TOXIC CHEMICAL MANAGEMENT IN MASSACHUSETTS:

THE SECOND REPORT ON FURTHER CHEMICAL RESTRICTION POLICIES

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TOXICS USE REDUCTION INSTITUTE

The Toxics Use Reduction Institute is a multi-disciplinary research, education, and policy center established by the Massachusetts Toxics Use Reduction Act of 1989. The Institute sponsors and conducts research, organizes education and training programs, and provides technical support to governments to promote the reduction in the use of toxic chemicals or the generation of toxic chemical byproducts in industry and commerce. Further information can be obtained by writing the Toxics Use Reduction Institute, University of Massachusetts Lowell, One University Avenue, Lowell, Massachusetts 01854.

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There were significant differences of opinion among those who reviewed the draft report. The final report includes many of the ideas and clarifications suggested by those who reviewed the draft. But, where there were broad differences the text may not satisfy all of the contributors. Yet, all of the comments were considered valuable even where reviewers differed or where the comments differed from the intentions of the authors.

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EXECUTIVE SUMMARY

When the Massachusetts legislators enacted the Toxics Use Reduction Act (TURA) of 1989 they recognized that further toxics management policies may be necessary in the future to reduce the risks of toxic chemicals in the state. Therefore, the legislature wrote into TURA a requirement that the Toxics Use Reduction Institute conduct studies on this possibility and prepare two reports on "chemical restrictions". The first report -- *Toxic Chemical Management in Massachusetts: An Analysis of Further Chemical Restriction Policies* -- was completed by the Institute and submitted to the Administrative Council on Toxics Use Reduction on January 1, 1993. During the Spring of 1993, the Administrative Council held two public hearings on the contents of that study.

The legislature went on to require a second report. By January 1, 1995, the Act required that,

> ...the institute will present to the council a further study on the Massachusetts experience with this chapter and how it relates to the issue of chemical restrictions.

The objectives of this report are derived from the language of the legislative mandate and from the comments put forward during the public hearings on the first report. Thus the objectives of this report are:

- to assess the Massachusetts experience with the state TURA program and how it relates to chemical restrictions
- to deepen the economic and policy analyses put forward in the first report
- to re-examine the issue of further chemical restrictions in light of this analysis

The Massachusetts Experience with Regards to Chemical Restrictions

In this report the Massachusetts experience with the TURA program and how it relates to chemical restrictions is assessed from the perspective of the two principal actors involved in implementing the Act: government and industry.

From the perspective of the principal government agencies responsible for implementing TURA -- Department of Environmental Protection (DEP), Office of Technical Assistance (OTA), and the Institute -- the program has met with both successes and shortcomings. Successes include 170 multi-media inspections by DEP, 750 on-site technical assistance visits by OTA, and 578 toxics use reduction (TUR) planners graduated from the Institute's toxics use reduction planning course. Shortcomings include a slow start up of the TURA program, reduced funding appropriation during the first two years, and an absence of effective coordination.

TURA does not require nor provide the authority to the TURA agencies to eliminate the use of toxic chemicals (that is, to carry out chemical restrictions). The Act does not require the state to set priorities among toxic chemicals, to assess the costs and benefits of restrictions, nor to coordinate activities among agencies to work towards the elimination of priority chemical.

Evaluating the experience of Massachusetts industry with TURA and relating it to chemical restrictions suffers from the same challenge of relating the work of the TURA-related agencies to chemical restrictions: TURA contains no language for restricting toxic chemicals. The principal goal of TURA that relates to industry focuses on byproduct reduction, whereas chemical restrictions are focused on eliminating the uses of priority chemicals. Thus two separate approaches are used to analyze industry's experience with TURA and to relate industry's experience to chemical restrictions.

The "priority chemical approach" analyzes industry's experience in reducing chemicals listed by the US Environmental Protection Agency, Swedish Government, and Montreal Protocol as priority chemicals. The results from the priority chemical approach indicate that total use and byproduct generation are declining for most of the 16 chemicals analyzed. Generally, byproduct reduction is declining faster than total use reduction (which is consistent with the goals of TURA). The Montreal Protocol chemicals show the greatest percentage decline for total use and byproduct generation. Of the 16 chemicals analyzed, only lead and lead compounds increased in both total use and byproduct generation.

The "state-wide goal approach" analyzed industry's experience in reducing total use and byproduct generation of all of the initial TURA chemicals. The results from the state-wide goal approach indicate that total use and byproduct generation are declining state-wide, with a much greater percentage decline in byproduct reduction than in total use reduction.

Economic and Policy Analyses of Chemical Restrictions

Comments received during the public hearings on the first chemical restriction report called for more detailed cost-benefit analyses. In response, cost-benefit analyses is performed on two chemicals being phased-out in Sweden. Due to the difficulty and lack of quantitative data on the health benefits of a restriction, the health benefit analyses is based on qualitative data.

The economic cost analyses reveal that many firms plan to eliminate, or reduce below 10,000 pounds, their use of the chemicals by the year 2000. The year 2000 was chosen as the point of implementing a chemical restriction because it was assumed that any restriction policy would provide firms with the needed time to phase-out the targeted chemicals and phase-in safer alternatives.

The potential impacts of restricting both chemicals, trichloroethylene (TCE) and cadmium, are analyzed based on worst case and best case scenarios. In the best case scenario for TCE all companies are able to adapt to changes in production and sales, with some even saving money. In the worst case scenario for TCE all companies incur costs and some companies (one to four) would be forced to relocate all or parts of their facilities.

In the case of cadmium, all companies plan to use less than 10,000 pounds by 2000 and all but two of the companies currently using cadmium plan on eliminating their use of it by 2000. In the best case scenario the two companies still using cadmium would eliminate their use by developing or finding adequate alternatives. In the worst case scenario the two companies would not develop or find adequate alternatives and would be forced to relocate.

The "policy analyses" assessed the existing models for restricting toxic chemicals and the policy options available to the state. The three existing restriction models analyzed were the Toxic Substances Control Act (TSCA), the Swedish Sunsetting Program, and the Montreal Protocol. Generally, the most successful restriction model is the Montreal Protocol and the least successful is the TSCA program. The Montreal Protocol is unique because it is an international agreement. Thus all companies bear the costs of switching to safer alternatives. While the Montreal Protocol has a clear mandate for chemical restrictions (eliminating ozone depleting chemicals) the use of TSCA for restricting chemicals suffers from the Act's broad and often times conflicting mandate.

The Swedish Sunsetting Program also has the potential for success because it includes joint industry-government efforts, the use of an array of policy tools (e.g., voluntary and mandatory policies), and realistic time frames for phasing-out the targeted toxic chemicals and phasing-in the safer alternatives.

The policy options available to Massachusetts include 1) do nothing more, 2) promote federal initiatives, 3) implement a "toxic chemical transition process" or a more "streamlined" chemical restriction process.

Re-examination of Chemical Restrictions

The analyses of the Massachusetts experience with TURA indicate an effective state toxics use reduction program with significant reductions occurring in byproduct reduction. Total use is also declining, though at a much slower rate than byproduct generation. The most dramatic reductions in total chemical use and byproduct generation occurred with the Montreal Protocol chemicals.

The analysis also clearly shows that TURA is not synonymous with chemical restrictions. Chemical restrictions represent a narrower approach targeted at eliminating the total use of specific chemicals. The TURA program is not designed to restrict chemicals, nor has it done so.

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CHAPTER 1 INTRODUCTION

1.1 Introduction to the Second Report

The United Nations Conference on Environment and Development convened in Rio de Janeiro in 1992 focused on the dual needs to promote global economic development and environmental protection. The Conference and the Agenda that was prepared as a declaration of the conference committed the participants to a new era of sustainable development that would meet the needs of the present without compromising the ability of future generations to meet their own needs.

The assumption that underlies this concept of sustainable development merges the traditional duality of economic development and ecological integrity into the single idea that development can be achieved through environmentally-conscious industry and clean production. Such a commitment requires the design of production systems that are efficient in the use of materials and energy, that reduce waste and prevent pollution at the source, and that produce products that are environmentally compatible in their use and disposal.

In 1989, the Massachusetts legislature passed a new law to do just that. The Toxics Use Reduction Act of 1989 (hereafter referred to as "TURA") established a new set of responsibilities on business and government. Firms that used toxic chemicals are required to report on their use and prepare plans to demonstrate how they would reduce or eliminate the use of those chemicals or the toxic waste generated by the use of those chemicals. New government agencies were established such as the Office of Technical Assistance (OTA) and the Toxics Use Reduction Institute (TURI), and the Department of Environmental Protection (DEP) was required to reorganize and re-establish its priorities, This was all to be implemented with the intention of promoting a safer environment and a better business climate by focusing on solving the problems caused by the use of toxic chemicals or by their release to the environment.

Yet, the legislature recognized that other policies, beyond the scope of toxics use reduction (TUR), might be necessary to reduce the risks of toxic chemicals in Massachusetts. Therefore, the legislature wrote into TURA a requirement that the Toxics Use Reduction Institute conduct studies on this possibility and prepare two reports on "chemical restrictions". The first report was to be,

...a detailed study on potential restrictions on the use of chemicals in the commonwealth. The study shall include, but not be limited to existing national and international experiences with restrictions; the social, environmental and economic costs and benefits of adopting chemical restrictions, the potential for restrictions in Massachusetts, and how a restrictions program could be implemented.

This study -- *Toxic Chemical Management in Massachusetts: An Analysis of Further Chemical Restriction Policies* -- was completed by the Institute and submitted to the Administrative Council on January 1, 1993. During the Spring of 1993, the Administrative Council held two public hearings on the contents of that study. Summaries of that first report and the comments received during those two public hearings are presented in the next two sections.

The legislature went on to require a second report. By January 1, 1995, the Act required that,

...the institute will present to the council a further study on the Massachusetts experience with this chapter and how it relates to the issue of chemical restrictions.

Five years have now passed since the passage of the TURA. Much has changed during those years. In 1989, the Massachusetts economy was still relatively robust, the environment was a high priority for the general public and toxic chemicals were of great common concern. Since then, the state economy, particularly the industrial sector, has suffered. The singular focus on toxic chemicals has been broadened throughout the business, public interest and government communities to a consideration of the aggregate environmental effects of production (materials, energy, and labor) and the life cycle of products.

In addition, Massachusetts citizens have accumulated a reasonable period of experience with toxics use reduction. Well over 600 firms have reported on their use of toxic chemicals. Over 400 Massachusetts firms have used the professional services of the state Office of Technical Assistance. The Toxics Use Reduction Institute has graduated 548 toxics use reduction planners and the state has certified 300 professional planners. On July 1 of this past year 600 firms completed toxics use reduction plans and submitted plan summaries to the state.

It has been this experience, in particular, that motivated the legislature to seek a second report from the Institute. Recognizing that the TURA program might have a significant effect on the use of toxic chemicals and the generation of toxic chemical wastes, the legislature required that two years after the Administrative Council first consider further chemical restrictions, that the Institute prepare a second report for the Council's consideration.

This, then, is that report.

1.2 Summary of Findings from the First State Report

Before moving to a detailed consideration of the Massachusetts experience with TURA and the implications for further chemical restrictions it is useful to briefly reconsider the findings of the first report and the comments that report generated.

While the findings in the first report are important to fully understand the analysis presented in the second report, this report will not re-present all of the data and analysis included in the first report. Such redundancy appears unnecessary. A careful reader may wish to contact the Institute for a copy of the first report.[1] For purposes here, only a brief summary will be provided.

The first report began with an examination of the use toxic chemicals in Massachusetts by presenting data on toxic chemical emissions, hazardous waste generation, toxic chemicals found in drinking water, coastal areas, and surface waters and reviewed the incidence of acute and chronic health effects associated with toxic chemical exposure.

The report went on to define a "toxic chemical restriction" as:

> Any policy that encourages or directs a company to reduce or eliminate production, uses, or distribution of a chemical (or class of chemicals) or product which contains the chemical.

The study presented six case studies of government initiatives to restrict the use of chemicals: carbon tetrachloride, DDT, ethylene dibromide, polychlorinated biphenyls, ozone depleting substances, and urea-formaldehyde foam insulation. In an effort to examine the effects that a chemical restriction might have on Massachusetts firms, the study included analyses of two specific chemicals used in Massachusetts and plotted the effects of any restriction on their use.

