

Final Report
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PREFACE

This study comes out of CEI's examination of its role as a community-based development organization and financial intermediary in supporting sustainable development. As Ron Phillips, CEI's founder and President, notes (Phillips 1993, 189):

We have struggled with economic development from the standpoint of creating economic opportunity while affirming local ownership and control of resources; cultural diversity, and reinforcement of businesses that are compatible with the environment. We have sought to establish a link between the broader concepts of sustainability on the one hand, and economic development on the other.

Traditionally CEI has supported small businesses as a vehicle to provide jobs and create wealth in rural Maine communities through financing and technical assistance.

At the same time, CEI has had an important relationship with Maine's natural environment. Many of our early sectoral projects focused on adding value to Maine's natural resource-base. These included shoreside value-added processing and marketing facilities to support small, family fisherman and cooperative storage and marketing facilities that purchased and collated produce from family farms to sell to large volume customers. The environmental industries sector is consistent with our interest in sustaining people, families and communities in businesses that also sustain the natural environment.

From past experience in launching sectoral development strategies in Maine, we have found that our ability to work as a practitioner is enhanced if we are also actively engaged in state and federal policy that can expand resources to these sectors and create a favorable investment environment. Thus, this study scans Maine's environmental industries with the purpose of suggesting areas where state policy interventions and particularly business assistance support can help accelerate development of this promising sector.

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Finally, we appreciate funding from the Rural Economic Policy Program at the Aspen Institute which made the project possible.

1. EXECUTIVE SUMMARY

1.1 Study Rationale and Approach

Coastal Enterprises, Inc. (CEI) undertook a market scan of Maine's environmental industries with a planning grant from the Aspen Institute in Washington, D.C. The study is a first step in advancing discussion on whether and how state policy should support emerging environmental industries as a targeted economic development strategy.

Targeting environmental industries is currently "an idea in good currency," both in Maine and nationally, for several reasons. First, various environmental industry segments have been growing faster than the economy as a whole. Second, environmental markets are held up as a potential for defense dependent firms that are looking to convert to commercial markets. Third, these industries create jobs, and in some cases, more jobs than the industries they replace.

Part of the difficulty in targeting environmental industries is defining them; they transcend traditional standard industrial codes (SIC) of the economy. In this study, environmental industries are defined broadly as:

firms that produce or sell products, or provide services that are involved with: the conservation of energy, the provision of energy from alternative sources, the conservation of natural resources or industrial materials, the reduction or prevention of pollution, the disposal or recycling of wastes and hazardous materials, the restoration of the environment and its resources or the production of "environmentally safe" products.

Even within this broad definition, environmental industries are not necessarily intuitive. Many technologies that use resources more efficiently and reduce the use of materials or energy have a positive impact on the environment and could be considered an environmental technology, such as computer technologies, advanced composite materials, precision fabrication, or miniaturization technologies that produce on a smaller scale and use less energy. Thus, a vast range of technologies that lead to process and product redesigns and substitute technologies or material inputs into the production process are environmental technologies.

Data were collected from secondary literature on environmental industries and from various agencies, nonprofits and consultants familiar with the industry in Maine and nationally. Unstructured personal and phone interviews were done with key management and marketing people at Maine firms in order to gain a better understanding of their products, markets, opportunities and barriers to growth. The study focuses on the dominant existing sectors of Maine's environmental industries that serve primarily pollution control, remediation, and recycling markets. It also begins to look at firms serving pollution prevention markets.

1.2 Key Findings

- Environmental industries are driven by regulation.
- Regulation, or the threat of regulation, creates the markets for emerging environmental products and services. The downside is that investment in these industries is also subject to the uncertainties of fickle governmental policy, changing regulations or lack of enforcement of regulations. For example, passage of the Clean Air Act promised a boon in pollution prevention technologies; yet appropriations lagged affecting enforcement of the regulations. Subsequently the market has not met expectations.
- Industry growth has been affected by the recession and lagging recovery. According to the Environmental Business Journal (EBJ), a leading industry journal, industry growth has declined since the peak 11.7 percent overall growth rates from 1988 to 1989. In 1989-90, industry growth was 9.5 percent but only 2.2 percent in 1990-91. It rose again to 3.9 percent in 1991-92, but only 3.1 percent in 1992-93. The slowdown reflects the recession and cutbacks in both public and private sectors. Firms were experiencing tougher competition and lower profit margins. Nonetheless, the growth rate exceeds the overall two percent growth rate of the national economy. Overall growth is expected to average around 4 percent over the next five years, with considerable variation between segments (EBJ April 1994).
- Service industries serving local waste management, cleanup, remediation, and recycling markets dominate Maine's environmental sector.

A 1993 survey of the Department of Economic and Community Development found that 81 percent of respondents were service firms, with environmental engineering and consulting the most common service provided.

- The Maine environmental services market is increasingly competitive.

 Engineering/consulting services markets have become saturated with entrants from other states. Canada and other types of engineering firms that sought new markets during the recession. Local analytical laboratories face stiff competition from national conglomerates.
- Pollution prevention and waste reduction are the long-term growth areas
 for environmental technologies.

Process and prevention technology was the fastest growing segment of the environmental industry with a 14 percent growth rate in 1992-93. As environmental regulations increasingly emphasize pollution prevention and waste reduction, growth opportunities shift from "end of the pipeline" cleanup and remediation solutions to the preventative end of the environmental continuum. These include new manufacturing technologies, material substitutes, and green consumer products and services.

Pollution prevention products, technologies and services displace other segments of the environmental industry, such as waste disposal, incineration, cleanup and remediation, as is already evident in the competition of landfills and incinerators for a decreasing waste stream. However, new markets in environmental strategic management are emerging for engineering/consulting firms to assist generators of wastes in assessing the life cycle effects of their manufacturing processes and implementing manufacturing processes changes:

The pollution prevention market is not well defined.

The firms generating wastes create the market for outside services and technologies, but the extent to which they opt to make significant changes in their production processes, or to what degree those changes are made inhouse rather than purchasing external services or technologies, will influence the scope of the market. Furthermore, pollution prevention can encompass changes in process, technology, product or strategic management. Management consultants and construction engineers that are not necessarily considered environmental firms compete in these markets.

1.3 Opportunities Identified for Maine Firms

Expansion of international markets is considered the major growth area
for traditional environmental consulting/engineering firms and
analytical laboratories.

The ability of small Maine companies to enter foreign markets is limited unless they are part of a larger consortium. The Maine Alliance is helping to

form an environmental trade association of Maine firms based on the model of the Boston-based Environmental Business Council.

- Requirements for firms to report to the government their use and discharge of toxics and generation of hazardous wastes are creating opportunities to develop markets for bar-coding chemicals, environmental software and data management. Waste minimization and liability for contamination, as well as emissions monitoring under the Clean Air Act, are also driving corporate interest in environmental data management systems. This industry is still young and volatile; nonetheless, huge hardware manufacturers, accounting firms, defense contractors, and other large corporations have entered the market. Several Maine engineering firms and software companies are
- Environmental regulations requiring wetland mitigation are creating markets for cultivating wetland plants.

finding niches to enter this market.

The Department of Transportation is the largest contractor for wetland recreation and in the last three years has spent about \$4.3 million on wetland mitigation projects across the state. However, the market poses substantial market risks because of long lead time to grow the plants and potential fickleness of public policy. Agency demand for wetland plants is not constant, and the long-term benefits of wetland remediation have not been determined.

Recycling markets are limited due to Maine's location and size.

High costs of waste disposal along with state regulations mandating local recycling have created expanded supply of recycled materials. Recycling, however, competes with existing incinerator and landfill facilities. When faced with a reduction in their waste stream due to recycling regulations and the recession, these facilities reduced their tipping fees and in some cases, have made it uneconomical to recycle.

The supply of potential recyclables still exceeds the demand for end products. Maine is at a disadvantage in stimulating markets using recyclables because of its low population density and distance from consumer markets. Nonetheless, market niches for recycling exist based on the strength of existing industries and customers; particularly in compost research and testing, services and related manufactured products; paper de-inking and recycling; and recycled tire products.

 Maine's technology industries serving environmental markets are in recovery scrubbers, air pollution control equipment, sensor and instrumentation technologies, advanced materials, precision fabrication, radio frequency and biotechnology.

The extent to which Maine firms have a comparative advantage needs further study. However, one likely area is in sensor and instrumentation technologies. The University of Maine's Laboratory for Surface Science and Technology is recognized nationally for its research in sensor technologies. In addition, a number of firms have commercialized sensor and instrumentation technologies or are in the pre-commercialization stage. Some of these are biotechnology companies that are developing biosensors for the growing field testing market.

 A potential pollution prevention market is non-toxic marine products/substitutes (e.g. solvents, biological paint stripping).

Maine's large defense and commercial ship building industry creates an instate market for those products. An in-depth market study would be needed to determine market potential.

 Wind power is now being evaluated to meet Maine's long-term energy needs despite the current energy glut.

Over the past few years, wind power technology has improved and costs have come down substantially. Utilities are the primary market. Two wind power companies are in the process of obtaining permits and raising capital. U.S. Wind power based in California is proposing a \$200 million dollar project northwest of Stratton, and Endless Energy Corporation is proposing a project at Sugarloaf.

 Photovoltaics (PV) are a possible market opportunity for renewable energy technology in Maine.

PV generated power is cost-effective for niche markets, such as in facilities that are remote, with small loads or difficult to serve with conventional technologies. PVs are also cost-effective for many commercial applications. Growing worldwide demand has been boosted by financing from the World Bank for renewable energy projects. The Department of Energy is also investing in PV R&D with \$78 million budgeted in 1994 and \$94 million in 1995. Further growth is expected through utility companies. Maine has at least four small-scale PV companies.

 New environmentally-efficient electrotechnologies may provide new distribution, if not manufacturing opportunities.

Central Maine Power Company, along with other utilities around the nation, has been promoting the concept of "ecowatts" to encourage electricity use in situations where electricity displaces dirtier fuel sources. CMP's interest in a wide variety of electrotechnologies may provide opportunities for entrepreneurs to distribute these technologies and possibly manufacture them under licensing agreements.

1.4 Barriers to Expanding Environmental Industries

Maine firms interviewed cited the following barriers that are consistent with the national literature on environmental industries.

 Availability of capital for R&D, working capital and equipment purchases

Financing new technologies is generally considered high risk; most conventional lenders are unfamiliar with the technologies. Furthermore, financiers tend to invest in people, not technologies. Technology developers often lack business acumen to test and market commercial applications effectively. Environmental service firms face special problems acquiring financing because they lack sufficient assets to collateralize loans.

 Lack of effective market demand for environmental products and services

Many small firms facing new state Toxic Use Reduction laws or Clean Air Act regulations do not have access to financing to make the necessary equipment or process changes in their businesses:

Lack of internal resources for market development

Firms do not have a great deal of slack for developing new markets; nor do they have in-house marketing professionals.

Imperfections in the flow of information

Generators that need to revamp their manufacturing processes to meet new regulations fear liability if they expose their problems. Consultants and engineers, who are close to the information and often identify market niches, are not entrepreneurs who will develop an idea.

· Lag in market demand

Small companies often lack the internal capacity to assess their needs for environmental technologies or services to meet new regulatory requirements. Businesses, government, and engineering/consulting firms are especially risk adverse towards new technologies. They want proven technologies, not innovation, to solve problems. Companies find they spend considerable time educating their market. New technologies also compete with existing capital investments in pollution control equipment. Markets for recycled products have also lagged behind public policies that mandate government procurement of recyclables or recyclable content.

Inconsistent regulatory policies

Changes in regulatory policies can create a fickle policy environment and consequently investment uncertainty. Alternative energy companies in particular cited changes in government programs and policies as a major problem. Regulations of environmental firms can also create an uneven playing field. Inconsistent enforcement of environmental regulations undermines the market for environmental services or products.

Other barriers to specific firms were gaps in work skills and expertise and high liability insurance:

1.5 Potential Interventions

 Provide gap financing to assist existing firms and develop new environmental technologies

A continuum of seed, equity and debt financing is needed to assist firms. CEI has already designed a \$2 million Green Fund to provide gap financing for companies that enhance pollution prevention. The Fund is designed to assist small firms (e.g., generators who create market demand), as well as finance the supply of goods and services by:

Financing audits, changes in manufacturing process, equipment and materials for generators who must meet toxic use reduction and clean air regulatory requirements; and

Financing firms providing green products and services for pollution prevention markets, especially in strong industry segments, such as sensors and instrumentation.

Provide resources for industrial market analysis

- Perform in-depth market analysis to seek new market opportunities and determine whether Maine companies have a comparative advantage.
- Facilitate more interaction between generators and potential environmental industries

This would improve flow of information on environmental problems and solutions and create potential leads for R&D and commercializing new products and technologies.

Broker technology transfer

Maine's quality of life is one comparative advantage for attracting entrepreneurs working with new pollution prevention technologies. A good deal of R&D and start-up companies are in our back door in Cambridge and other areas of New England. If Maine wants to lure start-up companies, it needs to develop its understanding of technology development and environmental technology networks.

Another source of new technologies is federal laboratories. Many have turned to environmental applications of their technologies as part of efforts to reinvent their missions away from defense-dependent research. Again, Maine needs to develop a capacity to match internal capacity of firms and entrepreneurs with emerging technologies.

1.6 Next Steps

CEI is already in the process of capitalizing its Green Fund to provide gap financing for environmental industries and small businesses that must comply with environmental regulations.

Further industry input is needed to determine whether the opportunities identified above can be encouraged through the various interventions described above. Focus groups could be convened by the new Environmental Business Council made up of:

- Industry representatives and researchers in related areas
- Generators with similar manufacturing and pollution problems and needs for new technologies

Feedback from the focus groups can help determine what activities require state or regional policy support and what actions can be taken through private initiatives. Findings would be particularly useful for the State Office of Economic Conversion in identifying opportunities for defense companies, the newly organized Manufacturing Modernization Partnership to improve technology and management systems in manufacturing industries, and the Economic Growth Council's mandate to develop a long-term state economic development plan and bench marking process.

2. INTRODUCTION

As in the rest of the country, Maine is undergoing a process of economic restructuring due to the internationalization of the economy, a new world order resulting in severe defense cutbacks, and increased environmental concerns and regulations. Between 1989 and 1992, Maine lost 13,200 manufacturing jobs (Maine Labor Market Review 1993, 3). Eight percent of Maine's jobs and ten percent of its earnings are directly or indirectly dependent on defense contracts (Adams, Schweppe and Karvonides 1993, 2).

One opportunity for diversification of the economy emerging from these structural changes is environmental industries, the fourth fastest growing sector in New England and the nation in 1991 (Maine Science and Technology Commission 1992). These are industries that manufacture environmental products and provide environmental services along the continuum of reducing, reusing, recycling, or cleaning up wastes and pollution. Environmental markets result from government regulation and enforcement.

Environmental industries are also a strategy for economic conversion of defense-dependent industries. They have potential for utilizing the existing capacity of the metals, electronics, construction and engineering industries that have been key defense industry suppliers in the state. A number of national defense contractors have already entered the industry in hopes of capturing remediation contracts under Department of Defense and Department of Energy (EBI December 1992).

Environmental industries dispel some of the polarization of the "jobs versus environment" debate. As money is invested to comply with environmental mandates, new industries surface that also create jobs, and in some cases, more jobs than the industries they replace. The U.S. EPA has estimated that every \$500 million spent on air and water pollution control creates over 10,000 new jobs in this country (Deiseso 1993). A recent study of the recycling industry in Maine documented that a total of 994 full-time equivalent manufacturing and brokering quality jobs were created in 1993, at an average wage of \$18,476 (O'Hara et al. 1993). Research shows that energy conservation technologies create more jobs than traditional energy sectors. In the manufacturing sector, envirotech firms create skilled and

The American Council for an Energy-Efficient Economy used an input-output model of 25 sectors of the economy to estimate the overall employment and income effects from changes in spending patterns in particular sectors. They compare a High Efficiency energy scenario to a Reference, business as usual scenario. The Council found that the High

semi-skilled assembly, electronic and engineering jobs similar to those of high tech firms (Driscoll 1991).

Finally, environmental industries contribute to sustainable development practices. As understanding of sustainability deepens, preventative approaches and technologies that reduce pollution and wastes at the source begin to overtake cleanup and disposal technologies. Pollution prevention and waste reduction can also reduce business costs and increase efficiency and competitiveness.

In Maine, a number of state agencies are giving priority to developing environmental industries. The Maine Science and Technology Foundation (MSTF) has targeted environmental industries as one of seven strategic sectors for the state requiring research and development. The Governor's Task Force on Defense Realignment and the Maine Economy is looking at environmental industries as a conversion strategy. And the Maine Waste Management Agency (WMA) convened a task force in the fall of 1992 to look at market development for recyclable products.

The State Planning Office and Maine's Department of Economic and Community Development (DECD) have played the strongest roles in organizing initial meetings to form a trade association to expand environmental industries and take advantage of new export market opportunities as well as DoD contracts for the cleanup of Loring Air Force Base in Presque Isle.²

Federal funds are becoming available for developing new environmental technologies and new commercial markets under the National Defense Authorization Act and the National Competitiveness Act. Furthermore, the Clinton administration has specifically singled out environmental industries as an emerging opportunity that also supports the country's environmental goals.

Efficiency scenario led to more jobs, higher personal income and marginally higher GDP throughout a projected period of 20 years. These results were due to the relatively low labor intensity of traditional energy sectors (coal, oil and gas extraction; fuel refining, and electric and gas utilities) compared to the economy as a whole. Energy conservation means that consumers shift purchases from the energy supply sector to other sectors of the economy that employ more workers per dollar invested. See Geller, DeCicco and Laitner 1992, pps. II-III.

² The Maine Alliance is now taking the lead in organizing the council.

If Maine is to build on its current strengths in environmental industries and capture resources to develop new environmental technologies and markets, public and private sector interests need to analyze opportunities and developmental barriers and articulate a strategy to support these emerging industries. This will require active involvement of existing environmental industries and other manufacturing industries with the potential of entering new environmental markets, along with state and local interests, including government agencies, legislators, and nonprofits.

In order to advance the discussion on state policy on environmental industries, CEI undertook a study of Maine environmental industries; funded by the Rural Economic Policy Program at the Aspen Institute in Washington D.C. This is a first step in determining whether the state should target these industries for business assistance support, and, if so, what methods are appropriate.

3. STUDY APPROACH

3.1 Overview

This study is an initial scan of Maine's environmental industries. It is by no means a comprehensive study of all Maine environmental firms, nor all environmental markets. The study first identifies the national, international and state trends in the structure of the environmental industries. It then discusses emerging market opportunities and threats in specific sectors and the barriers that firms interviewed for the study have identified. It does not examine the competitive position of Maine firms. The opportunities suggested require more in-depth market research to determine whether Maine firms are competitive and identify areas requiring possible public policy support and joint initiatives among firms or with university researchers.

3.2 Defining Environmental Industries

Environmental industries include firms that produce a good or service along the continuum of reducing, reusing, recycling, or remediating wastes and pollution. They are difficult to track because they consist of a number of sectors that fall into different Standard Industrial Classification (SIC) codes that include other non-environmental products or services. The Maine Department of Economic and Community Development has used a definition taken from the Commonwealth of Massachusetts:

those (firms) that produce or sell products, or provide services that are involved with the conservation of energy, the provision of energy from alternative sources, the conservation of natural resources or industrial materials, the reduction or prevention of pollution, the disposal or recycling of wastes and hazardous materials, the restoration of the environment and its resources, or the production of "environmentally safe" products.

Moteff. (1992) has noted additional problems in defining distinct environmental industries or technologies.

