing information in a fashion which maximizes communication to students. The need for information is not as an input to decision-making but rather to assist in presenting known principles and facts in a coherent, interesting and comprehensible form. Therefore, the teacher does not require the most up-to-date, highly technical experimental results needed by the researcher but rather a clear presentation of information at the textbook and science magazine level of sophistication.

The structure and organization of the information product is guided by the teacher's approach to the topic area. However, products developed for one teacher should have applications for other teachers using a similar approach. In the present teacher case study, the two information products were designed around practical environmental problems. Both the product on automobile exhaust and the product on solid waste disposal contained sections on problem description, problem source, problem impact and problem solutions. Any teacher interested in communicating to students on the practical environmental problems of automobile exhaust and solid waste pollution should find these products useful.

The products developed for teachers have more durability than those designed for researchers. A researcher needs an information product to help perform a research project task. Once the task is completed, the product has served its purpose. A teacher can use the same product several times to communicate to different groups of students. Over time, a product may require updating but much of the original material describing scientific principles should remain useful.

The general evaluations of products by researchers and teachers suggest that research results presented with a minimum of contextual information are usable in developing a further understanding of the variables in question. That is, it is possible to satisfy information needs through a compilation of literature extracts and these extracts can be used by researchers and teachers without additional descriptive material from original articles. In order to substantiate these findings, more detailed methods of product evaluation are needed. In the present study, product users were asked to evaluate products from two standpoints. First, did the information in the product help satisfy the task-related needs? Second, was the information presented in the product usable without reference to the whole article? As stated above, the responses from both researchers and teachers were generally positive; both groups felt the products were complete and workable. However, these evaluations lacked specificity. One reason for the lack of specific response was the size of the products and the time allowed for evaluation. A second reason was the time lag associated with product development. In all cases the users proceeded with their tasks while products were being developed. A third reason was the generality of the questions posed by the product developers. Further work is needed toward designing a more responsive evaluation system.

All information products were prepared by information specialists using traditional bibliographic tools. The major expenditure of time and effort in the product development process was devoted to the identification and retrieval of relevant documents. This part of the procedure required 75% of the searcher's time for both research products and teacher products while material extraction and compilation involved 25%. These figures suggest that an investment of a relatively small amount of time can result in the development of products which specifically focus on the needs of the individual user. The user can be provided with an organized compilation of excerpts as opposed to a set of full text documents.

APPENDIX A

INTERVIEW GUIDES

Interview Guide

Laboratory Manipulation Research

1. Define Research Problem

- Out of what context did the research problem arise: a literature review, prior personal research work, an applied problem area?
- What was the purpose of the study?
- What boundaries were imposed on the scope of the problem?
- What information resources/products were used at this stage of research planning?

2. Identify and Describe Variables

- What variables were considered relevant to the problem area?
- How was the variable domain pared down for purposes of the experiment and how were selected variables handled: systematically varied, held constant, randomized, taken as is and measured?
- What information support was required at this stage: lists of variables, properties of compounds, characteristics of organisms, known interactions among variables?

3. Select Measurement Methods

- What is the dependent variable - What will be measured?
- How will measurements be made?
- Is there a need to make measurements which are comparable with other research studies?
- What information about methods is needed to proceed in selection and development of methodology? What is the best format for presenting this information?

4. Develop Experimental Design

- What were the main considerations in selecting the design: factorial vs. correlational, for example.
- Did this task require information support? Could available materials be improved upon?

5. Select/Develop and Obtain Test Materials and Apparatus

- How did you decide on apparatus requirements? Did you build it yourself or buy components and assemble?
- How did you obtain required compounds/organisms, etc.?
- How did you select/obtain measurement equipment?
- Were there information resources available for these tasks? Did you have problems in their use? How could the information support be improved?

6. Maintain Sample Compounds/Organisms

- How did you insure sample integrity: purity of compounds, survival of organisms, etc? Did you find a need for information support here, could there be better information products supporting this task?

7. Data Collection

- Were these tasks done manually or with computer support?
- Were there information support needs in this task area?

8. Analyze Data

- What are the methods of analysis?
- Are computers required?
- Will statistical tests be used?
- What information is required to facilitate this analysis?

9. Interpretation of Results

- How was research related to prior knowledge in the field? Data comparisons, functions compared, graphic or tabular integration of other research results?

10. Report Results

Interview Guide

Field Observation Research

1. Define Research Problem

- What is the purpose of the study?
- How was research problem selected?
- Was any information needed to help in bounding the problem statement?

2. Characterize Research Environment

- What is the research environment - forest, stream, bay, marsh, etc.?
- What do you need to know about environment before research can be initiated?
  - Physiological characteristics
  - Interaction between plants, plants and animals, etc.
- Is information needed for this description? What is the best format?

3. Select Specific Research Site(s)

- Where will research be conducted?
- What criteria are used for selection?
- What kind of information is needed to assist this process? What format?

4. Selection Measurement Methods

- What is the dependent variable - What will be measured?
- How will measurements be made?
- Is there a need to make measurements which are comparable with other research studies?
- What information about methods is needed to proceed in selection and development of methodology? What is the best format for presenting this information?

5. Select/Develop Apparatus

- What apparatus is required?
- Is it available or does it have to be built?
- Is the construction and/or operation of the apparatus understood, is information support required?

6. Develop Data Collection and Sampling Plan

- How many samples will be taken?
- How frequently will samples be taken?
- Is information from other research efforts important to the data collection plan.

7. Collect Samples

- Any problems in implementing the methodology, taking measurements?

8. Analyze Samples, Analyze Data

- What are methods of analysis?
- Are computers required for analysis?
- Will statistical tests be used?
- What information is required to facilitate this analysis?

9. Interpret Results

- Are data compared to results from other research?
- What needs to be known about other research to make adequate comparisons?

10. Report Results

Interview Guide

Teaching

1. Select Course Objectives

- What are the objectives/purposes of the course?
- How should the course effect or change the students? Increase knowledge, skill, change attitudes?

2. Determine Course Format

- How is material presented - lecture, discussion, reading, laboratory, field work?
- What presentation method is emphasized?
- Is there an attempt at integrating lecture, laboratory, etc.?

3. Select Course Topics

- What topics have been selected for presentation?
- What criteria were used for their selection?
- What types of inofrmation support was used in this selection process? What type of support would have been most useful?

4. Select Student Reading

- Are students given outside reading assignments?
- What is the purpose of outside reading?
- What criteria were used in selection of reading materials in addition to the topic (content) coverage?

5. Prepare for Lecture/Discussion

- What types of information support are needed when preparing presentations on familiar topics? On unfamiliar topics?
- What formats are most useful for class presentation: tables, charts, tapes, pictures, text, films, slides?

6. Select Laboratory Exercises

- What are the laboratory exercises: content, level, etc.?
- Are the laboratory exercises integrated with the lecture or other parts of the course?

- How were exercises selected - criteria?
- Do students do independent projects?
- Is information support required in the selection of exercises? If so, what specific types of information would be most useful?
- Do students need information support in performing exercises? In writing up results?

7. Select Field Exercises

- What is the purpose of the field exercises?
- How are the field exercises selected?
- Do the students require information support in performing these exercises? What specifically is needed and in what format?

APPENDIX B

VARIABLE LISTS

CHEMICAL COMPOUNDS USED AS HERBICIDES IN MARYLAND

1. Atrazine - 95% use for corn

   Trade names - AAtraex - 80W or AAtraex 4L

   AAtram 20G

   Aiatol 8P

   Manuf. - Cibageigy

2. Alachlor - 90% used for corn and soybeans

   Trade Name - Lasso

   Manuf. - Monsanto Co.

3. Lienuron - 92% use for soybeans

   Trade Name - Lorox

   Manuf. - DuPont

4. Paraquat - 85 % use for soybeans

   Trade Names - Gramoxone

   Manuf. - ICI Plant Protection, Limited

   Trade Name - Orotho-paraquat

   Manuf. - Chevron Chemical Co.

5. Chloropropham - 30% use on alfalfa

   Trade Names - Furloe

   Chloro-itc

   Sproutnip

   Manuf. - PPC Industries

6. Simazine - 30% use on alfalfa and corn

   Trade Name - Princep

   Manuf. - Cibageigy

7. Trifluralin - 20% use on soybeans

Trade Names - Treflan

Trefanocide

Elancolane

Manuf. - Elanco Products Co.

8. Dinoseb - 15% use on soybeans and alfalfa

Trade Name - Premerge Weed Killer

Manuf. - Dow Chemical Co.

Trade Name - Basanite 5

Manuf. - BASS Co, Germany

9. Chlorbromuron - 10% use on soybeans

Trade Name - Bromex

Manuf. - Nor-Am

Trade Name - Maloran

Manuf. - Cibageigy

10. Butylate - 10% use on corn

Trade Name - Sutane

Manuf. - Stauffer Chemical Co.

11. 2,4-D - low volatile ester - 40-50% use on small grains

Trade Names - Weedon, Chipman, Esteron, etc. (30-40 different trade names)

12. EPTC - 10% use on alfalfa

Trade Names - Eptane

Knox Weed

Eradican.

Manuf. - Stauffer Chemical Co.

13. Benefine, Benefluralin (common names) - 15% for clover and alfalfa

Trade Names - Balan

Balfin

Banafine

Quilan

Manuf. - Elanco Products Co.

Order of Herbicides Based on Tons of Use as Estimated by J. V. Parochetti, University of Maryland.

1. Alachlor - high percentage increase in use since 1968.

2. Atrazine

3. Linuron

4. Dinoseb

5. Paraquat - very unlikely as cause of plant decrease, highly adsorbed to soil and will not desorb (Parochetti)

6. Simazine

7. Butylate

8. Trifluralin - unlikely as cause of plant decrease, leaches little, incorporated into soil (Parka and Worth, 1965)

9. EPTC

10. Chlorbomuron

11. 2-4-D

12. Benefin

13. Chlorpropham

AQUATIC PLANTS OF THE CHESAPEAKE BAY

(in order of relative abundance)[1]

*1. Widgeongrass (Ruppia maritima)

*2. Redhead-grass (Potamogeton perfoliatus)

*3. Eelgrass (Zostera marina)

**4. Algae

5. Southern Naiad (Najas guadalupensis) - significant decrease - 1971-72

6. Naiad (Najas flexilus)

*7. Sago pondweed (Potamogeton pectinatus)

8. Eurasian watermilfoil (Myriophyllum spicatum)

*9. Wildcelery (Vallisneria americana) - Significant decrease - 1971-72

10. Common elodea (Elodea canadensis)

11. Muskgrass (Chara spp.) - algae

12. Horned-pondweed (Zannichellia palustris)

13. Coontail (Ceratophyllum demersum)

14. Slender pondweed (Potamogeton pusillus)

15. Waterchestnut (Trapa natans)

16. Mud Plantain, waterstargrass (Heteranthera dubia and Heteranthera reniformis)

[1] Kerwin, Munro and Peterson. Distribution and abundance of aquatic vegetation in the Upper Chesapeake Bay, 1971-1974. September 1975 (draft).

*Food sources for water fowl.

**Included Genera Ulva, Enteromorpha, Ceramium, Polysiphonia, etc.

I. COLORINGS

A. Certified Colorings

1. Amaranth, FD&C Red No. 2, C.I. #16185
2. Erythrosine, FD&C Red No. 3, C.I. #45430
3. Indigotene, FD&C Blue No. 2, C.I. #73015
4. Tartrazine, FD&C Yellow No. 5, C.I. #19140
5. Fast Green FCF, FD&C Green No. 3, C.I. #42053
6. Ponceau SX, FD&C Red No. 4, C.I. #14700 (maraschino cherries - max. 150 ppm)
7. Sunset Yellow FCF, FC&C Yellow No. 6, C.I. #15985
8. Brilliant Blue FCF, FD&C Blue No. 1, C.I. #42090
9. Benzyl Violet 4B, FD&C Violet No. 1, C.I. #42640
10. Citrus Red No. 2, Citrus Red No. 2, C.I. #12156 (orange skins - max. 2 ppm)
11. Orange B, Orange B, C.I. — (frankfurter and sausage casings and surfaces - max. 150 ppm)
12. —, FD&C Red No. 40, C.I. --

B. Colorings Previously Certified

1. Light Green SF Yellowish FD&C Green No. 2, 1907-1966
2. Napthol Yellow X (Sodium Salts), FD&C Yellow No. 1, 1907-1959, C.I. #10316
3. Orange 1, FD&C Orange No. 1, 1907-1956
4. Ponceau 3R, FD&C Red No. 1, 1907-1961, C.I. #16155
5. Sudan 1) — 1918 - withdrawn 6 mos. after certification
6. Butter Yellow)
7. Yellow AB, FD&C Yellow No. 3, 1918-1959, C.I. #11380
8. Yellow OB, FD&C Yellow No. 4, 1918-1959, C.I. #11390
9. Guinea Green, FD&C Green No. 1, 1922-1966
10. Napthol Yellow S (Potassium Salts), FD&C Yellow No. 2, 1939-1959, C.I. #10316
11. Orange SS, FD&C Orange No. 2, 1939-1956
12. Oil Red XO, FD&C Red No. 32, 1939-1956

II. FLAVORINGS

1. Acetophenone
2. Benzaldehyde
3. Benzyl Benzoate
4. Benzyl Salicylate
5. Cinnamaldehyde
6. Cinnamic Acid
7. Dimethyl Anthranilate
8. Ethyl Anthranilate
9. Ethyl Benzoate
10. 2-Ethylbutyraldehyde
11. Ethyl Cinnamate
12. Ethyl Salicylate
13. Eugenol
14. Isoamyl Salicylate
15. Isobutyl Phenylacetate
16. Isobutyl Salicylate
17. Isoeugenol
18. p-Methoxygenazldehyde
19. Methyl Anthranilate
20. Methyl Benzoate
21. Methyl Salicylate
22. Phenethyl Phenylacetate
23. Phenethyl Salicylate
24. Phenylacetic Acid
25. Vanillin

III. PRESERVATIVES

1. Butylated Hydroxymethylphenol
2. Butylated Hydroxyanisole (BHA)
3. Butylated Hydrosytoluene (BHT)
4. Benzoic Acid
5. Sodium Benzoate

APPENDIX C

RESEARCH STUDIES ON HERBICIDES AND AQUATIC PLANTS

	Widgeongrass (Ruppia Maritima)	Redhead-Grass, Sago Pondweed Slender Pondweed (Potamogeton, sp)	Eelgrass (Zostera Marina)	(N
Alachlor		Frank		
Atrazine		Frank, Hodgson, Comes (1963) Johnson (1965) Walker (1964)		John Wal
Linuron		Lawrence (1965		Law
Dinoseb				
Paraquat/ Diquat		Wile (1968) Newbold (1975)	Lawrence (1965) Thomas (1967)	Blac Law
Simazine		Frank, Hodgeon, Comes (1963) Walker (1964) Sutton and Bhingham Wile (1968) Lawrence (1965)		Wal Law
Butylate				
Trifluralin				
EPTC				
Chlorbomuron				
2,4-D		Frank, Hodgson and Comes (1963) Steenis and Elser (1967) Younger (1959)	Thomas and Duffy (1968) Thomas (1967)	Stee (
Benefin				
Chlorphropham				