In examining the existing legal authority that the state had to restrict chemicals of concern, the report identified a fragmented and limited set of responsibilities and authorities. Specifically,

- The state has several laws which would authorize an agency to restrict hazardous household products, pesticides and chemicals by firm. The authorities of the state are spilt among the Departments of Environmental Protection, Public Health, Food and Agriculture, and Labor and Industries. But these authorities to restrict chemical usage, production or distribution are either limited in scope or ambiguous in the extent of their authorization of decisive regulatory action.

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[1] Ask for Mark Rossi and Ken Geiser, *Toxic Chemical Management in Massachusetts: An Analysis of Further Chemical Restriction Policies*, Toxics Use Reduction Institute, Lowell, MA, 1993.

- The state Toxics Use Reduction Act provides indirect opportunities for restricting toxic chemical use, but nowhere does it offer a clear state mandate for chemical restrictions.

- There is no formal, systematic process for guiding state action in restricting toxic chemicals. Although various state agencies could perform such a role, no state agency has a directive calling for a comprehensive review of toxic chemicals in order to set priorities for targeting chemicals and considering the social and economic effects of restricting those chemicals.

- With the exception of the limited research program of the Toxics Use Reduction Institute and the technical assistance of the Office of Technical Assistance, no state authority is seeking out and promoting substitutes for toxic chemicals that may be considered for restrictions.

The report then went on to identify a range of policy options that the state might adopt as instruments for restricting toxic chemical use. These policy options ranged from voluntary to market-based, to mandatory reporting, registration, regulations and, ultimate bans.

Finally, the report presented a four stage "toxic chemical transition process" that would progressively lead from the identification of chemicals of concern to the eventual phase-out and substitution of safer alternatives using several voluntary and mandatory instruments.

Stage One: Pre-screening. During this phase the state would identify a list of "priority toxic chemicals" using several different data sources and scientific and public input.

Stage Two: Promotion. During this phase the state would promote the reduction in use of chemicals on the priority list through the use of different voluntary, economic, reporting and planning incentives. Potential substitutes would be identified and research would be conducted to advance technologies that would assist users make transitions to safer substitutes.

Stage Three: Screening and Validation. The list of priority chemicals would be screened during this phase for more aggressive phase-outs, full impact analyses would be conducted to document the costs and benefits of such phase-outs, and mitigative measures would be identified to reduce the identified costs.

Stage Four: Reduction and Cessation. During this final phase those chemicals that remained after screening and impact analysis would be targeted for scheduled reduction programs leading to a cessation in use either by voluntary or legally mandated policies.

These stages encompass the elements needed to implement a chemical restriction policy: the identification of priority chemicals, the benefits and costs of such a policy, the policy options to be employed (such as voluntary or mandatory policies), and the "structure" of those policies (such as emphasizing the need for a transition period for firms to change production practices and the need for phasing-in safer alternatives).

The study closed with some recommendations on how the state might proceed with such a toxic chemical transition process with or without new legislation.

1.3 Summary of Comments from the Public Hearings

Following the release of the first state report, the Administrative Council held two public hearings -- one in Boston and the other in Springfield -- to collect and assess public reaction to the findings of the report. At these hearings a total of ten individuals testified and six of these presenters submitted written testimony.

The comments received broke fairly clearly into two perspectives representing the views of industry and the views of the public interest community.

Industry representatives argued in common that there was no justification for further chemical restrictions. Arguments were made that showed a decline in problems with toxic chemicals or, at least, called for more research and a full risk assessment before further consideration of chemical restrictions was warranted.

Industry representatives also argued that the study focused too heavily on mandatory policies, did not adequately consider voluntary policies and was flawed by not including more adequate cost-benefit analyses. While industry testimony found fault with the proposed 'toxic chemical transition process", there was a general consensus that the authority to phase-out chemical use was more appropriately a federal responsibility and that the Institute might better encourage a reform of the federal Toxic Substances Control Act.

Industry representatives suggested that:

- more attention should be paid to voluntary policy options
- federal Toxics Release Inventory data should be better reviewed
- the problems of mandatory chemical restrictions should be further developed
- better economic analyses should be developed
- chemical phase-out programs should not be promoted

The responses received from the public interest representatives were often quite to the contrary. The public interest representatives did see the current condition of toxic chemical use in Massachusetts as a problem serious enough to warrant more severe restrictions. These representatives were quite skeptical of voluntary programs and argued that the report had not been strong enough in promoting mandatory policy options. The public interest representatives did agree with the industry representatives that the proposed "toxic chemical transition process" was too bureaucratic and too process oriented. Instead, some speakers from the public interest argued that the Institute should simply put forward a list of chemicals to be phased-out.

The public interest representatives offered several recommendations including:

- national and international data should be used to identify target chemicals
- restrictions should be mandatory rather than voluntary
- a "short list" of chemicals should be identified for phase-out
- a less cumbersome chemical transition process should be developed that would expedite action
- a State Board of Toxic Chemical Management should be established with wide citizen participation

In summary, the key issues raised were: 1) whether a chemical restriction is needed in Massachusetts, 2) what would be the costs and benefits of such a restriction policy, 3) what chemical restriction policy options are appropriate for Massachusetts, and 4) what should be the structure of such a chemical restriction policy.

1.4 Objectives of this Report

The objectives of this report follow directly from the language put forward in TURA, but also respond to the comments put forward regarding the first report. Thus the objectives of this report are:

- to assess the Massachusetts experience with the state TURA program and how it relates to chemical restrictions
- to deepen the economic and policy analysis put forward in the first report
- to re-examine the issue of further chemical restrictions in light of this analysis

Meeting this first objective is challenging because the first report demonstrates that TURA does not provide the authority for chemical restrictions. TURA does not contain the legal authority to ban or phase out toxic chemicals, nor does it contain a list of priority toxic chemicals for toxics use reduction or language requiring a TURA agency to develop a priority list.

Meeting the second objective requires gathering more detailed economic and policy data and analyzing the data in regards to the comments received during the public hearings. The result is a much more detailed and sophisticated analysis of the potential economic effects and policy options associated with a chemical restriction.

This report has been written to present a coherent coverage of these three objectives. It can be read as a single document. However, this report does not attempt to re-examine all of the material developed in the first state report. That report still stands on its own merits and, while this report expands on the first report, it does not contradict or correct the findings in the first report. A careful reader may wish to read (or re-read) the first state report first in order to fully understand the arguments put forward in this report.

1.5 Organization of the Report

This report is bounded by an Introduction that notes the context and purpose of the report and briefly reviews the first report and the comments it received, and a Conclusion that provides some general final remarks. The report is organized into five substantive chapters that flow from an analysis of the current Massachusetts experience with the toxics use reduction program to a description of the range of policy options that could be adopted in Commonwealth:

- Chapter 2 describes the experience of the Massachusetts government agencies in implementing the state toxics use reduction law with regards to chemical restrictions.

- Chapter 3 uses the Massachusetts TURA data and program record to identify the experience of the state's industries in implementing the toxics use reduction program in regards to chemical restrictions.

- Chapter 4 presents an analysis of the potential economic effects of further chemical restrictions by analyzing the projected effects generated by potential restrictions on two specific chemicals.

- Chapter 5 reviews three models of chemical restrictions that were briefly described in the first report, but are more fully developed here.

- Chapter 6 presents an analysis of potential policy options for Massachusetts.

While this report is the last of the two chemical restriction reports required of the Institute by the legislature, it does not represent the final word on the subject. The issue of better toxic chemical management in Massachusetts will not evaporate with this report. While various parties in the state will continue to disagree on what needs to be done and, in particular, on what role state government should play, the need for a better coordinated and preventive approach to toxic chemical management remains significant.

CHAPTER 2 MASSACHUSETTS GOVERNMENT'S EXPERIENCE WITH THE TOXICS USE REDUCTION ACT

The Massachusetts "experience" with TURA can be described and evaluated from the perspective of the two principal actors involved in implementing the Act: industry and government. The roles of the two sectors differ with regards to implementing the Act. The Commonwealth of Massachusetts is responsible for facilitating, promoting, assisting in, and, if necessary, requiring the implementation of toxics use reduction programs in the private sector facilities. The State is also required to reorganize its structures and promulgate the regulations through which firms implement reporting and planning. The firms (often referred to as "large quantity toxics users" or "TURA filers") are responsible for implementing toxics use reduction programs in their facilities and meeting the data requirements of the Act.

To evaluate the experiences of government and industry with TURA, a set of criteria is needed for making this comparison. TURA provides these criteria in the form of six policy goals stated in the preamble of the Act:

1. To establish for the Commonwealth a statewide goal of reducing toxic waste generated by fifty percent (50%) by the year 1997 using toxics use reduction as the means of meeting this goal;
2. To establish toxics use reduction as the preferred means for achieving compliance with any federal or state law or regulation pertaining to toxics production and use, hazardous waste, industrial hygiene, worker safety, public exposure to toxics, or releases of toxics into the environment and for minimizing the risks associated with the use of toxic or hazardous substances and the production of toxic or hazardous substances or hazardous wastes;
3. To sustain, safeguard and promote the competitive advantage of Massachusetts businesses, large and small, while advancing innovation in toxic use reduction and management;
4. To promote reductions in the production and use of toxic and hazardous substances within the Commonwealth, both through the programs established in section three of this act and through existing toxics-related state programs;
5. To enhance and strengthen the enforcement of existing environmental laws and regulations with the Commonwealth; and
6. To promote coordination and cooperation between all state departments and agencies administering toxics-related programs.

These goals form the basis for describing and evaluating the Massachusetts experience for each sector. The first goal--the statewide reduction goal--commits both industry and government to a common purpose. The last five goals affect industry, but are directed at government and its agencies. TURA provides no priorities among the goals. Thus, all of the policy goals are assumed to be of equal importance.

2.1 Limitations in the Language of the Law

In directing the Institute to study the Massachusetts experience with toxics use reduction in regards to chemical restrictions, TURA creates a great difficuly. The Massachusetts Toxics Use Reduction Act was drafted and enacted to promote toxics use reduction. The act was not written to be a chemical restrictions law. The idea of providing more authority to the state to ban and phase out selected toxic chemicals was considered by those drafting the law and negotiated out of the law. The directive to the Institute to prepare two reports on the subject was a direct result of those negotiations.

As defined in the first report, a toxic chemical restriction is:

> Any policy that encourages or directs a company to reduce or eliminate production, uses, or distribution of a chemical (or class of chemicals) or product which contains the chemical.[1]

Toxic chemical restrictions are targeted at chemicals that pose threats to human or environmental health. The goal of a chemical restriction is to remove some or all uses of a chemical from the market. The potential advantage of a chemical restriction is that it removes the chemical of concern -- or, as is typical, removes key uses -- from the market. The potential disadvantages of chemical restrictions include negative economic effects, failure to promote safer alternatives, being implemented in a crisis atmosphere, and lack of comprehensiveness.

Although Section 10 of the law does require firms to report on toxic chemical use and Section 11 requires firms to prepare plans for reducing the use of toxic chemicals or the generation of hazardous wastes there is no formal requirement to limit or curtail chemical production or use. Firms remain free to continue to produce or use toxic chemicals, to generate toxic wastes, and to set goals for reduction if and as they wish.

Under Section 14 the state is granted the authority to establish "user segments" made up of classes of toxic chemical users that have certain production characteristics in common, and, under Section 15 the state is given the authority to set performance standards for these various user segments that may include a specified level of byproduct generated per unit of product. Although such a specified level of byproduct generation may result in the elimination of the use of a priority chemical, this performance standard is not a formal

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[1]Rossi and Geiser, *Toxic Chemical Management in Massachusetts*, 1993, p. 38.

chemical restriction as defined in the first state report and as noted in Chapter 1 of this report.

Thus, while TURA is properly seen as a law to promote the reduction in the use of toxic chemicals and the generation of toxic wastes it does not provide for state restrictions on the production or use of toxic chemicals.

The law does not require the state to:

- set priorities among toxic chemicals,
- conduct risk assessments on toxic chemicals,
- assess the economic effects of reducing the use of toxic chemicals or the generation of toxic wastes,
- assess problems associated with toxic chemicals in products,
- identify safer chemical or process substitutes for toxic chemicals, or
- establish a coordinated or integrated approach for the various state agencies to work towards the elimination of use of priority chemicals,

Because the law does not require the state to carry out any of these functions, the TURA program has not been directed towards the restrictions of any toxic chemical currently used in Massachusetts.