• Any technology that uses resources more efficiently and reduces the use of materials or energy has a positive impact on the environment and could be considered an environmental technology. Within this broader definition are a vast range of technologies that lead to process and product redesigns and substitute technologies or material inputs that are not usually thought of as environmental.³

- New environmental technologies may create unintended environmental problems. To classify an environmental technology would depend on its net effect, but, in many cases, the impacts are unknown or unclear.
- There is no consensus whether technologies that make incremental improvements in inherently environmentally adverse technologies are environmental technologies, such as improving the efficiency of fossil fuel combustion.

Until recently, environmental industries that investors and analysis typically tracked have fallen towards the remediation end of the continuum. One of the leading environmental business magazines, the *Environmental Business Journal (EBJ)*; only began tracking process and prevention technologies this past year in recognition of the growth in the pollution prevention market, as discussed below. The 13 industry segments that *EBJ* tracks are as follows:

EBJ's Environmental Industry Segments

Services.

Analytical Services
Solid Waste Management
Hazardous Waste Management
Remediation/Industrial Services
Consulting & Engineering

Equipment

Water Equipment and Chemicals Instrument Manufacturing Air Pollution Control Equipment Waste Management Equipment Process & Prevention Technology

Resources

Water Utilities Resource Recovery Environmental Energy Sources

For example, the World Resource Institute's list of 12 critical environmental technologies (see Appendix 1) focuses mainly on altering manufacturing processes.

3.3 Assumptions

This study is based on the assumptions that emerging environmental firms face barriers in commercializing new product or market opportunities and require state support in order to realize their full economic and social potential. Our working hypotheses are:

- Small Maine companies in this weak economic recovery are operating on the edge and lack resources to develop new products or markets as quickly as they perceive opportunities.
- Environmental companies face difficulties obtaining bank financing due to banks lack of familiarity with new technologies or perception of high risk.
- Regulatory issues above and beyond the business climate issues generic to Maine small businesses affect environmental firms.
- Firms with environmental problems are not always willing to expose themselves and share information openly because of potential liabilities.
 The fear of exposure can create imperfections in the flow of information for identifying environmental problems and potential markets.
- Targeted state business assistance policies are needed to overcome these barriers and accelerate the growth potential of environmental industries.

3.4 Approach and Data Collection

The study initially focused on the dominant sectors of Maine's environmental industries that serve primarily pollution control, remediation and recycling markets. It sought more in-depth qualitative data from selected firms to complement a survey by the Department of Economic and Community Development (DECD) that provided an overview of the industry. As the study progressed, it became clear that the greatest growth potential over the long run is in technologies addressing waste reduction and pollution prevention. The study identifies some of these technologies that are known in Maine. The vast array of green consumer products, while recognized as a growing trend, is beyond the scope of this study.

Data were collected from the following sources:

- Surveys of Maine environmental firms by the DECD and the Waste Management Agency (WMA).
- Secondary literature on environmental industries. For national trends, the study drew heavily on the Environmental Business Journal (EBJ).
- Personal interviews of one to two hours were conducted with 13 environmental firms and phone interviews ranging anywhere from 15 minutes to over an hour were conducted with 19 environmental firms in Maine in 1993. These firms represent environmental service and manufacturing industries in remediation and pollution control, data management, wetland plants for wetland recreation, recycling, instrumentation, analytical testing, pollution reduction and prevention products and technologies, and energy products and services.

Firms in these sectors were selected from CEI's own investment portfolio and from firms on the DECD list. Firms were also added at the suggestion of other environmental firms and agencies working with environmental firms. The selection was geared primarily towards Maine-based firms that represented different environmental market segments.

Interviews were unstructured. Firms were asked about their products, markets, and opportunities and barriers to growth.

 Phone interviews with national contacts in trade organizations, state and national governmental agencies, and nonprofit organizations knowledgeable about emerging industry trends and state and local initiatives to support these industries. (See Appendix 2 for list of interviews.)

4. NATIONAL ENVIRONMENTAL INDUSTRY TRENDS

Environmental industries emerge to solve environmental problems that become a matter of public policy and are eventually addressed through legislation, regulations, and enforcement procedures. Government intervention, or the threat of such intervention, drives the environmental market. Over time, the cost of environmental compliance and cleanup of wastes and pollutants creates incentives for both public agencies and private sector firms to reduce or reuse the wastes and pollutants that they generate. As new sustainable manufacturing processes and green products infiltrate the mind set of industry and the public sector, the growth of traditional environmental industries serving "end of the pipeline" markets starts to decline.

This section gives a brief overview of national trends in what has been traditionally called environmental industries, emerging approaches to pollution prevention and waste reduction, and green consumer industries.

4.1 Traditional Environmental Industries

According to *EBJ*; industry growth has declined since the peak 11.7 percent overall growth rates from 1988 to 1989. In 1989-90, industry growth was 9.5 percent, 2.2 percent in 1990-91, but rose again to 3.9 percent in 1991-92.

In 1993, the industry grew at an overall rate of 3.1 percent from 1992, lower than the previous year but higher than the two percent overall growth of the economy. Environmental industries produced \$133.5 billion in revenues in 1993, with solid waste management accounting for the largest segment of \$29.4 billion (see Table 1).

The slowdown in growth rates reflects the recession and the cutbacks in both public and private sectors. Firms were experiencing tougher competition and lower profit margins. Overall growth is expected to average around four percent over the next five years, with considerable variation between segments (see Table 2).

Available figures on the size and growth rates of the environmental industry vary and reflect, at least in part, the analyst's definition of the industry. For example, Washington, D.C. based environmental industry consultants Alan Farkas and Joan Berkowitz report a \$75 billion industry in 1992, with a growth rate of five percent from 1991. The Global Environment Fund (1992) projects an annual growth rate of eight percent between 1992 and 2000 in traditional markets.

TABLE 1
The U.S. Environmental Industry, 1989-1993

	REVENUE AND GROWTH (\$ Billions)										
ENVIRONMENTAL		88-89		89-90		90-91		91-92	200	92-93	
INDUSTRY GROWTH	1989	Growth	1990	Growth	1991	Growth	1992	Growth	1993	Growth	
SERVICES	医线道	N. T.				s e				uarra .	
Analytical Services	1.5	21%	1.5	6%	1.6	1%	1.6	3%	1.6	0%	
Solid Waste Management	23.5	14%	26.1	-11%	27.0	3%	28.2	4%	29.4	4%	
Hazardous Waste Management	7.5	21%	8.3	11%	8.5	2%	8.8	.4%	8.6,	-3%	
Remediation/Industrial Services	8.2	21%	8.5	3%	7.9	> -7%	8.2	4%	8.4	39	
Consulting & Engineering	10.2	26%	12.2	19%	13.4	10%	,14.2	6%	14.4	2%	
EQUIPMENT	N. 180								n - 1	3 (187) 188	
Water Equipment and Chemicals 🖰	11.7	7%	12.1	3%	12.5	3%	13.0	4%	13.2	2%	
Instrument Manufacturing	1.5	15%	1.6	9%	1.7	4%	1.8	5%	1.8	-39	
Air Pollution Control Equipment	3.6	-2%	3.7	3%	3.7°	-1%	> 3.8	2%	3.8	-19	
Waste Management Equipment	9.8	9%	10.4	6%	11.0	6%	11.4	- 4%	11.2	-1%	
Process & Prevention Technology	0.3	36%	0.4	37%	0.5	22%	0.6	. 20%	0.7	14%	
RESOURCES		ال معامل در المرا		医数 海点			建石火 管		in to Ag\$		
Water Utilities	18.8	× 8%	- 20.2	7%	21.1:	4%	. 21.7	3%	23.1	6%	
Resource Recovery	13.3	. 16%-	15.2	14%	5, 14.0	-8%	14.3	2%	15.2	69	
Environmental Energy Sources	1.6	12%	1.8	11%	1.9	7%	2.0	5%	2.1	59	
	1000		15.00				10.42				
TOTALS	111.5	11,7%	122.0	9.5%	124.7	2.2%	129.6	3.9%	133.5	3.19	

Source: Environmental Business Journal, April 1994

TABLE 2

Projected Revenue and Growth of

Environmental Industry Segments, 1993-1998

STORE AND STORE STORE A LANGE TO THE PROPERTY OF	1. Nov. 18 40			HE SANGGER	(6)((2));((6)	Rillional	
ENVIRONMENTAL	Avg. Ann.	of Parities.	34. 27. 63. 3. 3.	Page Septime		the section of the	
	Growth						
INDUSTRY SEGMENT	1993-1998	1993	1994	1995	1996	1997	1998
SERVICES		(1999) (1999)				in a state of the	
Analytical Services	2%	1.6	1:6	1.7	1.7	1.8	1.8
Solid Waste Management	4%	29.4	30.6	31.9	33.4	34.7	35.9
Hazardous Waste Management	-1%	8.6	8.6	8.6	8.6	8.5	8.2
Remediation/Industrial Services	4%	8.4	8.9	9.3	9.7	10.1	10.4
Consulting and Engineering	5%	14.4	15.0	15.8	16.6	17.3	17.8
EQUIPMENT						V 255 11357	1.
Water Equipment & Chemicals	5%	13.2	13.8	14.5	15.3	16.1	16.8
Instrument Manufacturing	6%	1.8	1.9	2.1	2.2	2.3	2.4
Air Pollution Control Equipment	4%	3.8	3.9	4.1	4.3	44	4.6
Waste Management Equipment	.2%	11.2	11.1	10.9	10.6	10.3	9.8
Process & Prevention Technology	15%	0.7	0.8	0.9	1.2	1.2	1.4
RESOURCES						自身應答(等)	
Water Utilities	4%	23.1	24.3	25.5	26.7-	27.9	29.1
Resource Recovery	6%	15.2	16.1	17.0	18.1	19.1	20.1
Environmental Energy Sources	11%	2.1	2.3	2.6	2.9	3.2	3.5
TOTAL INDUSTRY		133.5	138.9	144.9	151.0	156.8	161.9
							7.00 Sec. 3.00
AVERAGE GROWTH RATE		-3.1%	4.0%	4.3%	4.2%		3.3%

Source: Environmental Business Journal, April 1994

The highest concentration of environmental industries was in large manufacturing states (California, Texas, New York, Pennsylvania, Michigan, Florida and Ohio) that accounted for almost half of total private sector environmental revenues in 1992 (see Table 3). Maine's environmental industries accounted for \$729 million in revenues (.54% of U.S. 1992 revenues) and employed 5,850 people.

4.1.1 International Markets

Expanding international markets are considered the major growth potential for traditional environmental industries. Strong U.S. environmental regulations have created a comparative advantage for U.S. firms as the rest of the world seeks to improve their environmental quality. Many parts of the world are only beginning cleanup of their pollutants. Firms with established products are the most competitive in meeting governments' needs at different stages of regulatory development (EBJ August 1992). Multilateral development agencies are increasing their investment in environmental projects. The rising international markets are due to increased world pressure from such events as the Rio Summit in 1992, local public pressure, and demands of international trading partners to control pollution.

Analysts agree that the global market will grow dramatically but differ on market size. The Environmental Business Council of America estimates that the market is currently \$200 billion and will grow to \$300 billion by the year 2000, whereas the Environmental Technology Export Council estimates \$300 billion in 1992 that will double by the end of this century.

Although U.S. firms have dominated the international market in the past, both Japan and Germany are launching aggressive strategies to support development of their environmental industries. These countries, along with Sweden, Switzerland, Austria and most other industrialized countries, have stringent environmental and energy regulatory programs. They create pricing and tax structures to internalize external environmental costs or give preference to new solar and wind power energy sources (Lash 1993).

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⁵ Presentation by EBJ editor, Grant Ferrier, at conference on "Reaching Global Markets for Environmental Products and Services," March 24, Portland Regency Hotel.

State Environmental Markets, 1992-1995.

1995											
	le de la companya de		Employment	Revenues	Employment						
State	% of U.S.	(billions)	(Jobs)	(billions)	(Jobs)						
Alabama	1.49	1.999	16,045	2.414	18,562						
Alaska	.34	.457	3,665	.551	4.240						
Arizona	1.13	1.514	12,156	1.829	14,063						
Arkansas	.70	.940	7,548	1.136	8,732						
California	13.14	17.573	141,079	21.226	163,208.						
Colorado	1.37	1.831	14,697	2.211	17,002						
Connecticut	1.48	1.973	15,841	2.383	18,326						
Delaware	.51	.676	5,431		6,282						
District of Columbia	.60	.802	6,440	.969	7,451						
Florida	4.33	5:792	46,504	6.997	53,798						
Georgia	2.05	2.738	21,982	3.307	25,430						
Hawan	.28	.379	3,041	.458	3,518						
Idaho	.38		4,093	.616	4,735						
Dlinois	3.81	5.099	40,939	6.159	47,360						
Indiana	2.46	3.287	26,386	3.970	30,525						
Iowa"	1.02	1.364	10,949	1.647	12,667						
Kansaŝ	89	1.192	9,570	1.440	11,071						
Kentucky	1.23	1.651	13,254	1.994	15,333						
Louisiana	2.64	3.534	28,374	4.269	32,824						
Maine	- 54	.729	5,850	.880	6,767						
Maryland	1,53	2.050	16,459	2.476	19,040						
Massachusetts	2.26	2.021	24,254	3.649							
Michigan	4.40	5.887	47,263	7,111	54,676						
Minnesota	1.80	2.409	19,337	2.909							
Mississippi	73	970	7,766	1.171	9,007						
Missouri	1.66	2.219	17,814	2.680	20.608						
Montana	32	.424	3,405	512							
Nebraska	40	540	4,332	.652	.5,011						
Nevada	.26	.345	2,772	.417	3,207						
New Hampshire	.52	.693	5,567	838	6,440						
New Jersey	5.12	6.841	54,920	× 8.263	63,534						
New Mexico	48	.645	5,175	779	5,987						
New York	6.10	8.156	65,476	9.851	75,747						
North Carolina	2.20	2.947	23,661	3.560							
North Dakota	13	.180	1,443	.217	1,669						
The contract of the second	ا مەنى	- 5.539	44,471	6.691	51,446,						
Oklahoma	97	1.302	10,451;	1.572	12,090						
Oregon	1.02	1.364	10,952	1.648	12,670						
Pennsylvania	4.99	6.677	53,608	8.066	62,016						
Rhode Island	36	486	3,903	.587	4,515						
South Carolina	1.31	1.753	14,077	2.118							
South Dakota	.13	179	1,435	.216	1,660						
Tennessee	1.96	2.625	21,073		24.378						
Texas	8.09	10.812	86.799	13.060							
Utah	.71	.954	7,661	1.153							
Vermont	25	.337	2,703	.407	- V						
Virginia	2.01	2.681	21,526								
Washington	2.58	3.449	27,691	4.166							
West Virginia	.88	1.170	9.396	1.414							
Wisconsin	2.04	2.726	21,899	3,295	and the Charles of the Control of th						
Wyoming		275	2.208								
TOTAL U.S.	100.0%	133.7									
ALOTAT O'S	1 100:0%	133./	1,070,002	Tor"	1,291,744						

Source: Environmental Business Journal, April 1994.

TABLE 4 U.S. Environmental Industry Employment (1992) by Sector by State

		1.5	<u> </u>				in the contract		Sin March	12.			44 8 7	
1877 18 A.S. 18 A.	3000	1 3 34 5			The engineering	, Ü			14 (4) 15		36 4 3		Waste.	
	% of Total	35 Total	Analytical	_ sw _	, HW	- Asbestos	Water	Water	Env.	Res.	Instru-	APC	Mgmt.	Env
State	U.S. Market	Jobs	Services	Mgmt.	Mgmt.	Abatement	Equip:	<u>U</u> tilities	C& E	Recov.	ments	Equip.	Equip.	Energy
Totals	100 %	1,072,862	19,556	235,000	126,957	28,182	100,000	136,250	157,778	107.333	15,167	38,714	88.462	20,000
Alabama	1.49	15,994	291	3,502	1,892	420	1,490	2,030	2,351	1,599	226	577	1,318	298
Alaska	34	3,650	. 66	799	432	96	340	463	536	365	52	132	301	68
Arizona	1.13	12,129	221	2,656	1,435	318	1.130	1.540	1,783	1,213	171	437	1,000	226
Arkansas	.70	7,514	137	1,645	889	197	700	954	1,104	751	.106	271	619	140
California	13.14	141,045	2.570	30.879	16.682	3.703	13,140	17,903	20,732	14.104	1,993	5,087	11.624	2,628
Colorado	1.37	14,706	268	3,220	1,739	386	1,370	1,867	2,162	1.470	208	e. 3 530	1,212	27,4
Connecticut	1.48	15,886	289	3,478	1,879	417	1.480	2.017	2,335	1.589	224	573	1,309	296
Delaware	.51	5,474	100	1,199	647	144	510	695	805	547	77	197	451	102
A11 - A13 S A 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	.60	6,440	117	1.410	762	169	600	818	947	644	91	232	531	120
District of Columbia			847	10,176	5,497	1.220	4,330	5,900	6,832	4,648	657	1,676	3,830	866
Florida	4.33	46,478						2,793		2,200	311	794	1.813	410
-Georgia	2.05	22,005	40L	4,818	2,603		2,050		3,234	301	42	108	248	56
Hawaii	10 Mg 14 128	3,006	55	658	355	79	280	382	100	20 A 1 A 1	58	147	336	76
Idaho		4,079	74	893	482	107	380	518	600	(408)	578	1,475	3,370	762
Itlinois 200	3.81	40,897	745	8,954	4,837	1,074	3,810	5,191	6.011	4,089	1.0		2,176	492
Indiana	2.46	26,406	481	5,781	3,123	693	2,460	-3,352	3,881	2.640	373	952		204
lowa	1.02	10,949	199	2,397	1,295	287	1,020	1,390	1,609	1,095	155	395	902	the second of the
Kansas	. 89	9,553	174	2,092	1,130	251.	890	1,213	1,404	955.	135	345	787	178 246
Kentucky	1.23	13,203	241	2,891	1,562	347	1,230	1,676	1,941	1,320	187	476	1,088	
Louisiana	2.64	28,338	516	6,204	3,352	744	2,640	3,597	4,165	2,834	400	1,022	2,335	528
Maine	.54	5.796	106	1,269	686	152	540	, 736	852	580	82	209	,478	108
Maryland	1.53	, 16,423.	299	3,596	- 1,942	431	1,530	2,085	2,414	1,642	,232	592	1.353	306
Massachusetts	2.26	24.259	442	5311	2,869	637	2,260	3.079	3,566	2,426	343	875	1,999	452
Michigan	-, 4.40	47,230	860	10,340	5,586	1,240	4,400	5,995	6.942	4,723	667	1,703	3,892	880
Minnesota	1.80	19,321	352	4,230	2,285	507	1,800	2,453	2.840	1,932	273	~ 697	1,592	360
Mississippi	. 73.	7,836	143	1,716	927	206	730	995.	1,152	784	111	283	646	146
Missouri	1.66	17,818	~ 325	3,901	2,107	468	1,660	2,262	.2,619	1,782	252	643	1.468	332
Montana	32	3,435	63	752.	406	90	320	436	505	343	49	124	283	64
Nebraska	.40	4,294	78	940	508	113	400	. 545	631	429	61	155	354	80
Nevada	.26	2,791	51	611	330	73	260	.≤2 - 354°	410	279	39	101	230	52
New Hampshire	52	5.582	102	1.222	660		520	709	820	:558	79	201.	460	104
New Jersey	5:12	54.958	1,001	12.032	6,500		5,120	6,976	8,078	5.495	77	1,982	4,529	1,024
New Mexico	48	5,152	94	1,128	609		480	654	757	515	73	186	425	96
And the second of the second	6.10	65,477	1,193	14,335	7,744	1,719	6,100	8,311	9,624	6.547	925	2,362	5 396	1,220
New York	2.20	23,615	430	5.170	2,793		2.200	2,998	3,471	2,361	334	852	1,946	440
North Carolina			25	306	165	37	130	177	205	140	20	50	115	26
North Dakota	13	1,395	810	9,729	5,256	1 1 1 2 2 3 1 2	4,140	5,641	6.532	4,444	628	1.603	3,662	828
Ohio	4.14	44,439	190	2,280		273	970	1,322	1.530	1,041	147	376	858	194
Oklahoma	.97	10,412.	190	2,280	1,231 1,295		1,020	1,322	1,609	1,095	155	395	902	204
Oregon "	1.02	10,949	4 48 2 5 5 5 7 7			287	1.50	6,799	all the control of th	5,356	157	1.932	4.414	998
Pennsylvania	4.99	53,563	976	11,727	6,335	T	4,990 360	491	7,873 568	386	55	139	318	72
Rhode Island	36	3,864	70	846	457	101.	1	The state of the s		1,406	199	507	1,159	262
South Carolina	131	14,062	256	>3,079	1,663		1,310	1,785	2,067	4 1 2 2 2	20	50	1115	26
South Dakota	.13	1,395	25	306	165		130	177 2.671	205 3.092	140 2.104	297.	759	1,734	392
Tennessee	1.96	21,039	383	4,606	2,488	552	1,960			1.0	17.	4		# 40 PA
Texas	8.09	86,838	1,582	19,012	10,271	2,280	8,090	11,023	12,764	8,683	1,227	-3,132	7,157	1,618
Utah	71:	7,621	139	1,669	901	200	710	967	1,120	762	108	275	628	142
Vermont	25	2,683.	49	568	317	70	250	341.	394	268	1 7 38	97	221	50
Virginia	2.01	21.575	393	₹4,724	2,552	566	2,010	2,739	3,171	2,157	305	778	1,778	402
Washington	2.58	27,694	505	6,063	3,275	727.	2,580	3,515	4,071	2,769	391	999	2.282	516
West Virginia	.88	9,446	172	2,068	1,117	248	880	1,199	1.388	945	133	341	778	176
Wisconsin	2.04	21,897	399	4,794	2,590	575	2,040	2.780″	3,219	2,190	309	790	1,805	408
Wyoming	.21	2,254	41	494	267	59,	210	286	331	225	32	′18 · . ·	186	42,
TOTAL U.S.	100.00	1,072,862	19546	234,883	126,894	28,168	99,950	136,182	157,699	107,279	15,159	38,695	88,418	19,990
,	20000	- Por Elong,	1	,				-						T

Source: Environmental Business International, Inc. (San Diego, California)

There are also some signals that expensive Western cleanup technologies may lose out in emerging international markets. For example, the World Bank and the Organization for Economic Cooperation and Development prepared a \$30 million Environmental Action Program for former East Bloc countries, supported by Western nations, that targets small-scale, inexpensive methods of preventing and controlling wastes and pollution (West Offer Plan to Clean Up East. New York Times 4 May 1993).