Naiad (Najas, sp.)	Watermilfoil (Myriophyllum Specatum)	Wildcelery (Vallisneria Am.)	Elodea (Elodea Canadensis)	Muskgrass (Chara. Sp
son (1965) ker (1964)			Johnson (1965)	
ence (1965)			Lawrence (1965)	
kburn (1963) ence (1965)	Newbold (1975) Daly, et. al.		Blackburn (1963) Harrison (1964) Lawrence (1965) Johnson (1965)	
ker (1964) ence (1965)		Walker (1964)	Walker (1964) Sutton, et. al (1969) Lawrence (1965)	Walker (19
nis and Elser 1967)	Younger (1959) Stanley (1974) Steenis and Elser (1967)			

...s ...)	Coontail (Ceratophyllum, d.)	Waterchestnut (Trapa Natans)	Waterstargrass (Heteranthera sp.)	Horner-Pondweed (Zanichellia Palusties)
	Walker (1964)			
			Lawrence (1965)	
	Blackburn (1963)		Lawrence (1965)	
...64)	Walker (1964)		Walker (1964) Funderburk and Lawrence (1963)	Walker (1964)
		Steenis and Stotts (1966) Steenis and Elser (1967)	Funderburk and Lawrence (1963)	

APPENDIX D

EXAMPLES FROM HERBICIDE PRODUCT

Dinoseb

Mechanisms of Action Against Weeds

Chemical Structure

Adsorption in Soils

Leaching in Soils

Effects of Rainfall

Volatilization

Effects of Microorganisms

Effects of Sunlight

APPENDIX D

EXAMPLES FROM HERBICIDE PRODUCT

Dinoseb

Mechanisms of Action Against Weeds

Chemical Structure

Adsorption in Soils

Leaching in Soils

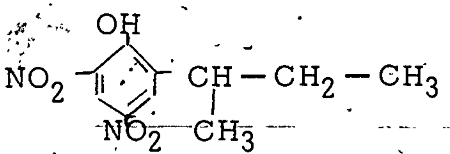
Effects of Rainfall

Volatilization

Effects of Microorganisms

Effects of Sunlight

Content Overview — A-1 Identification

Time History of Chemical Change				
Chemical Compounds Used by Area Farmers in Herbicides	Effects of Microorganisms	Effects of Sunlight	Effects of Leaching Through Soil	Other Effects
Dinoseb 2-sec-butyl-4, 6-dinitrophenol (2-(1-methylpropyl)-4, 6-dinitrophenol) or Dinitro-o-sec-butylphenol  Melting point = 38-39°C	There is microbial breakdown and dinoseb doesn't build up in the soil. (Herbicide Handbook, 1976) On silt loam treated for 3 yrs. at 6 lb/a, 15 lb/a and 30 lb/a. Dinoseb showed a possibility to accumulate over the years. (Jones and Andrews) Herbicidal action usually lost within 2-4 wks. (Mullison, 1970)	Does break down in sunlight. (Matsuo and Casida, 1970)	Solubility in water at 25°C = 0.0052 Not tightly adsorbed on most soils. Can leach in porous sandy soils, but under normal conditions it shouldn't leach out of the top foot of soil in the first year. (Herbicide Handbook, 1974) RF value - 0.[illegible]4 (Guardigli, Chow and Lefar)	Vapor pressure at 151.1°C = 1 mm Hg. (Herbicide Handbook, 1974) Volatilization is one method of residue dissipation. (Matsuo and Casida, 1970)

D-3

Behavior in Plants

D. Physiological and Biochemical Behavior

1. Foliar absorption characteristics: Principally direct contact effect. Salts readily washed from foliage; oil solution more resistant.
2. Translocation characteristics: Essentially no true translocation. No residues have been traced to foliar ~~or root~~ uptake.
3. Mechanism of action: Direct cell necrosis.
4. Biological properties other than herbicidal: Has fungicidal and insecticidal properties.

Herbicide Handbook (1974)

Adsorption

Table 3. Concentrations in ppm of herbicide solutions added to the adsorbents to give 50% inhibition of the test plant

Adsorbent	CIPC	Trifluralin	2,4-D	Diphenamid	DCPA	DNBP	Amiben	Paraquat
Activated carbon	41.00	6.10	3.80	26.3	72.0	165	34.5	21.0
Anion exchange resin	1.13	0.52	1.52	1.4	10.5	280	30.0	22.0
Cation exchange resin	0.89	0.68	0.97	1.4	10.5	51	8.0	34.5
Muck soil	0.78	0.64	0.13	1.1	10.5	37	6.8	31.0
Bentonite clay	0.45	0.58	0.12	1.4	10.5	34	8.3	81.0
Control (no adsorbent)	0.[illegible]6	0.14	0.12	1.4	10.5	30	6.8	21.0

Table 4. Relative adsorption of eight herbicides by five adsorbents as determined by a root bioassay

$$\frac{I_a \text{ With adsorbent}}{I_o \text{ Without adsorbent}}$$

Adsorbent	Herbicide							
	CIPC	Trifluralin	2,4-D	Diphenamid	DCPA	DNBP	Amiben	Paraquat
Activated carbon	157.7	43.6	31.6	18.1	6.9	5.5	6.1	1.6
Anion exchange resin	4.4	3.7	12.7	1.0	1.0	9.3	4.4	1.0
Cation exchange resin	3.4	4.9	8.1	1.0	1.0	1.7	1.2	1.6
Muck soil	3.0	4.6	1.1	1.0	1.0	1.2	1.0	1.5
Bentonite clay	1.7	4.1	1.0	1.0	1.0	1.4	1.2	1.9

Table 5. Effect of increasing the concentration of muck soil and bentonite clay on the adsorption of various herbicides.

Herbicide	Concentration of herbicide in ppm to give 50% root inhibition of the test plant				
	Control (no adsorbent)	0.01%		1.0%	
		Muck	Bentonite	Muck	Bentonite
2,4-D	0.12	0.13	0.12	0.43	0.12
DNBP	30	37	31	83	36
Amiben	6.8	6.8	8.3	11	8.3
DCPA	10.5	10.5	10.5	38	10.5
Diphenamid	1.4	1.4	1.4	4.3	5.1

Table 6. The desorption of seven herbicides from activated carbon as determined by a root bioassay.

Herbicide	Percent desorbed
2,4-D	73
Diphenamid	46
DCPA	42
Trifluralin	35
Amiben	34
CIPC	11
DNBP	0

Coffey and Warren (1969)
Weed Sci., pp. 17 & 18

Adsorption (continued)

The adsorption of DNBP in shown in Figure 1. Most striking are the total adsorption of DNBP by the anion exchanger and the lack of any adsorption by bentonite at pH 8.4. Bentonite also adsorbed nearly all of the DNBP when the pH was 2.3.

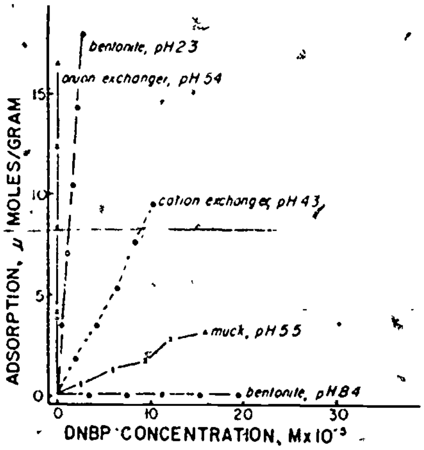


Figure 1 The adsorption of DNBP

p. 121

Table 1 Ranking of herbicides for solubility and extent of adsorption

Solubility[a]	Adsorption[b]				
	Bentonite high pH	Bentonite low pH	Muck	Cation exchanger	Anion exchanger
DNBP	Diquat	Diquat	Diquat	Diquat	DNBP
Atrazine	CIPC	Atrazine	CIPC	Atrazine	CIPC
CIPC	Atrazine	DNBP	DNBP	CIPC	Diquat
Monuron	Monuron	CIPC	Monuron	DNBP	Atrazine
Diquat	DNBP	Monuron	Atrazine	Monuron	Monuron

[a] In order of increasing solubility in water
[b] In order of decreasing extent of adsorption

p. 123

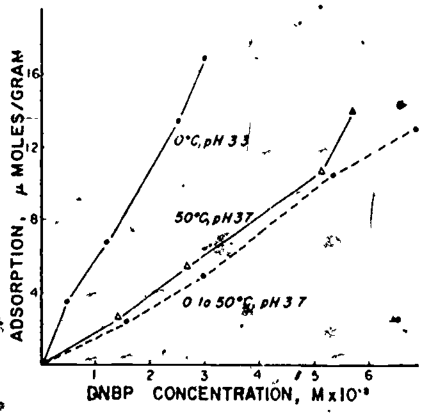


Figure 9 The adsorption of DNBP by bentonite (pH 3.3 or 3.7) at different temperatures.

p. 124

Harris and Warren (1964)
Weeds

Leaching

Table 2. Physical analysis of soils.

Soil Separate	Size limit mm.	Norfolk sandy loam %	Deer Creek silt loam %	Kaufman silty clay loam %
Very coarse sand	2.0 -1.0	6.6	0.1	0.3
Coarse sand	1.0 -0.5	21.4	0.3	3.1
Medium sand	0.5 -0.25	11.0	0.1	3.3
Fine sand	0.25-0.10	31.5	1.6	11.0
Very fine sand	0.10-0.05	8.1	13.0	7.6
Total sands	2.0 -0.05	78.6	15.0	25.3
silt	0.05-0.002	15.0	68.2	52.6
clay	-0.002	6.4	16.8	22.1
Totals		100.0	100.0	100.0

Table 3. Chemical analysis of Soils.

Soil Type	Organic matter content %	Soil reaction pH	Cation exchange capacity m.e./100g	Exchangeable Ca m.e./100g	Percentage calcium saturation %	Exchangeable K m.e./100g	Exchangeable Na m.e./100g
Norfolk sandy loam	1.14	6.00	2.51	1.25	49.8	0.153	0.182
Deer Creek silt loam	0.81	5.65	14.16	9.62	67.9	0.425	0.326
Kaufman silty clay loam.	2.02	6.30	16.35	13.81	84.5	2.94	0.256

Davis and Selman (1954)
Weeds, pp 12 & 13

Leaching (continued)

Table 4. Distribution of dinitro in Norfolk sandy loam leached with 1½ inch of water.

Soil section	Composition D			Composition E			Composition F		
	I	II	av	I	II	av	I	II	av
Depth	Lb./a.	Lb./a.	Lb./a.	Lb./a.	Lb./a.	Lb./a.	Lb./a.	Lb./a.	Lb./a.
0 -¼"	4.22	4.28	4.25	3.83	3.59	3.71	4.22	4.41	4.32
¼"-½"	3.25	3.29	3.27	2.40	2.51	2.46	1.92	1.92	1.92
½"-¾"	1.19	1.28	1.24	1.49	1.44	1.46	1.41	1.27	1.34
¾"-1.0"	0.45	0.48	0.46	0.5[illegible]	[illegible]	0.64	0.90	0.70	0.80
1.0"-1½"	0.08	0.06	0.07	[illegible]	[illegible]	0.18	0.47	0.34	0.40
1½"-2.0"	0.05	0.01	0.03	0.01	[illegible]	0.01	0.04	0.01	0.02
Total recovered	9.24	9.40	9.32	8.40	8.51	8.46	8.96	8.65	8.80
Amount added	9.40	9.40	9.40	9.00	9.00	9.00	9.00	9.00	9.00

Table 5. Distribution of dinitro in Norfolk sandy loam leached with 1.0 inch of water.

Soil section	Composition D			Composition E			Composition F		
	I	II	av.	I	II	av.	I	II	av.
Depth	Lb./a.	Lb./a.	Lb./a.	Lb./a.	Lb./a.	Lb./a.	Lb./a.	Lb./a.	Lb./a.
0 -¼"	1.84	1.85	1.84	2.58	2.71	2.65	1.47	1.86	1.67
¼"-½"	1.92	2.08	2.00	2.03	1.73	1.88	1.76	1.93	1.84
½"-¾"	1.82	2.10	1.96	1.56	1.39	1.48	2.01	2.10	2.06
¾"-1.0"	1.54	1.55	1.55	1.19	1.21	1.20	1.69	1.54	1.61
1.0"-1½"	1.40	1.32	1.38	1.06	1.19	1.12	1.54	1.27	1.41
1½"-2.0"	0.20	0.18	0.19	0.23	0.23	0.23	0.28	0.12	0.20
2.0"-2½"	0.04	0.03	0.03	0.04	0.04	0.04	0.03	0.03	0.03
2½"-3.0"	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02
3.0"-3½"	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01
Total recovered	8.78	9.15	8.98	8.72	8.54	8.63	8.81	8.88	8.85
Amount added	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00

Table 6. Distribution of dinitro in Norfolk sandy loam leached with 1½ inches of water.

Soil section	Composition D						Composition E			Composition F		
	In 6" tube			In 24" tube*			In 6" tube			In 6" tube		
	I	II	av.	I	II	av.	I	II	av.	I	II	av.
Depth	Lb./a.			Lb./a.			Lb./a.			Lb./a.		
0 -¼"	1.54	1.58	1.56	0.68	1.25	0.97	1.61	1.22	1.42	1.54	1.89	1.72
¼"-½"	1.44	1.28	1.36	0.75	1.35	1.05	1.44	1.61	1.52	1.34	1.50	1.42
½"-¾"	1.33	1.36	1.34	1.16	1.52	1.34	1.55	1.65	1.60	1.44	1.45	1.45
¾"-1.0"	1.31	1.30	1.31	1.47	1.52	1.50	1.42	1.50	1.46	1.31	1.28	1.30
1.0"-1½"	1.92	1.94	1.92	2.36	1.55	1.95	1.84	1.76	1.80	1.92	1.65	1.78
1½"-2.0"	0.86	0.92	0.89	1.08	0.38	0.73	0.65	0.69	0.67	0.91	0.72	0.81
2.0"-2½"	0.18	0.15	0.17	0.33	0.10	0.21	0.12	0.18	0.15	0.22	0.15	0.18
2½"-3.0"	0.02	0.02	0.02	0.09	0.04	0.06	0.02	0.04	0.03	0.02	0.02	0.02
3.0"-3½"	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Total recovered	8.63	8.57	8.60	7.94	7.73	7.83	8.67	8.66	8.66	8.71	8.67	8.69
Amount added	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00

*Four 6-inch steel tubes taped together at joints

In Dear Creek silt loam - movement stopped at 4".

In Kaufman silty clay loam movement stopped at 3".