2.2 Assessment of Government Activities

The Toxics Use Reduction Act had a significant impact on the Massachusetts state government.[1] New institutions were established including the Administrative Council on Toxics Use Reduction, the Advisory Board on Toxics Use Reduction and the Toxics Use Reduction Institute and existing institutions were reorganized to create the Office of Technical Assistance in the Executive Office of Environmental Affairs and the Bureau of Waste Prevention in the reorganized Department of Environmental Protection. Toxics use reduction was established as the priority approach for state enforcement of regulatory compliance and hundreds of state regulatory inspectors and environmental program administrators have been trained in the concepts of toxic use reduction.

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[1]Information presented in this section is derived from the *Annual Report of the Massachusetts Administrative Council on Toxics Use Reduction*, unpublished draft, Boston, MA, September 20, 1994

The Bureau of Waste Prevention in the state Department of Environmental Protection has engaged in a major reorganization aimed at integrating a multi-media and pollution prevention approach to all of its enforcement efforts. Through a special program called Waste Prevention FIRST the department has sought to integrate comprehensive, multi-media approaches into all of its inspections. During 1993 the Department conducted 170 FIRST inspections of firms reporting under TURA.

The Bureau has promulgated five sets of regulations that have served to guide the reporting and planning requirements of the law. Since 1990 the Department has collected the data from the annual reports of the 566 to 681 firms filing under TURA. This data has been integrated into the Department's comprehensive Facility Master File data base and beginning in 1993 the Department has released annual reports based on these data. During the first two years of reporting many firms had difficulty in completing the reporting forms adequately. During both years the Bureau conducted follow up activities with nearly 80 percent of the reporting firms in order to effectively qualify the data.

The Office of Technical Assistance has organized its services into four regional teams that have provided over 750 specifically tailored technical assistance on site visits to over 400 Massachusetts firms during the past four years. The office prepared a special self-help manual on toxics use reduction, printed up 23 short case studies on Massachusetts firms' experience with toxics use reduction, and sponsored over 150 workshops and conferences that have attracted over 4500 attendees. The office has also provided toxics use reduction workshops for over 500 federal, state and local inspectors. In 1992 the Office prepared a special training package on costing and financial analysis. In addition to its regional services the Office has implemented specially targeted projects in the Blackstone Valley region and in the Merrimack Valley region.

The Toxics Use Reduction Institute has presented 22 toxics use reduction planner courses and graduated 578 planners, many of whom went on to pass the state certifying exam. Today there are 302 certified toxics use reduction planners in the state. A special graduate level course in toxics use reduction has been offered in the Engineering College at the Lowell campus over the past four years. The Institute has convened two major conferences on toxics use reduction and conducted focus groups on toxics use reduction in four different industrial sectors.

The research program at the Institute has supported 16 graduate Research Fellows over three years and provided matching funds for joint research programs with twelve Massachusetts firms implementing new toxics use reduction technologies. The Institute has set up a special Technology Transfer Center that has provided services to over 1600 individuals since 1991 and over 60 per cent of these individuals were employed in Massachusetts firms. The Institute's Surface Cleaning Laboratory which was opened less than a year ago has provided laboratory services to 23 Massachusetts firms.

Together in 1993, the three agencies launched a special one year program to assist firms in preparing high quality toxics use reduction plans due in July of 1994. This included a special planning newsletter, telephone outreach, regional technical assistance "clinics" and 36 public workshops attended by 438 participants representing 43 per cent of the firms reporting under TURA.

By July of 1994 the state's large quantity toxics users were required to prepare and certify toxics use reduction plans and submit plan summaries to the Department of Environmental Protection. The Bureau of Waste Prevention followed up on these plans with a sampled survey of 59 participating firms. The survey revealed that 96 percent of the firms had complied (or attempted to comply) with the planning requirement. Of the total 66 percent were in full compliance, 6 percent had incomplete plans, 9 percent had paperwork problems and 15 percent simply were late. Even more encouraging were the responses the Bureau received from the respondents. Of the respondents 77 percent thought that the planning process was useful while 92 percent reported that they expected to implement at least parts of their plan.

In overview, it appears that the law has had a significant impact on state government and that the operating agencies that have been reorganized or created to implement the law have implemented aggressive programs to require, encourage and assist firms in implementing toxic use reduction programs. Yet, it is important to note that the program is still in process of developing. Toxics use reduction plans were just completed in the summer of 1994. It is only as of July of 1995 that the state can define "priority user segments" and promulgate performance standards. Thus, while four years have transpired since the program began, the full consequences of the program have yet to be felt.

While there is much to praise in the Massachusetts Toxics Use Reduction program, there are also some limitations. In regards to the concept of further chemical restrictions some of the limits are built into the language and intent of the law and some are located in the implementation of the program itself.

2.3 Limitations in Program Implementation

The state TURA program got off to a slow start. Some of this slowness had to do with state government limitations on hiring personnel during the program's first two years, Yet, the most significant limitations had to do with reduced funding appropriations during the first two years and the absence of an effective coordination capacity among the divisions due to the limited functioning of the Administrative Council on Toxics Use Reduction. During 1994 two public interest organizations released reports that, while supportive of the TURA program in general, identified specific weaknesses in the implementation and management of the program.[1]

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[1]See Paul Burns and Hillel Gray, *Tracking the Toxics Crisis: A Call for State Action on Toxics Use Reduction*, Massachusetts Public Interest Research Group and the National Environmental Law Center, Boston, MA, January, 1994; and James R. Gomes, *Halfway to ...Where? A Report on the Implementation of the Massachusetts Toxics Use Reduction Act*, Environmental League of Massachusetts Education Fund, Boston, MA, May, 1994.

Although the program achieved adequate revenue for initial program development from the first year forward, the level of appropriation was less than the generated revenue. Not only did this slow the early start of the program, but it created a surplus in the program fund that became a contentious symbol among the contributing firms of the lack of state commitment towards the program.

The absence of an effective agency coordinating capacity left the participating agencies with voluntary liaison efforts, but no central guidance authority for the program as a whole. Beginning in late 1993, the Administrative Council began a new era of activism and during 1994 the Council was significantly augmented by the hiring of an Executive Director.

In regards to restrictions on toxic chemicals these conditions and the language of the law resulted in the following:

- the TURA program has not prioritized the chemicals that are found on its broad list of "Toxic or Hazardous Substances" in terms of risk, exposure, endangerment, ease of substitution, criticalness to the state economy, or any other appropriate criteria,
- the TURA program has not coordinated or integrated its technical, research or educational services in an effective approach towards a priority list of chemicals, industries or processes,
- although the reporting and planning requirements written into TURA and the annual fee firms pay when they file their reports do create disincentives to the use of the listed toxic chemicals these requirements are not intended to formally restrict the use of toxic chemicals, and
- while the TURA program has developed a collection of case studies that have achieved substantial savings from implementing toxics use reduction programs, there has been no state wide assessment of the economic effects of reducing the use of those chemicals that have been reduced.

While these limitations potentially have curtailed some of the TURA program effectiveness with regards to the stated goals of the law, they specifically have limited the role of the law in promoting toxic chemical restrictions. Whether by limitations intentionally written into the language of the law or by limitations in the implementation of the TURA program, TURA has not resulted in any legal or programmatic restriction in the use or production of any toxic chemical in Massachusetts.

2.4 Summary

This brief review of the government experience reveals that there has been a significant amount of program activity. Although the program got off to a slow start the implementing agencies have completed most of their mandates. While there have been some problems in full program coordination due to the limited functioning of the Administrative Council this has recently been corrected. The program has met with high levels of industry compliance and there exists a substantial amount of interaction between the state agencies and a large number of the reporting firms.

The reporting and planning requirements and the annual fee paid by firms that use toxic chemicals results in substantial incentives for reducing the use of toxic chemicals. Indeed, the services of both the Office of Technical Assistance and the Institute are focused on assisting firms in reducing the use and waste generated by the use of toxic chemicals. The Office of Technical Assistance has documented many examples of firms eliminating the use of targeted toxic chemicals. In fact, there are over 50 firms that have stopped reporting under TURA and many of these have done so by substituting technologies or materials and, thereby, reducing or eliminating the use of targeted toxic chemicals.

But, the incentives affecting chemical use under TURA are economic or voluntary by design. Nowhere in the language or implementation of the law are firms required to eliminate the use of toxic chemicals. Neither the law nor its implementation mandates restrictions on the production or use of toxic chemicals.

Therefore, studying the Massachusetts experience with toxics use reduction with chemical restrictions poses a conceptual challenge. TURA requires that the Institute study the Massachusetts experience with the toxics use reduction program and "how it relates to the issue of chemical restrictions". But, TURA does not require Massachusetts firms to implement toxic chemical restrictions. The principal quantitative goal of TURA is to reduce byproduct generation by 50 percent. The goal of a toxic chemical restriction is "to reduce or eliminate production, uses, or distribution of a chemical (or class of chemicals)".
This creates a methodological problem. The Institute is required to study an "issue" that the law does not require to occur.

CHAPTER 3 MASSACHUSETTS' INDUSTRY EXPERIENCE WITH THE TOXICS USE REDUCTION ACT

Among Massachusetts firms there are many stories of successful implementation of toxics use reduction programs that have resulted in operational cost savings and dramatic reductions in chemicals released to the environment.

- The Robbins Company of Attleboro installed a closed-loop wastewater treatment and metal recovery system that reduced hazardous waste generation by 87 percent, reduced water usage by 47 percent and produced an annual operating savings of $71,000.

- The Lampin Corporation of Uxbridge replaced its chlorofluorocarbon (CFC) degreasing operations with a hot water washing process that improved cleaning efficiencies, created two thirds less sludge, and saved the firm $6,000 per year in CFC purchase costs alone.

- The Lowell Corporation added a dead-water rinse tank, drip boards and a drain rack to its zinc phosphating line at a nominal cost and cut zinc discharges by two thirds while producing a $26,000 per year savings.

- The Presmet Corporation of Worcester substituted a synthetic fluid for a sulphurized oil for use as a coolant in its honing processes and cut the firm's coolant purchase costs by two thirds, reduced dermatitis problems among its workers, and reduced its oily waste water discharges.[1]

These and many other anecdotal cases suggest that some Massachusetts firms are effectively implementing toxics use reduction programs. Yet, to present a comprehensive assessment of the experience of Massachusetts industry requires a review of the data reported by these firms over the four years of the program's implementation.

[1]All examples are from one page, case studies prepared by the Massachusetts Office of Technical Assistance. Additional case examples can be acquired by directly contacting the Office at 100 Cambridge Street, Boston, MA 02202.

3.1 Methodology

The goals of toxics use reduction and the goals of a chemical restriction policy are different. A study of the relationship between TURA and a toxic chemical restriction from the goal of a restriction policy requires examining whether total use of a priority chemical is being reduced (i.e., towards elimination of "production, use, and distribution"). A study of the relationship between TURA and a toxic chemical restriction from the statewide reduction goal of TURA requires examining whether or not byproduct is being reduced (i.e., towards the 50 percent reduction goal).

Under the first approach TURA can be related to chemical restrictions by evaluating the need for restrictions based on reductions in "priority" chemicals (hereafter referred to as the "priority chemical approach"). This approach flows from the definition of a chemical restriction policy, which emphasizes targeting priority chemicals or chemical classes for reduction or elimination of use (as opposed to byproduct). In the priority chemical approach the rationale is: if facilities are reducing "priority" chemicals then mandatory chemical restrictions are unnecessary, however, if facilities are not reducing priority chemicals then chemical restrictions are necessary. A key issue surrounding the priority chemical approach is identifying priority chemicals.

Under the second approach TURA can be related to chemical restrictions by evaluating the need for restrictions based on reductions in state-wide byproduct generation (hereafter referred to as the "state-wide goal approach"). This approach flows from one of the goals of TURA, which is to reduce byproduct generation by 50 percent. In the state-wide goal approach the rationale is: if Massachusetts facilities are meeting the 50 percent reduction in byproduct generation then chemical restrictions are unnecessary, however, if Massachusetts facilities are not meeting the goals of the Act then chemical restrictions are necessary.

Rather than choosing one approach as the "best" approach for analyzing how TURA relates to chemical restrictions this chapter examines the Massachusetts experience with TURA from the perspective of both approaches. In the priority chemicals approach the analysis is based on trends in total use and byproduct generation of priority chemicals. In the state-wide goal approach the analysis is based on trends in total use and byproduct generation of all TURA chemicals.

The objective of this chapter is to analyze the relationship between TURA and chemical restrictions based on these two different approaches. The basis of these analyzes is total use and byproduct generation data from the Massachusetts TUR reporting database.