4.2 Pollution Prevention

Pollution prevention includes four categories: efficient operations and maintenance of existing production, materials substitution, manufacturing modifications, and resource recovery (Schmidheiny 1992). Yet it is only a small portion of environmental compliance, mainly because government regulations and practices have favored end-of-the-pipeline approaches.

Most regulatory agencies are now making prevention and source reduction a priority, as are more large companies. More than two-thirds of respondents to a survey of the Standard & Poor's 500 said that they have modified products and technology in the last three years in response to environmental concerns. Many changes involved product packaging and process and control (EBI December 1992). The World Resources Institute reports substantial increases of corporate R&D in environmental technologies, with most of the focus on pollution prevention and waste minimization (Heaton et al 1991, 1992). According to a report from the World Resources Institute, corporate investment in environmental technologies is unprecedented. Finding substitutes for the 17 chemicals listed under EPA's 33/50 program to encourage voluntary reductions in toxic releases, or alternative processes that avoid them, is driving considerable R&D. Foreign regulations are also influencing U.S. export firms that must comply with these regulations.

Most pollution prevention technology is still in product substitution, incremental improvements by engineering teams, and only occasionally in manufacturing processes (EBJ May 1993). There is some question how far companies will go to change their production processes in order to prevent pollution. According to Joel Hirshhorn, formerly of the Office of Technology Assessment (OTA), a serious pollution prevention program can represent a "considerable threat" (EBJ May 1991, 1). It requires that a

For example, a new German law requires that manufacturers take back and recycle their packaging materials or else pay fees to fund a private system of collection and sorting system. If the European community adopts the legislation, it will affect many U.S. firms (A Nation's Recycling Law Puts Businesses on the Spot. New York Times July 12 1992).

company revamp its total way of thinking and operating, from procurement to worker rewards. Technological change can be very expensive, and not all processes and products are easily replaced. In his remarks to the Senate Committee on Environment and Public Works, Frank Popoff (1993), Chairman and CEO of Dow Chemical, stressed that incremental technological changes are just as important as the development of new technologies and in most cases considered them more cost-effective. The issue, in his mind, is setting priorities for pollution prevention efforts based on efficient use of limited resources.

Other industrial leaders take a more comprehensive, systems based, multidisciplinary view of industrial operations known under a number of labels: "industrial ecology," "design for environment," and "life cycle analysis." According to an MIT study, the primary motivation for firms undertaking life cycle analysis is a desire to capitalize on strategic and market opportunities and to gather information on customer environmental concerns (Sullivan and Ehrenfeld 1992-93). David Chittick (1993, 2) of AT&T notes that this new realm of industrial ecology and design for environment is very different from our present production systems. In his words:

We are talking about restructuring the technological basis of our entire economy to make it sustainable over the long haul. We are not talking about devising better scrubbers; we are talking about recreating economic, legal, and technical institutions, practices and systems.

The life cycle approach seeks to optimize the total materials cycle from procurement of virgin material, through manufacturing and distribution of products and production and disposal of wastes. Thus, environmental considerations become part of all technology and economic decisions. Design for environment helps firms internalize the environmental costs by focusing on the design stage when inputs and materials are chosen, manufacturing technologies are implicitly selected, and maintenance requirements are determined. At AT&T, manufacturing technologies, not environmental technologies, were critical for its successes in pollution prevention.

4.3 Developing New Technologies

4.3.1 The Role of Generators

The biggest source of advances in environmentally friendly products and new manufacturing technologies is generators—the businesses generating wastes and pollutants. (EBJ May 1992). New technologies designed to solve companies internal waste and pollution problems may present opportunities for commercialization if the technology is not industry specific.

Generators rarely commercialize their technologies (*EBJ* May 1993), and those that do have tended to do so under licensing agreements. Generators are beginning to cooperate with each other, former staff, and environmental companies to develop environmental technologies.

4.3.2 Critical Environmental Technologies

The Department of Defense and Department of Energy are expanding their support for R&D in environmental technologies. Further public investment in environmental technologies may come as a result of recent efforts to define critical environmental technologies. While various agencies and organizations have developed lists of critical technologies that are of core importance for the nation's future (e.g., U.S. White House Office of Science and Technology Policy, or Council on Competitiveness), the World Resources Institute (Heaton 1992) has compiled a list of 12 critical environmental technologies (see Appendix 1).

Often these are technologies that alter manufacturing processes themselves. Among the technologies with the most impact on eliminating industrial wastes are breakthroughs in separation technologies (e.g. distillation, drying, cleaning, degreasing and evaporation) that are used in numerous manufacturing processes. They will have a major impact on extending the lives of cleaning baths or reducing the amount of cleaning required (EBI May 1991). These are some of the most difficult environmental areas in

For example, the National Center for Manufacturing Sciences in Michigan is facilitating a collaborative R&D process among electronics, chemical and auto industries to address solvents; substitution; solvent-less cleaning methods; plating emissions control and remediation of industrial wastes. According to EBJ (May 1993), several new public offerings in pollution prevention, resource recovery and bioremediation are the result of strategic partnerships between generators and environmental companies or generators and former staff.

industry and represent 20 percent of industrial and five percent of total U.S. energy demand (ORNL 1989, cited in Heaton 1992, p. 15).

Technological advances in other fields, such as advanced materials, biotechnology, information technologies and miniaturization for precision fabrication, are also contributing to envirodesign and are among WRI's list of critical technologies (Heaton et al 1991, 1992). Biotechnology not only can reduce dependence on agrochemical, but it also has widespread industrial applications, such as microbial recovery of metals, waste degradation, and biomass fuels and feedstocks. New composite materials perform better per unit of weight and require less raw material and produce less waste. Computerized manufacturing systems make it possible to do real-time monitoring of reaction conditions and effluent streams. Computers, combined with sensors that recognize changes in these conditions, can be used to prevent pollution and produce more efficiently. Miniaturization of production means producing on smaller scale with less energy and material expenditures.

4.3.3 Barriers to Commercializing New Environmental Technologies

Environmental technologies are generally perceived to be high risk for the following reasons:

- Regulators, investors and users are all concerned about the long-term liability of new technologies.
- Users tend to buy reliability, not innovation. Engineers are risk adverse and will often pay more for a proven technology than for a less costly innovation (Berkowitz and Farkas 1992).
- Venture capitalists tend to avoid early stage technology and consider the process of regulatory approval for a new environmental technology too long and risky.
- Investors invest in management and business, not in technologies. Technology developers often lack the business ability to test the commercial applications of a technology under field use conditions, develop commercial markets and attract capital.

- New technologies are competing with existing capital investments in pollution control equipment that need to be written off. Because of the high cost and rapid change of new technologies, companies may find it cost-effective to maintain current approaches.
- Changes in regulatory priorities and government policies also create uncertainties for environmental technologies. As with all environmental industries, regulation drives the market demand for the technology and can make technologies obsolete. Government policies that at one time privilege targeted technological priorities (e.g., solar energy) can become very fickle with a change in administration.

Uncertainty may be a particularly difficult problem in environmental technologies because of the constant learning about environmental impacts, their interactions and risks. In any case, these uncertainties can shorten the necessary pay back period for investment.

4.4 Green Products

Increasing "green" consciousness among consumers is contributing to new environmentally friendly consumer products⁸ and also to firms' decisions to invest in more environmentally friendly manufacturing processes that may reap benefits of better public relations and increased sales.⁹ Roper (1992)

Several national surveys confirm that consumers support environmentally friendly products. A national survey for the Council on Packaging in the Environment (COPE) on consumer environmental awareness found that nearly half of consumers surveyed said that they shopped with the environment in mind by checking for environmental labels, purchasing products because of environmental benefits or avoiding products out of concern for the environment. This report, conducted by Penn & Schoen Associates, Inc. is based on 1,000 telephone interviews of randomly selected American adults from 50 states, conducted between November 11-15, 1992. For other examples, see "The Environment: Public Attitudes and Individual Behavior." The Roper Organization, Inc., July 1990, and a 1990 Gallup survey cited in Buying "Green": Federal Purchasing Practices and the Environment, Hearing Before the Subcommittee on Oversight of Government Management of the Committee on Governmental Affairs, U.S. Senate, November 8 1991, 1.

⁹ For example, Procter and Gamble began producing more environmentally sound products and packaging. In addition to legislators in several states preparing bills to ban certain types of plastic, the majority of its 40,000 customers that called each week on its consumer hotline, as well as its retailers, such as Walmart, demanded environmentally friendly products (Maxwell et al 1991, 5:)

EPA has included this appeal to consumers and customers for green products as part of a total cost assessment tool to help businesses evaluate the full costs and benefits of investing in pollution prevention. See "Economic Analysis of Pollution Prevention Projects"

cited in Ottman 1993, 42) found that on average consumers say they would pay a 4.6 percent price premium for certain types of environmentally sound products, and a small segment of the population (9 million) would be willing to pay as much as a 15-percent price increase. Sales at green businesses provide empirical support for these trends. 10 Customer surveys even indicate that 25 to 50 percent of utility customers are willing to pay a 10 percent or higher premium for electricity produced in an environmentally safe manner. The U.S. Department of Energy has funded a Green Power Pricing Pilot Program in four states to test actual consumer behavior (Moskovitz 1992).

Despite these trends, Green Market Alert reports that the percentage of new products carrying environmental claims fell during the first half of 1992 for the first time since these products were tracked in 1986. The percentage of new products that were green rose from 1.1 percent in 1986 to a peak of 12.6 percent in 1991. In the first half of 1992 that percentage fell to 11.5 percent (EBJ August 1992, p. 9). However, public standards for environmentally friendly products now emerging are expected to contribute to renewed growth of environmental products by enabling consumers to make informed purchases. The Federal Trade Commission has set national guidelines to prevent misleading environmental marketing claims (FTC News July 28 In addition, independent nonprofit consumer organizations are attempting to set and maintain industry standards on a fee for service basis, Green Seal will verify whether a company's products and production processes meet rigorous environmental criteria. Scientific Certification Systems (SCS) certifies specific environmental claims of products and provides a detailed environmental report card.

reprinted from Facility Pollution Prevention Guide, EPA/600/R-92/088 in Maine State Department of Environmental Protection, Planning for Toxic Use, Toxics Release and Hazardous Waste Reduction in Maine, December 1992.

¹⁰ For example, Seventh Generation, an environmentally conscious catalogue company in Vermont, reached \$10 million in just a 3.5 year period (Otterman 1993, 131), and the Body Shop, a specialty retail chain of all natural cosmetics founded in the United Kingdom in 1976, has grown to more than 700 outlets in 41 countries, with 84 outlets in the United States (Ibid. 68).

5. MAINE ENVIRONMENTAL INDUSTRY TRENDS

5.1 Traditional Environmental Industries

Because environmental industries are not classified as a separate sector, it is difficult to determine precise numbers of environmental firms in the state. In 1993, the Maine Department of Economic and Community Development (DECD) identified over 200 firms that were exclusively or primarily serving environmental markets based on the Commonwealth of Massachusetts' definition stated above. The survey excluded firms that were exclusively involved in waste hauling and disposal and firms producing environmentally friendly consumer products. Out of a sample of 218 environmental firms that DECD surveyed in early 1993, 72 firms responded. Key findings are summarized below.

5.1.1 Profile of Maine Environmental Firms

Out of a sample of 218 environmental firms that DECD surveyed in early 1993, 72 firms responded. Key findings are summarized below.

Services dominate Maine environmental industries.

Over 81 percent of respondents described themselves as service providers, nearly 13 percent as manufacturers, and 6 percent as sales and/or distributors.

Environmental engineering/consulting was the most common service provided, such as geotechnical engineering design, site assessments and project management, hazardous waste management (especially remediation), solid waste management, analytical services, waste water treatment and testing equipment manufacturing.

Most environmental firms are Maine firms.

One-eighth of the respondents were subsidiaries of larger corporations, with two-thirds of the parent corporations located in New England, and all but one located in Massachusetts. Over 22 percent of the parent corporations were based in Atlantic Canada.

Firms were identified through contacts at trade organizations, other government agencies, particularly the Department of Environmental Protection, business networks, and word of mouth. The Department of Environmental Protection provided lists of firms licensed to do environmental work in the state. Because so many of the firms were small, young firms, DECD felt that the total number was low

The industry is very young.

Over 86 percent of Maine's environmental firms were established since 1970; 54 percent established between 1980 and 1990; and over 11 percent, since 1990.

· Maine environmental firms serve primarily local markets.

In 1991 over 71 percent of the sales of responding Maine environmental businesses went to Maine customers, 24 percent to other U.S. markets, and only 4 percent to international markets. Over 23 percent of respondents generated sales exclusively in Maine; over 50 percent of companies generated 90 percent or more in-state sales, 60 percent generated 80 percent in-state sales; and 70 percent generated 70 percent in-state sales.

The majority of sales (58 percent) were to businesses; 24 percent to state and local governments; hearly 10 percent to consumers; and over 6 percent to national governments.

Despite declining sales and employment in 1991, firms are optimistic
 about growth by 1994.

In 1991, responding Maine environmental firms generated sales of \$91.2 million and employed 2,078 workers. These figures represent declines of 2.3 percent in sales and 10.5 percent in employment from 1989. However, survey respondents projected strong sales and employment growth for 1994. They expect to generate nearly \$140 million in sales, an increase of 53.3 percent since 1991, and they expect to employ 2,430, an increase of 16.9 percent from 1991.

Environmental firms cited the weak economy most frequently as a potential barrier to their growth.

Other barriers listed (in order of frequency) were Maine's business climate, availability of capital, and regulatory issues.

5.2 Industries Serving the Pollution Prevention Market

Maine has a substantial number of industries that create toxics and are in need of pollution prevention assistance. In 1990 the state's manufacturers released 17.1 million pounds of toxic chemicals. The biggest emitters were the pulp and paper industry, with Georgia Pacific Corporation heading the list of the ten top facilities for releases (see Table 5). Other major polluting sectors include leather, textiles, plastics, electrical, transportation, and chemicals (see Table 6).

Top Ten Facilities for Releases

TABLE 5

Facility	City, County	Air Emissions Pounds	Surface Water Discharges Pounds	Under- ground Injection Pounds	Releases to Land Pounds	Total Releases Pounds
Georgia-Pacific	Woodland, Washington	2,078,702	28,820	0	0,.	2,107,522
International Paper	Jay, Franklin	1,169,110	46,600	0	35,655	1,251,365
Prime Tanning Co. Inc.	Berwick, York	1,058,585	0	0	0	1,058,585
Great Northern Nekoosa Corp.	Millinocket, Penobscot	985,300	30,800	0	0	1,016,100
James River Paper Co. Inc.	Old Town, Penobscot	993,154	12,914	0	0	1,006,068
Boise Cascade Paper Group	Rumford, Oxford	959,022	28,546	0	0	987,658
S.D: Warren Co.	Westbrook Cumberland	809,450	6,600	0	0	816,050
Jones & Vining Inc.	Lewiston, Androscoggin	768,325	0	. 0	0	768,325
Lincoln Pulp & Paper Co. Inc.	Lincoln, Penobscot	437,260	4,810	0	264,850	706,920
Pioneer Plastics Corp.	Auburn, Androscoggin	464,245	5	0,	0	464,270

Source: 1990 Toxics Release Inventory, Maine Department of Environmental Protection

TABLE 6

Total Releases	of Toxic	Chemicals	by Man	ufacturing	Industry, 19	90
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Industry	Cancer Releases	Birth Defects	Air Releases	Water Releases	Total Releases
Paper	772,628	1,585,340	6,280,985	509,114	7,751,907
Leather	21,882	325,858	1,938,733	. 0	2,111,626
Textiles	185,422	139,430	217,825	24,000	955,277
Plastics	30,701	752,491	775,200	0.	783,697
Electrical	96,695	356,235	273,557	9	772,578
Transportation	123,121	492,097	563,673	98	706,516
Chemicals	5. (4.4. § .15)	10	296,344	5,467	313,391
Lumber	119,487	206,546	202,825	0	207,441
Fabricated Metals	. 86-	151,437	161,469	0	203,271
Food	83,575	3,027	57,902	58,328	150,955
Machinery	. 0	116,070	115,777	0	116,076
Furniture	-0	92,723	105,803	0	107,483
Printing		. 0	65,800	0	70,635
Stone/Clay	13,950	13,950	13,771	37	17,898
Instruments	,0,	10,321	10,321	0.	10,321
Misc. Manufacturing	6,350	6,350	7,100	0	7,100

Source: Environmental Protection Agency, Citizens Fund calculations.

Under Maine's Toxic Use Reduction Act, businesses that are currently regulated 12 must develop plans with graduated targets of reducing toxics use, waste and release by 10 percent in 1994, 20 percent by 1996, and 30 percent by 1998. Approximately 2000 companies are affected by the legislation and 800 of these are large quantity generators that must develop full-fledged plans. 13 Small businesses will need assistance in preparing their plans and complying with the legislation.