Davis and Selman (1954)
Weeds, p.18

Leaching (continued)

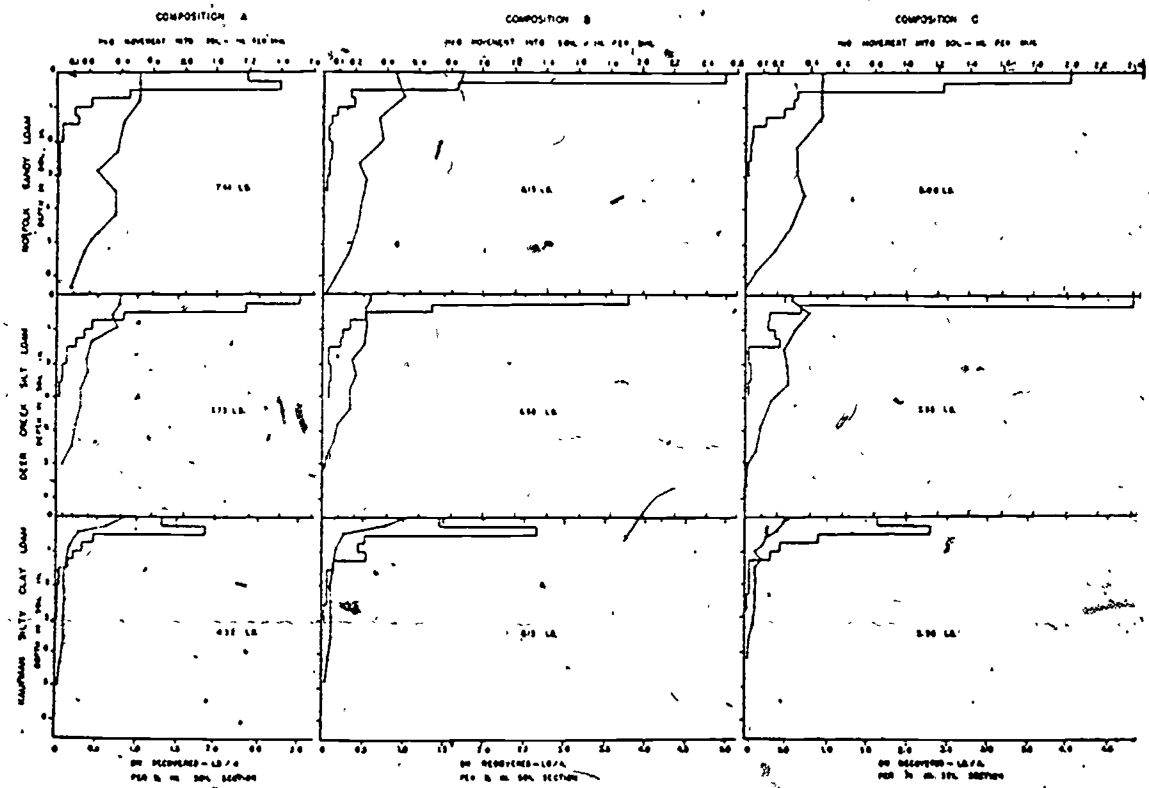


FIG. 2. The rate of movement of 2.0" of water into the soil and the resulting distribution of oil-soluble dinitro in three soil types.

Davis and Selman (1954)
Weeds, p. 16

Leaching (continued)

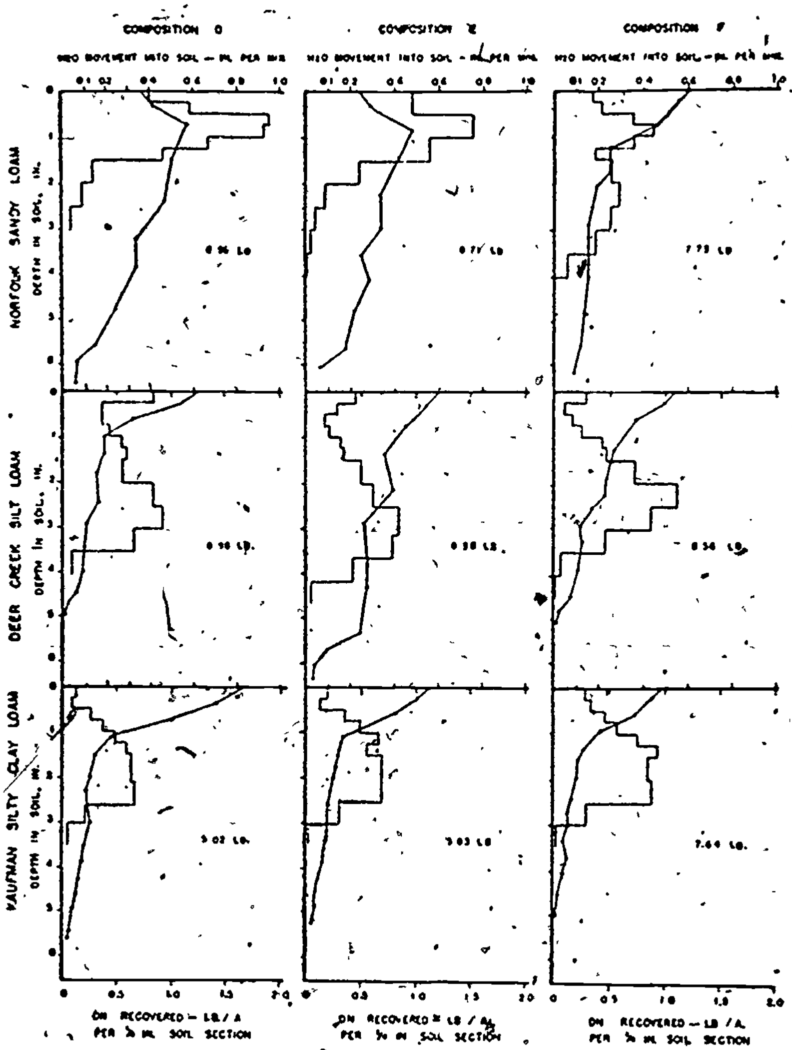


FIG. 3. The rate of movement of 2 ∅ inches of water into the soil and the resulting distribution of water-soluble dinitro in one quarter inch sections of three soil types.

Davis and Selman (1954)
Weeds, p. 17

Effect of Rainfall

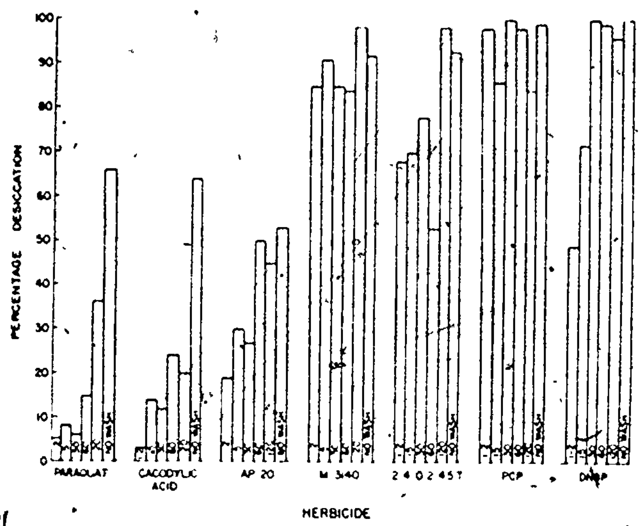


Figure 1. Percentage desiccation of guava (field) as a result of washing with 1 inch simulated rainfall 1 to 2, 15, 30, 60, and 120 min after application of paraquat, cacodylic acid, AP-20, M-3140, 2,4-D 2,4,5-T, PCP, and DNBP at 3 lb/A. Data taken 14 days after treatment.

p. 155

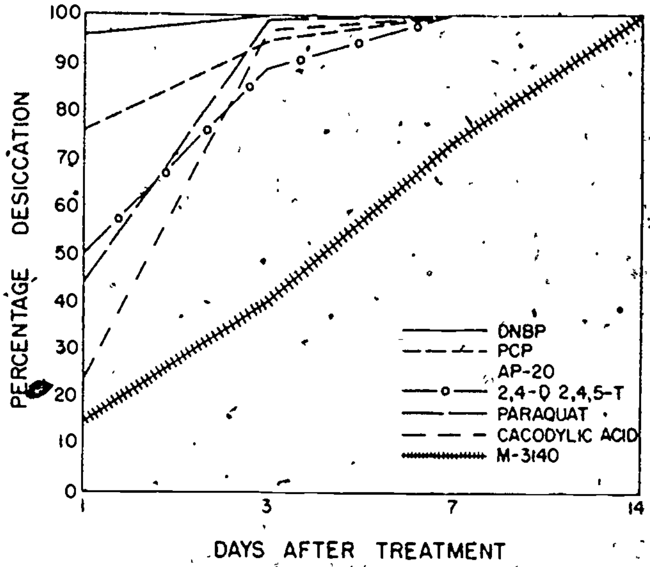


Figure 2. Percentage desiccation of mango (greenhouse) 1, 3, 7, and 14 days after treatment with PCP, DNBP, M-3140, 2,4-D: 2,4,5-T, AP-20, paraquat, and cacodylic acid at 3 lb/A.

p. 155

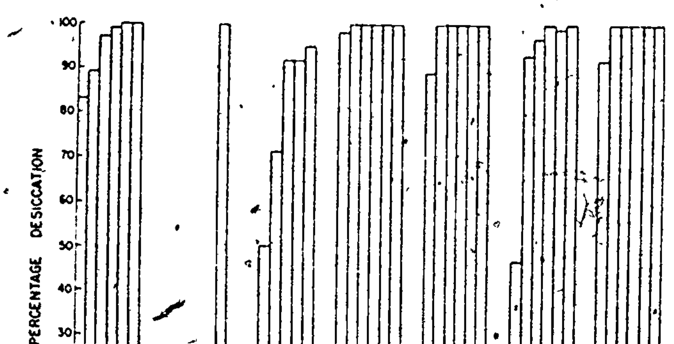


Figure 3. Percentage desiccation of mango (greenhouse) as a result of washing with 1 inch simulated rainfall 1 to 2, 15, 30, 60, and 120 min after application of paraquat, cacodylic acid, AP-20, M-3140, 2,4-D:2,4,5-T, PCP, and DNBP at 3 lb/A. Data taken 14 days after treatment.

p. 155

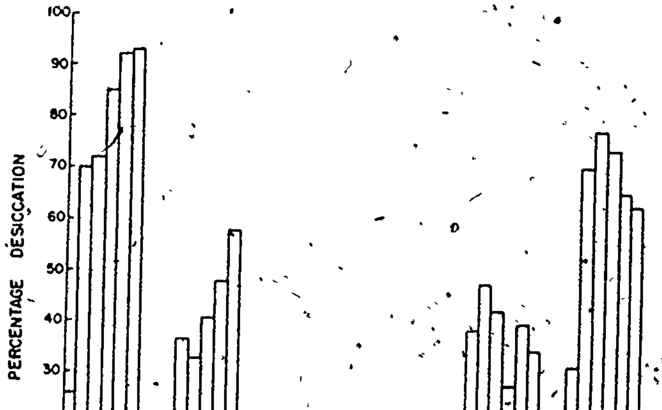


Figure 4. Percentage desiccation of sorghum (greenhouse) as a result of washing with 1 inch simulated rainfall 1 to 2, 15, 30, 60, and 240 min after application of paraquat, cacodylic acid, AP-20, 2,4-D:2,4,5-T, PCP, and DNBP at 1 lb/A. Data taken 8 days after treatment.

p. 156

Bovey and Diaz-Colon (1969)
Weed Sci.

Effect of Rainfall (continued)

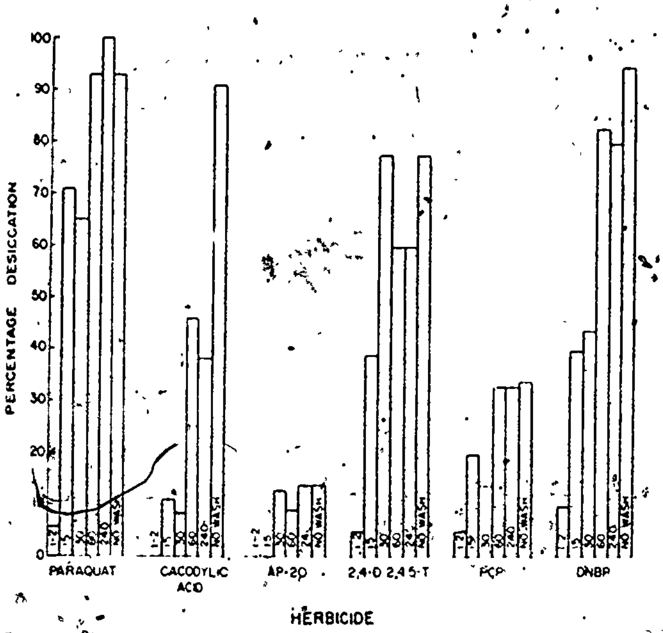


Figure 5. Percentage desiccation of dioscorea (greenhouse) as a result of washing with 1 inch simulated rainfall 1 to 2, 15, 30, 60, and 240 min after application of paraquat, cacodylic acid, AP-20, 2,4-D, 2,4,5-T, PCP, and DNBP at 1 lb/A. Data taken 8 days after treatment.

Bovey and Diaz-Colon (1969)
Weed Sci., p. 157

Dinoseb on Apples - Volatility or Leaching

Table 2. Distribution of Radioactivity in Apples After Topical Application of [^{14}C] Dinoseb and Atmospheric Exposure

Period of Atmospheric Exposure	Recovery of [^{14}C] After Exposure (% dose)				
	Fruit Skins		Flesh Tissues		
	Methylene Dichloride-Soluble Constituents	Water-Soluble Constituents	Methylene Dichloride-Soluble Constituents	Water-Soluble Constituents	Total
0.5 h	90.9	4.4	None	None	95.3
4.0 h	81.7	11.8	None	None	93.5
8.0 h	69.6	14.4	None	None	84.0
1 day	68.7	9.1	1.3	None	79.1
2 day	52.6	9.3	5.2	None	67.1
4 day	34.2	20.2	6.7	None	61.1
8 day	17.2	21.2	9.6	None	48.0
16 day	3.1	18.1	7.4	None	28.6
21 day	5.4	13.7	7.6	None	26.7
28 day	6.7	13.2	8.2	None	28.1

After 24 hrs. - about 20% radioactivity lost
After 28 days - 70% lost

Hawkins and Saggers (1974), Pestic. Sci., p 499

Table 3. R_F Values on Thin-Layer Plates of Authentic Reference Compounds

	Solvent System		
	Chloroform	Toluene-Methanol (3:1, v/v)	Ethanol
Dinobuton	0.72	0.76	0.66
Dinoseb	0.71	0.67	0.65
2-Amino-4-nitro-6-s-butyl-phenol	0.13	0.53	0.63
3-(3,5-Dinitro-2-hydroxyphenyl)-butyric acid	0.03	0.18	0.46

Hawkins and Saggers (1974), Pestic. Sci., p. 503

Dinoseb on Apples - Volatility or Leaching (continued)

Methylene dichloride - soluble fraction from skins contained the unchanged compound (15% of original after 28 days).

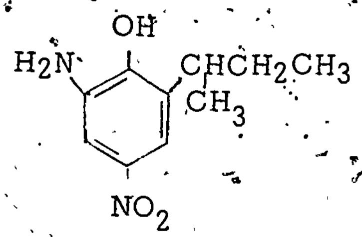
Greatest proportion of radioactivity after 8 hours associated with polar transformation products - including two compounds chromatrographyically similar to the amino compound and the carboxylic acid.

Hawkins and Saggers (1974)
Pestic. Sci.,

Dinoseb - Fate on Apples

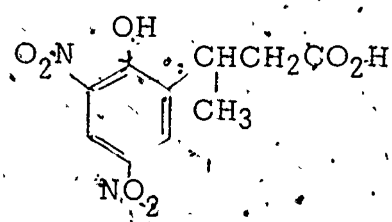
Readily converted into polar and water-soluble transformation products.

2-amino-4-nitro-6-s-butylphenol (III) and 3-(3,5-dinitro-2-hydroxyphenyl) butyric acid (IV), and were formed by hydrolysis of the ester, followed by either reduction of a nitro group or oxidation of the termal carbon in the s-butyl side-chain respectively.



(III)

Amino Compound



(IV)

Carboxylic Acid

Hawkins and Saggers (1974), Pestic. Sci., p. 502

After application - large amounts of material are lost from the surface by leaching or volatilization.

The material remaining undergoes transformation either by photochemical or enzymatic action to give more polar products.