3.2 The TURA Data

The analysis in this chapter is based on toxics use data collected by the Massachusetts Department of Environmental Protection (DEP) under TURA. TURA requires that all large quantity users of toxic chemicals file toxic chemical use and byproduct data with DEP. The reporting requirements relevant to evaluating industry's experience with TURA are described below.

All "large quantity users" of toxic chemicals must file chemical use data with the Massachusetts DEP under TURA. "Large quantity users" in 1989 were defined as:

- facilities with ten or more full-time employees
- facilities included in the Standard Industrial Classification (SIC) codes 2000-3999 (representing all manufacturing industries)
- facilities that manufactured or processed more than 25,000 pounds, or otherwise used more than 10,000 pounds, of a listed chemical in one calendar year

Beginning in 1991, the filing requirements under TURA were expanded beyond SIC codes 2000-3999 to include facilities in the following two-digit SIC codes:

10-14	Mining	50	Wholesale Trade -- Durable Goods
40	Railroad transportation	51	Wholesale Trade -- Non-Durable Goods
44	Water Transportation	72	Personal Services
45	Transportation by Air	73	Business Services
46	Pipelines, except natural gas	75	Auto Repair, Services, & Parking
47	Transportation Services	76	Miscellaneous Repair Services
48	Communications		
49	Electric, Gas, & Sanitary Services		

The list of chemicals facilities are required to report on also increased in 1991. Initially, facilities were required to report their use of all federal Emergency Planning and Community Right-to-Know Act (EPCRA) Section 313 chemicals above the thresholds of 25,000 pounds for manufactured or processed chemicals, and 10,000 pounds for otherwise used chemicals.[1] Beginning in 1991, the number of chemicals facilities are required to report on expanded to include all chemicals listed in sections 101 and 102 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, also popularly known as "Superfund"). The CERCLA chemicals were phased in over three years, 1991-1993.

The data that facilities file with DEP under TURA are submitted on a form called the "Form S". Under TURA, facilities must file a Form S and a "Form R" (facilities are required to file a Form R with the US Environmental Protection Agency on toxic chemical releases and transfers) for each chemical manufactured, processed, or otherwise used at a facility.

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[1]Reporting requirements are triggered at the same levels established under EPCRA (manufacture or process 25,000 pounds, or otherwise use 10,000 pounds per year). The one difference under TURA is that once reporting requirements are triggered a facility must report each TURA chemical that it manufactures or processes in amounts equal to or greater than 10,000 pounds. In other words, the reporting threshold for manufactured or processed chemicals drops from 25,000 pounds to 10,000 pounds once a facility is reporting under TURA for another chemical.

TURA data is divided into two major areas, facility-wide data and production unit data (see Figure 3.1 for a graphic illustration of the major Form S reporting requirements). Facility-wide data is submitted on a chemical-by-chemical basis and includes the following information:

- amount manufactured
- amount processed
- amount otherwise used
- amount generated as byproduct
- amount shipped in or as product

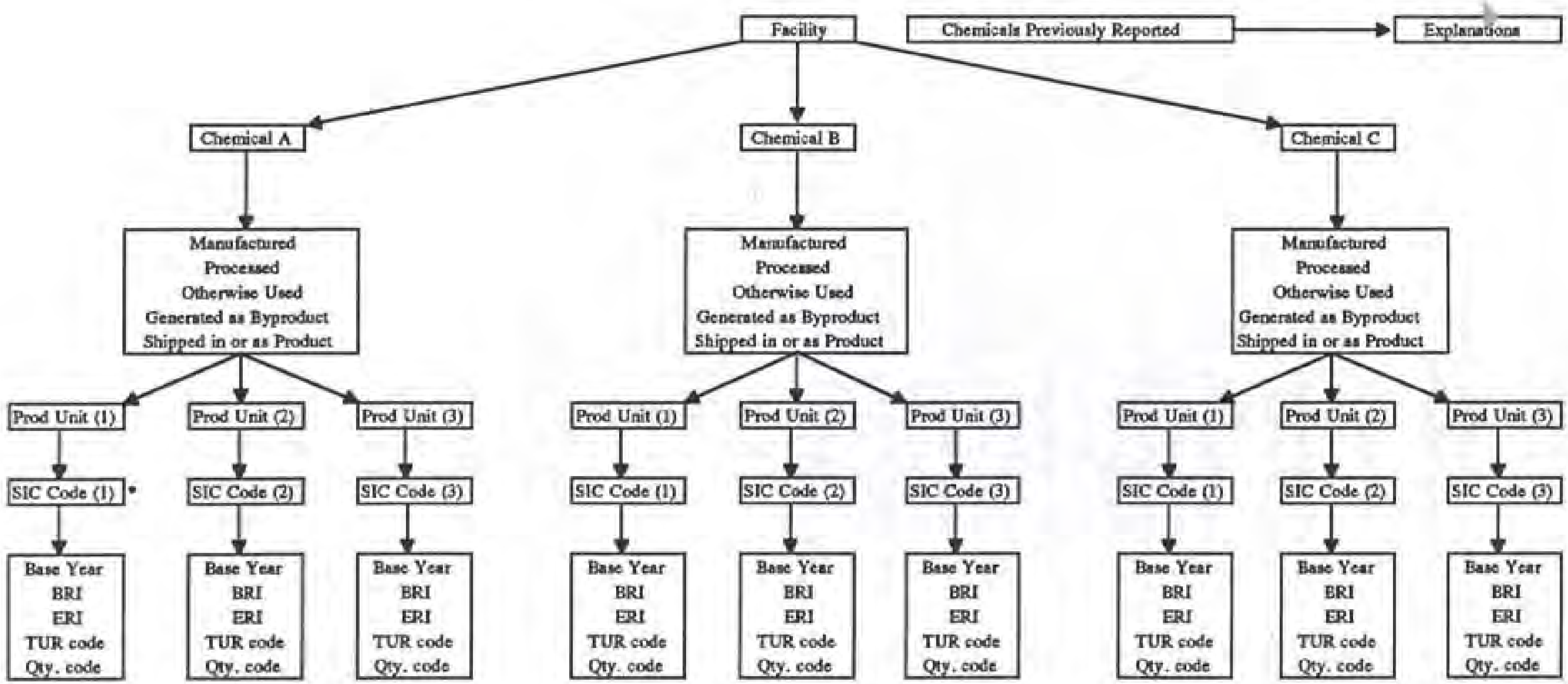
In addition to the required data, a facility can voluntarily include information on why chemicals reported in previous years are not reported in the current year. Specifically, the Form S includes six reasons why a chemical is no longer reported in the current year:

[1] chemical below reporting threshold but greater than 0
[2] no chemical usage in reporting year
[3] chemical substitution
[4] chemical eliminated (no substitution)
[5] decline in business
[6] other

Different data are reported at the "production unit" level. The production unit is a unique element of TURA. It was incorporated into the Act to encourage facilities to develop a more methodical understanding of how they use toxic chemicals and provide some of this information to the public. Specifically, TURA defines a production unit as follows:

> A process line, method, activity, or technique, or a combination or series thereof, used to produce a product.

FIGURE 3-1. GRAPHIC PRESENTATION OF THE MAJOR FORM S FILING REQUIREMENTS



* An SIC code is reported for each production unit (i.e. if two chemicals are reported for a single production unit, they will both be classified by the same SIC code).

For each production unit in a facility the following data is reported (many facilities have multiple production units):

- byproduct reduction index (BRI)
- emission reduction index (ERI)
- TUR technique code(s)
- quantity of chemical use code
- SIC code(s)
- production unit process description
- product description

The BRI is calculated from the following equation:

$$BRI = \frac{(Q_b/P_b) - (Q_n/P_n)}{(Q_b/P_b)} * 100$$

where:
Q_b = byproduct generated in base year
P_b = product produced in base year
Q_n = byproduct generated in reporting year
P_n = product produced in reporting year

Similarly, the ERI is calculated from the following equation:

$$ERI = \frac{(E_b/P_b) - (E_n/P_n)}{(E_b/P_b)} * 100$$

where:
E_b = emissions generated in base year
P_b = product produced in base year
E_n = emissions generated in reporting year
P_n = product produced in reporting year

"TUR technique codes" describe the types of TUR techniques implemented in a facility. TURA identifies and defines six TUR techniques:

1) improved operation and maintenance
2) input substitution
3) production unit modernization
4) production unit redesign or modification
5) product reformulation
6) recycling, reuse, or extended use.

These six techniques form the basis of a TUR technique matrix that is part of the Form S.

The "quantity of chemical use code" provides a rough indicator of the amount of a chemical used in a production unit. The Form S contains three codes, defined as follows:

A = greater than 0 pounds but less than or equal to 5,000 pounds
B = greater than 5,000 pounds but less than or equal to 10,000 pounds
C = greater than 10,000 pounds

The data used in this chapter are principally the facility-wide data on total use -- manufactured, processed, and otherwise used -- and byproduct generation. The production unit data are used to determine which chemicals are used in SIC codes 2000-3999 (see Figure 3.1) and to provide qualitative indicators of TUR activities.

One caveat must be made here prior to discussing the findings from the analysis of the TURA data. The TURA data, in particular the 1990 data, is filled with reporting errors, data entry errors, and data anomalies.[3] For example, in 1990, total cadmium use (excluding cadmium compounds) totaled 0.58 million pounds. For 1991, 1992, and 1993 total cadmium use never climbed above 0.12 million pounds. The company that accounted for over 0.4 million of the 0.58 million pounds never used over 0.1 million pounds after 1990. The discrepancy seems to be a reporting error. Therefore, it is prudent to view the TURA database as a rough guide of the quantity of toxic chemical use and byproduct generation in Massachusetts. As the TURA program matures the data will become, as it already is, more accurate.

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[3]Data input errors were identified in chemical quantities, BRI's and ERI's, TUR techniques codes and SIC codes. The percent error rate was fairly low (<0.1%). Measuring progress could be distorted by these errors for metrics which use a small number of data points (e.g., progress for one chemical in one SIC code), but is unlikely to be affected on the larger scale.

3.3 Toxic Chemical Restrictions and Reductions in "Priority" Chemicals

TURA requires that the Institute study the Massachusetts experience with the toxics use reduction program and "how it relates to the issue of chemical restrictions". As Chapter 2 clearly concludes, TURA does not require Massachusetts firms to implement toxic chemical restrictions.

Therefore, in order to meet the spirit of this requirement of the law, this section of the study will assess the Massachusetts experience in regards to lists of chemicals that might be the subject of chemical restrictions recognizing that Massachusetts firms have not been directed to restrict the production or use of the chemicals on these lists.

First, it is necessary to identify lists of chemicals that might be the subject of toxic chemical restrictions. As noted in Chapter 2 neither the Commonwealth nor any of the TURA agencies has developed a list of priority chemicals. In the absence of any toxic chemical management priorities in Massachusetts, three priority toxic chemical lists developed by other governments are used in this section to provide lists of chemicals for analysis. Two of the lists include chemicals that are targeted for phase-out: the Swedish "sunset chemicals" list and the Montreal Protocol list of ozone depleting chemical targeted for phase out. The third list is a set of chemicals the US Environmental Protection Agency (EPA) targeted for voluntary release reductions.

The toxic chemicals targeted for international phase-out by the Montreal Protocol include:

carbon tetrachloride
chlorofluorocarbons (CFCs)
1,1,1-trichloroethane (TCA)
halons

Sweden is pursuing a "multi-policy" approach (i.e., voluntary, economic, and mandatory policies) to reduce and phase-out the following thirteen chemicals[1]:

arsenic
brominated flame retardants
cadmium
chloroparaffins
creosote
dichloromethane
lead
mercury
noyl-phenol ethoxylates
organotin compounds
phthalates
tetrachloroethylene
trichloroethylene (TCE)

[1]The Swedish National Chemicals Inspectorate and the Swedish Environmental Protection Agency, *Risk Reduction of Chemicals: A Government Commission Report*, (Stockholm: Swedish National Chemicals Inspectorate), 1991.

The US EPA identified a list of seventeen chemicals that are targeted for reduction in their voluntary "33/50 Program"[1]. The "33/50" refers to the two goals of the program: a 33 percent reduction in releases by 1992 and a 50 percent reduction in releases by 1995 based on 1988 as the base year. The seventeen chemicals are:

benzene	methyl isobutyl ketone
cadmium & cadmium compounds	methyl ethyl ketone
carbon tetrachloride	nickel and nickel compounds
chloroform	tetrachloroethylene (perchloroethylene)
chromium & chromium compounds	toluene
cyanides	1,1,1-trichloroethane
dichloromethane (also known as methylene chloride)	trichloroethylene
lead & lead compounds	xylene
mercury & mercury compounds	

Since Massachusetts has not identified priority chemicals for reduction, these three lists of chemicals are used in this chapter as proxies for a Massachusetts priority list.