Some of the larger companies, such as Statler Tissue Corp. in Augusta and Bath Iron Works (BIW); have implemented waste and toxic reduction programs that have reduced pollution and wastes substantially. Statler eliminated all chlorinated organic solvents, low flash solvents, fluorocarbon aerosol carriers and toxic solvents used as parts washers, degreasers and floor cleaners. These solvents either were eliminated or replaced with environmentally acceptable products such as kerosene, mineral spirits and citrus-based cleaners (Pollution Prevention News 1992). BIW is analyzing wastes in each of 80 departments from purchasing, receiving, storage, use and disposal. Changes at all stages have already resulted in savings of \$1.5 million over a two and a half year period. Some of these have involved substitute equipment, such as a distilling unit that cleans hazardous solvents and reduces wastes by 60 to 70 percent. Over the next year BIW expects to save \$10 million dollars (Recycling "Greens the Bottom Line." Portland, ME: Press Herald, 10 June 1993)

Smaller metal product companies have been able to reduce wastes throughparticipation in a toxic use reduction project of the Maine Metal Products Association and the Natural Resources Council of Maine. For example, the Lemforder Corporation in Brewer has installed a tank that filters and separates water and solvents from the production floor, enabling it to reduce

Toxic users who are owners or operators of facilities subject to reporting the presence of extremely hazardous substances under the Superfund Amendment and Reauthorization Act of 1986 (SARA) Title III, Section 312; Toxic Releasers who are owners or operators of facilities required to report under SARA as above, and Hazardous Waste Generators who are owners or operators of facilities that generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) and Maine's Hazardous Waste Management Rules. (See Maine Department of Environmental Protection 1992.)

¹² Regulated businesses consist of:

Conversation with Ron Dyer, Director of Pollution Presentation, Maine Department of Environmental Protection, July 7, 1993.

¹⁴ Conversation with Kevin Gildart of BIW, January 31, 1993.

drastically its waste water treatment and toxic chemical use (Plant Points Way to trim Chemical Use. Portland Press Herald 14 March 1993). The Irwin Corporation in Gorham saves \$50,000 annually by replacing toxic solvent degreasers with a non-toxic citrus-based compound, installing an evaporation unit to reduce coolant water and eliminating unnecessary cleaning and rinsing processes (Maine Environment, May-June 1993).

These companies are using different equipment or materials to reduce wastes and toxics. We have not yet found examples of firms commercializing new products or equipment based on their pollution and waste reduction efforts, although BIW has indicated some interest in helping to commercialize non-toxic marine products (See Non-Toxic Marine Products below). We do have examples of Maine firms that are finding new environmental markets for their products because of pollution prevention. These firms do not fall into the traditional segments of "environmental" industries. For example:

Soleras Ltd, Biddeford is a growing high-tech machine shop that serves a highly specialized vacuum metal coating industry. This vacuum process is nonpolluting and replaces toxic electroplating processes that use chromium. Substituting vacuum processes for processes that use toxics is expected to grow because of industries' desire to reduce costs of toxic waste disposal and bad press for pollution violations.

Kady International, Inc. in Scarborough is now looking for environmental applications for its Kady Mill which it has produced for 42 years. The Kady Mill is a specialized rotor-stator dispersion technology used to disperse and mix materials for paint, ink, paper; ceramics, cosmetics, pharmaceuticals, and miscellaneous chemical applications:

Kady is testing its Kady Mill for waste water treatment and soluble sludge reduction. It has been demonstrated in lab and small pilot tests that processing waste water sludge through the Kady Mill reduces sludge output by up to 50 percent. Kady has been granted an apparatus patent for this application and has received first office action on a methods patent. It is also applying the Mill to plastic recycling in the United States, Canada and Japan. The Kady Mill acts as a high powered washing machine that tosses off adhesives, and cleans, dries and separates plastics that are then extruded and pelletized into a recycled resin. All fluid, filtered sand and labels are reused.

5.3 Growing Green Consumer Consciousness

Little public research is available showing green consumer trends specifically in Maine. One survey of Maine residents, attitudes towards recycling for the Maine Waste Management Agency (Market Decisions, Inc. 1990) found that Maine people strongly supported recycling. Eighty-two percent of those surveyed supported mandatory recycling, and two out of five Maine households perceive themselves as recyclers.

Both Shaw's and Hannaford Brothers, Maine supermarket chains, are now selling more environmentally friendly products. Over the last year Shaw's has noticed a shift from environmental awareness to commitment in purchases of environmentally responsible products. Not surprising, sales are heaviest in stores located in higher income areas. Some of the trends include lower demand for products packaged in aerosol containers versus the same product packaged in other forms and more demand for refillable containers and organic produce.

Manufacturers of green consumer products in Maine range from well-established firms such as Tom's of Maine, a national leader in personal hygiene products, to start-ups such as Coastal Products, a manufacturer of non-toxic cleaning products and Coveside Conservation Products, which makes bat houses that attract bats to control insects naturally

5.4 Regulatory Trends

Strong state enforcement over the past several years has generated substantial work in Maine, particularly among consulting firms. However, the amount of consulting work or sales generated from the state's regulations and enforcement has not been documented.

New federal and state environmental legislation is expected to generate additional opportunities for Maine environmental industries. At the same time, budget cuts at the DEP are causing the Enforcement Division to shift its priorities, with some public speculation that firms will have less pressure to seek environmental services and products for compliance. In the past, small land cases represented most of DEP's enforcement cases. The Land Bureau, which has taken the most significant cuts, is trying to allocate its

¹⁵ Phone Interview, Margaret McEwan, Vice President of Consumer Information, Shaw's, May 20, 1993.

reduced budget more strategically to education and outreach which would prevent violations and reduce enforcement costs. 16

The Enforcement Division will focus more on larger actions, primarily in the Air Bureau. Compliance staff have been cut back in the Water Bureau resulting in fewer towns submitting required forms and reducing the sampling schedule for laboratories. There has also been a cutback in work designated for uncontrolled sites, or the state designated superfund sites. 17

The DEP is placing more emphasis on pollution prevention and has received an EPA grant to provide technical assistance to Maine firms. The shift to prevention should create some opportunities for new technologies and substitute materials. It will also create some work for engineering and consulting firms in process engineering and waste minimization.

Phone conversation with Sandy Talbot-Thompson, Portland Regional Director, May 27, 1993.

¹⁷ Conversation with Patrick Higgins, Environmental Diagnostics, April 27, 1993.

6. OPPORTUNITIES AND THREATS FOR MAINE INDUSTRIES

Opportunities and threats were identified for Maine environmental industries based on interviews with environmental companies already in CEI's investment portfolio, other leading and emerging firms, staff of the Department of Environmental Protection, and the literature on industry trends. These are discussed below.

6.1 Environmental Engineering/Consulting and Remediation

The environmental engineering/consulting (E/C) business in Maine (as well as the country as a whole) has been in a shakeout phase of the industry for the past three years. As other engineering and consulting markets dried up during the recession, many firms entered environmental markets. The industry is now saturated with local and out-of-state firms, and it is difficult for new firms to enter.

Although the recession has been a significant factor in industry changes, the *EBJ* (December 1992) argues that the inevitable maturation of the industry has been an even more important factor in structural changes. The proliferation of new entrants has meant that suppliers must compete more on lower costs than differentiation of services. 18

Environmental customers have become more sophisticated and sensitive to pricing and product delivery rather than study and analysis. Furthermore, more companies now have their own environmental specialists that demand more from external consultants. *EBJ* warns that consulting firms will need more sophisticated management if they are to compete in these markets. Most firms grew from an engineering/ scientific talent pool rather than business or marketing. In Maine, few E/C firms have professional marketing staff.

The remediation market depends largely on federal funding from EPA, DOE and DoD, and evolving cleanup standards. Remediation of federal facilities are among the fastest growing segment of this market, growing from \$150 million in 1984 to \$3.95 billion in 1993 (EBJ February 1993). However, remediation appropriations are often slow to translate into actual spending. Some of the current federal debates concern whether to spend for cleanup or

¹⁸ One Maine consultant interviewed noted that competition is now moving back to quality rather than price. There has been some backlash against low-cost competitors who cannot meet quality standards:

to invest in containment with the hope that new remediation technologies under development can be used later and will reduce the costs.

The following are the major opportunities identified through interviews with companies operating in the state.

6.1.1 Site Assessments and Remediation of Underground Storage Tanks

The underground tank insurance fund, with \$10 million dollars and capped at \$15 million in 1993, creates the market for tank remediation. Under an EPA mandate to create state tank insurance funds, the state collects \$7 million per year in gas taxes that should be sufficient for cleanup costs.

DEP keeps two lists of qualified companies for site assessment of underground storage tank removals in Maine and pre-qualified hydrogeological investigators. These lists are updated every 12-18 months. Of the 63 companies on DEP's list of site assessment consultants in 1993, 45 were Maine-based or have branch offices in Maine. Thirteen of the 19 firms on the prequalified consultant list for hydrogeological investigation were Maine companies or companies with Maine offices. Companies must meet a set of minimum standards to qualify for the list. Then DEP ranks the companies and has developed a "Fast Track Consultant List for Soil and Ground Water Remedial Actions at Petroleum Contaminated Sites."

In addition, many other firms are actually doing site assessments. They determine whether underground tanks have leaked and whether it is necessary to remove tanks. One out of every two tanks usually needs to be removed. In general, the market is well covered. There may be opportunities for small site assessment firms north of Millinocket. 19

Other market niches may be commercial underground tank auditing services. Owners of underground tanks are eligible to be covered under the state insurance policy if they are largely in compliance with the law. An auditing service could verify whether a tank is "largely in compliance." This service would not stand alone since a company would need the expertise of an underground tank installer, too. In mid-February, Portland Pump began offering this service.

For example, County-Environmental, an Aroostook-based company, recently started up and is very busy.

6.1.2 Groundwater Cleanup

Four to six million dollars per year are generated from taxes on bulk transfers of fuels at terminals and barrel taxation on crude oil that DEP can use for administrative costs and groundwater cleanups.

6.1.3 Hazardous Waste Remediation

In Maine the hazardous waste market is the largest in volume but draws heavy national competition. Firms qualified to undertake hazardous waste remediation are large, out-of-state firms. Firms are required to have heavy insurance against liabilities, very specific support services and background training, and medical monitoring. Maine companies lack the bonding to undertake large projects: Sometimes, Maine firms do successfully bundle services together and bid on projects.

Maine has only two or three Superfund sites. There are many uncontrolled hazardous waste sites but not of the severity or political pressure to make the list. The hazardous cleanup market is driven by concerned people who demand enforcement.

The other major opportunity is the cleanup of Loring Air Force Base. The federal government is overseeing the project, but there will also be some DEP review of the work. This is a \$150 million job that is subcontracted to ABB Environmental (Asea Brown and Boveri, Inc.), an international firm headquartered in Portland, working with Martin Marietta. The smaller environmental firms in the state are hoping to subcontract with the larger contractors in order to fulfill their small business set-aside requirements. ABB is also doing a cleanup of a leak at Brunswick Naval Air Station, which also provides work for subcontractors.

Only a few major opportunities arise in the state. If firms miss these, they must have other baseline work. There has been a history of national firms setting up a Maine-based office for a year or so and then leaving because there is insufficient business. Some out-of-state firms, such as Balsam Engineering, have done well in the Maine market and have stayed.

6.1.4 Landfill Closures

Landfills that do not meet the state's regulations for state-of-the-art liners and monitoring devices were supposed to close by December 31, 1992.

Legislation was passed allowing municipalities to do a reduced closing

procedure according to DEP guidelines, depending upon their class of landfill. The cost of capping the landfill (not including any other closing costs such as groundwater remediation) can range from \$10,000 to 15,000 per acre to \$50,000 per acre, depending on the level of engineering required. A full hydro/geothermal investigation could cost in the range of \$100,000-200,000 per acre. 20

Closures are a very competitive market, particularly among small Maine firms. The closure business tends to be an entry business for one and two-person businesses that will cut costs. The larger companies steer away from bidding on the work. Some towns prefer to hire Boston firms that then team with local firms.

6.1.5 Real Estate Transfer Market

Both banks and industries are hiring engineers to tell them whether properties they are financing are contaminated. This market has been an entry-level strategy for one and two-person offices. A number of these offices have opened because of layoffs in larger firms. It is very competitive and very risky because the consultant takes on all legal liability.

Maine banks have different policies on these assessments. Casco Northern Bank hires engineers to do a phase one environmental assessment on all commercial properties that seek financing, averaging about \$1000 per assessment. Casco estimates it does between 100 and 200 per year throughout the state. For properties that may raise some red flags, Casco then requires a phase two assessment at about \$2000-3000.

Key Bank uses a questionnaire to screen properties first to determine if they need an assessment. The assessments costing approximately \$1500 to \$2000 are included in the closing costs and raise the cost of doing business with the bank. Key Bank has put out a RFP (request for proposals) to engineering firms and will hire a couple of firms to handle all its assessments. In addition to looking at factors such as qualifications and cost, Key Bank also wants engineers who can assess a property in relation to its concerns as lender and enable it to make a reasonable judgment about the risks for a business decision. It is not necessarily looking for large firms that use expensive equipment and have high overhead.

Conversation with Mike Barden, Director of Division of Site Investigation and Remediation, Maine Department of Environmental Protection, January 29, 1994.

6.1.6 Water and Waste Water Treatment

Markets include water districts, small water systems, manufacturing and agricultural industries, state and local governments, and other utilities. The federal government has created big markets in safe drinking water and waste water treatment. The Federal Safe Drinking Water Act forces utilities to do different things each year, such as treating surface water, testing for lead and copper, or testing for radon. The new regulations passed in 1991 requiring radon testing will have a strong impact on New England where a high percentage of drinking water comes from groundwater. This groundwater comes in contact with radium-bearing rocks and soil.

Radon monitoring is also growing in small drinking water systems of less than 3300 people and very small systems less than 500 people. Sixty percent of all wells are expected to have radon problems under the radioactivity standard that EPA is expected to set for drinking water. One company that capitalized on this market is Lowry Engineering that began in Unity, Maine in 1984. It does turnkey design and build systems and has had 40 percent growth per year with 1992 sales of \$1.5 million. The company also produces equipment to remove radon, VOCs and petroleum. In 1993 Lowry moved its expanding production and main office to Durham, North Carolina, mainly because of the founders' personal preferences. Other factors for the move were that North Carolina is the fifth best state for density of small systems; it is a manufacturing state with a surplus pool of trained workers; and production costs are cheaper. The company maintains one engineer and a field person in Unity.

Waste water treatment systems that the federal government financed 20 years ago now need upgrading to new equipment, technologies and expansion because of population growth. Many waste water treatment plants have been enlarged to the extent possible and will have to minimize their water flow. Consulting services will be needed to help licensees with technical permits. So far the federal and state governments have spent over \$1 billion in construction of waste water treatment plants. Since the 1950s, maintenance of these facilities has been two or three times that cost.

Other opportunities exist in point source discharge and control of dioxins and heavy metals. The federal government is in the process of defining dioxin standards. Once these are defined, Maine mills will move to a technology to control dioxin. They are likely to contract with some outside consultants to gain expertise.

6.1.7 Environmental Audits

Several E/C firms perform environmental audits of businesses. So far, the auditing market in Maine has been minimal except for subsidiaries of larger companies with corporate environmental programs.

This market has some difficulties. Once a company uncovers problems, these are part of its records, and it creates a criminal liability for managers. However, if a company develops a plan to deal with it and shows good faith, the EPA will leave it alone. Law firms are also vying for this business with the claim that environmental audits should be done through a lawyer to manage any liabilities.

A firm's motivation for eliminating toxics and wastes is the bottom line. Firms must be convinced that they will save money over the life cycle of their production. As more firms realize that they can save money, they will have a different attitude towards audits. Small and medium-sized firms face the biggest difficulties. They cannot afford environmental managers and do not know the regulations and their liabilities. The threat of criminal liability may change their perceptions for cleanup.

Audits themselves are not particularly lucrative for consulting firms. The profit is in the potential follow-up work on compliance planning and redesign of manufacturing systems. However, larger firms that undertake audits often have the internal capacity to do their own follow-up work. Smaller firms that do not have the capacity cannot afford the audit nor the follow-up consultation.

6.1.8 Strategic Environmental Management

According to EBJ (December 1992), relatively few E/C firms are offering strategic environmental management services. These services teach companies to take a life cycle analysis of their production process and incorporate environmental management systems into their businesses, beyond compliance requirements. Most E/C firms do not have the planning and management skills to offer strategic environmental management. On the other hand, E/C firms claim that management and accounting firms lack the technical and engineering skills to implement these strategies effectively. Teaming with complementary companies may be one solution.

One national company, Environmental Resource Management Group (ERM), reports that environmental management services is its fastest growing business, with 15 percent of its revenues worldwide. ERM's Portland office does not find a large market for strategic environmental management in Maine. This market of larger Fortune 1000 companies that have the attention of senior management or have been fined is not present in Maine, except in the paper industry. Twenty percent of ABB Environment's \$90 million in revenues were from pollution prevention. Demand for their services is largely in process improvements, such as from textile, auto and hospital industries (EBJ August 1993). Jacques Whitford, a New Brunswick E/C firm, is also targeting pollution prevention and redesign of manufacturing systems as a new market niche.

6.1.9 Export Markets

As the engineering and consulting segment of the environmental industry matures in this country, the major growth opportunities are in foreign markets that are just beginning to mandate pollution control and cleanup. Consulting services, however, are hard to sell without offices located in the market area. The crux of what a company sells is the relationship with the regulators.

Three E/C firms interviewed were looking towards expansion, primarily in Canadian markets. One considered the Canadian market a poor bet because enforcement is lax there. Canadian enforcement varies among provinces but is generally more lenient in the Maritimes. Of the five firms interviewed, one international firm was already in European markets and only one other showed immediate interest in entering European markets.

Export is high risk for small engineering and remediation firms that represent most of Maine's industry. In order to pool resources and pursue international markets, the Maine Alliance is helping Maine companies form an Environmental Business Council modeled after the Massachusetts' Environmental Business Council. This effort comes out of initial organizing efforts of the DECD to bring firms together.

6.2 Remediation Technologies and Equipment

6.2.1 Water and Waste Water Treatment

Much of the market in water and waste water treatment is for new technologies and equipment that physically separate contaminants, use biological processes to degrade the contaminants; thermal treatment of separated chemicals; and advanced oxidation process to break down organic molecules and oxidation of inorganic substances. The March 1993 EBJ reports a strong market for these technologies and related specialty services in the United States of \$13 billion in 1992 with strong growth potential. Opportunities in Maine are as follows.

Using Natural Systems to Purify Waste Waters

Researchers in the Department of Agricultural and Resource Economics are looking at the potential of using natural waste systems to purify waste waters. One possibility is to take sewage waste from coastal communities, mix it with sea water, and use shellfish and fin fish to purify the wastes. A research question is whether the wastes can be used to seed plants that are used as feed, or whether it must be composted or dumped at sea. These systems produce clean water at the end with no chemicals or mechanical methods. Current systems use a great deal of electricity to mix air to purify waste water.

The process would lower operating costs but not eliminate capital costs. The system would require facilities to compost the wastes and possibly greenhouses, with energy costs, to use the wastes to grow plants. It would also require a trained botanist to supervise the process.

To pursue the research on this system, University of Maine faculty would have to do considerable up-front work to obtain a federal grant with considerable risk. Other competing research projects that have less risk are commanding their time. The project requires some seed funds in order to develop a full research proposal.

Dewatering Sludge

Several companies are at different stages in applying existing technologies or develop new ones for dewatering sludge. Kady International has applied its Kady Mill to dewater sludge and reduce the soluble compounds. Dewatering Technologies in Lewiston is producing a sludge dewatering filter press with applications for municipal and industrial waste water treatment. Resource Recovery, Inc., in Caribou is seeking financing to commercialize its

dewatering technology, which it claims can also evaporate leachate from landfills. RF Technologies in Lewiston sends microwaves to sludge that separate tar from sludge for reclaimable oil.

6.2.2 Bioremediation of Soils

Woods End Laboratory in Mt. Vernon is applying its recipes in composting to bioremediation of soils contaminated by petroleum-based hydrocarbons, such as gasoline, diesel fuel and motor oil. (See Composting, p. 51.) Woods End designs, manages and monitors the bioremediation process. It determines the appropriate mixture of carbon and nitrogen with the contaminated soil in the composting process that enable micro-organisms to degrade the organic hydrocarbons.