Hawkins and Saggers (1974), Pestic. Sci., p. 503

Effect of Microorganisms

Klingman (5) reports that 4,6-dinitro-o-sec-butylphenol is very rapidly rapidly broken down in the soil, lasting only 3 to 5 weeks under warm, moist conditions. Warren (74) reviews the literature and concludes that once within the soil and under suitable conditions of temperature and moisture, it will be attacked and quickly decomposed by soil microorganisms. At least 2 species of Pseudomonas have been reported to utilize DNBP as a source of carbon and energy (71). In terms of time interval, microbiological breakdown in soil occurs rapidly under warm, moist conditions. Herbicidal action usually is lost within 2 to 4 weeks under conditions conducive to microbial activity (5). Also reported is lack of any residue from one year to the next and, consequently, any build-up from yearly applications. This material is not readily adsorbed by plant roots or translocated within the plant from the leaves as it acts as a contact herbicide. Towers (73) points out that plants respond to the application of phenolic substances by converting them to glycosides. These are then transferred to sites of low metabolic activity where they remain until the death of the cell.

Mullison (1970), p. 121

TABLE 1

The Effect of Exposure to Sunlight on Total Recovery of Radioactive Residues from Bean Leaves following Application of Ring-C^{14}-labeled Dinobuton and Dinoseb

Hours of exposure to sunlight after applic.	Recovery[a)] of radioactive compounds in residue, %, after application of: Dinobuton — Dinobuton	Dinobuton — Dinoseb	Dinobuton — Products of intermediate R_f values	Dinobuton — Products at or near origin	Dinobuton — Water-soluble products	Dinobuton — Total	Dinoseb — Dinoseb	Dinoseb — Products of intermediate R_f values	Dinoseb — Products at or near origin	Dinoseb — Total
0	96	4	0	0	0	100	100	0	0	100
0.5	56	10	13	8	14	101	78	12	4	94
1	37	10	20	13	14	94	40	13	9	62
2	27	12	20	14	14	87				
4	33	[illegible]	13	16	11	77	8	11	15	34
6	27	3	15	16	12	73				
8	24	3	10	17	8	62	6	4	18	28
12	11	2	9	16	10	48				
16	5	2	7	20	8	42	4	0	16	20
20	3	1	7	18	8	37				

a) Sum of surface- and penetrated residues.

Matsuo and Casida (1970), Bull. of environ. contam. & Tox., pg. 75

D-16

Photodegradation - Effects of Sunlight (continued)

Volatilization is one mechanism of residue dissipation for both compounds because there is a progressive loss of the applied radiocarbon with time. A portion of the labeled materials is not extracted from the plant, accounting for another source of loss. The products persisting for 2 hours or longer after treatment mostly are degradation products, not dinobuton or dinoseb.

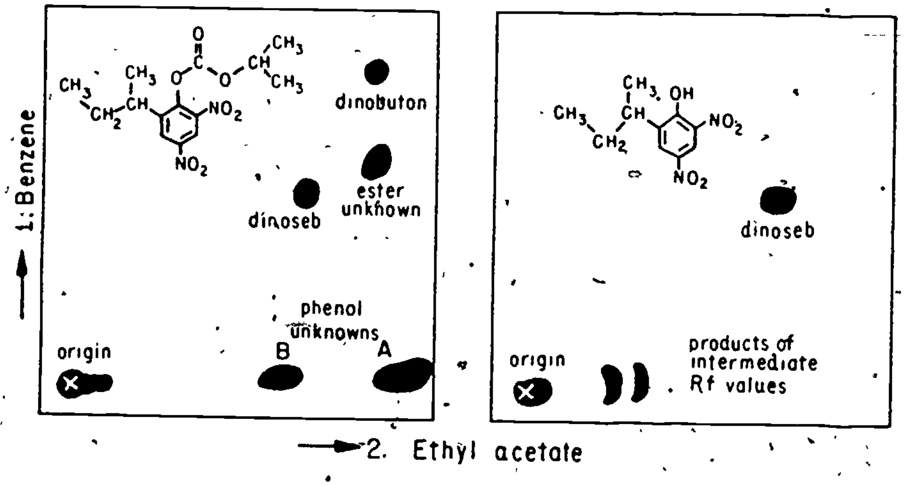


Fig. 1. Illustrative chromatograms showing TLC characteristics of labeled products recovered from bean foliage treated with ring-C^{14}-labeled preparations of dinobuton (left) or dinoseb (right) and exposed to sunlight.

Matsuo and Casida (1970)
Bull. of environ. contam. & Tox., p. 74

Under the photoconditions used, dinoseb converts to more persistent products of lower R_f values. The time-sequence involved suggest that, as with dinobuton, the products remaining at or near the origin are the terminal products found by the analytical procedure employed. Differentiation of intermediate products, and intercomparison of these products with unknowns A and B derived from dinobuton, are not possible because the large amounts of interfering plant extractives present disturb the TLC patterns.

. . . have photosensitizer activity. In similar studies involving photodegradation under ultraviolet light, dinoseb acetate as a thin film or as an oxygenated methanol solution yields trace amounts of degradation products, several of which, by ultraviolet and mass spectroscopy, appear to be 2, 4-dinitrophenols containing modifications on the sec-butyl grouping. The chromatographic position (TLC) of phenol unkown B is generally that associated with isomeric 6-hydroxybutyl- and 6-butenyl-2, 4-dinitrophenols, based on comparison with authentic compounds. Interfering materials in the plant extractives make it difficult to compare the R_f values of the products of dinoseb acetate photolysis. Amino and diamino derivatives of dinoseb chromatograph at or near the origin in the solvent systems used. With some compounds other than dinobuton and dinoseb, photoreduction of nitro groups takes place when the irradiation is done under anaerobic conditions (4,5).

Matsuo and Casida (1970)
Bull. of environ. contam. & Tox.,
p. 77

. . . Also, a portion of the degradation following the application to bean leaves may result from plant metabolism of the penetrated materials; dinoseb and certain esters of dinoseb are known to undergo nitro reduction and side

Photodegradation - Effects of Sunlight (continued)

chain oxidation on metabolism in mammals (6). In any case, analyses made by methods which are specific for dinobuton and dinoseb, or for other dinitrophenolic pesticide chemicals, probably do not give a reliable measure of the residue content of plants treated with the respective pesticide chemical.

Matsuo and Casida (1970)
Bull. of environ. contam. & Tox., p. 78

APPENDIX E

EXAMPLES FROM AUTOMOBILE PRODUCT

- Problem Description: Carbon Monoxide
- Problem Impact: Sulfur Oxide
- Solutions and Costs

Problem Description: Carbon Monoxide

Environmental Pollution. William F. Andrews

4.5 CARBON MONOXIDE

(a) **Sources.** Carbon monoxide (CO), a colorless, odorless gas, accounts for more than [illegible]1% of the total annual air pollutant emissions in North America. This gas is almost entirely a man-made pollutant. The most significant source is incomplete combustion, during which each carbon atom combines with only one atom of oxygen. Estimates show that automobile engines alone contribute more than 80% of the *global* carbon monoxide emissions. Combustion in industry, power plants, residential heating, and refuse disposal accounts for the remainder (Fig. 4-8). Photochemical reactions (reactions initiated by light) of hydrocarbons in polluted atmospheres also produce tiny amounts of carbon monoxide. Very few natural sources of this gas are known. Under abnormal conditions plants can produce carbon monoxide. Certain marine organisms, such as jellyfish, can emit gas bubbles containing as much as 80% carbon monoxide. However, these natural contributions are not considered significant.

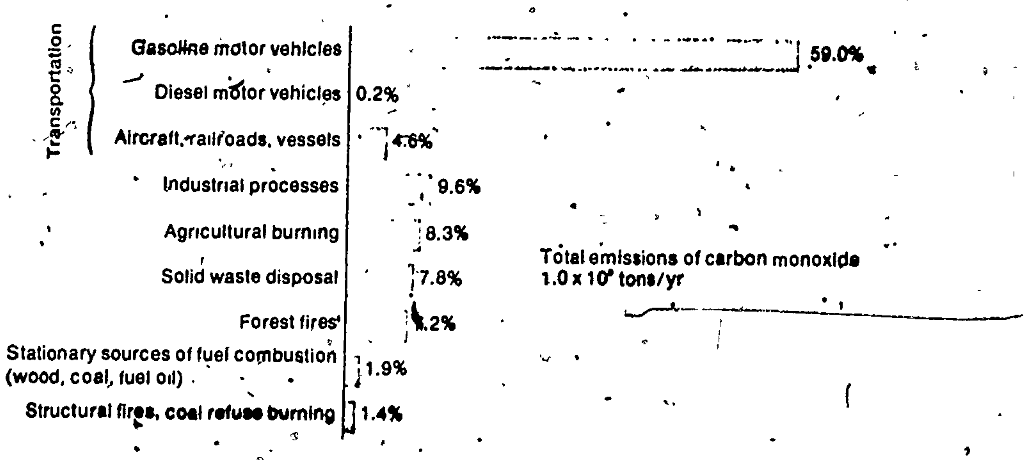


Fig. 4-8. Nationwide sources of carbon monoxide emissions — U.S. 1968. (Data published by U.S. Department of Health, Education, and Welfare.)

Table 2. Carbon Monoxide Levels at Various Locations

Location	CO Levels (in average ppm's)
Los Angeles Freeways	37
Los Angeles Freeways, slow, heavy traffic	54
Los Angeles, severe inversion	30 for over 8 hours
Parking garage	59
Cincinnati intersection	20
Detroit, short peak	100
Detroit, residential area	2
Detroit, shopping area	10
Manhattan intersection	15 all day long
Allowed industrial exposure for 8 hours (for comparison)	50 recently lowered from 100

ENVIRONMENT

Air Pollution—Detection and Abatement

RICHARD KRAFCHIK, Helping Teacher, Prince George's County Public Schools, Upper Marlboro, Maryland, and Participant, Academic Year Institute for Science Supervisors, University of Maryland, College Park

Prince George's County is a suburb of Washington, D.C., and has its share of air pollution as a result of heavy commuter traffic and industry. There is great interest in air pollution, even at the junior high school level, but there are few materials on the subject which are appropriate for this age group. Upon contacting the Division of Air Pollution Control of the county health department, it became apparent that Division staff had been approached by many other teachers looking for materials in this field. The Division readily agreed to serve as a resource for materials, and set about developing demonstrations and experiments that could be used in the junior high school classroom and adapted to other levels as well.[1] My role was to be that of "helping teacher," a liaison between the Division and the schools.

Seven exercises were developed from sampling techniques used by the Department of Health, Education, and Welfare and by the Prince George's County Department of Health. In addition, the Division drew freely from available sources; two of the most useful of these are listed in the references at the end of this article. The end-product was a 16-page teachers manual titled "Air Pollution Experiments."[2]

Some of the experiments, such as that illustrating the deterioration of nylon, are undoubtedly familiar to teachers. I would, therefore, like to describe three exercises that may be less familiar. The first, Detection of Carbon Monoxide and Carbon Dioxide, illustrates the use of detector tubes in identifying pollutants. The following two exercises, Afterburner and Wet-Scrubber, illustrate current technological devices to curtail air pollution.

Detection of Carbon Monoxide and Carbon Dioxide

Glass detector tubes provide a method for determining the presence of various gases in the atmosphere. The detector tube is a cylindrical glass tube with closed ends approximately 6 mm in diameter and 10 cm in length. Inside the tube is a chemical reagent sensitive to the gas you wish to detect. To use the tube, the closed ends are snapped off, and a given volume of the air to be tested is pumped through the tube. A color change occurs that is related to the quantity of the gas present in the sample.

The most difficult problem with using these tubes is knowing the quantity of air that passes through them. A rubber aspirator bulb with a 100 cm³ capacity is available from Mine Safety Appliances (MSA) Company,[3] but it is also possible to buy an inexpensive rubber bulb pump in a drugstore and calibrate it yourself. To calibrate, the bulb is squeezed once, and the air passing through it is directed through a rubber tube to a bottle arranged to collect gas by the water-displacement method. The volume displaced is measured. Then the number of squeezes to achieve the required volume of air flow through the detector tube is computed.

Procedure. Obtain a detector tube, and carefully break open both ends. Squeeze the bulb. Place the end of the detector tube which is more tightly packed with crystals into the rubber tubing. Make an air-tight connection by wrapping a rubber band around the tubing that holds the detector tube.

Use the smoke emitted from the end of a cigarette as a source of carbon dioxide. Keep the open end of the detector tube directly in the stream of smoke. Release the bulb, thus sucking one bulb volume of gas through the detector tube. The blue reagent crystals in the tube will change to a light gray color in the presence of carbon dioxide.[4] Measure the length of the gray stain; then use the calibration scale supplied by MSA to calculate the percent by volume of carbon dioxide in cigarette smoke. The value you will obtain is only approximate, however, since one cannot control the amount of time the gas is in contact with the reactor chemical when using a squeeze bulb.

A similar procedure may be used to test for carbon monoxide. Automobile exhaust may be used as a source of the gas. (**Caution:** Carbon monoxide is a deadly gas; do not run an automobile motor in an enclosed place.) The yellow detector chemical will become brown in the presence of carbon monoxide.[5] Measure the length of the brown stain, and consult the calibration scale to find the carbon monoxide content. Test first directly at the carbon monoxide source; then vary the distance from the source. You may wish to test a heavily traveled area such as a superhighway at different times of the day.

The Department of Health, Education, and Welfare has established threshold limits for each of these gases. The threshold limit is the maximum safe allowable limit of a specific gas in the atmosphere. Anything over this limit is a hazard to health. The threshold limit for carbon dioxide is 5,000/1,000,000 (5,000 ppm) by volume of air. The threshold limit for carbon monoxide is 50/1,000,000 (50 ppm) by volume of air.

Wet-Scrubber

The wet-scrubber is one of the most common anti-pollution devices em-

[1] The materials were actually written by Frederick V. Wootton, Sanitarian II, Division of Air Pollution Control, and Jo Ellen Baker of the Department of Health Education, Department of Health, Prince George's County, Maryland. They were field-tested by Michele Bellante at the Thomas Johnson Junior High School, Prince George's County.

[2] Single copies are available at no cost from the Prince George's County Department of Health, Division of Air Pollution Control, Cheverly, Maryland 20785. Send a self-addressed, 8½ x 11-inch envelope with 32 cents return postage.

[3] Mine Safety Appliances Company, Pittsburgh, Pennsylvania 15208. MSA has detector tubes for carbon monoxide, carbon dioxide, sulfur dioxide, and many other gases. A package of 12 tubes of any one type costs approximately $7. Write for a free catalog.

[4] Carbon dioxide detector-tube reaction: An organic amine and the indicator thymol blue are impregnated on activated alumina. These chemicals change from blue to nearly white when in contact with carbon dioxide.

[5] Carbon monoxide (length of stain) detector-tube reaction. Carbon monoxide reacts with potassium pallado sulfite impregnated on silica gel to give a brown stain.

ployed by industry. It depends on the fact that when a polluted gas stream is brought into contact with water, the pollutants are absorbed by the water.

Procedure: Set up the apparatus as shown in Figure 1. Place a paper towel in a 500 ml flask, and place this above the Bunsen burner. Using a double-hole stopper that makes an air-tight seal with the flask, insert a 5-inch section of glass tubing through one of the holes. The glass tubing should reach approximately one-half inch from the bottom of the flask.

Insert a 1-inch piece of glass tubing into the other hole of the stopper. Connect approximately 1 foot of rubber tubing to the 1-inch piece of glass tubing, making sure that an airtight seal exists.