The three lists together total 34 chemicals or families of chemicals. Eight chemicals are "duplicates" because they are included on two lists (1,1,1-TCA, cadmium, carbon tetrachloride, dichloromethane, lead, mercury, tetrachloroethylene, and TCE). Another ten chemicals were not used in large quantities (over 10,000 pounds) in Massachusetts (benzene, brominated flame retardants, carbon tetrachloride, chloroform, chloroparaffins, creosote, halons, mercury, nonyl-phenol ethoxylates, and organotin compounds).

Since the mandated purpose of this report is to focus on the Massachusetts experience with TURA, these chemicals are excluded from analysis because they are outside of the scope of TURA. This leaves a priority list of 16 chemicals for analysis which includes:

arsenic compounds	methyl isobutyl ketone
cadmium and cadmium compounds	nickel and nickel compounds
chlororfluorocarbons (CFCs)	phthalates
chromium and chromium compounds	tetrachloroethylene
cyanide compounds	1,1,1-trichloroethane
dichloromethane	trichloroethylene
lead and lead compounds	toluene
methyl ethyl ketone	xylene

Tables 3.1, 3.2 and 3.3 demonstrate the trends in total use and byproduct generation for this amalgam priority list of 16 chemicals. The chemical amounts listed in these tables were used

[1]U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, *33/50 Program Company Profiles: Reduction Highlights*, EPA 745-K-94-017, Washington, D.C., October, 1994.

by facilities in SIC codes 2000-3999. Uses in other SIC codes were excluded so that the 1990 to 1993 comparison would be based on the same universe of facilities (i.e., those between SIC codes 2000 and 3999). All chemicals were reported on beginning in 1990.

TABLE 3.1 TRENDS IN TOTAL USE AND BYPRODUCT GENERATION: THE SWEDISH PRIORITY CHEMICAL LIST

Chemical	Category	1990 (thousand lbs)	1993 (thousand lbs)	Percent Change
Arsenic Compounds	total use	374.3	525.9	41
	byproduct	1.4	0.5	-64
Cadmium and Cadmium Compounds	total use[1]	852.9	259.3	-70
	byproduct	27.7	18.1	-35
Dichloro-methane	total use	6,884.4	6,366.2	-8
	byproduct	2,161.8	2,917.6	35
Lead and Lead Compounds	total use	6,993.8	8,912.6	27
	byproduct	419.5	501.4	20
Phthalates[2]	total use	17,092.8	20,624.3	21
	byproduct	250.2	232.7	-7
Tetrachloro-ethylene	total use	991.4	1,199.8	21
	byproduct	401.0	239.5	-40
Trichloro-ethylene	total use	3,567.1	4,483.9	26
	byproduct	2,326.8	1,754.4	-5

[1]Cadmium use in 1990 was atypically much higher than all the other years. A detailed review of the cadmium data indicates a potential reporting error. One firm in 1990 reported a one time use of cadmium of over 400,000 pounds. In 1991-1993 the firm never reported cadmium use greater than 100,000 pounds.
[2]"Phthalates" = butyl benzyl phthalate, butyl phthalate, diethyl phthalate, diethylhexyl phthalate, dioctyl phthalate, and phthalic anhydride.

TABLE 3.2 TRENDS IN TOTAL USE AND BYPRODUCT GENERATION: THE MONTREAL PROTOCOL PRIORITY LIST

Chemical	Category	1990 (thousand lbs)	1993 (thousand lbs)	Percent Change
CFCs (Freon 113)	total use	4,295.9	1,442.6	-66
	byproduct	2,433.4	615.6	-75
1,1,1-Trichloro-ethane	total use	15,987.5	6,740.2	-58
	byproduct	5,243.9	1,189.2	-77

TABLE 3.3 TRENDS IN TOTAL USE AND BYPRODUCT GENERATION: THE "33/50" PRIORITY LIST

Chemical	Category	1990 (thousand lbs)	1993 (thousand lbs)	Percent Change
Chromium and Chromium Compounds	total use	15,868.1	14,077.0	-11
	byproduct	2,456.0	1,413.0	-42
Cyanide Compounds	total use	168.4	122.3	-27
	byproduct	143.7	106.3	-26
Methyl Ethyl Ketone	total use	20,591.4	13,675.3	-34
	byproduct	12,284.4	9,541.4	-22
Methyl Isobutyl Ketone	total use	1,540.1	963.0	-37
	byproduct	227.4	208.3	-8
Nickel and Nickel Compounds	total use	16,351.4	18,865.5	15
	byproduct	3,504.0	1,189.8	-66
Toluene	total use	40,931.4	24,121.3	-41
	byproduct	16,287.2	12,567.6	-23
Xylene[1]	total use	7,684.1	3,773.8	-51
	byproduct	1,443.4	1,777.0	23

[1]"Xylene" = para-xylene and mixed isomer xylene.

In general, the use and byproduct generation of these 16 chemicals declined over the 1990-1993 period in Massachusetts:

- total use increased for only six chemicals: arsenic compounds, lead and lead compounds, nickel and nickel compounds, phthalates, tetrachloroethylene, and trichloroethylene
- byproduct generation increased for only three chemicals: dichloromethane, lead and lead compounds, and xylene

The most significant reductions in both use and byproduct generation were made in the Montreal Protocol chemicals, CFC-113 and 1,1,1-TCA. This finding is not surprising, as the US is phasing-out CFC-113 and 1,1,1-TCA under authorization of the Clean Air Act Amendments of 1990. Massachusetts facilities have reduced their use and generation of both CFCs and 1,1,1-TCA by over 50 percent. No similar reductions were achieved during this time period for any of the other priority chemicals (see Table 3.4).

The use and byproduct generation of both cadmium/cadmium compounds and cyanide compounds were reduced by over 25 percent. Significant reductions were also made in the use and byproduct generation of MEK and toluene, and to a lesser extent of MIBK and chromium (see Table 3.4).

TABLE 3.4 SUMMARY OF CHEMICALS WITH REDUCTIONS OF BOTH TOTAL USE AND BYPRODUCT GENERATION (based on Tables 3.1, 3.2 and 3.3)

Chemicals with use and byproduct reductions >50%	CFCs 1,1,1-TCA		
Chemicals with use and byproduct reductions >25%	CFCs 1,1,1-TCA	Cadmium Cyanide	
Chemicals with use and byproduct reductions >15%	CFCs 1,1,1-TCA	Cadmium Cyanide	MEK Toluene
Chemicals with use and byproduct reductions >0%	CFCs 1,1,1-TCA Chromium	Cadmium Cyanide MIBK	MEK Toluene

Thus both total use and total byproduct decreased for eight of the chemicals examined here. For five of the remaining eight chemicals total use increased while byproduct decreased (see Table 3.5): arsenic compounds, nickel/nickel compounds, phthalates, tetrachloroethylene, and trichloroethylene. The trend for these five chemicals, increased use/decreased byproduct, is a positive change from a TUR perspective. Increased use/decreased byproduct is an indicator of increased efficiency (greater use, less byproduct) in the use of toxic chemicals (assuming no confounding factors are at play, such as plant closures). However, from a chemical restriction perspective increasing use runs counter to the goal of a restriction (which is both decreased use and byproduct generation). The increased use/decreased byproduct phenomenon is illustrative of 1) how the goal of TURA (reduction of byproduct) differs from the goal of a chemical restriction (elimination of some or all chemical uses) and 2) how TURA does not act as a chemical restriction law.

TABLE 3.5 SUMMARY OF CHEMICALS WITH INCREASES IN TOTAL USE AND DECREASES IN BYPRODUCT GENERATION (based on Tables 3.1, 3.2 and 3.3)

Chemical	Total Use Trend (1990-1993)	Byproduct Trend (1990-1993)
Arsenic Compounds	increase > 40%	decrease > 60%
Nickel/Nickel Compounds	increase = 15%	decrease > 60%
Phthalates	increase > 20%	decrease = 7%
Tetrachloroethylene	increase > 20%	decrease = 40%
Trichloroethylene	increase > 25%	decrease = 25%

The total use of the remaining three chemicals -- dichloromethane, lead/lead compounds, and xylene -- either increased or decreased while the byproduct generation increased. Both dichloromethane and xylene are anomalies from a TUR perspective because total use decreased while byproduct increased. This is an unusual occurrence because it is an indicator of increased inefficiencies in toxics use (in contrast to the chemicals listed in Table 3.4). More analysis is required to understand why these anomalies are occurring. Two potential explanations are that byproduct increased dramatically because of 1) closed-loop recycling or 2) reporting or data entry errors.

The only chemical class that experienced an increase in both total use and byproduct generation was lead/lead compounds. Lead/lead compounds along with dichloromethane and xylene were the only three chemicals whose byproduct generation increased over the four year period (see Table 3.6).

TABLE 3.6 SUMMARY OF CHEMICALS WITH LITTLE TO NO DECREASES IN TOTAL USE OR BYPRODUCT GENERATION (based on Tables 3.1, 3.2 and 3.3)

Chemical	Total Use Trend (1990-1993)	Byproduct Trend (1990-1993)
Dichloromethane	decrease = 8%	increase = 35%
Lead/Lead Compounds	increase > 25%	increase = 20%
Xylene	decrease > 50%	increase > 20%

In summary, the analysis of total use and byproduct trends for the proxy lists of priority chemicals reveals:

- the lack of a priority chemical list in Massachusetts
- the general trend towards both use and byproduct reduction, with the trend stronger in byproduct reduction than in total use reduction
- the significantly larger reductions in the Montreal Protocol chemicals for both use and byproduct

Despite, the lack of a priority chemical list, Massachusetts facilities are reducing their use and byproduct generation of toxic chemicals. A priority chemical list with targeted technical and financial assistance, however, may have led to overall reductions closer to those of the Montreal Protocol chemicals as well as to more uniform decreases across all chemicals. True to the goal of TURA, this analysis reveals that a TURA-oriented priority chemical program would most likely focus solely on byproduct generation. This would differ from a chemical restriction-oriented priority chemical program which would focus on both use and byproduct generation reductions.

3.4 Chemical Restrictions and the TURA Statewide Goal of 50 Percent Reduction

The second approach to relating the Massachusetts experience with TURA to chemical restrictions is to examine state-wide progress in all chemical use and byproduct generation. This approach is also somewhat presumptuous from the perspective of chemical restrictions because no one is proposing to restrict all toxic chemicals. Restrictions are targeted to specific chemicals or classes of chemicals of high public or environmental health concern. It could be argued, however, that a state-wide approach is relevant because progress in TUR eliminates the need for restrictions.

This section takes a first step at evaluating the progress Massachusetts firms are making towards the goal of a "50 percent reduction". As noted in Chapter 2, the preamble of TURA includes a goal of 50 percent reduction in toxic waste by 1997 (hereafter referred to as the "50 percent reduction goal"). The goal sounds straightforward. Unfortunately, developing a methodology for measuring a 50 percent reduction is a complicated task. No attempt is made here to develop the definitive methodology for measuring progress to the 50 percent reduction goal. The 50 percent reduction is raised here because it is one interpretation of how to evaluate whether or not restrictions are justified in Massachusetts. The purpose is to shed light on the state-wide quantitative chemical use and byproduct data and how it relates to chemical restrictions.

3.4.1 Methodology for Measuring Progress on the 50 Percent Reduction Goal

Developing a methodology for measuring the 50 percent reduction goal is a complicated task because:

1. the goal is stated differently at two points in the Act
2. the base year is set at 1987 yet state-wide use data is not reported under TURA until 1990
3. attributing reductions to TUR techniques is difficult

First, the 50 percent reduction goal listed in the preamble of TURA is ambiguous because the Act does not define the term, "toxic waste". "Toxic waste" can have many definitions. Two possible definitions of toxic waste are:

1. all wastes that meet the "listed" and "characteristic" hazardous waste definitions under the federal Resource Conservation and Recovery Act, or
2. all toxic chemicals that leave a facility as transfers or releases under the federal Emergency Planning and Community Right to Know Act.