6.3 Air Pollution Control

6.3.1 Impact of the Clean Air Act

The Montreal Protocols of 1987 and the Clean Air Act of 1990 require stratospheric ozone controls to reduce chlorofluorocarbons (CFC) products. By the end of 1995, the more reactive chemicals in air conditioning, refrigeration, and chiller operations will be phased out. *EBJ* (December 1992) projects that as traditional CFCs are phased out, the market for alternative electronic cleaning equipment, such as those that are alcohol or water-based, will double over the next six years from \$491 million in 1992 to \$984 million in 1998.

EPA will soon publish regulations on air toxic controls which will require new construction or placement of equipment at the source to control ozone forming pollutants. Larger sources will have to use nitrogen oxide controls. According to environmental consultants Farkas-Berkowitz (1992), environmental consulting firms that can engineer process equipment changes to prevent toxic emissions are likely to benefit rather than manufacturers of end-of-pipe control equipment.

Total dollar impacts of the Act on Maine are not known. The Maine DEP has estimated some impacts resulting from auto emissions testing as shown below.

- Maine's air quality permitting program will have requirements beyond its
 present scope that will employ some E/C firms to handle permitting and
 compliance.
- EPA will require industries, particularly in Southern Maine, to put in nitrogen oxide controls.
- Maine is establishing a car emission inspection system and has put out to bid a \$40 million contract (the second largest in the state) for firms capable of setting up and operating emission testing facilities. All of the bidders were out-of-state firms that have sufficient capacity and past experience to establish these facilities. According to the DEP, Maine firms did not have the track record or capacity to compete. However, it may have been possible to ensure participation of Maine firms as subcontracts through more advanced notice of the opportunity or specific set asides.

- Approximately 25 percent of the cars inspected are expected to fail the test. Annual repair costs are estimated at \$12.5 million.
- Air quality controls on industry will require installation of equipment and create opportunities for dealers of equipment.
- Firms using CFCs in refrigeration, air conditioning and chiller operations for marine use, restaurants, hotels, food transportation and processing, electronics, and in automobiles will have to substitute new technologies. Small companies and municipalities are likely to be unaware of the impacts that CFC compliance can have on their businesses and communities. Companies that wait too long to replace their systems may find the necessary technology in short supply:

Consulting on CFC compliance, planning and retrofitting of existing systems is one business opportunity directly resulting from the legislation. Already, a former BIW employee responsible for BIW's refrigeration and air conditioning systems has established his own consulting firm. Peregrine Environmental educates businesses and certifies workers about CFC compliance regulations and helps them assess their options. Not all CFC chemicals are the same, and different equipment is needed for different chemicals. As 1995 draws closer, more people will be willing to pay for these services directly.

Markets also exist for retrofitting marine and nonmarine equipment using CFCs. BIW workers have the expertise to retrofit U.S. navy ships, foreign navy ships, commercial fleets and cruise ships with non-CFC technologies. The largest potential in the marine retrofit market is offshore with contracts from the United Nations.

6.3.2 Equipment

Passamaquoddy Technologies in Thomaston, Maine has developed a recovery scrubber technology that uses solid wastes containing alkali to scrub acidic flue gas and produce salable by-products. The recovery scrubber is a small chemical reactor that combines sulfur dioxide and ash in factories to make fertilizer. The scrubber controls pollution at a very high standard with the following benefits:

 Reuses reacted solid waste, thus eliminating the need to landfill. It reduces condensable and soluble gaseous emissions by over 90 percent, including sulfur dioxide emissions.

- Removes all measurable dioxin from flue gas.
- Reduces particulate emissions to the highest level of any system.

Although a number of systems remove sulfur dioxide from flue gas, Passamaquoddy does this and also recirculates all the wastes in a closed loop system. The innovation resulted from the Natural Resource Council of Maine's effort to lower sulfur content in burning coal. The Dragon Cement Co., which originally developed the technology before it was spun off as an independent company, realized that the higher costs of lower sulfur requirements could close down the company. The Clean Air Act of 1990 establishes sulfur emissions standards that the scrubber helps fulfill.

Applications of the technology are for wet, dry, or semi-wet cement plants, waste incinerators, pulp and paper mills, and other combustion processes. Ordinary coal burning plants do not produce enough ash to sustain the reaction, but those in Eastern Europe, which use poor quality coal with high ash content, would be suitable. The retrofit cost for a plant costs from \$15 to \$20 million depending on plant size. According to the scrubber's inventor, Garrett Morrisson, the pay back is from three to five years through savings on waste and sale of the fertilizer produced or sale of the right to pollute. For example, disposal of municipal incineration ash is \$46 to \$47 per ton in Maine; \$100.500/ton in New Jersey, and higher abroad.

There has been a lot of interest in the scrubber, particularly in Canada, but as of this writing none have been sold. A potential customer in Kansas is seriously evaluating the technology and a sale is expected this year. EPA is writing new regulations for the cement industry which, if strict enough, would mandate use of Passamaquoddy's technology.

The poor economy is one key reason for lack of sales. The initial cost of equipment is very high during poor industrial markets despite the projected pay back period. Potential customers also want to see the scrubber operate. Dragon Cement, where the scrubber is located, has been operating at only 40 percent capacity. Poor transportation connections from Bangor airport for potential customers also hinder marketing. The EPA is conducting a year review of the company, which will further impede sales. Investors will wait to see the results.

Hague International in South Portland also provides air pollution control equipment and technologies. It supplies and manufactures low excess air burners, which have met the emission standards of the South Coast Air

Quality Management District of California. The burner operates with a micro-processor control system taking a signal from an oxygen sensor in the exhaust to maintain tight control of the air/fuel ratio. It also maintains a proper recirculation ratio consistent with flame stability. By reducing excess air and using an electronic variable speed motor drive on the combustion air blower, the burner saves fuel costs.

Hague has also pioneered a new clean coal technology for existing coal plants. The technology improves energy efficiency, lowers electricity costs and reduces air emissions of coal burning plants. In May 1993, the DOE's Clean Coal Program awarded a \$73 million research and development grant to the Pennsylvania Electric Company to use Hague's technology to repower its Warren Station.

6.4 Environmental Data Management

The requirements for firms to report to the government their use and discharge of toxics and generation of hazardous wastes are creating opportunities to develop markets for barcoding chemicals, environmental software and data management. Waste minimization and liability for contamination, as well as emissions monitoring under the Clean Air Act, are also driving corporate interest in environmental data management systems.

According to the *EBJ* (June 1992), the industry is still very young and volatile. Generators are inhibited from investing in software systems because of fear these companies will go under and will not be able to service them over the long run. The 1992 *Environmental Software Directory* lists about 250-300 companies selling 600 to 700 environmental software packages, including health and safety and materials management, compared to 150 companies selling 500 packages in 1991. For every 200 new packages, 100 have disappeared *EBJ* attributes the failure rate, not to the recession, but to the lack of standards and uniformity in software applications due to historical inconsistencies in environmental regulation and management. The software does not yet meet standards for electronic data interchange (EDI).

EBJ reports no wide consensus on the size of the U.S. environmental software and supportive services market. One analyst estimates it at \$50 to \$100 million annually. However, a number of generators spend at least five times that much in-house. Some market estimates go as high as \$500 million over the next few years. However, product development costs are high, and no firms are making huge profits. Nonetheless, huge hardware manufacturers (DEC, IBM, and Sun), the big six accounting firms (e.g., Arthur Anderson), and defense contractors (Lockheed, Hughes) have entered this market, as well as corporations, such as DuPont, and are commercializing their own internal environmental software systems.

Maine engineering firms with computer skills and others knowledgeable about environmental regulations are moving into this market. For example, Entec, a start-up software company based in Lincolnville, has developed a low cost, user friendly environmental management system that combines a data base with statistical functions, graphs and charts. Competing software packages are very expensive and provide either data base capacity only, or convert off the shelf software to one or two specialized functions.

Demand for the software has been mostly from larger environmental consulting firms and regulatory agencies. Smaller consulting firms are not knowledgeable enough about the regulations and what they will need in the future.

Opportunities for developing new software applications include:

- Accepting data from analogue devices that do environmental monitoring through remote instruments.
- Linkage with high end graphics used by large companies.
- Tracking wastes through the life cycle of an industry to assist in waste, reduction that meets requirements under Toxic Use Reduction laws:
- Linkage with geographic information systems.

6.5 Wetland Plants for Wetland Recreation and Erosion Control

Since 1990 Maine's environmental regulations have required mitigation of wetlands that are affected by development. It is possible to recreate wetlands by using an array of special plants and dune grass for sand dunes.

In Portland vegetation is used to control erosion on Back Bay. Plants are presently coming from a German company, Bessman Green, with a Boston office. Most dune grass comes from New Jersey. State requirements to replace buffer strips could also provide opportunities to grow native species.

The Department of Transportation (DOT) is the largest contractor for wetland re-creation and in the last three years has spent about \$4.3 million on wetlands mitigation projects across the state. The cost per site averages between \$140,000 to \$150,000. The program is new and several projects are expected to go on line in the next few years.²¹

DOT uses a mixture of woody and nonwoody species and is expanding the number of species it is using. Often it looks at an adjacent wetland to determine the plants it wants. However, the program is still experimental and the DOT does not know the effects over the long run. Nor does it have any funds to monitor the sites more than two years after they are established; it is depending on surveillance by local groups (State Considers New Approach to Cut Cost of Saving Wetlands. Maine Sunday Telegram 23 May 1993). Woody species have a longer track record and are more available locally. Herbaceous plant material, such as grasses, sedges and rushes, have not been used much in the state. Herbaceous seeds come from Wisconsin. The DOT has difficulty getting plants out of state and tries to design projects based on what is available locally.

One supplier of wetland plants is Pierson Nurseries in Biddeford. Plants grown for wetlands and ornamental purposes are approximately 15 percent of its business. Dale Pierson tracked lists for revegetating wetlands for five years before entering the market. He saw an opportunity because he already

²¹ The site-to-site approach is very expensive. As an alternative the DOT is looking at a mitigation banking system that would assess all the wetlands in a watershed to determine which ones are the most important to preserve. The benefits of the wetlands would be converted into dollar values. The DOT could acquire key wetlands or protect them through easements. Any developer that wanted to build a project that required altering wetlands would have to contribute money or services to the initigation bank to restore, improve or add to the wetlands in the bank.

owned unused land conducive to grow wetland plants, and secondly, he had developed an expertise in plant materials and landscaping.

However, the market poses substantial market risks for entrants. According to Pierson, a \$100,000 investment in these plants is a small commitment. The plants can require a relatively long growing period. Depending on the species, it takes a minimum of one year and can go up to five or 10 years. For example, red maple costs \$10 per acre to seed and takes six to eight years to grow to eight to 10 feet. If a 10-foot-tall plant is needed, he has to plant four-year-old plants. Bigger plants require more labor.

The material is very different from any other commodity that a nursery might grow. Like food crops, these plants are perishable although they are a longer term crop. Agency demand for wetlands plants is not constant and firms, cannot predict the market. State policies can change abruptly, although the proposed mitigation bank approach may help stabilize the market. Nevertheless, there is no history showing the long term benefits of wetland remediation, and policies may not support remediation long enough to determine the impacts. University research is not yet being done on this industry.

Maine nurseries face competition from those collecting the plant material in the wild. As this becomes a bigger market, the state needs to pay more attention to regulating collection that could be environmentally damaging.

There is potential for out-of-state markets, but the same risks apply. Other midwest, and mid-Atlantic states have been involved longer than New England in wetland recreation.

6.6 Recycled Products

6.6.1 Background to the Waste Industry

A recent survey revealed that waste disposal costs in Maine were among the highest in the country. Maine's tipping fees for waste disposal are among the highest in the country, running from \$42 per ton to \$175 per ton in a few facilities. This compares to the national average tipping fee in 1992 of \$30.21, according to the Association of Solid Waste Management. Disposal costs are expected to reach \$100-200 per ton by the year 2000.

Concerned about high tipping fees and limited disposal options, the Maine State Legislature created the Maine Waste Management Agency in 1989. This agency was charged with siting new landfills in the state, developing and implementing state recycling goals, and providing towns with capital to make recycling investments.

On the municipal and commercial waste side, Maine law has required businesses and communities to recycle a portion of their waste stream. By July 1, 1993, all Maine companies with 15 or more employees are required to implement an office paper and corrugated cardboard recycling program although the WMA does not have the resources and tools to monitor and enforce this requirement.²³ The state government has set a goal that 50 percent of its purchases have recycled content by October 1993. Municipalities are expected to give preference to purchasing materials from recycled sources. Finally, Maine's returnable bottle, which in the early 1970s was one of the first bills of its kind in the country, has been expanded to include wine, cooler and juice bottles and cans.

These regulations, together with the high cost of waste disposal, have created opportunities for many municipalities and entrepreneurs to develop recycling programs. These programs are generally designed to collect newspaper, mixed paper, corrugated, plastic and glass. As consumer demand for recycled product has increased (either through personal decisions or mandatory procurement requirements), markets for these collected recyclables have improved.

²² Conversation with Denise Lord, Director of Planning, Maine Solid Waste Agency, June 29, 1994.

Experience so far with larger businesses required to recycle has shown relatively high compliance even without penalties for nonenforcement.

The supply of recyclables through expanded recycling programs in many cases still exceeds the demand for end products. Over the past few years, many waste brokers found themselves burning recyclables at incinerators because of poor market demand and lack of storage space (Big Supply: Low Demand: How Soon Can Maine Really Begin Recycling? Maine Times 3 July 1992). Demand for recyclables tends to lag until sufficient incentives driven by regulations create new products to use the feedstocks.

Newsprint is a case in point. Paper companies have now invested in facilities to recycle paper in order to meet growing government procurement and composition laws. In June 1992, Bowater/Great Northern Paper Company announced construction of a 140,000 ton per year newspaper recycling facility in East Millinocket. Because of these plans, the capacity within the state to handle newsprint is expected to be much greater than the in-state availability of newsprint (roughly 60,000 tons per year). Stone and Webster's waste paper recycling plant in Auburn, which will take 89,000 tons of high grade office and computer ledger paper per year, is expected to open in 1994 at a cost of \$65 million.

Other recycling opportunities could arise from federal laws. For example, the Intermodal Surface Transportation Efficiency Act (ISTEA) requires increased use of recycled products in paving, such as glass or chipped tires in asphalt. The Maine Department of Transportation does not support recyclables for paving but does support chipped fill for road bed and road barriers and is testing these applications as described below.

6.6.2 Threats to Continued Growth of the Recycling Sector

Despite market development opportunities over the long run, the industry faces the following difficulties.

Competition from Existing Disposal Facilities

The recession and mandatory recycling have reduced the amount of material going to incinerators and landfills. In an effort to meet their capacity demands, at least in the short run, tipping fees in New England have been lowered to attract more material. As an example, the spot market (non-contract price) tipping fee in Massachusetts was \$80 per ton two years ago. Today the spot market price dips as low as \$30 per ton. If tipping fees are low enough, it is cheaper to throw out wastes instead of going through the effort to recycle them, even if recycling opportunities exist.

Over the years, waste generators who get excited about recycling have learned an important lesson: only on rare occasions can they expect to earn money from their waste stream. At best, a successful recycling program costs less than the cost of disposal. As long as this avoided cost (the cost at which it is cheaper to recycle than to landfill) does not drop too low, recycling can remain profitable for government or nonprofit recycling operations.

Sometimes a company absorbs a slightly higher cost to recycle either because recycling is mandatory or because the public relations value of recycling is worth it. However, in the short-term, if landfill and incinerator costs are lowered to attract materials, the avoided cost is also lower, making recycling options more expensive than disposal options. This limits short-term opportunities for new businesses.

Insufficient Wastes Generated

The demographics of a largely rural state prohibit amassing large volumes of feedstock for recycling manufacturers. Maine produces over 2 million tons of solid waste annually. The municipal solid waste stream contributes about 800,000 tons of waste each year. Municipal waste water treatment plant sludge contributes about 100,000 tons per year. The balance of the waste stream comes from industrial and commercial sources.

Remote Location

Maine's location as the most northeast state in the country also puts some limitations on the state to amass wastes and further develop recycling market opportunities. The pulp and paper industry in the state grew because of the proximity to the forest resource. Mills in Maine have the technology to include fiber from recycled paper into the paper-making mix. However, the transportation costs to and from larger urban centers have also meant that some mills using recycled fibers are choosing more central locations for their operation. For example, Keyes Fiber in Waterville, which was converting newsprint to egg cartons and food trays, moved this division to Indiana and closed its Maine operation. Keyes needed to consolidate its operations. The Waterville plant was old and further away from their markets.

Rural Waste Collection

The rural nature of Maine makes it difficult to collect wastes profitably within the state for recycling. Rural businesses will find it difficult to meet their recycling requirements because there are insufficient volumes of recycled paper in any one location to make it profitable for brokers to haul it (State expands recycling mandate. Maine Sunday Telegram 20 June 1993).

High Entry Costs

Products from recyclables often require high collection costs and expensive capital equipment to sort and compact the recyclable materials. The capital barriers prevent most would-be entrepreneurs with product ideas from even preparing a market study. The pay back is not quick enough to overcome high start-up costs. Furthermore, recycling industries can face difficulties obtaining commercial loans for recycling plant and equipment. 25

6.6.3 Recycling Market Opportunities

The Maine Waste Management Agency formed a Recycling Market Development Task Force in the fall of 1992 in order to determine how the state could help develop markets and manufacturing capacity for secondary recycled materials. Priority materials considered were food waste composting, demolition debris, plastics, and residential paper. The following discussion, based on Task Force meetings, as well as interviews with key firms in these and other sectors; indicates opportunities that build upon the skills and knowledge base of existing companies, as well as some of the barriers they encounter.

6.6.3.1 Composting Organic Wastes

Maine businesses have developed specialized and marketable expertise in handling organic wastes. Organic food wastes alone account for 350 tons of the waste stream per year. Projects in Fort Fairfield and Machias are already composting industrial food wastes such as potato culls and blueberries. Because of the dominance of the state's pulp and paper industry, waste water treatment plant sludge and other mill-generated wastes make up over 50 percent of Maine's waste stream. Other industrial organic wastes are wood ash produced by the eight stand-alone wood-fired electric plants and the food and fish processing industries:

Agronomic values of sludge generated from pulp and paper mills were explored. This material is generally high in organic matter, although fairly low in other nutrients needed for plant growth. Generators of sludge and private entrepreneurs developed programs to recycle this sludge on forest

²⁴ Phone conversation with Diane Branscombe, Counselor, SBDC, University of Southern Maine:

²⁵ A California study (Wirka 1993) has found that the financial community views recycling plants and equipment as "special purpose" and therefore of low liquidation value.

soils. Specialized spreading and hauling equipment were located and adapted to allow for sludge spreading over Maine's rocky and hilly terrain.

With over half of Maine's municipal landfills closing in the late 1980s and early 1990s, pulp and paper mill sludge has been mixed with low grade soils and pond sands to create an artificial low-cost topsoil. This soil substitute is spread on top of the final clay cap at closed landfills to support vegetative growth. Towns using the sludge mixture have realized a savings of approximately \$4,500 per acre. In addition, this artificial topsoil has been very effective in controlling erosion.

Two Maine companies in particular, Resource Conservation Services Inc. (RCS) in Brunswick and Woods End Research Laboratory Inc. in Mt. Vernon, have grown as national leaders in the field of composting and organic waste recycling.

RCS built on the experience in organic wastes and developed a lime substitute for farmers by examining the wastes generated from pulp and paper mills and from wood-fired boilers for their agronomic and silvicultural value. RCS found that the high pH of the wood ash meant that New England farmers could use it as a lime substitute to offset the naturally low pH found in most agricultural soils. Based on this finding, RCS quickly moved from a two-person, kitchen table operation in 1983 to a successful firm with 100 employees. RCS was fortunate to have access to equity capital necessary to take advantage of the market opportunity and capitalize its rapid expansion. It could not have survived with conventional financing. Browning Ferris Industries (BFI), the nation's second largest waste management company, bought out RCS in 1991.