Fill a second 500 ml flask approximately three-fourths full of water. Taking a second double-hole stopper, place two 1-inch pieces of glass tubing into the top holes. Connect the rubber tubing from the first flask (the combustion chamber) to one of the pieces of glass tubing in the second stopper. Insert the wide end of the glass impinger into the bottom of the same hole in this second stopper which is connected to the rubber tubing. The glass impinger is a straight piece of glass tubing drawn to a smaller diameter at one end, which causes the release of smaller bubbles. These smaller bubbles bring more gas in contact with the water. Taking a second piece of rubber tubing, connect it to the remaining unused glass tubing. Hook this rubber tubing to a vacuum source.

Heat the first flask (the combustion chamber) until smoke appears. Draw a vacuum on the system causing a stream of smoke to be drawn through the second flask (the wet-scrubber).* Observe the change in the color of the water. If smoke collects in the second flask above the water, a second wet-scrubber can be added.

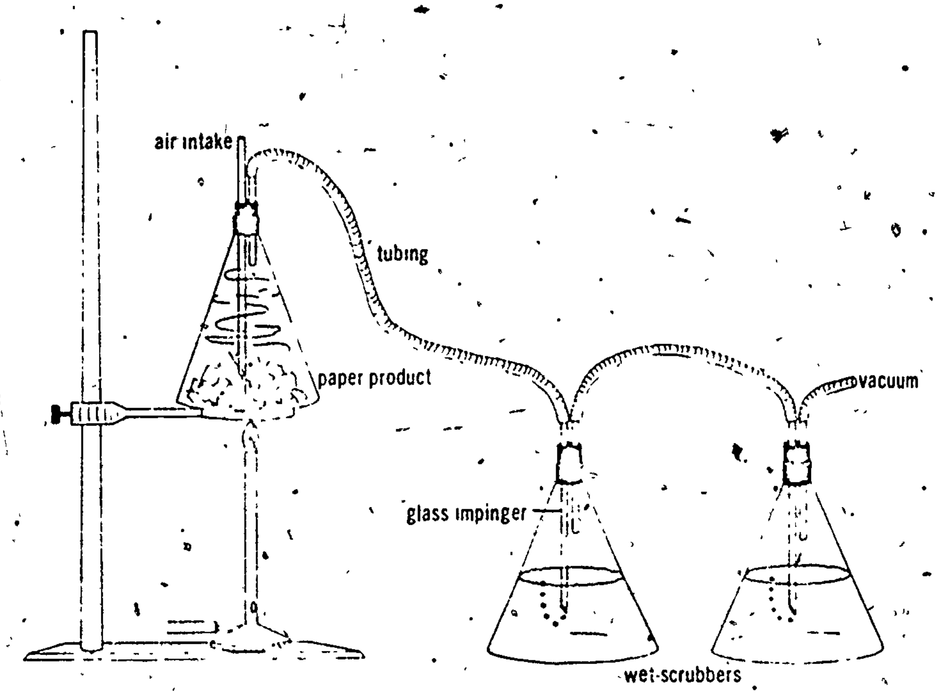


Figure 1. Apparatus for demonstrating the wet-scrubber, a device used by industry to remove pollutants from gases.

Afterburner

The complete combustion of fuels containing carbon and hydrogen yields water vapor and carbon dioxide. Most air pollution results from material that is not completely burned. A fire that smokes is a familiar example of incomplete combustion. These smokey gases can be reignited by an afterburner to cause the further combustion of the particles that cause air pollution.

Procedure: Arrange a ring stand as shown in Figure 2. Clamp a rubber strip, and mount it under the inverted funnel as shown. (**Caution:** Use a small piece of rubber, but do not use rubber bands or other rubber products which will "pop" and cause burns.)

Ignite the rubber strip, thus producing a black stream of smoke, the unburned portion of the rubber. Make sure that the stream of smoke is directed up through the funnel. The funnel is employed to simulate a chamber comparable to a boiler or incinerator. The neck of the funnel is analogous to a smokestack or chimney. Position a Bunsen burner by hand above the stream of smoke until the smoke is completely burned and can no longer be seen.

Explore with your classes the kinds of industries that use wet-scrubbers and afterburners and the advantages and disadvantages associated with each. ☐

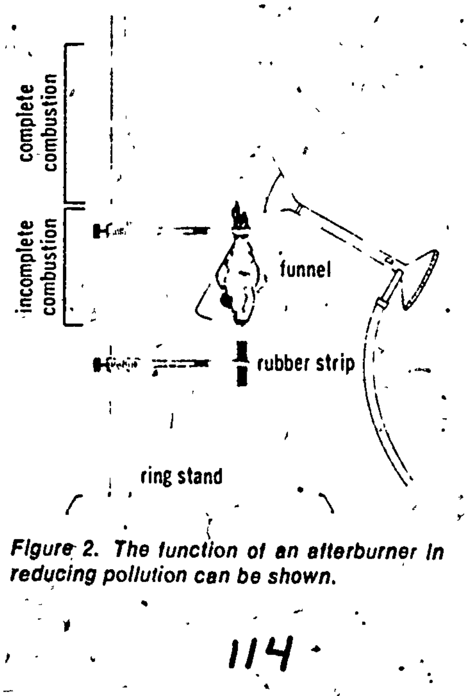


Figure 2. The function of an afterburner in reducing pollution can be shown.

* Use a water-siphon-type draft on a low-pressure mechanical pump. Too much pressure will pull water through.

References

1. *Air Pollution Primer*. National Tuberculosis and Respiratory Disease Association. New York. 1969.
2. Hunter, Donald C., and Henry C. Wohlers, Editors. *Air Pollution Experiments for Junior and Senior High School Science Classes*. Education Committee, Mid-Atlantic States Section, Air Pollution Control Association. 1968. (This publication is available for $1 per copy. In quantities of ten or more, price is 50 cents per copy, plus postage. Requests for copies should be addressed to: Student Manual, Air Pollution Control Association, 4400 Fifth Avenue, Pittsburgh, Pennsylvania 15213.)

DETECTION OF ATMOSPHERIC CARBON MONOXIDE

I. BACKGROUND

Carbon monoxide, an odorless and colorless gas has its origin in the incomplete combustion of carbonaceous materials; for example, auto exhaust. It has long been known as a noxious inhalant that has its effects because of a strong affinity for combining with the hemoglobin of the blood. When a sufficient amount of carbon monoxide attaches itself to the hemoglobin in the circulating red blood cells, it reduces the availability of the hemoglobin to combine with oxygen, and this results in the reduction of the amount of oxygen available to the tissues.

There are various methods for detection of carbon monoxide. One in particular is the use of N. B. S. Colorimetric Indicating Gel. (National Bureau of Standards manufacture this). The air to be analyzed is passed through a tube containing a silica gel impregnated with ammonium molybdate, sulfuric acid and palladium chloride. A yellow silico-molybdate complex is formed, and the palladium serves as a catalyst for the reduction with carbon monoxide. Upon reduction, the indicating gel turns from yellow to either a green or blue, depending on the concentration of the carbon monoxide present.

II. OBJECTIVE

To be able to detect carbon monoxide in the air.

III. STATEMENT OF THE PROBLEM

The purpose of this experiment is to familiarize the student with a simple method for detection of carbon monoxide in the air.

IV. APPARATUS AND REAGENTS

1. Vacuum pump, hand bulb pump or vacuum line for drawing air sample through tube.
2. Absorbent cotton
3. Guard gel*
4. Indicating gel*
5. Glass (filter) tube, about a 7 mm bore
6. Two 1-hone No. 000 cork stoppers
7. Sufficient tubing to fit 7 mm bore tube
8. Two pieces of glass tube approximately 1 inch each

*The guard gel and indicating gel may be purchased from:

Central Scientific Company
Division of Cenco Instruments Corp.
237 Sheffield St.
Mountainside, N.J. 07092

Price list

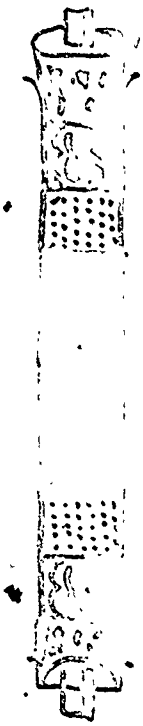
Catalog #38530, Size 1P - Silica Gel Indicating (6-16 Mesh)...$2.70
Catalog #38532, Size 1P - Silica Gel Refrigeration (Grade 6-12 Mesh) ...$2.10

V. PREPARATION OF FILTER TUBE

1. Clean 7 mm bore filter tube with sulfuric acid, rinse with distilled water. Make sure tube is dry before using.
2. Insert one glass tube into one hole No. 000 cork stopper.
3. Into filter tube, insert a small wad of absorbent cotton, so that it forms a loose pad against the cork.
4. Fill the tube with 5 cm length of guard gel.
5. Add 2 cm length of indicating gel.
6. Then add a second 5 cm length of guard gel.
7. Insert a cotton pad, tapping the side of the filter twice gently, making certain the filter is packed firmly.

*Item checked is not standard in most high schools.

8. Insert second one hole 000 cork stopper; then, insert the other glass tube.



VI. PROCEDURE

Connect a hose leading to a vacuum pump or vacuum line to the end of the tube. Pull atmospheric air through the tube until the indicating gel turns to either green or blue. This is an indication of carbon monoxide.

A. Quantitative Test

In order to determine the amount of carbon monoxide in the atmosphere, known amounts of carbon monoxide are passed through indicating tubes, the resulting colors are used as standards to determine unknown concentrations by comparing the colors obtained from polluted air, with standard colors.

VII. REFERENCE

Bell, F.A., Jr., N. B. S. Detector Tube Method for Carbon Monoxide in Air, Technical Assistance Branch, Division of Air Pollution, R. A. Taft Sanitary Engineering Center, 1961.

Problem Impact: Sulfur Oxide

Environmental Pollution. William F. Andrews

Effects of Sulfur Oxides. Sulfur oxides combine with moisture to form sulfurous acid and the extremely corrosive sulfuric acid.

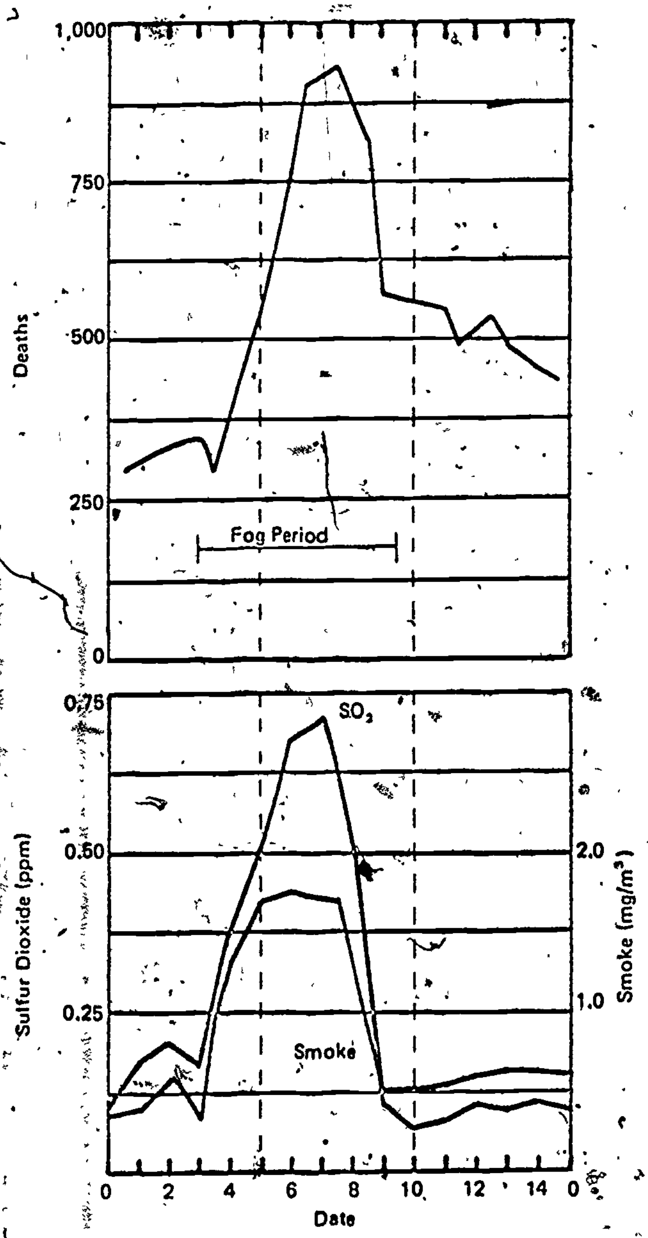
Sulfur Dioxide + Water → Sulfurous Acid
$$SO_2 + H_2O \rightarrow H_2SO_3$$
Sulfur Trioxide + Water → Sulfuric Acid
$$SO_3 + H_2O \rightarrow H_2SO_4$$

Each day, the air which you inhale passes through the nasal cavity and the windpipe to contact directly an area 25 times greater than your exposed skin surface. This region is provided by the tiny membranes of your lungs. Every square inch of your respiratory system provides moisture, an ideal reactant for the sulfur oxides which enter your system. (They also irritate the eyes and the skin.) How is the delicate lung tissue affected? Clinical studies on humans are surprisingly limited to date. Yet even if sulfur dioxide were not regarded as a health hazard, its destructive nature would warrant the removal of this gas from the air.

Acids forming in the atmosphere fall with rain and create havoc with crops and wild plants. Since lichens store the acids in their roots and then die, botanists use them as indicators of sulfur dioxide fallout. This accurate test has designated Ontario cities such as Sudbury, Hamilton, and Toronto as "lichen deserts" because these plants cannot survive in the surrounding areas. The numerous crop plants killed, even at low fallout levels, include wheat, barley, oats, white pine, cotton, alfalfa, buckwheat, sugar beet, and a score of others. Within a 20 mile radius of Kingston, Tennessee, 90% of the white pine trees have been killed. Sulfur dioxide from a Tennessee Valley Authority power plant is the recognized culprit. Over 50 years ago, two copper smelters near Ducktown, Tennessee, released enough airborne sulfur to poison the surrounding soil. Even today, this land remains almost totally devoid of vegetation.

Concentrations of airborne sulfur compounds also threaten aquatic life. Rain and snow absorb these compounds and carry the resulting acids into soil, rivers, lakes, and ponds. Most aquatic organisms cannot survive when the *p*H falls below

FIGURE 4-3
Deaths and Air Pollution in London, 1952



Deaths, sulfur dioxide concentrations, and particulate mass concentrations during the December 1952 episode in London. (After E.T. Wilkins, *Journal of the Royal Sanitation Institute*, 74, 1, 1954.)

Environmental Science Lab Manual, 1972.