Because of the ambiguity surrounding the term "waste" in the preamble, Section 13 of TURA provides more clarity as to what the framers of the law meant as an indicator of TUR progress. Section 13 defines the same quantitative goal as in the preamble, but with a little twist:

> ... to achieve by 1997, through toxics use reduction, a fifty percent (50%) reduction from 1987 quantities of **toxic or hazardous byproducts** generated by industry in the Commonwealth of Massachusetts [emphasis added].

In Section 13, "toxic waste" is replaced with "toxic or hazardous byproducts", which is a better indicator of toxics use reduction because byproduct, unlike waste, is defined in TURA. In Section 2 byproduct is defined in TURA as:

> All non-product outputs of toxic or hazardous substances generated by a production unity, prior to handling, transfer, treatment or release.

This might seem like a semantic nuance -- distinguishing between "byproduct" and "waste". However, these two terms are not synonymous and clarifying the differences determines what indicator(s) are used for measuring TUR progress.

Because the Act clearly defines "toxic or hazardous byproduct" and does not define "toxic waste", the Section 13 description of the 50 percent goal is considered in this report as the defining goal for measuring TUR progress.

Second, Section 13 of TURA sets the base year for measuring progress at 1987. However, TURA reporting data is only available beginning in 1990. The law provides no guidance in defining what data base is to be used to fill the data gap between 1987 and 1990. While this problem will need to be solved to fully evaluate the TURA program in 1997, for the more limited purposes of this study the TURA data from 1990 to 1993 will serve as an adequate data base for assessing the Massachusetts experience in regards to chemical restrictions,

Third, and quite challenging, is determining how to link changes in state-wide byproduct generation to toxics use reduction; the goal "is to achieve by 1997, through toxics use reduction, a fifty percent reduction". The challenge arises because toxic chemical use changes with the amount of product manufactured. The challenge is how to remove this confounding factor in the analysis, or in other words, how to "normalize" the data based on changing levels of production.

In preliminary analytical work for this report byproduct data were normalized using employment data from four different industry sectors, as distinguished by their four-digit SIC code. The results of that work showed no clear association between changes in employment and toxics byproduct generation and revealed many problems associated with the use of employment data as a means of normalizing the TURA data. The results of that analysis are presented, along with descriptions of other normalization methodologies in Appendix A.

The question of how to link changes in byproduct generation with implementation of TUR techniques is not answered in this report. Ultimately the answer may lie in changing reporting requirements, as opposed to finding the right normalization factor.

3.4.2 Indicators of TUR Progress

Broadly, indicators of TUR progress can be divided into two categories: qualitative and quantitative data. Sources of qualitative data include case studies, journal articles, facility reports, interviews with facility staff, and some elements of the TURA database. The primary source of quantitative data is the TURA database. The federal Toxics Release Inventory (TRI) database offers a supplementary source of quantitative data on toxic chemical releases and transfers. The TRI database does not, however, include data on toxic chemical use; it only contains data on toxic chemical releases and transfers. For a fuller analysis of the limits of using the TRI database for measuring TUR progress see Appendix B.

Qualitative Analysis

Discussions and interactions with individuals in firms and case studies performed on the firms provide ample evidence that TUR techniques are being implemented in Massachusetts facilities. The Office of Technical Assistance and the Toxics Use Reduction Institute have prepared various case studies on the implementation of toxics use reduction in Massachusetts firms. A somewhat more generalizable form of data can be gleaned facilities reporting production units with a positive byproduct reduction index (BRI). A positive BRI usually means that firms have implemented a TUR technique that resulted in less byproduct generated per unit of product manufactured. Less byproduct per unit of product could indicate the substitution of non-listed chemicals for listed toxic chemicals, higher levels of efficiency in converting raw chemical inputs into products, better management of toxic chemicals otherwise used in production, or more toxic chemicals going into finished products.

Table 3.7 lists the percentage of positive BRIs for four SIC codes:

2672 Paper Coated and Laminated, not elsewhere classified
2821 Plastic Materials and Resins
3471 Metal Plating and Polishing
3679 Electronic Components, not elsewhere classified

TABLE 3.7 PERCENT OF BRIs GREATER THAN ZERO FOR FOUR SIC CODES (1990-1992)

SIC Code	1990	1991	1992
2672	36%	55%	67%
2821	79%	49%	46%
3471	61%	44%	55%
3679	86%	65%	60%

These four industry sectors were selected for review here because they each manufacture different types of products and include significant processors and "otherwise users" of toxic chemicals.[1] In some cases these SIC codes contain the largest amounts of chemicals in the TURA data use categories.

- 2821 contains the largest volumes of chemicals used, processed and released and transferred,
- 2821 contains the second largest volume of chemicals shipped in or as product,
- 2672 contains the largest volume of chemicals generated as byproduct, and
- 2672 contains the second largest volume of chemicals otherwise used.

Yet, even in these toxic chemical intensive industry sectors, the BRI reports suggest that consistently over a three year period a significant amount of byproduct is being reduced and this suggests that a significant amount of toxics use reduction is taking place.

The positive BRIs and the TUR case studies provide qualitative evidence that TUR techniques are being implemented in Massachusetts facilities. But, the qualitative data provides no indication of the impact of implementing TUR techniques. To determine the extent to which TUR activities are (or are not) resulting in state-wide reductions in chemical use or byproduct generation requires quantitative data. A quantitative assessment of trends in chemical use data provides a measure of the impact of firms implementing TUR techniques.

Quantitative Analysis

The TURA data offers a unique data base for assessing the effects of the TURA program on the use of toxic chemicals and the generation of toxic chemical byproducts over time. Now with four years of data available it would appear fairly easy to identify trends in byproduct generation. This could be accomplished by taking the statewide total byproduct generation for each year and identify the trends. Table 3.8 displays the state-wide aggregate data for all the major "use" categories: manufactured, processed, otherwise used, byproduct generation, and shipped in/as product. But Table 3.8 offers little more than an illusion because of complexities inherent in the data.

First, Table 3.8 excludes all "trade secret" data. A few firms file trade secret claims for part or all of their chemical uses. The trade secret claim protects the data from public analysis. Trade secret claims, although made by only a few firms, account for large quantities of toxic chemicals. For example, in 1990, over 300 million pounds of chemical use data were

[1]Manufactured chemicals were not considered here because of the high percentage of manufactured chemicals claimed as trade secrets.

protected from public analysis by trade secret claims.[1] Unless otherwise noted, none of the TURA data analyzed in this report contains trade secret data.

Second, the 1990 database is different from the 1993 database. In fact, the databases are quite different because the 1993 data universe is much larger than the 1990 data universe. In 1991, additional SIC codes were added to the TURA universe increasing the number of facilities that fall under the TURA reporting umbrella. Additionally, between 1991 and 1993 additional chemicals were added to the TURA universe, further increasing the quantities of chemicals reported under TURA.

Table 3.9 corrects for the differences in reporting requirements between years by holding the years 1991, 1992 and 1993 to the same reporting universe as the one established in 1990. Therefore, in this table the data represents the same chemicals and SIC codes for each of the four years. This produces a significant difference in the data. In the case of "total use" and "byproduct" over the period 1990-1993, both decreased in Table 3.9 whereas in Table 3.8 they increased.

Unfortunately the data in Table 3.9 still contains some complications. If the TURA database was perfect, the 1990 data in Table 3.8 would be the same as the 1990 data in Table 3.9. This is not the case because in 1990 facility reports included chemicals that were not required to be reported until 1991 and 1992. Additionally, for each of the years, some facilities reported on chemicals without identifying the SIC codes associated with them. In those cases it is impossible to know whether the data falls within the 1990 TURA universe or not. Table 3.9 excludes these "non-SIC code associated data".

Table 3.10 includes the "non-SIC code associated data". The result is a decrease in the percent reduction of "total use" from -21 percent to -20 percent and increase in the percent

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[1]One caveat to the TURA database is that seven facilities file trade secret claims. The trade secret claims are most widely claimed for manufactured and processed chemicals, and much less so for otherwise used chemicals. For example, in 1990:

- 26 percent of total chemical use was protected from public analysis by trade secret claims
- 80 percent of manufactured chemicals were protected from public analysis by trade secret claims
- 22 percent of processed chemicals were protected from public analysis by trade secret claims
- less than 1 percent of otherwise used chemicals were protected from public analysis by trade secret claims
- five percent of byproduct chemicals were protected from public analysis by trade secret claims
- 27 percent of shipped in or as product were protected from public analysis by trade secret claims

reduction of "byproduct" from -16 percent to -17 percent. Since the majority of chemicals are used by facilities in the SIC codes 2000-3999 (the 1990 data universe), the "non-SIC code associated data" are included in the following tables.

The next level of data refinement is the result of a DEP reporting exemption for metal bending facilities. Facilities that merely bend of form copper or stainless steel alloys were exempted from filing under TURA (only for their copper and stainless use) beginning in 1993 because it was argued that these facilities can do nothing to reduce the amount of metal they use and because they generate almost no byproducts from the processing. The outcome is that the data from 20 metal bending facilities were not entered into the TURA database in 1993. Table 3.11 lists the amount of "processed" and "byproduct" chemicals produced in 1990-1992 by the exempted metal benders. Due to the nature of the process of metal bending, the processed amount is much larger than the byproduct amount. These data, then, must be subtracted out of the 1990 TURA data universe to account for their failure to appear in the 1993 data. The outcome is shown in Table 3.12. The percent reduction in total use decreases from -20 percent (Table 3.10) to -18 percent and the percent reduction in byproduct decreases from -17 percent (Table 3.10) to -16 percent.

The final level of data refinement requires the removal of data associated with the closing of one large chemical using facility (the Novocor Corporation). Chemical use at the facility decreased from 109 million pounds in 1990 to a little over 0.1 million pounds in 1993. The reason for removing this data is similar to the reason for removing the metal bending facility data. This large reduction in use and byproduct is not caused by the implementation of TUR techniques (as stated in the 50 percent reduction goal). Table 3.13 presents total use and byproduct data without the chemical use data from this facility. The result is a dramatic decrease in the percent reduction of total use, from -18 percent (Table 3.12) to -6 percent, and no noticeable decrease in byproduct generation.

Table 3.14 presents the results of this step-wise effort to refine the TURA data down to its most consistent and meaningful form. In this table the total use and byproduct reduction are displayed for each level of data refinement. From this it can be seen that refining the data does little to the percent change in byproduct generation, but significantly affects the percent change in total use.

Finally, in Table 3.13 there appears a reasonably meaningful representation of the trends in toxic chemical use and byproduct generation during the years in which the state TURA program has been in effect. In a fairly simplistic sense this represents the Massachusetts industry experience with toxics use reduction. The data presented in Table 3.13 indicates an uneven decline in both use and byproduct generation over the four years that the program has been in effect.

This association between the existence of the TURA program and percent change in total toxic chemical use and byproduct generation should not be considered causal. Little attempt has been made here to ascertain the percentage of change in toxic chemical use and byproduct generation that is due to TUR techniques as compared to changes in production levels and plant closures and openings. Nor was the data related back to 1987 as required by the 50 percent reduction goal. But, this analysis of the data does reveal a decline.

TABLE 3.8 AGGREGATE TURA DATA (all chemicals and all SIC codes)[1]

Chemical Use Category	1990 (million lbs)	1991 (million lbs)	1992 (million lbs)	1993 (million lbs)
Manufactured	25.8	15.3	20.4	23.6
Processed	763.1	842.4	824.2	750.2
Otherwise Used	138.1	152.1	192.6	195.0
Total Use	927.0	1,009.8	1,037.2	968.8
Byproduct	116.0	137.1	144.7	132.7
Shipped In/As Product	334.7	448.4	434.0	430.7

[1]Trade secret claims are excluded from this data.

TABLE 3.9 AGGREGATE TURA DATA: CHEMICALS AND SIC CODES HELD CONSTANT AT 1990 LEVELS (chemical use data not associated with a SIC code are excluded)[1]

Chemical Use Category	1990 (million lbs)	1991 (million lbs)	1992 (million lbs)	1993 (million lbs)	Percent Change ('90-'93)
Manufactured	25.6	10.7	11.0	7.3	-71
Processed	752.8	759.0	687.3	593.8	-21
Otherwise Used	124.5	122.5	120.5	110.2	-11
Total Use	902.9	892.2	818.8	711.3	-21
Byproduct	111.3	116.3	109.4	93.4	-16
Shipped In/As Product	325.3	377.9	340.9	296.0	-9

[1]Under TURA, companies file SIC codes in association with production units. However, in some cases chemical uses were not allocated to a SIC code. These chemicals and their amounts were excluded from the above table.