RCS has developed local organic waste management markets for municipalities, supermarkets, waste water treatment, and food processing. In some cases markets were slow to develop: RCS invested in R&D for soil erosion materials for road applications. However, for several years the costs of processing and transporting the composted material could not compete with virgin materials provided by local farmers who were willing to strip their top soil. Only recently has the price of composted materials been cheaper than virgin materials because of efficiency gains in production as well as procurement policies of the Department of Transportation.

RCS is limited by sheer population and volume of wastes in Maine. Its major expansion is national and in Canada. It exports its expertise to other localities where it operates composting services. As RCS expands out of

state, it has moved people out to develop new markets and has had a net reduction in jobs in-state.

Woods End began providing composting research and development in 1974. It has remained relatively small (approximately 10 people) by choice. Nonetheless it has developed a national and international reputation for its expertise in characterizing wastes and designing composting methods for converting residues to useful products. This includes everything except operating full scale compost sites: i.e., testing, experimental scale composting design and implementation, design and testing of marketable products, and quality control for commercial composting. Woods End acts as a consulting firm that troubleshoots composting problems for clients, such as farms, industries, schools, or state agencies. It has also used composting for bioremediation of contaminated soils.

Woods End's research is now spinning off manufactured products, such as a household paper compost bag that is being manufactured in Kentucky (for lack of local capacity). Woods End will distribute the bags from its Maine location. Another product is an oxygen probe to measure oxygen levels in compost piles. It is now completing final tests on its compost test kits that can be used on site to improve compost management and thus reduce the costs and time of laboratory testing. Woods End estimates that field testing kits can increase the amount of materials by 30 percent in compost sites. Eventually Woods End hopes to manufacture the kits in Maine.

Barriers to Expanding Composting Markets

- Capital requirements for large composting facilities are high.
 Few commercial composting facilities are operational in the United States, although the numbers are rising. No known large-scale food waste composting programs are located in New England.
- The quality of the incoming material is costly to collect and contaminants are difficult to separate.
 Adequate source separation is particularly difficult in Municipal Solid Waste.
 (MSW) plants.
- Opposition to siting composting facilities has arisen because of odor and other nuisance problems, particularly for larger facilities.

¹⁵ According to Jonathan Collinson of Woods End Laboratory, with a proper recipe and monitoring of the compost pile, odors can be eliminated.

Composting Opportunities

 The market for composting in Maine and the nation exceeds current supply.

The potential market for composting in Maine is five times the 20,000 cubic yards of available compost. Nationally there is 5 million tons of compost sold, with projections that it could expand easily to 50 million tons. 16

 Despite siting problems, large plants are expanding rapidly here in the United States.

Currently there are about 4000 compost facilities, and it is clear from compost facilities surveys that many new facilities in the United States are scheduled to be built in the next five years.

Smaller operations are easier to site, both for regulatory approval as well
as from the point of view of neighbors and abutters:

The technology to handle small and mid-size volumes of organic materials on a daily basis needs to be developed.

Farm-based composting and composting products

An alternative approach to building large centralized composting facilities is creating smaller community composting systems in local farms. Compost Connections in Pittston already works with local farmers to create recipes of organic wastes and other materials collected from the community that can be utilized on the farm. It also works with communities to separate and clean the materials properly. In this approach, composting is incorporated into the normal activities of the farm and provides internally processed inputs to the farm, such as paper bedding or organic fertilizer.

Opportunities exist for farmers to increase their income by selling compost in bulk to landscapers or others who may want to package and distribute it. To do composting on a larger scale, farms would require substantial investment in equipment. Bulk sales would enable them to avoid some equipment expenses for packaging or labeling requirements.

Small-volume composters

Over the past ten years there has been dramatic increase in composting and composting interest. More and more families have their own backyard compost pile and similarly every year more large-scale, high-technology

Conversation with Jay Kilbourne, formerly of RCS in Brunswick.

systems are proposed. On the commercial side, a number of effective technologies have been developed and are in use to accept and handle both separated and/or mixed organic waste streams. Many municipalities use systems demanding very low technology to handle leaf and yard wastes generated in their communities.

On the individual, residential side, small volume composters are available which are primarily designed to contain, cover and occasionally turn collected organic wastes. Programs such as the Master Composter developed in Washington State have been created to teach interested individuals how to compost their organic waste stream.

In between the large-scale composting systems and backyard compost piles is a market opportunity which has not been fully realized and developed. Organic wastes are generated daily in nearly every household and institution. Organic waste dominates the waste stream from commercial establishments, such as restaurants and supermarkets.

A Maine-based company could be in the forefront in developing composting technologies for organic waste streams of 5 to 6 cubic yards per day. Successful development of these systems would incorporate existing technology into smaller-scale operation and would take into consideration the need to:

- handle material on a daily basis
- secure the operation against vectors and other nuisance
- operate with an effective technology
- be affordable and easy to operate

Because of the understanding by organic waste experts in Maine of operating technologies, compost recipe development, input characteristics and technology transfer, Maine is well positioned to take advantage of this market opportunity. The Maine Waste Management Agency is eager to use some of its funds to help develop and trial different small to mid-volume composting systems. If successful, there will be sales opportunities both within and outside of Maine.

Compost Testing for New Markets

As composting becomes more prevalent in the United States, there will be more and more compost on the market for distribution. The skills and knowledge base needed to market compost is very different from the skills needed to create compost. In addition, depending upon the input materials

in the compost mix, different composts will be appropriate for different horticultural and agronomic uses and will provide a wide range of business opportunities. The technician who is developing the compost may not have appropriate skills to determine the best end use for the compost.

As more compost comes on the market, it will be increasingly important to insure that the compost is sold and used for the correct applications. If any compost causes problems with plant growth response, it will affect the user's view and opinion of all composts.

As already noted, Woods End Laboratory tests the maturity of compost from samples received from all over the country. Woods End, along with Johnny Selected Seed Company in Albion, Maine, have developed field testing systems. A logical and marketable extension could bundle these skills and services to develop a service that can test, through laboratory, greenhouse and field testing, the horticultural and agronomic value of a given compost in order to provide marketing advice. A small-scale composter may be included on-site that could test different recipes and the compostability of different materials.

6.6.3.2 Demolition Debris

Maine generates approximately 160,000 tons of demolition debris per year, which consists of masonry, plaster, wires, asphalt, concrete, wiring, window glass, ceiling tiles, gypsum, dirt, asphalt, shingles, and wood waste. The material is low value, although the constituent parts have possible uses. Demolition debris costs municipalities anywhere from \$50 to \$80 a ton to dispose.

The recycling technology is available and markets are not an impediment. According to the Maine Waste Management Agency, recycling commingled materials is time consuming, capital intensive, and expensive. Private contractors or demolition contractors will separate easily identifiable materials such as metals and perhaps wood. Separation of the other material is expensive and discourages recycling. The markets for these materials are very competitive, and virgin materials outprice recyclables. There are also concerns about delays and inconsistencies in the regulatory environment. Recycling would require a regional initiative to generate sufficient economies of scale to purchase the costly equipment.

Sawyers in Hampden is one firm that has inaugurated a program for sorting demolition debris. Sawyers has recycled white goods and clean wood for years. What is new is the immense sorting operations. The cost of equipment is a significant barrier, ranging anywhere from \$500,000 to \$1.5 million. Demolition requires three types of equipment: a shredding machine to sort materials, a trommel mill to sort different sizes, and a tub grinder. Sawyers is still experimenting with machinery and is only renting equipment.

The very fine material resulting is used as landfill cover, and the wood is used for steam powered generating plants. Some of the materials are reusable depending on markets for metals, glass, and plastic. Sawyers' entry into the demolition debris market is based on anticipated markets created from the state's legislation to close landfills. However, the DEP has extended closure dates twice and may again a third time. If state policy continues to support an uneven playing field, Sawyers will be unable to compete with cheap tipping fees in unlined landfills for the debris.

6.6.3.3 Plastics

Plastics account for six percent of Maine's municipal solid waste stream, or approximately 82,500 tons in 1988. Nationally much of the thrust towards plastic recycling is coming from the large petrochemical companies that are trying to preclude banning of plastics. Markets for recycled plastics do exist, but the costs to sort, bail, and transport plastics are generally higher than market value. For example, it costs Regional Waste Systems (RWS) in Biddeford \$200 per ton to collect and process plastic, whereas the recycled product only commands a net value of \$100 per ton. To develop a consistent feedstock, the use of plastic resins needs to be standardized. Also buyers' needs must be met. Maine has few plastic manufacturers and, as far as WMA knows, they are not purchasing recycled feedstock.

One Maine company that is using recycled plastics is Gates Form Fibers in Auburn. It is purchasing recycled PET (Polyethylene Terephthalate) cleaned and separated from soda bottles from out-of-state recyclers. Gates then converts it to polyester fibers for nonwoven fabric used in carpeting or trunk linings of automobiles. The company is able to use green and amber plastics which are cheaper than clear plastics because the plastic is converted to a black fiber. Nonetheless, the company does not save very much from the recycled plastics. Gates main incentive is that the recycled PET makes a very high quality product even after reprocessing. Gates would prefer a local supplier to avoid high freight costs, but it is questionable whether a Maine-based plant could operate at sufficient scale to be profitable.

Other potential reuses of plastics are carpets and textiles, but these are not yet developed in Maine. There is also a possibility of recycling containers for water, dairy and cosmetics. Tom's of Maine has expressed some interest in reusable cosmetic containers.

6.6.3.4 Paper

Recycled paper consists of mixed waste paper and newsprint. Maine generates annually approximately 100,000 tons of commercial mixed waste paper, 94,000 tons of residential mixed paper, and 60,000 tons of newsprint.

The paper market is very cyclical and tends to follow the price of world virgin pulp markets. There is a wide range of values. The mills dictate the quality, and suppliers must produce supply to meet their quality. However, quality can also shift. Historically much of Maine's waste paper has been exported.

Many private brokers and suppliers have fallen out of the paper market. In some cases, brokers have had to compete with nonprofit organizations that are subsidized in what they consider an uneven playing field. The Maine Recycling Cooperative was established to serve small isolated communities that are not profitable for private brokers. One firm noted that the cooperative began serving larger communities as well. Because it operates without profit, it can sell paper at a lower price than private brokers.

Current players are Zaitlan Co. in Biddeford, William Goodman in Scarborough, Great Northern in Lewiston, and Sawyers in Hampden. Except for a few mills, such as Scott Paper in Winslow, Bowater, and the Stone and Webster plant under construction, the recycled paper market is located outside of Maine. There are also opportunities in mixed paper grade, but to take advantage of them, it will be necessary to overcome technical challenges, identify components, specifications and quality needs.

Over the long term, greater demand for recycled paper and newsprint is expected as the paper mills install new processing equipment in order to meet increased government regulations for post-consumer paper content. Maine will not be able to supply the anticipated demand. Stone & Webster anticipates transporting waste paper as far away as Baltimore and New York to supply the necessary 250 tons of waste per day (Waste Paper Plant under

Construction. Portland Press Herald 31 March 1994). However, in the short run, the industry faces difficulties in cyclical markets.²⁸

6.6.3.5 Recycled Paper End Products

One end product for recycled paper currently produced in Maine is packaging materials at Moulded Fibre Technologies in Westbrook. The U.S. market for moulded fiber production is estimated at between \$200 and 400 million. Part of Moulded Fibre's market is generated from international environmental regulations. Kodak, for example, is buying its recycled packaging explicitly to meet the requirements of the German packaging laws.

Moulded Fibre grew out of a local base of expertise in mould making. Its machine shop that produces the moulds employs engineers using computer aided design (CAD) and skilled technicians. Despite this technical base in Maine, Moulded Fiber is opening a plant in California to be closer to its market, such as major contracts with Apple Computer. Although it will keep its R&D activity in Maine, the bulk of production and jobs will be exported. The company recently merged with United Foam Plastics Corporation, a \$30 million company north of Boston, and is building a worldwide distribution network.

6.6.3.6 Corrugated Cardboard (OCC)

Approximately 10 percent of Maine's waste stream is OCC (or 137,564 tons in 1988). The only Maine plant taking OCC is Yorktowne Paper Mills in Gardiner, which manufactures end pieces for paper rolls, brown Kraft paper bags, and paperboard. Most surplus OCC that is not recycled through commercial corrugated cardboard programs is exported overseas.

The Market Development Task Force recommended using state incentives to attract a corrugated cardboard manufacturer to Maine. However, Maine is competing for feedstock with a new paperboard mill in Jackson, Florida, which is drawing OCC from 1200 to 1400 miles away.

²⁸ Conditions in early 1993 are illustrative. The market for newsprint soared, only to have a glut by the following May. The economy was poor, and mills that were purchasing postconsumer feedstock were overstocked. Furthermore, world pulp prices were at all time lows because of oversupply. Without a mandated recycled content in paper; there was no incentive to purchase recycled paper. Finally there was almost no export to Europe and Asia on either the east or west coast because of massive recycling programs. It was cheaper for Europeans to ship to Asia. Even the Canadian market shut down despite reduced transportation costs through back hauling. Zaitlans exported more than 20,000 tons per year to the Canadian waste paper market, but in May 1993 the Canadians took nothing

6.6.3.7 Tires

Maine alone has 50 million tires and generates 1.5 to 1.6 tires per year. People are paying a tipping fee to take the tires off their hands. "Tire jockeys" sort out good from bad tires for reuse, retread and disposal.

Maine has a number of tire chipping companies but has not created many high added value products with the tires. One use of tires is for tire derived fuel (TDF). Burning the tire chips increases the heat content of the trash burned and results in complete combustion of other waste materials. Maine has the infrastructure to burn about 20 million tires per year. With changes in national energy law, paper plants have put in modern cogenerator boilers that supply the electricity grid and process steam for the paper making process. This has created a use for scrap tires on mass. TDF costs about 30 percent less than the coal it replaces. Carbon dioxide and sulfur dioxide emissions are about the same as coal, but heavy metals are reduced. The paper companies require a shredding process that produces very small chips with no metal content.

Much of the feedstock is coming from out-of-state (as far as Washington, D.C.). It is anticipated that much larger amounts will be transported by barge and then by rail to the paper mills. Some of the tires are chipped out of state to reduce their volume.

Presently three Maine companies — Seaward in Eliot, Pine State Recycling in Nobleboro and Sawyers in Hampden — are chipping about 4 million tires a year for burning. Sawyers chips tires from all over Maine and out of state for sale to Champion paper mill as fuel. Pine State Recycling Co. in Nobleboro also chips tires at a rougher grade for the Penobscot Energy Recovery Company. Seaward, the newest chipper, has built its own shredder that has enormous capacity and could create a competitive advantage for the company. In addition, a Texas firm, Waste Recovery Inc., which supplied Champion paper in its original test of TDF in Atlanta, wants to enter the Maine market.

The markets both for feedstock and for end users is very competitive. At this point, the only way a business can survive is by collecting tipping fees to dispose of the tires. The economics do not work if abandoned tires are picked up from existing sites without the tipping fees. Even so, the costs of chipping tires to the specifications needed for burning are high.

Ideally, Maine should be making higher value-added products from the tires. One example is Environomics Inc. in Portland that is in the prototype development stage of manufacturing recycled tires into bulk products. Specific product and market information is proprietary. As more tires are used for fuel, the company will also have to compete aggressively for feedstock. Researchers at University of Maine are also testing chipped tires as a base for gravel roads and backfill for foundation and retaining walls. 29 However, the costs of recycling tires in this way may be very expensive because of the need to process the tires into very small particles. 30

²⁹ This research is conducted by Associate Professor Dana Humphrey

³⁰According to DEP Environmental Specialist, Terry McGovern, a Department of Transportation study concluded that it could cost up to \$1,000 per ton to recycle tires as subgrade fill material in civil works projects.

6.7 Instrumentation

The instrumentation industry has had steady growth and is usually the first to benefit from new regulations that have required more sampling and testing. According to the EBJ (August 1992), the industry had a steady 15 percent or more annual growth rate for more than a decade before the recession. Since the recession, sales of lab instruments have dropped from 15 percent-25 percent + annual growth to as low as 5 percent in 1991. Worldwide demand for instrumentation in 1991 was estimated at \$1.7 billion, with demand for lab instruments comprising \$1 billion. Exports to governments with varying levels of sophistication and regulation provide a growth opportunity for instrument companies with a long product history (EBJ August 1992).

In the last few years there has been a shift in DOE and EPA from lab testing to field testing both to reduce costs and the risks associated with transporting contaminated samples. New portable technologies that test on site detect positive samples and reduce the number of samples needed to be tested at the labs. Most of the innovation in field instruments is coming from smaller firms. Some of the growth areas include on-line sensor, technologies to monitor water, soil and air.

The instrumentation industry is also expected to benefit from the shift from command and control regulations to performance standards. More sophisticated measurement and data interpretation will be needed if firms are permitted more flexibility in attaining performance standards (EBJ December 1992).

Estimations of the impact from the Clean Air Act go from \$550 million for air-related instrumentation equipment (EBJ, Ibid.) to \$19.4 billion in the costs of control and monitoring equipment incurred in this decade to comply with section 112 of the Act (McIlvane 1991 cited in Dudley 1993, 59). However, sales of air monitoring equipment to utility companies, have been relatively slow, partially due to budget problems. The Bush regulatory moratorium has meant that rules on air toxics are not due until 1997.

6,7.1 Opportunities in Existing Companies

Intelligent Controls, Inc. (INCON) in Saco manufactures electronic instruments that are sold to power utility, petrochemical, and liquid handling industries. In recent years INCON has been focusing on the growing market for Underground Storage Tank (UST) Monitor/Leak Detection systems. INCON has produced an Automatic Tank Gauging (ATG) line for

monitoring and leak detection. It uses a magnetostrictive liquid level probetechnology to detect leaks and a point liquid sensor technology to monitor the area between walls in a double-walled storage tank.

The market is driven by EPA regulations requiring new tanks to include corrosion protection or secondary containment measures. Existing tanks must be tested periodically to detect leaks. Approximately 2 million USTs in the United States must come under compliance with EPA's regulations. ATG is one of several EPA-approved methods to meet the regulations. DoD facilities also provide a huge market of underground storage tanks. A 1989 inventory indicated 30,692 USTs subject to EPA or state regulations, not counting other inactive facilities with tanks. Sales in the ATG market alone are estimated at over \$60 million in 1990, and sales in the entire UST monitoring market are estimated to exceed \$3 billion over ten years. INCON also has opportunities to expand into export markets but is presently focusing on meeting the rising domestic demand for its instruments. In order to meet its capital needs for expansion and three new R&D projects, INCON has gone public. Its first public offering was over-subscribed, and it plans to do a second offering.

Immunosystems, a biotech firm in Scarborough acquired by Millipore, a Massachusetts-based company, considers the environmental area its only growth area. The company produces an amino acid field test kit used in testing pesticides and superfund chemical contaminants such as PCBs, petrol, hydrocarbons and dioxin. The technology is marketed as a screening technology that is a faster, cheaper and more portable testing instrument than the traditional chromotology system. The testing kit allows a customer to screen positive samples and then confirm them through conventional means in a laboratory, making the laboratory more efficient.

Immunosystems markets include food processors, environmental laboratories, state and federal agencies, remediators, and universities. Over half of its market is international, primarily in Europe.

Hague International in South Portland produces the Oxsen stack emission monitoring system that continuously measures the oxygen content in combustion products. The sensor probe is used to maintain optimum efficiency of boilers and furnaces without operator intervention. According to Hague, the probe allows these systems to maintain the lowest acceptable level of oxygen content, resulting in fuel savings of three to five percent on boilers and up to 30 percent on furnaces. It also keeps a boiler cleaner and saves maintenance costs.