D

Effects of sulfur dioxide

Sulfur dioxide concentration, ppm	Exposure period and effect	Measurement methods
	Yearly exposure	
Trace	Metal corrosion begins	PbO_2 candle
0.01 to 0.02	Significant metal corrosion	PbO_2 candle
	Impaired pulmonary function	PbO_2 candle, West-Gaeke
	Increased cardiovascular morbidity	PbO_2 candle, West-Gaeke
0.02 to 0.03	Increased respiratory death rates for area studied	PbO_2 candle
	Detectable chronic injury to perennial vegetation	Thomas autometer
	2- to 4-day exposure	
0.07 to 0.25	Hospital admissions for cardiorespiratory diseases increase	H_2O_2
0.20 to 0.30 for 3 days	Rhinitis, sore throat, cough, and eye-irritation rates increased	By electroconductivity
0.20 to 0.86 for 3 days	Cardiorespiratory mortality increased	H_2O_2
	Acute vegetation injury	Pure gas
	24-hour exposure	
0.21	Bronchitic patients' health deteriorates	H_2O_2
0.25	Increased total death rates	H_2O_2
0.28	Detectable injury to sensitive vegetation	Pure gas
	Brief exposures	
0.04	Visibility reduced to 10 miles at 70% relative humidity	Calculated effect
0.08	Cortical conditioned reflexes produced; repeated 10-second exposures	(No method indicated)
0.10	Visibility reduced to 4 miles at 70% humidity	Calculated effect
0.30	Taste threshold	Pure gas
0.50	Visibility reduced to 0.85 mile at 70% humidity	Calculated effect
0.5 for 1 sec	Odor threshold	Pure gas
0.5 for 4 hr	Detectable injury to sensitive vegetation	Pure gas
0.5 for 7 hr	Acute injury to trees and shrubs	Pure gas
1.0 for 10 min	Respiration and pulse rates increase	Pure gas
1.6 for 1 to 5 min	Threshold for inducing measurable bronchoconstriction in healthy people	Pure gas

McGuiness, B. J. 1968. Problems of air pollution. Manuscript presented at Purdue University, Indianapolis, Indiana.

PURPOSE: To observe the effects of sulfur dioxide on certain material.

LEVEL: 10-12

SUBJECT: Science

CONCEPT: IV-1 Organisms and environments are in constant change.

PROBLEM: II-3 Health Considerations--air quality.

REFERENCE: "A Supplementary Program for Environmental Education--Science," Project I-C-E, 1927 Main Street, Green Bay, WI 54301.

ACTIVITY: Use a chemistry laboratory manual of instruction in producing sulfur dioxide (SO_2) from $S + O_2$ or $Na_2SO_3 + H_2SO_4$. Follow the procedure carefully and observe all safety rules. Collect several bottles of pure SO_2.

Using the bottles of pure SO_2, immerse such materials as plant tissue, animal tissue, natural fibers, and synthetic fibers into the gas. Observe changes in these materials after an hour and after 24 hours.

Locate local industries which produce SO_2 as a by-product. Ask representatives of these groups to discuss with the class how the company tries to eliminate SO_2 from its discharge.

Solutions and Costs

Solutions: Stratified Charge Engine - A Look Under the Hood

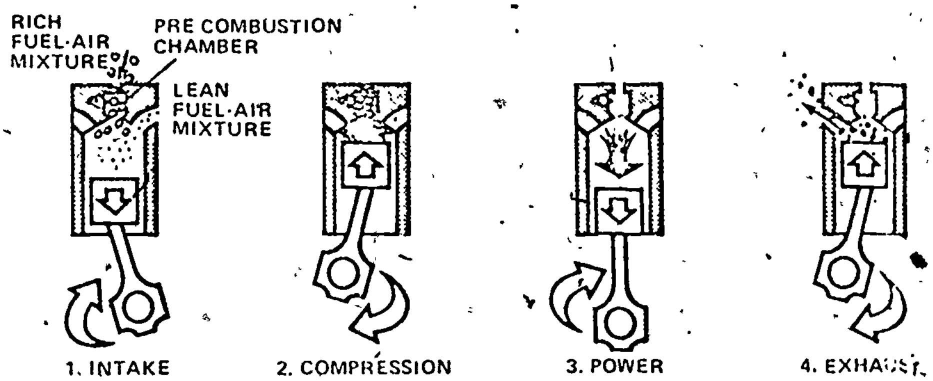
The stratified charge engine — One of the modifications, known as a three-valve, stratified charge, carbureted engine, is being developed by a Japanese firm. Three vehicles using this engine have completed EPA'S 50,000-mile durability tests and have met the 1975 standards. In a stratified charge engine, the central idea is to supply a rich mixture near the point of ignition inside the cylinder. But the rest of the mixture is kept lean. This helps to reduce the mass of nitrogen oxides formed, allowing better burning of hydrocarbons and carbon monoxide.

The Japanese firm's engine has a conventional block, pistons and spark plugs. Only the cylinder head and intake and exhaust manifolds are modified, and two carburetors are used instead of one.

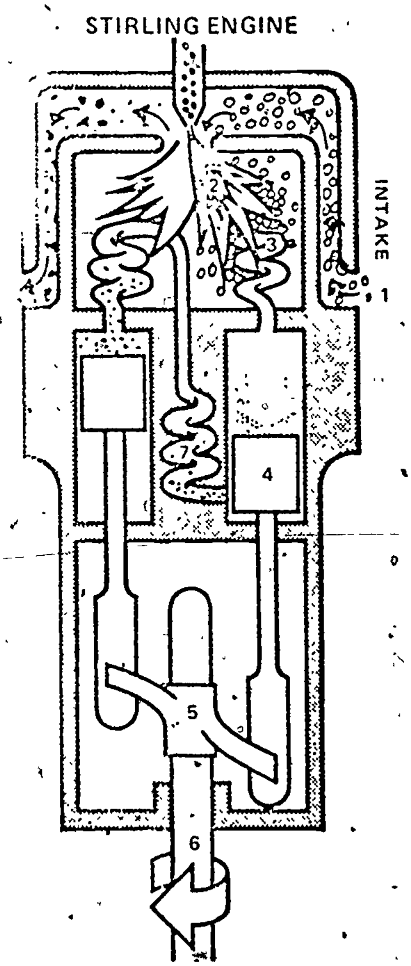
The essential part of this system is a small, pre-combustion chamber in the cylinder head. The small chamber contains the spark plug. A rich air/fuel mixture is supplied to this chamber by one carburetor through the third valve. A lean air/fuel mixture is supplied by the other carburetor to the normal chamber through the normal intakes (1). The rich mixture in the small chamber (2) provides good ignition, and the flame spreads to the lean mixture in the main chamber (3). Burning in the cylinder is slower and more efficient than in conventional engines and by prolonging the combustion most exhaust pollutants are burned up inside the cylinder. Test results suggest a gain, rather than loss, in fuel economy with this system.

A National Academy of Sciences report says the stratified charge engine should be capable of meeting the 1976 standards, if used on small cars. Maintenance should be no greater than is required by 1973 conventional engines. Fuel economy should be comparable to 1972 engines and superior to a 1976 conventional engine equippped with the dual catalyst control system.

STRATIFIED CHARGE SYSTEM

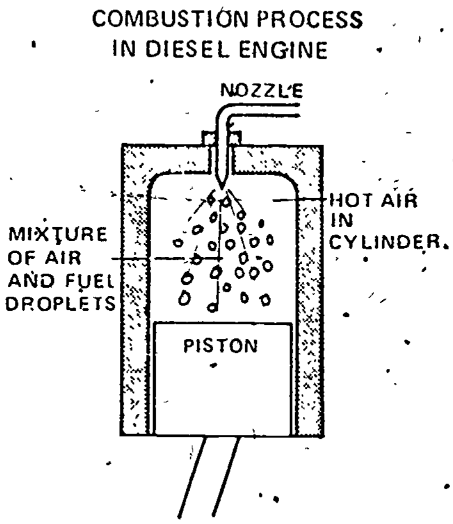


Solutions: Stirling Engine — A Look Under the Hood



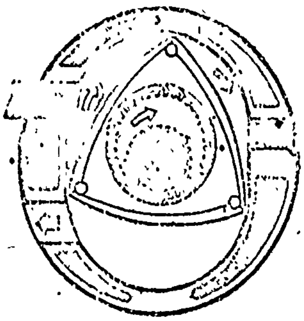
The Stirling engine — This is an external combustion heat engine. Fuel enters at the intake (1) and burns in the combustion chamber (2) which heats gas (hydrogen) in tubes (3). The heated gas expands and forces the piston (4) to turn a swashplate (5) that rotates the drive shaft (6). The gas moves into a cooling chamber (7), and the process is repeated. The engine has low hydrocarbon and carbon monoxide emissions but is a little high on nitrogen oxides. A prototype engine is reportedly heavy, complex and expensive.

Solutions: Diesel Engine — A Look Under the Hood



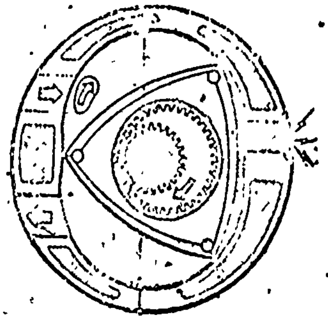
The Diesel engine — In the diesel process, only air is compressed in the cylinder, while fuel is injected late in the compression stroke and is ignited by the heat of compression. This engine has been tested successfully in EPA laboratories and meets Federal emission limits on carbon monoxide and hydrocarbons. It also obtains 75 percent better fuel economy than a conventional internal combustion engine of the same weight.

HOW THE WANKEL WORKS



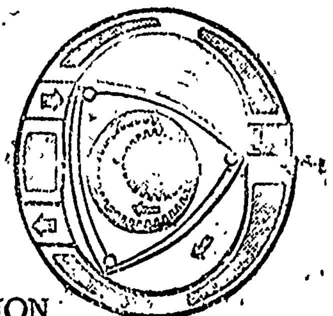
INTAKE

As the piston at right starts downward in the cylinder, it opens a valve at the top and draws in a gas-air mixture. In the Wankel, this "charge" flows into the chamber when one of the three points of the triangular rotor sweeps past an intake port (white arrow) in the wall.

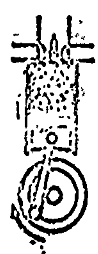


IGNITION

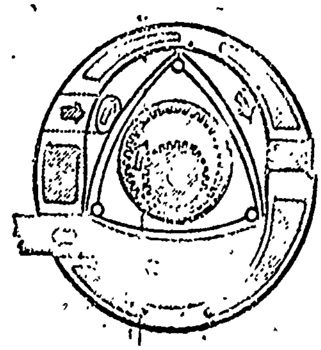
As the rotor face moves down the comparatively flat side wall, the gas is ignited and expanded, providing the thrust to keep the rotor turning. At right, ignition propels the piston on its downward "power stroke."



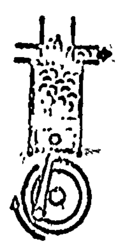
COMPRESSION



As the Wankel rotor turns, the gas (in dark gray area) is pushed toward the spark plug, while a second point of the triangle trails across the intake port and covers it momentarily. At right, the valve shuts as the piston starts upward, beginning to compress the fuel mix.

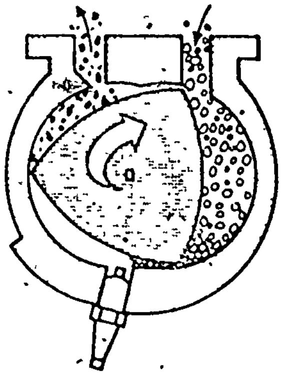


EXHAUST



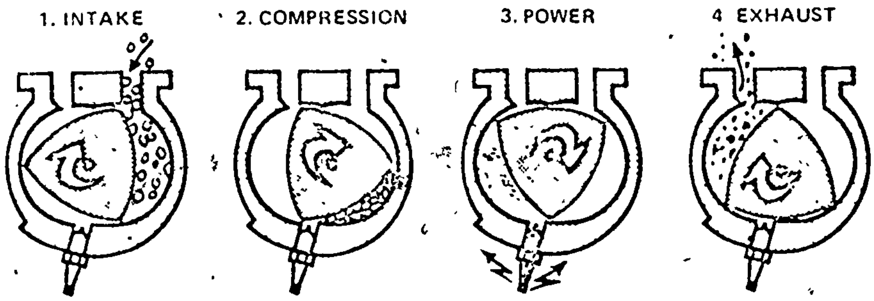
The rotor cleans house by sweeping the waste products of combustion out an exhaust port (white arrow). While this completes the final phase, new cycles have already begun in what is a continuous process. In the conventional piston engine, the exhaust goes out through a second valve as the piston thrusts up for the last time.

Solutions: Wankel Engine -- A Look Under the Hood



In the Wankel, the intake, compression, power and exhaust functions take place almost simultaneously in only one turn of the three-lobed rotor.

WANKEL OR ROTARY ENGINE



Wankel or rotary engine — Another Japanese manufacturer is using a totally different type of spark-ignited engine and emission control. This engine is known as the Wankel or rotary. The emission control is called a thermal reactor. A compact car equipped with this system meets the emission standards for 1975.

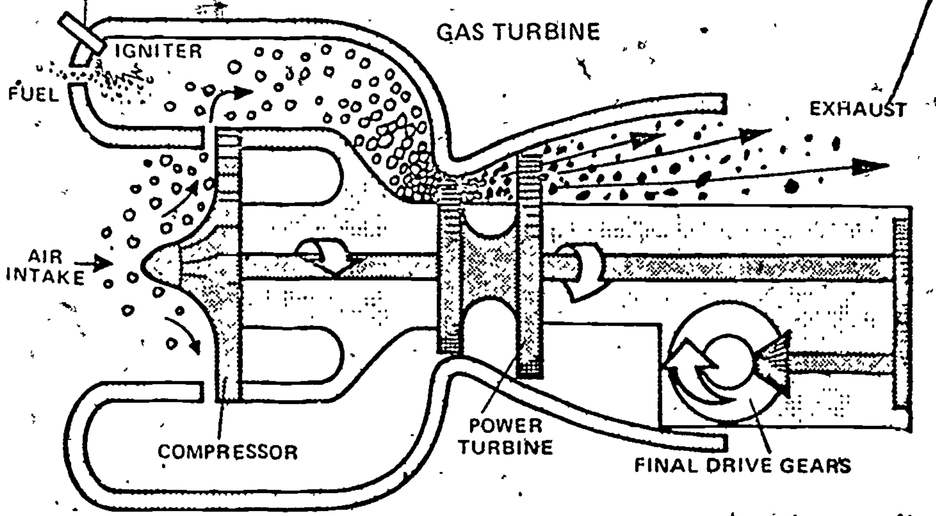
The Wankel, or rotary, engine has no pistons or conventional valves. Instead, the engine block contains one or more rotors shaped like triangles. These rotate on an eccentric shaft in a rotor housing. Compression and combustion of fuel take place as the volume changes between the rotor and the housing.

A thermal reactor is a high-temperature chamber that replaces the conventional engine's exhaust manifold. In the Japanese firm's system, hot gases from the rotary engine enter the reactor where further burning of hydrocarbons and carbon monoxide occurs.

The Japanese-made car with this system does not yet meet the original stringent standards (90 percent reduction from uncontrolled cars) for emissions of nitrogen oxides, but durability tests suggest that the rotary with thermal reactor is superior to the dual-catalyst system. Compared to 1973 conventional engines, however, the rotary uses more fuel. A fuel penalty of 30 percent is predicted.

Solutions: Gas Turbine — A Look Under the Hood

The gas turbine is potentially reliable and quiet. It uses a **single** combustion chamber and combustion is continuous. Power is generated when heat expands gases from the combustor to drive a high-speed turbine. Power from the moving turbine is then transmitted through a set of gears to the car's transmission. An advantage of the turbine is that combustion can be adjusted for very efficient burning of the fuels and minimum pollutants in the exhaust. However, it has problems of high fuel consumption and low acceleration.



21

Cost — The Automobile: Energy and the Environment, March 1974.