TABLE 3.10 AGGREGATE TURA DATA: CHEMICALS AND SIC CODES HELD CONSTANT AT 1990 LEVELS (use data not associated with a SIC code are included)

Chemical Use Category	1990 (million lbs)	1991 (million lbs)	1992 (million lbs)	1993 (million lbs)	Percent Change (1990-1993)
Total Use	912.9	899.7	824.3	726.7	-20
Byproduct	114.5	116.7	109.7	95.0	-17

TABLE 3.11 CHEMICAL AMOUNTS SUBJECT TO THE METAL BENDING EXEMPTION

Category	1990 (million lbs)	1991 (million lbs)	1992 (million lbs)
Processed	31.2	21.6	26.0
Byproduct	0.8	0.8	0.7

TABLE 3.12 AGGREGATE TURA DATA: LESS METAL BENDER DATA, CHEMICALS AND SIC CODES HELD CONSTANT AT 1990 LEVELS (non-SIC code associated data are included)

Chemical Use Category	1990 (million lbs)	1991 (million lbs)	1992 (million lbs)	1993 (million lbs)	Percent Change (1990-1993)
Total Use	881.7	878.1	802.6	726.7	-18
Byproduct	113.7	115.9	108.9	95.0	-16

TABLE 3.13 AGGREGATE TURA DATA: LESS METAL BENDER AND NOVACOR DATA, CHEMICALS AND SIC CODES HELD CONSTANT AT 1990 LEVELS (non-SIC code associated data are included)

Chemical Use Category	1990 (million lbs)	1991 (million lbs)	1992 (million lbs)	1993 (million lbs)	Percent Change (1990-1993)
Total Use	772.6	773.6	756.1	726.6	-6
Byproduct	113.0	115.4	108.4	95.0	-16

TABLE 3.14 SUMMARY OF PERCENT CHANGES IN TOTAL USE AND BYPRODUCT FOR EACH STAGE OF DATA REFINEMENT

Chemical Use Category	Table 3.8 (data w/out non-SIC associated data)	Table 3.9 (data, w/non-SIC associated data)	Table 3.11 (data w/out metal benders)	Table 3.12 (data w/out metal benders & Novacor)	Percent Change (1990-1993)
Total Use	-21	-20	-18	-6	-6
Byproduct	-16	-17	-16	-16	-16

3.5 Summary

An analysis of the TURA data such as this needs to respect the limits of the data. This analysis does not cover all industries or all toxic chemicals. Smaller firms are excluded as well as larger firms using less than 10,000 pounds of TURA chemicals. Indeed, some TURA reporting firms are excluded from this analysis due to their trade secret claims.

In addition, it must be rembered that the TURA data used here represents only the years 1990 to 1993. The 50 percent reduction goal requires that the program be evaluated from a base year of 1987. This earlier base year does not affect this report, because the analysis carried out here is designed only to account for those years in which Massachusetts firms had an "experience" with the toxics use reduction program (i.e., 1990-1993).

Yet, even this early analysis suggests some conclusions. Data from the qualitative and quantitative analyses suggests that in the aggregate Massachusetts industry is implementing toxics use reduction programs. Further, the data shows that over these past four years total toxic chemical use and byproduct generation is decreasing, although the decline in byproduct generation is significantly larger than the decline in use.

The specific chemicals with the greatest reduction in both use and byproduct generation were the chemicals targeted for phase out by the Montreal Protocol. This would suggest that the TURA program may have been of great assistance in reducing the use and byproduct generation of ozone depleting chemicals, but the primary driving force is most likely the international chemical restrictions placed on these chemicals.

The goals of the TURA program are different from the goals of a chemical restriction policy. TURA focuses on a reduction in byproduct reduction and this appears to be occurring. A chemical restriction policy would focus on achieving a reduction in use as well as byproduct and this is occurring less dramatically.

Finally, any conclusions must respect the early stages of program development and data collection activities. It must be remembered that facilities only completed their required toxics use reduction plans during this past year and the state is only now beginning to prepare for the identification of "user segments" and the setting of performance standards for "priority user segments". It is yet too early to develop final conclusions.

CHAPTER 4 COSTS AND BENEFITS OF TOXIC CHEMICAL RESTRICTIONS

Under the TURA program and on their own initiative Massachusetts facilities are reducing their byproduct generation. The data analysis indicates that industry activities are resulting in significant reductions in toxic byproducts and, less so, reductions in the use of toxic chemicals. These activities are consistent with the goal of TURA: byproduct reduction. Byproduct reduction activities are only consistent with the goal of a chemical restriction though when they also result in use reduction.

The goal of a chemical restriction policy is to reduce or eliminate production, use, or distribution of a chemical. This is clearly a more aggressive goal then a reduction in byproducts. For this reason it is important to examine the economic costs and benefits of a chemical restriction policy quite carefully. In the mandate for the first restriction report TURA demanded that the Institute analyze the "social, environmental and economic costs and benefits of adopting chemical restrictions". The Institute responded by evaluating the functional characteristics of two TURA chemicals and the potential substitutes for those chemicals in the first restriction report. Comments received during the public hearings, however, expressed a desire for a more complete cost and benefit assessment of potential chemical restriction policies. This chapter has been prepared in response to the comments of those who testified seeking more detailed economic analyses.

Preparing a comprehensive analysis of costs and benefits of chemical restrictions is difficult at best. Not only is it difficult to identify the full range of costs and benefits, but many identified costs and benefits are not easily described in numerical terms. The costs and benefits of potential effects on the business climate or the health of ecosystems are difficult to quantify.

The analysis presented here focuses on the potential economic effects and health benefits that would result from the implementation of a chemical restriction policy. In order to narrow and focus the analysis the study focuses on two chemicals offered here for illustrative purposes alone. The chemicals selected for study are trichloroethylene (TCE) and cadmium, including both elemental cadmium and cadmium compounds. These two chemicals were selected because they are on the TURA list and have been considered for restriction by other state, federal or provincial governmental agencies, e.g., the use of both TCE and cadmium is being phased-out in Sweden.

The analysis of each chemical is composed of three parts. First, a brief description of the chemical, its uses, and its potential health effects are presented. Second, the potential for improvements in worker, public, and environmental health, i.e., the non-financial benefits, are considered for each chemical. Third, the types of financial costs and savings that would be incurred in displacing usage of the chemical in Massachusetts are considered. In order to perform this analysis consistently for both case studies a methodology was developed and applied to both chemicals.

4.1 Methodology

To perform a comprehensive cost analysis involves collecting detailed information on chemical uses, available alternatives, and the costs of alternatives; requires setting boundaries for the analysis and making assumptions about the chemical restriction policy; and requires developing a methodology for performing the costing analysis.

4.1.1 Data Collection

In the first step of data collection companies using TCE, cadmium, and cadmium compounds in 1992 were identified by searching the TUR database. By using the TUR data as the starting point, the analysis was limited to companies using more than 10,000 pounds of the relevant chemical.

After the companies using the chemicals were identified, they were categorized into use-related categories based on production unit data from the TUR database and discussions with company representatives. Four use categories were identified for TCE: high technology degreasing, general degreasing, adhesives, and repackaging. Likewise, four use categories were identified for cadmium and cadmium compounds: plastics, plating, metal parts fabrication, and production of metal parts with special electrical properties.

After the specific uses were identified, companies' plans regarding substitution away from cadmium or TCE were used to further narrow the groupings. Data on company plans were collected from the 1994 TUR plan summaries submitted to the DEP and from direct contacts with the companies. The following six substitution-related categories emerged from this data analysis:

1. use of the chemical has already been eliminated
2. use of the chemical has been reduced below the TURA threshold
3. use of the chemical will be reduced below the TURA threshold by 1995
4. use of the chemical will be virtually eliminated by 1995
5. use of the chemical will be virtually eliminated by 1998
6. use of the chemical is expected to continue, though possibly at levels below the TURA threshold, after 1998

The years 1995 and 1998 were used to categorize companies because these are the years specified in the TUR plan summaries submitted to DEP. The TUR plan summaries use a base year of 1993, and companies project their anticipated changes in chemical use two and five years after that base year, i.e., 1995 and 1998.

Companies that indicated in their TUR plan summaries that they expect to reduce use below the TURA threshold by 1998 were included in the sixth category. These companies were analyzed to assess the potential impacts of use restrictions on TCE and cadmium, since their ability to reduce usage below the TURA threshold is not certain at this time. In contrast, companies in the third category (use reduced below the TURA threshold by 1995) were not included in the impacts assessment, since contacts with the companies in this category indicated that they are well on their way to achieving the reductions needed to move below the threshold.

Finally, literature searches and personal contacts with users of the chemicals and vendors of alternative equipment were made to identify alternative systems and chemistries and their associated costs.

4.1.2 Assumptions

To perform a meaningful cost analysis of this complexity requires that clear boundaries be set and that assumptions be made. The economic analysis was limited to Massachusetts companies that are under the TURA umbrella. By using the TURA-universe of companies, all companies using less than 10,000 pounds of TCE, cadmium or cadmium compounds were excluded from analysis. Because these companies do not file TUR reports, data were not available to characterize their chemical usage patterns.

In addition, the analysis is limited to companies that would incur costs directly related to complying with a chemical use restriction that is assumed to take effect in the year 2000. The year 2000 was chosen as the time of implementation because it is assumed that companies would have time to phase-out the chemical of concern and time to phase-in safer alternatives (in a fashion similar to how the Montreal Protocol is being implemented). Since the present analysis is estimating the costs and savings attributable to a future policy of the state government, any substitutions undertaken for other reasons prior to 2000 (even though they may have required significant costs or netted significant savings) are not considered here.

4.1.3 The Economic Cost Analysis Methodology

The primary industrial process using TCE in Massachusetts is degreasing. TCE was used for degreasing in 1992 more often than for all other process applications. In addition, considerable data are available regarding the cost of degreasing alternatives. For these reasons, a detailed analysis of degreasing conversion was conducted. The methodology for this analysis is described below. Certain aspects of the analysis were used to estimate the repackagers' potential sales losses. However, limited data prevented the same level of quantitative analysis of TCE use in adhesives, or of cadmium use in the production of metal parts with special electrical properties. According to the TUR plan summaries plastics, plating, and parts fabrication uses for cadmium are scheduled to be eliminated from Massachusetts by 1998, and on that basis were not analyzed.

The quantitative estimates of the costs for alternative degreasing equipment were based on conversion costs at similar facilities, rather than on equipment selected specifically for the companies in question. Where quantitative estimates could not be made for the relative costs of the present TCE or cadmium system vis-a-vis a replacement system using alternative materials or procedures, a qualitative discussion of significant costs is presented.

As a first step in estimating the costs of conversion from TCE, data were gathered from companies that have already made similar conversions. Costs not in current dollars were inflated to 1994 dollars. Some data were gathered directly from companies; other data came from case studies compiled by the Northeast Waste Management Officials' Association, Massachusetts Office of Technology Assistance, and the Institute. This information was used to estimate the costs associated with the alternative systems and the operating costs that companies using TCE typically incur (i.e., costs that would be avoided if TCE were replaced by an unregulated substance).

An incremental operating cost or savings was identified for the potential conversion by comparing TCE-related operating costs to the operating costs of the alternative. This incremental value was assumed to remain constant over a project life of ten years following the conversion. The stream of annual costs or savings was discounted at 10 percent to estimate the net present value of the incremental operating costs. Finally, the net present value of the incremental operating costs was combined with the estimate of initial conversion costs (capital equipment, facility or process adjustments, research and development, and water treatment, if applicable), to estimate the net present value of the company's potential conversion. This process was conducted for each company that has not yet committed to eliminating TCE use in degreasing applications by 1998, or to reducing use to below the TURA reporting threshold by 1995.

The values for all companies were combined to arrive at an estimate of potential state-wide conversion costs or savings. Best and worst case values were calculated to establish a range of probable costs or savings. What constitutes best and worst was decided from the perspective of a company evaluating a potential conversion project. For example, lower capital equipment costs for the alternative were used to calculate the best-case scenario. Higher operating costs for TCE usage were also used in calculating the best case scenario, since the higher the costs of using TCE, the better a given alternative's operating cost will appear. The distinctions between best and worst case scenarios are explained in more detail, along with the rest of the calculation procedures, in Appendix C.