Woods End has developed an oxygen probe and compost test kits to monitor compost piles, as discussed above.

Other local biotech companies, such as Idexx in Westbrook, Binax, and Virostat in Scarborough, are all looking at pockets of the field testing market. Virostat is developing a biosensor that marries biotech with on-line sensor technology to sense liquids. It has had a number of small business innovation research grants, but is not yet at the commercialization stage. And Woods End, described above, is producing compost field testing kits.

6.7.2 Comparative Advantages in Sensor Technologies

Sensor technology is needed for other local environmental applications. A study for the Center for Technology Transfer (The Portia Group 1991) found that metal products manufacturers, a major sector in Maine, are a potential market for cost-effective sensor technologies to monitor toxics and detect leakages created in the production process.

An important resource for developing sensor technology is the Laboratory for Surface Science and Technology at the University of Maine in Orono, which is recognized nationally for its research on sensors. For the most part, the laboratory is focused on pure rather than applied research. Periodically, entrepreneurs have inquired about the technology but usually with little follow through. The laboratory has negotiated with National Semiconductor in South Portland to commercialize some of its devices. The laboratory's D demanding director, Dan Dwyer, recognizes the importance of their research for the state and is open to other commercial environmental applications even though current research does not focus on the environment. New partnerships are likely to require facilitation with Maine companies that do not tend to travel to Orono.

6.8 Analytical Services

Analytical services include environmental analytical laboratory testing and laboratory services. *EBJ* reports that the Analytical Services sector was a \$1.7 billion dollar industry in 1991, with growth of only one percent, compared with a 23 percent growth rate in 1989. The projected growth rate is five percent until 1997.

Growth areas in Maine are laboratory services for air monitoring due to the impact of the Clean Air Act and international markets. The groundwater market in Maine has been shrinking. Fewer parameters are being tested because of cutbacks at the DEP, and towns are refusing to pick up the additional costs. Nor is there much expectation of increased markets from monitoring programs at closed landfills. Despite laws mandating closures, many towns cannot afford the costs. One area requiring more testing is ambient water quality. If a state bill is passed, it will require new testing parameters.

The major environmental laboratories in the state are Environmental Diagnostics Laboratory in South Portland, Northeast Laboratories in Waterville, Peck Labs in Arundel, and Coast to Coast in Portland which bought out ABB's laboratory. Maine laboratories also face stiff competition, particularly from New Hampshire and Massachusetts laboratories. Laboratories have become specialized and will often solicit business from other laboratories for areas where they have specialized equipment and expertise.

Maine laboratories face a disadvantage competing for both in-state and outof-state work. Maine is one of four states that does not require waste water
certification of its laboratories. The lack of licensing creates an unfair
playing field for Maine companies. They cannot compete in other states
because their licensing requirements are very expensive. States only
reciprocate with other states' certification. At the same time, Maine
laboratories face competition for in-state work from numerous out-of-state
laboratories that do not have to meet any standards.

Private laboratories also compete with a state environmental testing laboratory operated by the Human Services Department for drinking water tests. Drinking water tests are mandatory under the Clean Drinking Water Act and require yearly analysis of the public water supply and noncommunity water supplies, such as campgrounds, schools or trailer parks. Each analysis is approximately \$4000 to \$5000. The state laboratory underprices the

private laboratories. One argument for the state laboratory is that an independent testing source is needed. However, as one private laboratory noted, private laboratories which, unlike the state, can be sued are thus held accountable to quality standards. The only way private laboratories can compete is based on quick service.

Similarly, passage of the state bill on ambient water quality (mentioned above) is likely to result in more work for the state laboratory rather than private Maine laboratories. The testing requires very expensive equipment which the state already has

The Maine-owned laboratories are finding considerable business going either out of state or to a national conglomerate, Coast to Coast, that can charge lower prices than local firms. National companies are establishing or buying out regional offices in order to tap new markets. Laboratories are facing high costs of new equipment and technology and are seeking larger markets to spread out those costs. A national laboratory has the choice of sending any work overflow to their other laboratories out of state, whereas a local firm must hire new people.

With Federal Express, the geographic proximity of a laboratory is not an important consideration, and engineers do not care where laboratory work goes. For example, the cleanup of Loring Air Force Base is going to an out-of-state firm which has subcontracted the laboratory analysis to a Rhode Island Firm. There are no set-asides for Maine companies.

One Maine laboratory, Environmental Diagnostics in South Portland, sees potential in the Eastern European market which has very little infrastructure for testing. It would like to team with instrumentation firms in the field testing business to develop a cooperative venture in order to reduce testing costs there.

6.9 Pollution Reduction and Prevention Technologies and Products

Both national analysts and local environmental industries interviewed for this paper point to pollution prevention technologies and services as the long-term growth opportunities. According to EBJ (May 1993, 7), many of the clean technologies and material substitutes are the product of new business ventures attached to parent manufacturers, or entrepreneurial outfits on the fringes of the industry at which the new product or process is targeted. For example, at least half of the solvent substitutes in a study by Los Alamos National Lab were developed not by large chemical companies but by detergent and janitorial firms or one-product outfits.

Opportunities in Maine are discussed below.

6.9.1 Marine Technologies

Maine has concentrated markets for marine products at Bath Iron Works and small commercial boatyards. In the past BIW has shown some interest in helping to develop new marine-related technologies that are currently being tested in federal laboratories; both as solutions to internal problems as well as commercial opportunities. Three coating systems with application in shipbuilding and offshore construction have been identified.³¹

One is a biological-based paint stripping system which uses a solution of microbes to remove paint from steel structures. It has been developed by the Naval Research Laboratory. If successful, a spray-on paint removal system that eliminates most of the hazardous wastes as part of the paint removal process will be developed. The costly and hazardous shot blasting process could be eliminated from shipbuilding operations. It could be transitioned into commercial product development within two years.

The second is a defect detecting paint system developed by Lehigh University. The system allows early visual detection of cracks in steel structures by leaching a dye through the paint when micro-structure defects occur in the steel. It can also be commercialized in two years:

The third system, developed at the Naval Research Laboratory, is a method of applying metal coatings to plastics with extremely strong adhesion. It can be used to metal coat pipes and other plastic parts to increase durability and heat resistance.

4

³¹ Pat Cahill, BIW, Memorandum, January 5 1993.

Further research and development would be needed on these marine applications.

6.9.2 Kelp Agricultural Substitutes

The ocean also is a source of kelp, which has long been used for as mulch and fertilizer in coastal areas. The ocean produces trace minerals that are major and minor nutrients. The largest producer of kelp agricultural products in the United States is Atlantic Laboratories located in Waldoboro. Atlantic Laboratories maintains that through proper kelp processing, the hormones which regulate the sea plants' growth are also available to land plants. Its products are used as fertilizers and plant growth conditioners, as well as animal feed supplements and pharmaceutical and food grade products. Although Atlantic Laboratory's products are certified organics, there is little market for organics. Instead, Atlantic's products are mixed with chemicals to reduce herbicide or chemical fertilizer use. The company now sells in 11 foreign countries, with 25 more countries testing the products.

The company has identified a number of difficulties in the regulatory and testing process, both in the United States and Canada, that it attributes to the bias of the entrenched system against organic products. For example, Atlantic has 60 minerals in its products, but the United States Department of Agriculture only recognizes 15. In general, it has found regulators and university researchers are ignorant of natural minerals. This may change with a new Clinton administration plan to reduce the use of pesticides on fruit and vegetables. The EPA will consider canceling pesticides from its list of approved pest control methods as alternatives are developed. As of this writing, details of the plan have not been published (Agencies Seek to Cut Pesticide Use Portland Press Herald 26 June 1993).

6.9.3 Applications of Electrostatic Powder Coating

Powder coating is an existing dry paint technology, primarily for metal products, that reduces the need to recover solvents, prevents emissions of volatile organic compounds (VOCs) and provides a superior finish quality at less cost than wet painting process. Advanced Product Finishing in Sanford provides coating services in northern New England. It also provides consulting services to guide customers through the transition from solvent-based finishing to powder coating.

6.9.4 Fish Oil as Alternative to Petroleum-Based Hydraulic Fluids

University of Maine professor Tom Christianson is testing a food-grade, fishoil based non-toxic replacement for common hydraulic fluid that reduces
environmental damage and cost of spills and leaks. The first test at a seafood
processing plant has been successful (Fish oil successfully tested as
alternative to petroleum Portland Press Herald 9 December 1993). The
product can be repackaged in Maine by adding additives to fish oil shipped
from Virginia. Christianson is looking for a partner to commercialize the
non-toxic oil. The oil will not totally replace petroleum-based oils because it
congeals below 28 degrees and is not useful in outdoor operations.

6:10 Energy Products and Services

6.10.1 Background to the Industry

Sales at energy companies in Maine involved in both renewable energy systems and conservation services have fluctuated according to state energy policy. Beginning in 1979, Maine allowed a tax credit for the purchase and installation of renewable energy systems. Renewable energy systems were systems that provided heating and/or cooling, produced electrical or mechanical power, heated water or any combination thereof by means of collecting and transferring solar, wood or wind generated into such uses. 32

This period also coincided with a period of very high public awareness and concern for energy. According to one dealer interviewed, before the tax credit was phased out in the early 1980s, there were over 200 dealers of solar technologies in the state, with a statewide trade organization. At most, five dealers of solar technologies are remaining. 33

Consumer services in the mid-1980s took the form of programs to reduce total energy consumption through the installation of energy efficient lighting, weatherization programs, and energy audits. During the economic growth period of the mid to late 1980s, these programs were designed to increase energy efficiency and reduce power demand. Businesses were offered a percentage rebate on the total cost of system, based upon the actual electricity savings resulting from the installation. At times, CMP offered rebates of up to 95 percent of the total cost of a system, although more typically, the rebates were in the 25-35 percent range.

Energy businesses in demand side management (DSM) offering energy audits and installations of electricity-reducing systems grew based upon this policy, and CMP developed contractual relationships with many of them; two

³² A qualified solar system could be active or passive. It had to be a system which collected, stored and transferred solar energy into thermal energy in a controlled manner. A wind system included any machine or device which had four subsystems—rotor, power-processing components, frame, control components—and which converted available energy into electrical or mechanical output form. A qualifying wood system had to be a central furnace designed and used to distribute heat by a series of pipes or ducts through a building or group of buildings. It could burn wood solely or burn wood in combination with another fuel. The furnace must have been purchased as a system and must have been the initial purchase of new equipment.

³³ Conversation with Dave Sleeper, Brook Farm, Inc., March, 1993.

were Maine firms. Furthermore, state energy policy priced electricity high inorder to discourage its use and encourage electricity savings.

Today, Maine utilities claim that the combination of a recession and increased efficiency has slashed electricity demand. As a result, utilities now have a surplus of power and the cost of increasing energy efficiency in most cases, even when calculated out over the full life of the modification, is more expensive than the cost of electricity. To adjust to lower demand, the utilities are working with the state's Public Utilities Commission to lower electricity prices to encourage, not discourage, electricity use. At the same time, rebates to companies installing energy-saving equipment have been eliminated and DSM companies, which developed precisely to fill this market niche, are either closing or are changing their marketing focus. At the request of the utilities, the Public Utilities Commission has terminated an energy conservation program, and a number of conservation companies have been forced to restructure or even close shop.

There is much conjecture as to how future regulatory decisions will affect electricity consumption, conservation and market opportunities in Maine. The National Energy Policy Act deregulates utilities and will force competition from alternative energy sources. Utilities like CMP are beginning to examine whether they should enter new markets, such as renewable energy resources.

6.10.2 Renewable Energy Resources

Renewable energy resources, based upon solar energy, wind, geothermal, biomass and other non-depletable fuels, can play a growing role in meeting the nation's electrical energy needs (Moskovitz 1992). Renewables currently provide about eight percent of the nation's electricity, mostly by means of relatively large hydro-electric facilities. In Maine, the combination of biomass and hydro power means that an even larger percent of electricity (over 36 percent) is renewable (Final Report of the Commission of Comprehensive Energy Planning 1992).

According to the 1991 U.S. Department of Energy's National Energy Strategy, renewables have the potential of providing as much as 18 percent of the total U.S. electricity production by 2030. An alternative national energy strategy prepared by a coalition of energy and environmental groups projects that renewables could meet 35 to 53 percent of electricity needs by 2030 (Union of Concerned Scientists 1991).

While even by conservative projections the potential for renewables is far greater than the reality, the current institutional and regulatory environment is believed to be far from conducive to the accelerated development of these resources, despite recent federal policy support. The National Energy Policy Act gives tax incentives for renewable energy, and the Clean Air Act has a renewable energy allowance. The Department of Energy has also increased its R&D budget for renewables. Private investment in the sector has increased, but there is still considerable uncertainty about the regulatory and policy environment for the industry to thrive (EBJ February 1994).

Early experiences with wind and solar technologies have inhibited the development of renewable resources and created lasting negative impressions with utility engineers, planners and regulators. As Moskovitz (1992, v.) notes, "Costs were high, reliability was poor, and not all developers were reputable." Significant advances in cost and performance have been made, yet these have not been well communicated.

Moskovitz argues that, on a state policy level, renewables do not easily fit into the methods developed by public utilities to evaluate avoided costs. Current planning and resource evaluation methods fail to measure the actual value of these resources. Also, the time and expense of the regulatory process and the "credibility" of these energy providers can be a special problem for renewable resources. Additional barriers are the current recession and a resulting "energy glut" which discourage the development of any energy generation system.

Biomass plants are one example of renewable resources encouraged in the mid-1980s to lessen Maine's dependency on oil. These are wood-fired electricity plants that use much of Maine's lower grade underutilized tree species. Many of these are at heavily overstocked sites that cannot absorb these trees once they reach maturity. Historically, there has been no use for these small-diameter stemmed trees which have come to dominate the Maine forest.

Wood-fired electricity plants offered a market outlet for these trees. Trees could be harvested, chipped (bark, needles and wood) and used as fuel. Although landowners did not receive much cash from these harvests, they did not have to pay for the removal of these trees. In return, they received some silviculture management of their forest lands.

During the mid to late 1980s, ten wood fired boilers, producing between 15 to 34 megawatts of power per plant, were built in the state. Plant owners

negotiated power contracts with their local utility. These plants use about 2.5 million tons of fuel chips annually, of which about 70 percent comes from Maine, and the balance mostly from Canada. Wood supply projections predict ample supply of wood for the lives of the plants and enough wood to support the development of additional plants.

However, because of the present oversupply of electric energy, there is no growth opportunity in this industry at this time. Building plans have been indefinitely postponed for two plants which were permitted and scheduled to be built over the next few years. In addition, Maine Public Service, the utility company in northern Maine, has a bill before the legislature to terminate their contract with a wood-fired boiler. In general, utilities believe that the avoided costs at which the contracts were negotiated presumed continued economic growth. With the current energy surplus, the price of electricity from wood sources is considerably higher than electricity available from other sources.

Wind power is now being evaluated to meet Maine's long-term energy needs despite the current energy glut. U.S. Windpower, based in California, is proposing a \$200 million dollar project to build 761 wind-powered turbines on about 30 miles of remote ridge tops owned by paper companies northwest of Stratton. This system is expected to generate one-third as much energy as the Maine Yankee nuclear plant and sell power to utilities in Maine and to the New England Power Co. of Massachusetts. Utilities are forecasting a need for new power sources to fill peak demands by the turn of the century. Since the early experiments with windpower in New England, these plants are now more reliable and cost competitive due to technological changes. The project must be approved by the Land Use Regulatory Commission (LURC) which is examining all environmental impacts of the project, as well as clean renewable energy (Wind Power Should Light Northeast, Maine. Maine Sunday Telegram 20 June 1993.)

Photovoltaics are one possible near-term market opportunity for renewable energy technology in Maine. Photovoltaic (PV) cells are used in panels to convert the sun's energy into electricity. According to Hill and Hasbrouck (1992) the cost of electricity from PVs is three to four times that of energy from alternative sources.

However, PV-generated power is cost-effective for niche markets, such as in facilities that are remote and loads are small or difficult to serve with conventional technology (Moskovitz 1992). The Electric Power Research Institute has identified more than 60 different applications, for both utilities

and customers, where installation of PV modules are potentially costeffective. Selected commercial applications where PV modules are in use
include navigational aids, water temperature sensors, lights, backup
generator starters; automatic gate openers, warning sirens and water
pumping systems. PV power has proven especially valuable for mainstream
commercial businesses during peak loads and as a backup system where
reliability is an absolute necessity, such as for dialysis machines or milking
machines.

PV technologies are improving and costs are dropping. According to the U.S. Department of Energy's 1992 Solar 2000 plan, PV module costs are now 1/100 of those in 1972, dropping from \$500 per watt in 1972 to about \$5 per watt in 1990. Further increased demand is expected to drive the prices down even more.

These trends suggest to some analysts growing opportunities for PVs in residential and commercial markets.³⁴ On the residential side, the rural nature of Maine means that there are more applications for PV technology than are currently being applied. Island residences and remote camps are using PVs to a small, but growing extent. When used, these modules and appliances are frequently purchased from out-of-state sources.

On a commercial side, the Public Utilities Commission and state utilities would have to develop pricing policies to support increased acceptance and reliance on PVs. The success or failure of such policies will influence the extent to which there are strong market opportunities for PVs in the commercial sector.³⁵

At least four companies produce PVs in Maine.³⁶ One company interviewed, Brooke Farm in Falmouth, only builds large PV turnkey systems; it cannot make a profit on smaller systems. Brooke Farm considers the growth potential in third world countries where many areas do not have access to grid technology.

35 Moskovitz (1992) argues that the current methods of analyzing the costs of renewable energy are biased against renewable resources such as PVs. See Moskovitz for a full discussion of the barriers against renewables.

³⁴ See Heaton et al (1992) and Moskovitz (1992).

These include Brooke Farm, Falmouth; Peter Talmadge, Kennebunk; Maine Solar Power, Warren, and Central Maine Solar, Athens.

6.10.3 Electrotechnologies

A strong effort has been underway since mid-November 1992 to change the public perception and public use of electricity. Recognizing that in the recent regulatory climate, the electric utility industry has been encouraged to pursue more efficient use of electricity or "negawatts," current electric utilities planners and economists are suggesting that consumers and the environment would be better served if more electricity, not less, were used (Mills & Pestorius 1991). These utility experts point to data showing that pollution in the form of CO₂ emissions would be reduced if fuel consumption were re-directed from small, wasteful and dirty end-of-the-line burners to large, efficient power plants. In this concept, the term "ecowatts" is used to describe situations where electricity displaces dirtier fuel sources, thereby improving the atmospheric quality

A wide range of electrotechnologies, some familiar, some more obscure, use electricity in place of technologies requiring on-site burning of fossil fuels. Heat pumps, microwave ovens, ultraviolet-light dryers, lawn mowers, electric light rails, lasers, electric beams, and electric induction furnaces are examples of technologies in which a device requiring burned fuel is replaced with one requiring kilowatt hours. In each case, pollution at the point of use is eliminated, total energy requirements are lowered, and carbon dioxide levels are reduced (Mills & Pestorius 1991).

Central Maine Power Company (CMP) is working with its commercial and industrial customers to evaluate each company's total energy use and determine whether fuel burning systems could be replaced with a less polluting, electrotechnology. CMP staff and a hired electrotechnology engineer are doing energy audits of the ten largest commercial and industrial users of electricity in the state in order to determine if there are electrotechnologies which could replace already existing machinery. CMP is locating markets for this electrotechnology equipment and will be linking equipment manufacturers with specific industries.

For residential customers, CMP is focusing on the electric hot water heating sector. It is also looking at a water purifying system as a replacement to purchasing bottled water. CMP considers residential applications of electrotechnologies tactically important for the public to understand that increased use of electricity is beneficial, even if electric rates remain the same.