Table 6. *Characteristics of Alternate Propulsion Systems*

(Note: Values are for engines only, as synthesized in 1971)

System Type	Power	Weight (lb)	Economy (mpg)	Unit Cost ($)
Baseline - Current Standard ICE	165 hp	965	13.4	910
Advanced Spark Ignition ICE	150 hp	930	12.8	1,277
Advanced Diesel System	150 hp	1125	16.7	1,845
Rotary Combustion (Wankel) System	150 hp	730	13.8	1,231
Rankine Cycle System	150 hp	1145	11.0	1,320
Brayton Cycle (Gas Turbine) System	150 hp	785	11.0	2,220
Stirling Cycle System	150 hp	1560	19.5	3,780
Hybrid, Heat Engine/Electric (Ni-Zn)	Engine 100 hp Storage 11.3 Kw-hr	1480	12.5	2,380
Hybrid: Heat Engine/Flywheel	Engine 100 hp Storage .37 Kw-hr	1010	12.5	1,451
Electric: Alkali Metal Battery (Li-S)	150 hp	1410	1.6 Kw-hr/mi	10,673
Electric Fuel Cell	150 hp	2110	14.0	10,000

APPENDIX F

EXAMPLES FROM TRACE METAL PRODUCT

CADMIUM (mg/Kg)
BALTIMORE HARBOR
PATAPSCO RIVER

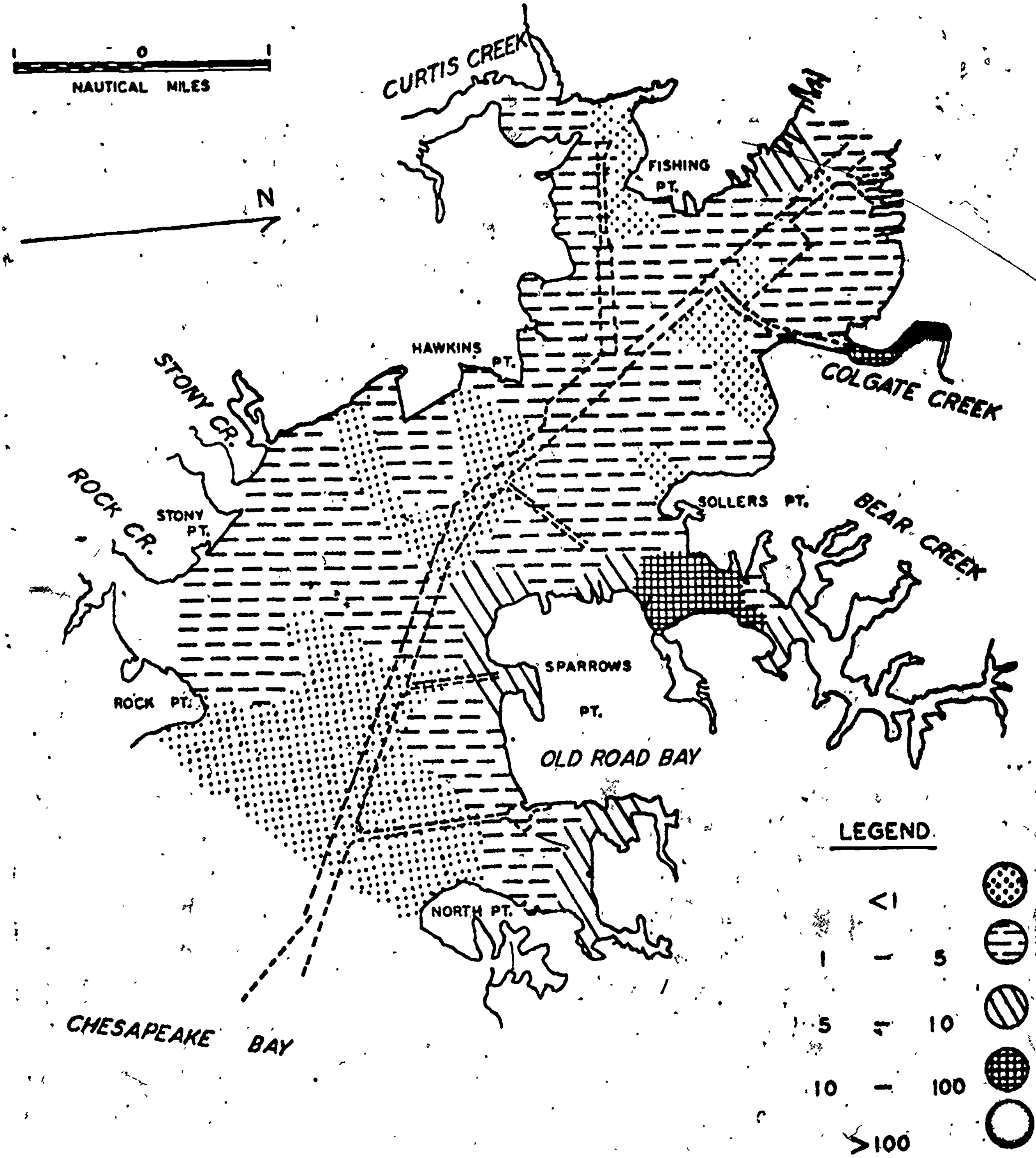
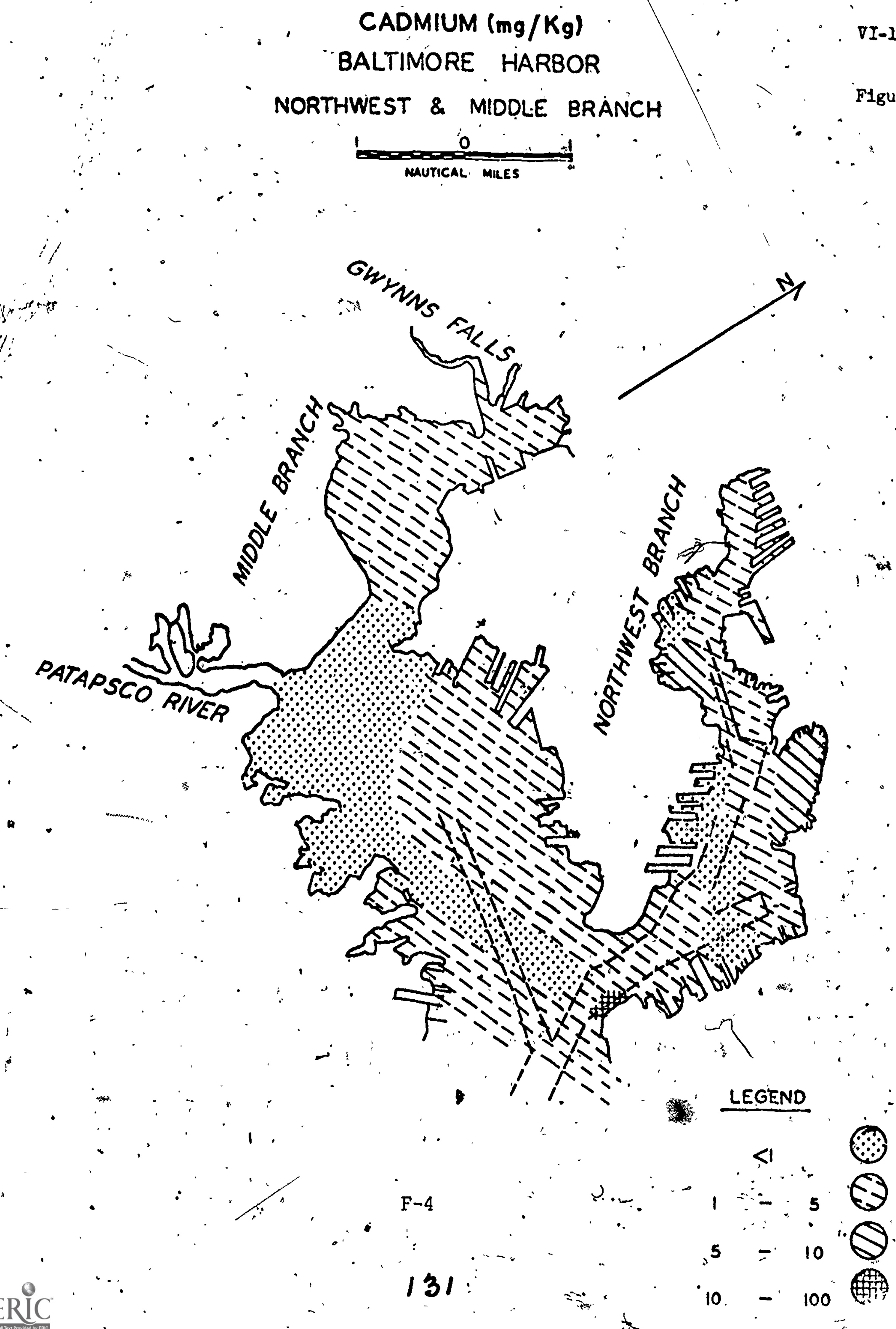


Figure 5


CADMIUM (mg/Kg)
BALTIMORE HARBOR
NORTHWEST & MIDDLE BRANCH
0
NAUTICAL MILES
GWYNNS FALLS
N
MIDDLE BRANCH
NORTHWEST BRANCH
PATAPSCO RIVER
LEGEND
<1
1 - 5
5 - 10
10 - 100