CMP is also beginning a program to sell Black and Decker electric lawn mowers at a lower cost than retail costs. It is undertaking a study comparing pollution (CO₂ production) from gasoline-powered mowers to pollution produced when using an electric mower. Electric mowers will likely be an option for lawns that are less than a quarter acre.

The largest barrier associated with electrotechnologies is that the "ecowatt" movement is in its infancy. While broad-based analyses have been undertaken that illustrate the economic savings and environmental benefits from switching to selected electrical applications, groundwork needs to be done to confirm that such analyses are realistic for Maine and New England companies. Case studies in Maine would look at the availability and cost of replacement technology, efficiency of the replaced technology, energy requirements and comparative CO₂ production.

CMP's library has started the Center for Energy Information, an internal CMP business, to sell energy information. It is putting together a database of electrotechnologies (and other new energy technologies involving electromagnetic fields) worldwide. This involves scanning thousands of other databases, and reading foreign newspapers. CMP will produce a newsletter on electrotechnologies available by subscription.

A CMP task force is also looking at electric car options. Preliminarily, the task force feels it is premature to consider electric cars an immediate option. However, it would like to become familiar with electric car technology and is considering putting some electric cars and/or service vehicles in CMP's fleet or cost-sharing with Metro Portland to help purchase one or two electric buses.

6.10.3.1 Market Opportunities

Electrotechnology Suppliers

Currently, because of the diverse nature in the electrotechnologies, there are no companies in Maine which are general suppliers of the type of systems described above. The most promising opportunities are to supply these technologies, particularly for residential uses. CMP does not yet know whether it will enter this market itself or set up an unregulated subsidiary. CMP already has a precedent. Fifty years ago it ran hardware-type stores.

Manufacturing under Licensing Agreements

There may also be opportunities to license existing technologies from Asian, European and other U.S. companies and manufacture them in Maine Some of the most interesting technologies come from Sweden and Germany. Sweden is committed to phasing out all nuclear energy by next century and replacing the power with energy efficient technologies, such as a photovoltaic roof shingle that should be on the market in a couple of years.

Firms were identified through contacts at trade organizations, other government agencies, particularly the Department of Environmental Protection, business networks, and word of mouth. The Department of Environmental Protection provided lists of firms licensed to do environmental work in the state. Because so many of the firms were small, young firms, DECD felt that the total number was low.

7. BARRIERS TO EXPANSION

Maine firms identified the following barriers to starting and/or expanding their businesses. General economic and business climate issues are not included.

7.1 Capital Availability

Eight of the firms interviewed for this report specifically mentioned capital availability as a problem they faced in their current operations. For two start-up companies and one existing firm, financing for R & D was a barrier. Other financing needs were for working capital and equipment costs, which were particularly high in recycling industries. Two firms had access to capital but it was the wrong kind; they did not want venture capital that would compromise their control over the company.

Another seven firms, however, cited capital availability as difficult and generally a problem for other small firms in the industry. Some of these already relied on existing gap financing. One of these seven firms found it would have been unable to secure conventional financing for its start-up without the loan guarantee it received from the Finance Authority of Maine (FAME). Other technological industries noted that it took deep pockets (and usually deeper than they anticipated) to get where they were, but they did not raise capital as a current barrier.

One firm explicitly stated that access to local "angel" capital was not an issue for technological firms that were well managed. From this person's perspective, Maine had a great deal of risk capital, but investors had difficulty evaluating the competency of management.

7.2 Regulatory Policy

Eleven companies interviewed mentioned regulation as a problem but for different reasons.

Fickle Policy

Five energy companies mentioned fickle public policies that led to enormous cutbacks or closures. Another nursery in wetlands recreation feared policy reversals because of the unknown impacts of the procedures. As one entrepreneur put it, "A public entrepreneurial policy is a thin reed to invest savings; we need long-term public policy to create certainty for the investment environment."

Uneven Playing Fields

Public policies that were either passed, not passed, or not enforced created a number of situations where four companies thought there was an uneven playing field. These included state support for a recycling cooperative, a state testing laboratory, the lack of licensing of environmental laboratories that created advantages for out-of-state firms, and the lack of enforcement of landfill closure legislation that created cost advantages for landfills that did not meet state-of-the-art standards. One engineering company also mentioned that Maine's procurement policies do not give preference to local firms as do New Hampshire's; thus firms have uneven access to markets. In another case, a manufacturer of organic products felt that regulatory bias against products that were not well understood and properly tested created a competitive disadvantage.

Poor Enforcement and Coordination

In three cases, companies noted that lack of enforcement of environmental regulations had affected their markets. And in one case, a company was delayed in getting its permit because of lack of coordination between city and state regulators.

7.3 Accessing Markets

Lack of Set Asides in Remediation Contracts

One firm noted that contracts went out of state because there were no setasides for Maine subcontracting firms on DoD projects.

• Lack of Internal Resources for Market Development

The present economic climate has meant that firms do not have a great deal of slack for developing new markets. One consulting firm eliminated its R&D department to develop new markets. Another that does finance its internal R&D commented that it was in an unusual position; most peer companies do not have the time and money to develop new services and markets, nor do they have in-house marketing professionals.

Lag in Market Development

Six companies mentioned a lag in market demand for their products. This is particularly true for technological products; one firm noted delays in marketing because it had to educate its market. It is also true for recycling industries where markets have lagged behind public policies that mandate government procurement of recyclables, recyclable content or community and business recycling goals.

Lack of Effective Market Demand from Small Firms for Services

Two environmental consulting firms noted that small firms that must comply with toxic use reduction laws do not have the internal capacity to prepare reduction plans. They need consulting services but cannot afford them. The state DEP is providing free environmental audits, but some firms are wary of exposing any liabilities to an agency that is also a regulatory body.

7.4 Organizational Barriers to Technological Innovation

Aside from problems in obtaining R&D financing, several companies identified organizational issues that result in missed opportunities in the innovation process. Two engineering firms pointed out that engineers and technicians often see opportunities for new products or technologies through their daily work but are not inclined to act upon them. Their proficiencies are in designing and building for someone else rather than playing an entrepreneurial and development role.

Entrenched attitudes and work routines also prevent people from perceiving and innovating new solutions to environmental problems. One entrepreneur noted that managers and technicians in generator firms (i.e., manufacturers that generate environmental problems) often take positions that problems cannot be solved and do not try to innovate. Most university researchers under contract with industry are too removed from industry to understand the problems. Problems cannot be analyzed as isolated entities; a researcher must examine a problem in an applied setting.

7.5 Gaps in Skills and Expertise

Three companies identified gaps in acquiring the necessary skills and expertise locally. Maine lacks skilled people for some specialties in analytical laboratories and heat recovery and crystallization specialties in engineering. These firms seek out-of-state personnel and consulting services to fill the gaps. The ability to attract permanent staff from national searches varies. Maine's quality of life does not always compete well with substantially larger salaries elsewhere.

Another firm found it difficult to hire designers and programmers with sufficient training in computer aided design.

7.6 High Business Costs

One environmental consulting firm noted that the cost of liability insurance for a one person firm was between \$10,000 and \$20,000. Only four companies write professional errors and emissions insurance in Maine, and half of the consulting companies do not have the insurance.

In order to meet OSHA requirements, it costs approximately \$1500 to train a new technician without experience. As a result this firm tries to hire only experienced personnel.

The barriers identified by firms interviewed are consistent with the national literature on environmental technologies as well as with results cited above in the Department of Economic and Community Development's (DECD) survey of environmental firms.

8. CONCLUSIONS

8.1 Opportunities for Further Investigation

This study has identified a number of promising sectors and markets. The following suggests some specific areas and approaches for further investigation.

Environmental Consulting, Testing and Remediation Services

The growth in environmental consulting and testing is largely in international markets, although individual firms find niches in traditional regulated Maine markets. Domestic growth for small Maine environmental laboratories would probably require changes in regulatory and licensing policies to improve their competitive ability in Maine and other states. The growth in remediation will depend largely on political priorities for government financing.

Work is already underway to organize an environmental trade association that could help these firms (along with others) access international markets. More work needs to be done both on organizational structure and how small Maine firms, even in consort, can access these markets given the positioning already underway of large international environmental firms.

Remediation and Pollution Control Equipment and Technologies

Maine has several firms already serving remediation and pollution control markets; others are still in the research and development stages. Further research is needed to determine what the long-term market prospects are for these technologies and whether public resources should specifically target their development.

Recycling Industries

Long-term growth prospects for recycling industries depend largely on aggressive public policies that privilege recycled products (e.g., mandatory public procurement of products with recycled content) and increase the costs of other waste disposal options. Even with these policies; Maine's location and demographics limit its prospects for manufacturing value-added recycled products because of difficulties amassing sufficient wastes and accessing markets. New niche markets should be pursued according to Maine's strengths, such as was the case in recycled paper or mould making for recycled packaging.

In the short-term, composting services, products, and equipment are one area where Maine already has a track record and has capacity for R&D. Manufactured products are already beginning to spin off from Woods End's research. Maine needs to address how it can keep the production in the state.

There also are possibilities of incorporating composting as a business within existing farms to strengthen family farms. This may be one of several environmental industries that could help diversify small farms. This is also of interest to University of Maine Professor Stewart Smith (former Commissioner of Agriculture) who has argued that farms should produce more internally to take advantage of excess management capacity and reduce their purchased inputs (Smith and Marra 1993). Possible pilot projects could be designed with both research and commercial benefits.

Environmental Data Management

This is a new sector in Maine in a growing market. It is possible that small firms could develop their markets further by collaborating with current efforts in pollution prevention and toxic use reduction and with assistance from the University of Maine's National Center for Geographic Information and Analysis.

Instrumentation

Maine also has strength in instrumentation that should be developed further. This comes both from a skilled workforce experienced in electronics and fabrication as well as the emerging biotech industry. Specifically, markets for sensor technology and field testing kits are promising. The University of Maine has a nationally recognized research laboratory in sensor technology to draw upon.

Energy Products and Services

Markets for renewable energy systems will require public policy support although some niche markets already exist for photovoltaics. CMP's interest in electrotechnologies may provide opportunities for entrepreneurs to distribute these technologies and possibly manufacture under licensing agreements. CMP's work with technologies should be monitored for possible partnerships of spin-off opportunities.

Pollution Prevention Services and Technologies

The growth market for environmental industries is pollution prevention services, products and technologies. The market is driven by regulations requiring firms to reduce their toxics and wastes. Because of high costs of

disposal and fines for not complying with regulations, it behooves firms to engage in pollution prevention analysis and implementation simply to save their bottom line. Regulations based on performance standards rather than command and control give the greatest impetus for new technology development. To the extent that regulations are not enforced, it will weaken demand for prevention services and technologies.

The opportunities for pollution prevention stem from both the demand and supply side of the market. Firms have a need for pollution prevention, but small firms, in particular, often lack effective market demand, i.e., they cannot afford the front-end costs of identifying specifically what they need and making changes or investments in their operations.

Interventions to assist small companies in pollution prevention are needed to stimulate the pollution prevention market. This is already beginning to happen in Maine although some companies have expressed some hesitation working with public agencies. Further work needs to be done to determine to what extent companies can do their own environmental audits with internal resources, whether external agencies can provide the necessary assistance, or whether resources should be made available to companies or trade associations to hire external consultants.

On the supply side, Maine should give a priority to supporting the development of new pollution prevention technologies. It can start with some of the strengths it already has in sensor and instrumentation technologies and kelp fertilizers. The state should also look at areas where it creates demand for products and technologies. For example, there is demand for non-toxic solvents for marine applications; is there also a capacity and niche to produce them locally?

Areas to explore are:

- Encouraging greater cooperation among firms to identify potential markets and shared production capacities.
- Linking companies and entrepreneurs with the University of Maine, other academic research centers, federal laboratories, and out-of-state entrepreneurs to identify, develop or transfer new technologies and product ideas.

- Working with companies that are implementing environmental audits and pollution prevention measures to identify any innovations that could be commercialized.
- Determining needs for gap financing, facilities, or other managerial or technical resources to support the commercialization process. The availability of financing for R&D, while not a problem for all firms, warrants investigation. Maine ranks at the bottom nationally in R&D expenditures.
- Supporting entrepreneurs and spin-offs of existing companies.

8.2 Next Steps

The two major questions to follow up are how to encourage small firms to engage in pollution, prevention measures and what interventions could encourage further development of the various opportunities already identified.

CEI is already in the process of capitalizing its Green Fund to provide gap financing for environmental industries and small businesses that must comply with environmental regulations.

Further industry input is needed to determine whether the opportunities identified above could be encouraged through various business supports, such as:

- Developing industry networks
- ♦ Brokering new technologies
- Facilitating problem solving among generators
- Gap financing mechanisms
- Marketing and management assistance
- ♦ Skill training
- ◆ Regulatory interventions

Focus groups of these industry representatives and researchers in related areas should be organized to examine opportunities, clarify whether external interventions are useful to accelerate action, and how these should be designed. Focus groups could also be held with generators with similar manufacturing and pollution problems to determine whether market opportunities exist for new technologies. A number of people interviewed for this study were interested in participating in such a process.

The feedback from the focus groups could help determine what activities require state and regional policy support and what actions can be taken through private initiatives. Findings would be particularly useful for the State Office of Economic Conversion in identifying opportunities for defense companies, the newly organized Manufacturing Modernization Partnership at the Maine Science and Technology Foundation to improve technology and management systems in manufacturing industries, and the Economic Growth council's mandate to develop a long-term state economic development plan and bench marking process.

APPENDIX 1: CRITICAL ENVIRONMENTAL TECHNOLOGIES

Energy Capture

Energy extraction, processing and use, including photovoltaics; geothermal, solar thermal electricity, and nuclear fission.

2. Energy Storage

Improved energy storage and applications, such as batteries, superconductors, hydrogen storage, heat storage, and fuel cells

Special Energy End-Uses

Technological improvements in transportation and buildings.

4. Agricultural Biotechnology

Microbial inocula that diminish need for fertilizer and pest control, biological pesticides, modification of gene characteristics; bioremediation of hazardous wastes.

5. Improved Agricultural Techniques

Alternative agriculture that uses techniques for taking advantage of natural cycles; precision agriculture that uses monitoring and information technologies to target inputs of fertilizer, pesticide or water.

Manufacturing, Monitoring, Modeling and Control
 Intelligent manufacturing systems that use sensors, process models, and controlled actuators.

7. Catalysts

Catalysts that trigger chemical reactions in ways that prevent pollution.

8. Separations

Substituting appropriate non-toxic technologies for distillation, drying, degreasing and evaporation processes.

9. Precision Fabrication

Manipulating matter precisely to reduce industrial use of natural resources and emissions; use of precision coating techniques to improve performance of electronic components.

10. Materials Design and Processing

Development of new and superior metals, polymers, ceramics and composites as well as producing them in a radically different way.

11. Information, Communications and Computing Dematerializing or using information to substitute for material use; improving environmental quality through information use.

12. Contraception
Stemming population growth in order to limit demands on natural resources.

Source: World Resources Institute, Heaton et al. (1992, 9-17).

APPENDIX 2: INTERVIEWS

1. FIRMS INTERVIEWED

Personal Interviews

Atlantic Laboratories - Bob Morse, President

Waldoboro 2/3/93

Dufresne Henry, Inc. - Ruth Carr, Marketing Manager

South Portland 12/2/92

Environmental Diagnostic - Patrick Higgins, Vice-President

South Portland 4/27/93

Environomics - Chari Chalmers, President

Portland 3/8/93

Immunosystems - James Fecteau, Senior Vice-President

Scarborough 4/27/93

Moulded Fibre Technologies, Inc. - Peter Troast, Managing Director

Westbrook 7/28/92

Northeast Energy Systems - Angus King, President

11/23/92

Passamaquoddy Technologies - Garrett Morrison, President

Thomaston 2/13/93

Resource Conservation Services of Browning Ferris Industries - William

Ginn, President

Brunswick 1/23/93

Robert G. Gerber Inc. - Tyrrell Hunter, Marketing Director

Freeport 1/8/93

Woods End Laboratory - Jonathan Collinson, Senior Program Officer

Mt. Vernon 6/4/93

Wright Pierce Associates - Charles Martin, Marketing Director

Topsham 1/29/93,

Zaitlan & Sons - Sam Zaitlan, Président 1/29/93

Phone Interviews

Acadia Environmental Engineering - Tom Schwarm, President Portland 4/13/93

Access Technical Corporation - Tom Gosze Bangor

Brook Farm - David Sleeper, President Falmouth

Compost Connections - B.J. Jones, President Pittston 6/16/93

Cyro Dynamics - Christopher and Emily Weatherall Bangor

Energy Reduction Systems of New England - Chris Paquette, President Portland

Energy Technology Inc. - Dennis Long, President
Portland

Entec - Julie Mitchell, Partner Lincolnville 4/22/93

Energy Resource Management - Rob Stockwell, Project Manager Portland 5/5/93

Intelligent Controls - Alan Lukas, President Saco 6/15/93

Lowry Engineers - Jerry Lowry, President Durham, NC 5/23/93

Moulded Fibre Technologies, Inc. - David Freeman, President Westbrook 1/26/93

Northeast Laboratory - William Colby, President

Waterville 5/20/93

Pierson Nurseries - Dale Pierson, President

Biddeford 5/4/93

Resource Recovery Inc. - Alban Cyr, Sr., President

Caribou

Sawyers Environmental - Bill Shook

Steve Benjamin, Vice-President

Judy Perkins, Recycling Coordinator

Hampden 4/19/93

Viewtech - Dan Barter, Manager

Westbrook

Virostat-Doug McAllister, President

Scarborough 6/23/93

2. OTHER SOURCES CONTACTED

Private Sector

Bath Iron Works - Kevin Gildart, Spokesman
Pat Cahill, Senior Systems Engineer,

Central Maine Power Co. - Richard Spellman, Vice-President
Michele Brown, Marketing
Alan King, Center for Energy Information

Gates Form Fiber - Woody Trask, Technical Director

Kady International - Kent Peterson, President

Peregrine Environmental - Jerry Tudan, President

Soleras, Ltd. - Dean Plaisted

Key Bank - Rob Burgess, Environmental Specialist

Maine Chamber of Commerce- Chris Hall, Vice-President

Jaques Woodford-Scott Collins, Manager

Shaw's Supermarkets - Margaret McKewan, Vice President, Consumer Information

Agencies

Portland Small Business Development Center
Diane Branscombe Counselor

Department of Environmental Protection

Sandy Talbot-Thompson-Portland Regional Manager
Mike Barden- Director, Site Investigation and Remediation
Ann Pistel- Planning and Research Associate
Ron Dyer- Director, Pollution Prevention
Jim Brooks- Director, Air Bureau Department
John Moulton- Director, Waste Bureau
Brooke Barnes - Director of Enforcement
Terry McGovern- Environmental Specialist, Solid Waste

Maine Waste Management Agency - Denise Lord, Planning Director

Department of Economic and Community Development
Brian Dancause- Development, Project Officer

Maine Science and Technology Commission-Terry Shehata, Associate Director

Center for Technology Transfer - Bob Dalton, Director

Center for Innovation in Biotechnology - Don Kolbert, Director

Economic Conversion Project - Frazier Kellogg, Board Member

Natural Resources Council
Everett Carson, Director
Lawrence Horwitz, President
Stan Eller, Staff Attorney
Beth Nagusky-Staff Attorney

Maine Peoples' Alliance - John Diefenbecker-Kroll

University

Production Technology Center, University of Southern Maine - Ivan Most, Director

Center for Innovation and Entrepreneurship, University of Maine Jake Ward, Director

Laboratory for Surface Science Technology, University of Maine
Dan Dwyer, Director

Agricultural and Forest Engineering, University of Maine Tom Christianson, Associate Professor

Agricultural and Natural Resources, University of Maine Stewart Smith, Professor George Crinerm, Associate Professor

Wolfe's Neck Center, University of Southern Maine Harris Gleckman, Special Assistant to the Provost

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