F-4

Figure 6

CHROMIUM (mg/Kg)
BALTIMORE HARBOR
PATAPSCO RIVER

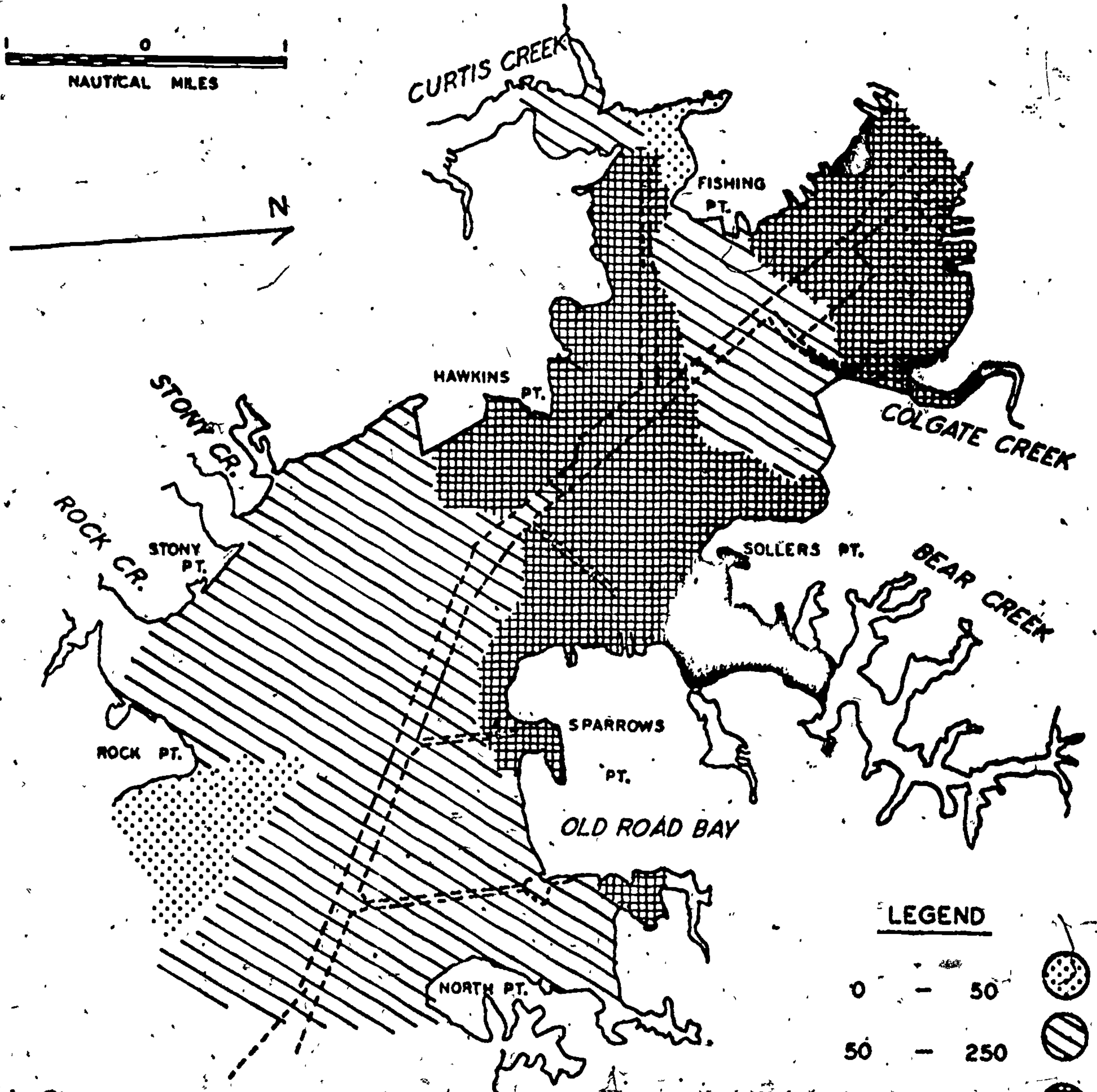


Figure 7

CHROMIUM (mg/Kg)
BALTIMORE HARBOR
NORTHWEST & MIDDLE BRANCH

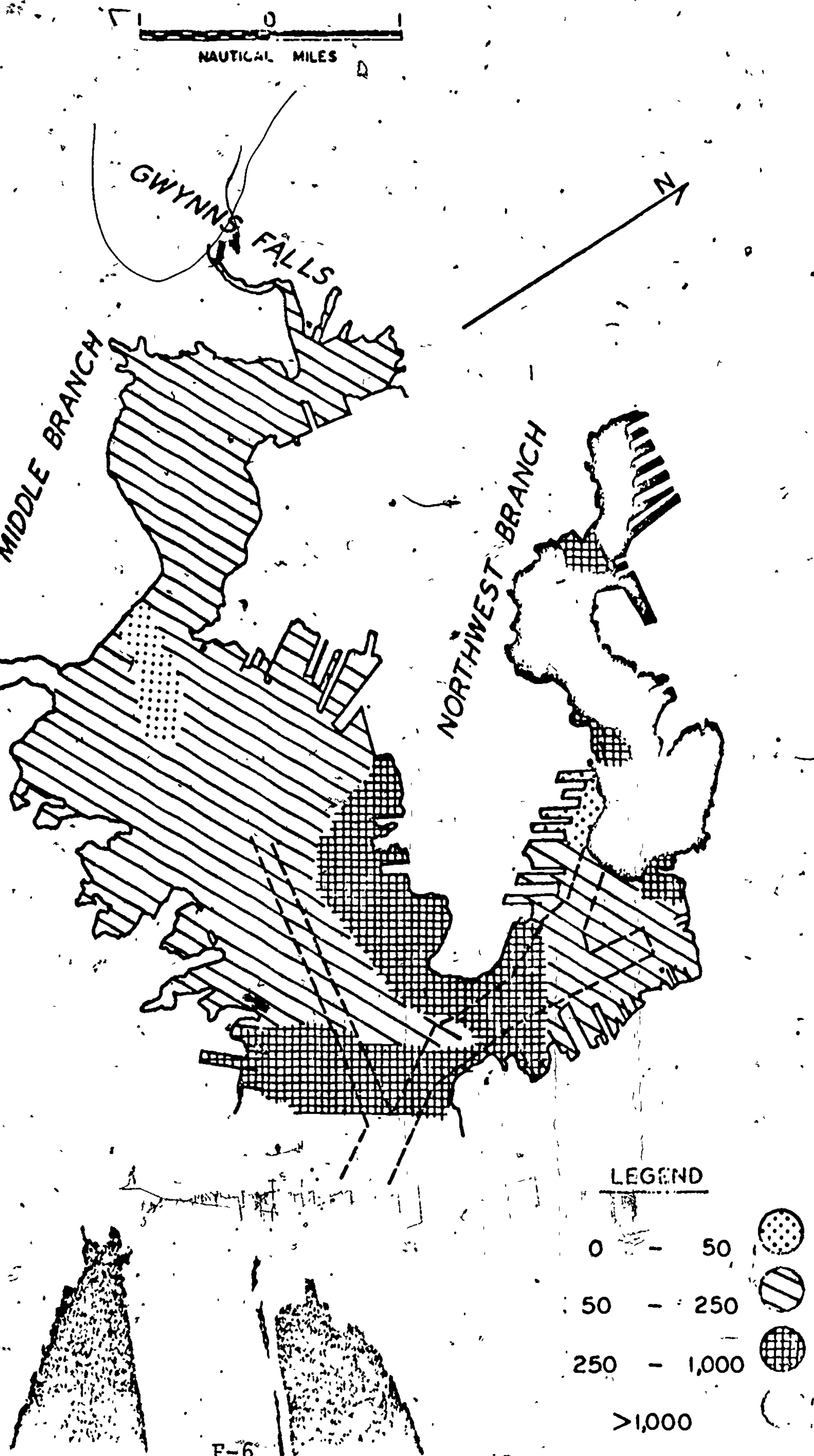
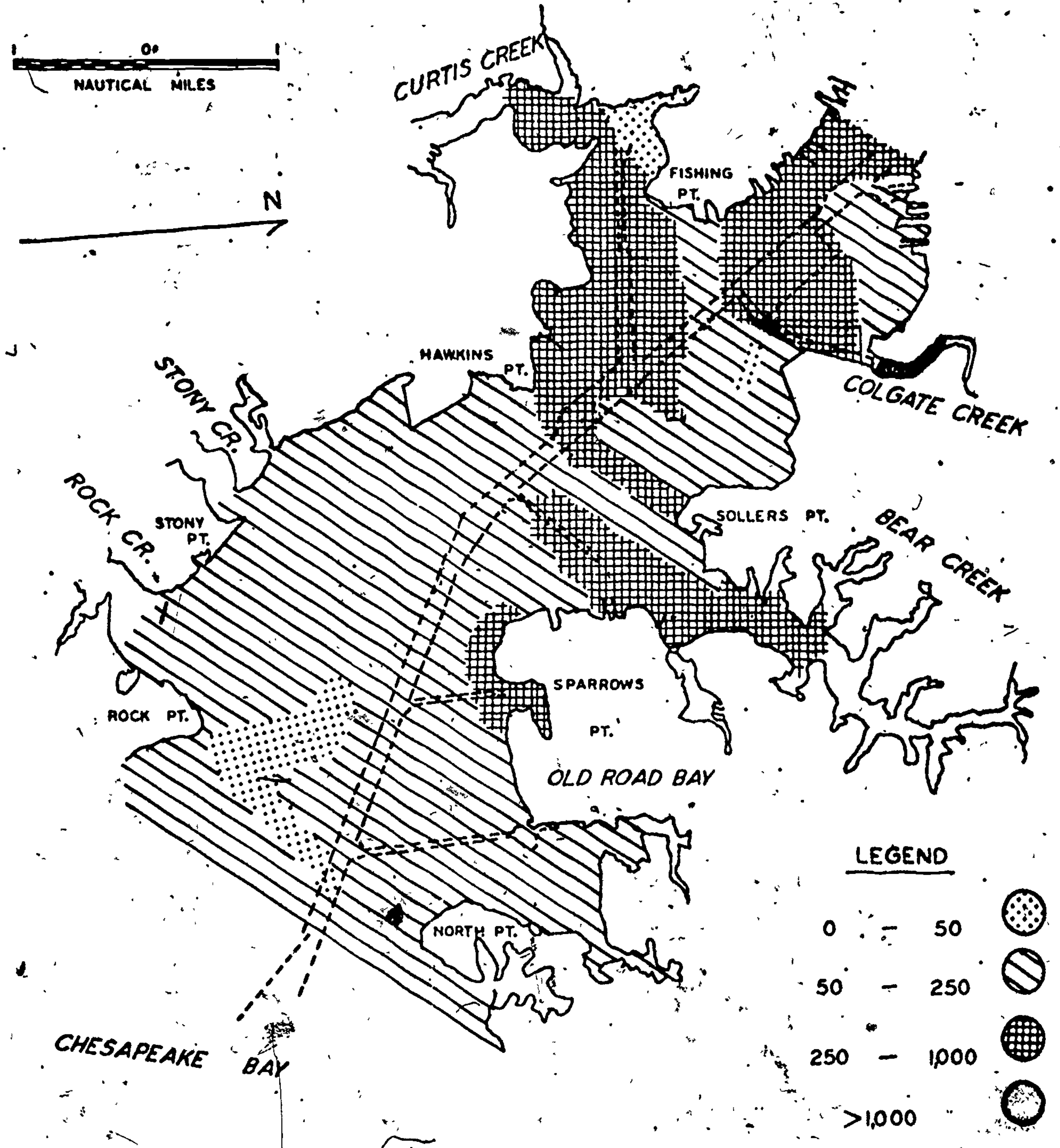


Figure 8

COPPER (mg/Kg)
BALTIMORE HARBOR
PATAPSCO RIVER



F-7

Figure 9

COPPER (mg/Kg)
BALTIMORE HARBOR
NORTHWEST & MIDDLE BRANCH

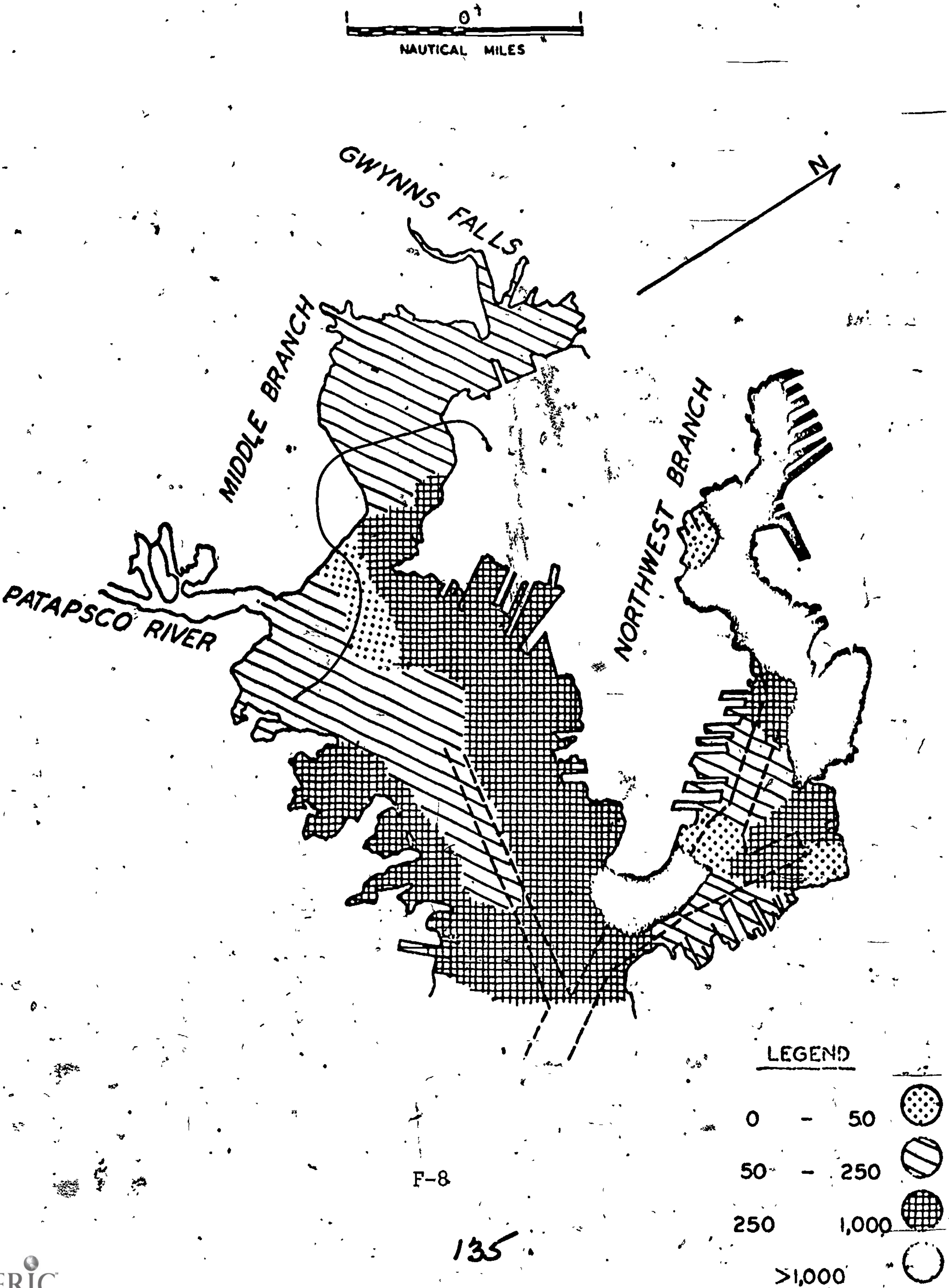
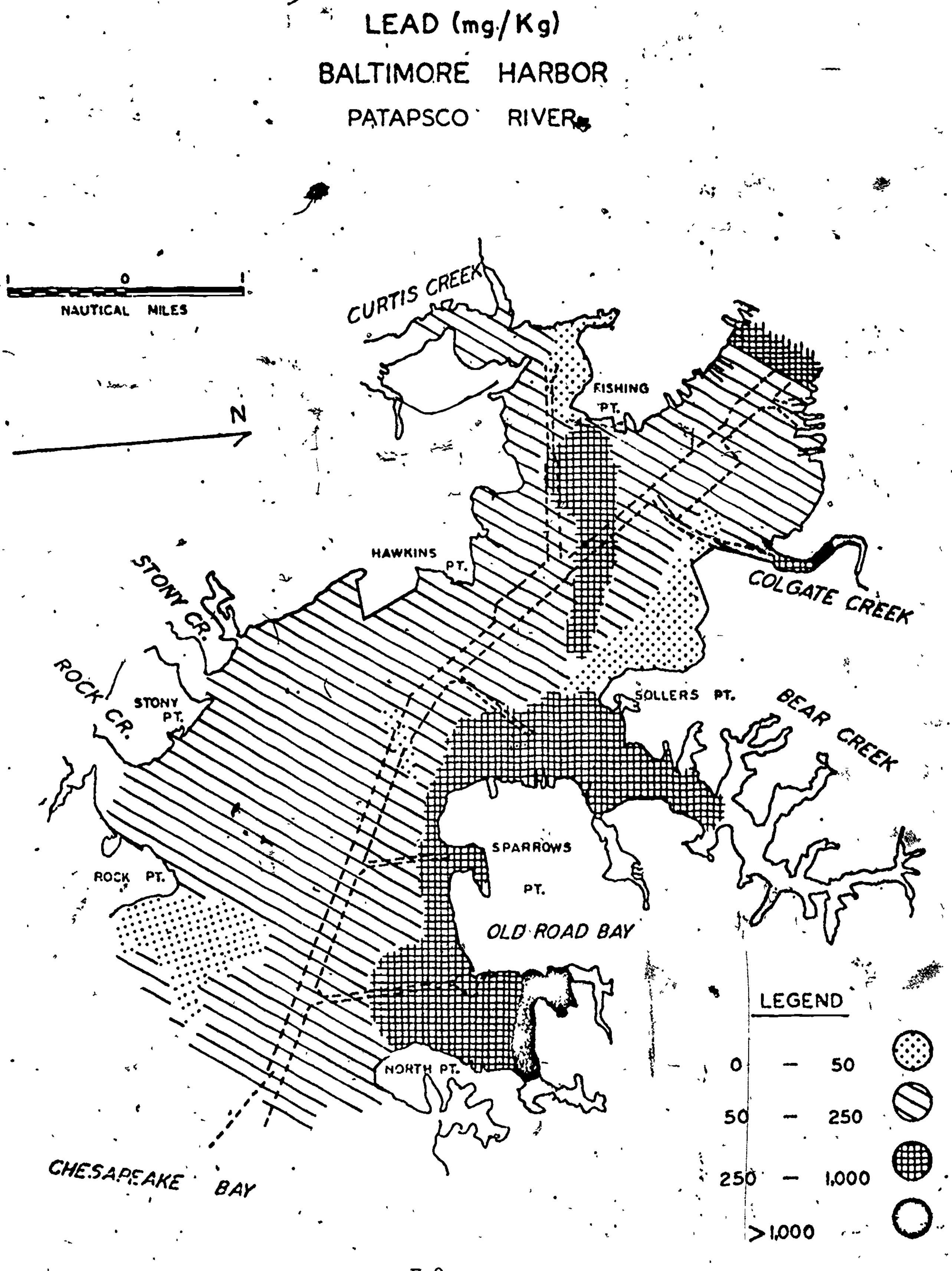


Figure 10



LEAD (mg/Kg)
BALTIMORE HARBOR
PATAPSCO RIVER
0
NAUTICAL MILES
N
CURTIS CREEK
FISHING PT.
HAWKINS PT.
COLGATE CREEK
STONY CR.
ROCK CR.
STONY PT.
SOLLERS PT.
BEAR CREEK
SPARROWS PT.
ROCK PT.
OLD ROAD BAY
NORTH PT.
CHESAPEAKE BAY
LEGEND
0 — 50
50 — 250
250 — 1,000
>1,000

TABLE VII

METALS IN BALTIMORE HARBOR, DELAWARE RIVER, POTOMAC RIVER AND JAMES RIVER SEDIMENTS

Metal	Baltimore Harbor[22]	Delaware River[22]	Potomac River[17]	James River[16]
Chromium, mg/kg				
Low	10	8	20	NO
Average	492	58	--	
High	5745	172	80	DATA
Copper, mg/kg				
Low	<1	4	10	NO
Average	342	73	--	
High	2926	201	60	DATA
Lead, mg/kg				
Low	<1	26	20	4
Average	341	145	--	27
High	13890	805	100	55
Zinc, mg/kg				
Low	31	137	125	10
Average	888	523	--	131
High	6040	1364	1000	708
Cadmium, mg/kg				
Low	<1	<1	<1	NO
Average	6.3-6.6	2.9-3.1	--	
High	654	17	.60	DATA
Nickel, mg/kg				
Low	12	NO	20	NO
Average	36		--	
High	94	DATA	45	DATA
Manganese, mg/kg				
Low	121	NO	500	NO
Average	739		--	
High	2721	DATA	4800	DATA
Mercury, mg/kg				
Low	<.01	<.01	.01	.02
Average	1.17	1.99	--	.32
High	12.20	6.97	.03	1.00

-- Data taken from tables - ranges only

TABLE VIII[23, 24]

CONCENTRATION OF HEAVY METALS IN EARTH'S CRUST, AVG. RANGE

Metal	Range, mg/kg
Chromium	.10 - 100.00
Copper	4.00 - 55.00
Lead	7.00 - 20.00
Zinc	16.00 - 95.00
Cadmium	.05 - .30
Nickel	2.00 - 75.00
Manganese	50.00 - 1100.00
Mercury	.03 - .40