The cost elements considered for degreasers include operating costs and capital costs (see Appendix C for a detailed listing of the cost elements). One of the most significant operating cost elements is the purchase of the chemical itself. The costing analysis used two prices for TCE, $0.50 and $1.00 per pound. While recent data indicate that TCE costs approximately $0.50 per pound when delivered by the truckload, case studies describing conversions from TCE indicate that companies using TCE for degreasing generally buy it from repackagers in

55-gallon drums and pay prices near or slightly above $1.00 per pound.[1] The quantity of TCE used was derived from each company's 1992 TURA submissions, adjusted to reflect use reductions delineated in the 1994 TUR plan. If a company indicated in its federal Toxics Release Inventory (TRI) report that it recycled TCE on site, the quantity assumed to be purchased was reduced by the recycled amount.[2]

Another significant operating cost for TCE use is waste disposal. The present analysis relied on TRI submissions and TUR plan summaries to estimate the quantity of TCE-containing waste each company is likely to dispose in 1998 or after. The high estimate for the cost of waste disposal, $320 per 55-gallon drum, was derived from available case studies and represents an average of what can be expected over the next ten years.[3] The low estimate for cost of waste disposal is zero cost, because in some cases used TCE is recycled or TCE-contaminated waste is allocated to fuel use for a nominal charge.[4] The other major sources of operating costs in TCE use are associated with responses to regulation, including labor hours spent completing required forms or permit applications, safety training and equipment, and required waste testing or fees, such as the TURA fee. A labor rate of $30 per hour was used for these cost elements, and the numbers of hours costed were derived from case studies.[5] The cost elements considered for alternative degreasing systems are separated into two categories, initial costs and operating costs. Initial costs are those costs associated with the physical change at the plant, whereas operating costs are the on-going costs that will be incurred yearly. The most significant cost associated with alternative systems is the cost of the new system itself. Estimates for this cost element were derived from the case studies, conversations with companies, including those for whom costs were being estimated, and from the trade press.

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[1]Personal communication with Chemical Marketing Reporter Information Department, October 1994; Mitch Kennedy, *Cost of Changing: Total Cost Assessment of Solvent Alternatives*, prepared for the Toxics Use Reduction Institute, June 1994; and Marlene Wittman, *Costing and Financial Analysis of Pollution Prevention Projects*, prepared for Lightolier, Inc., July 1991.

[2]In several cases the amount of TCE reported as recycled in the TRI listing for a company was greater than the amount of TCE they reported themselves using for TURA. Since this is unlikely, the quantity assumed to be purchased was not reduced.

[3]Mitch Kennedy, op. cit., and personal communication with representatives of two Massachusetts companies that formerly used TCE, October, 1994.

[4]Personal communication with a representative of a Massachusetts company that formerly used TCE.

[5]Mitch Kennedy, op. cit., and personal communication with representatives of four Massachusetts companies that formerly used TCE, October, 1994.

4.2 Trichlorethylene Case Study

Since the 1940s, TCE has been widely used as a "universal" industrial degreasing agent and as a solvent in paints, adhesives and variety of other products. It has been the subject of environmental and health concern and controversy since the late 1970s. In recent years, TCE has been detected in groundwater used for human consumption in many parts of the United States. Because of its toxic nature and substantial use it has been targeted for phase-out by the Swedish Government.[1]

4.2.1 Potential for TCE Exposure

Most of the TCE used in the US is released into the air by evaporation, primarily from vapor degreasing operations. Once in the atmosphere, TCE is readily degraded to phosgene, trichloroacetic acid, dichloroacetyl chloride, formyl chloride and other compounds; the half-life of TCE is 7 days. Over the years, TCE has been released to surface water and groundwater by industry, commerce, and individual consumers. TCE in surface water and soil tends to evaporate into the atmosphere. TCE in subsurface soil and water (i.e., groundwater) persists for a considerable time.

Massachusetts has been particularly hard-hit by TCE contamination of aquifers used for drinking water. According to a 1986 report by the Massachusetts Public Interest Research Group, 11 drinking water wells in Massachusetts were contaminated with TCE at levels above proposed federal drinking water standards; TCE was present in another 15 wells at levels close to the standard.[2] Between 1964-1979, a toxic waste site in Woburn leached solvents, mainly TCE and perchloroethylene, into two public drinking wells. Lagakos, et al, reported a doubling, and potentially a quadrupling of the number of childhood leukemia cases among families exposed to the contaminated water from the years 1970-1985, birth defects doubled, and rates of urinary tract infections among children increased significantly.[3] Another study documented a measurable slowing in blink reflex (suggesting nerve damage) in Woburn residents who drank TCE-contaminated water.[4]

Nationwide, TCE has been detected at approximately 60% of the 1300 sites proposed for inclusion on the Superfund National Priority List. An assessment of state and federal

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[1]The Swedish National chemicals Inspectorate, the Swedish Environmental Protection Agency "Risk Reduction of chemicals, A Government Commission Report," 1991.

[2]MassPIRG, "Hazardous Waste in Our Drinking Water," 1986.

[3]S.W. Lagakos, B.J. Wesson, M. Zelen, et al, "An Analysis of Contaminated Well Water and Health Effects in Woburn Massachusetts," *Journal of the American Statistical Association*, 1986, 81:583-614.

[4]Robert Feldman, et al, "Blink Reflex Latency After Exposure to Trichloroethylene in Well Water," *Archives of Environmental Health*, March/April 1988, Vol. 43, No. 2.

groundwater studies found that TCE was detected in 16% of samples analyzed. The public's average daily intake of TCE was estimated at 11-33 micrograms per day.[1]

A variety of consumer products contain TCE, including some typewriter correction fluids, paint removers, strippers, adhesives, spot removers, and rug-cleaning fluids. When these products are used the TCE component is breathed in by the consumer, released to air, discharged to the sewer, or disposed of with municipal waste. Current EPA regulations prohibit land disposal of TCE. The recommended mode of disposal is incineration after mixing with a combustible fuel. If incompletely combusted, TCE forms phosgene, a potent respiratory irritant.

Workers, particularly those in industries using vapor degreasers, are exposed to TCE by inhalation. Monitoring surveys have shown that these workers may be exposed to levels ranging from 1 to 100 parts per million (ppm). The Occupational Safety and Health Administration permissible exposure limit for TCE is 100 ppm, based on an 8 hour time weighted average.

4.2.2 Health Effects of TCE Exposure

The primary effect of acute, high-level TCE exposure is on the central nervous system. In fact, TCE was once used as an anesthetic for surgery; a use that was banned by the federal Food and Drug Administration in 1976. People who are exposed to high levels of TCE can become dizzy or unconscious and develop short-term memory loss and central nervous system depression.[2]

As evidenced by the work of Lagakos, et al, chronic exposure to TCE, perchloroethylene and other solvents through contaminated drinking water from two wells is suspected to have increased rates of childhood leukemia in the Woburn (Massachusetts) community that drew water from these wells.[3] In this same community, a higher than average number of children were reported to be born with cardiac abnormalities. However, other chemicals were present in water from these wells and it is not known whether TCE or TCE acting alone caused these effects. Laboratory animals exposed to moderate levels of TCE had enlarged livers, and high-level exposure caused liver and kidney damage.[4]

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[1]Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, "Toxicological Profile for Trichloroethylene." PB93-182533, April, 1993.

[2]ibid.

[3]Lagakos, et al, op. cit.

[4]ibid.

4.2.3 The Benefits of Restricting TCE Use

A TCE use restriction would eliminate the potential for further drinking water contamination cases such as occurred in Woburn. Restricting TCE use would also eliminate the potential for worker exposure in plants that operate TCE degreasers. Eliminating fugitive emissions from these plants would also benefit public health in surrounding communities.

According to the 1992 TURA data, TCE repackaging and use in adhesives constituted 53 percent of TCE manufactured, processed, or otherwise used by reporting firms. Eliminating the use of 0.47 million pounds of TCE in adhesives production in Massachusetts would cut both TCE emissions from manufacturing and TCE released by the factories or homes that ultimately use and dispose of adhesive products. An expected outcome of reducing TCE use in Massachusetts is a reduction in the approximately 2.4 million pounds per year of TCE that was "repackaged" by TURA filers and an associated reduction in routine and accidental releases of TCE from this activity.

The benefits of reducing TCE use in Massachusetts will extend "upstream" of the industrial user. If demand for TCE is cut, reductions in chronic or accidental hazards from TCE manufacturing and shipping would be reduced. While not all of these benefits will accrue directly to the Commonwealth, they are no doubt a benefit to the larger ecological community of which Massachusetts is a part.

4.2.4 TCE Usage Trends in Massachusetts

Thirty-six Massachusetts companies reported using TCE in 1992. The primary use for TCE in Massachusetts, as is true for the rest of the country, is for degreasing.[1] Of the 36 companies, 21 used TCE for general, lower technology degreasing applications, such as metal stampings and parts; and seven used TCE for high technology degreasing applications. Three companies used TCE in adhesives-related applications. The other five companies repackaged TCE for sale.

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[1]"Trichloroethylene Chemical Profile," *Chemical Marketing Reporter*, February 3, 1992, p. 42. Repackagers reported a higher quantity of TCE use than degreasers, but the repackagers are not actually utilizing the TCE. They handle the chemical between its production and sale to ultimate users, such as the degreasers and adhesives-related companies.

TABLE 4.1 ANTICIPATED USE REDUCTIONS FOR TRICHLOROETHYLENE (in thousands of pounds)

Application	1992		Eliminated by 1994		Below Threshold by 1995		Eliminated by 1995		Eliminated by 1998		Not Substituting[1]	
	firms	lbs	firms	lbs	firms	lbs	firms	lbs	firms	lbs	firms	lbs
Degreasing												
General	21	814	6	274	4	74	2	109	3	129	6	228
High Technology	7	733	1	12	3	137	0	0	0	0	3[2]	584
Adhesives	3	470	0	0	0	0	0	0	0	0	3	470
Repackaging[3]	5	2,462	1	26	0	0	0	0	0	0	4	2,436
Total[4]	36	4,480	8	313	7	211	2	109	3	129	16	3,718

Source: 1992 TURA submissions, 1994 TUR plan summaries, and personal communications.

[1] In some cases, these companies expect to reduce TCE use, perhaps even to levels below the TURA threshold by 1998. However, 1992 use estimates are shown in all columns for consistency.

[2] These companies may be substituting away from TCE on some of their production units.

[3] These companies were not contacted concerning their specific plans regarding future TCE usage; however, one of the companies closed in 1994.

[4] Totals may not add up due to rounding.

The total volume of TCE reported as "processed" or "otherwise used" in 1992 was approximately 4.48 million pounds. General degreasing accounted for approximately 0.814 million pounds (18 percent), while high technology degreasing accounted for approximately 0.733 million pounds (16 percent). The three companies with adhesives-related TCE applications used approximately 0.47 million pounds (10 percent). Approximately 2.462 million pounds of TCE (55 percent) was repackaged for sale.

The majority of Massachusetts' TCE users indicated in their TUR plan summaries that they have already switched to other chemicals or processes, or plan to do so by 1998. As shown in Table 4.2, among the 21 companies with general degreasing applications, all but six will have virtually eliminated TCE use by 1998. Six companies have already eliminated their use of TCE, and another four have reduced their use below the TURA reporting threshold. Two more companies are expected to eliminate TCE use by 1995, and three more plan to make the switch by 1998.
Prospects for elimination of TCE in high technology degreasing and adhesive applications are not as promising, however. Only one of the seven companies in the high technology use category has already substituted for TCE. None of the other six companies plan to completely eliminate their TCE use by 1998, although three plan to reduce their use below the TURA threshold by 1995. Similarly, none of the companies using TCE for adhesives-related applications reported plans to switch to other chemicals. One of the repackagers closed in 1994, but available data indicate that the other firms expect to continue supplying TCE.

4.2.5 Potential Costs and Savings of a TCE Use Restriction

The potential implications of a TCE use restriction were analyzed for each of the following use categories: degreasing, adhesives, and repackaging. Quantitative and qualitative results are presented below.

4.2.5.1 Degreasing

The two types of alternative degreasing methods considered in the present analysis were aqueous and semi-aqueous systems.[1] These types of systems range from simple dishwasher-type tanks with platform agitators or sprayers, to in-line conveyors with sprayers.[2] Six companies with general applications and three companies with high technology related applications were analyzed. Table 4.2 presents the key findings from this analysis.

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[1]Positive environmental aspects of aqueous and semi-aqueous alternatives are that emission control is not necessary, workers are not continuously exposed to solvents, fire risk is reduced, and little hazardous solid waste is produced.

[2]"There's A Lot of Help for Parts Cleaning," *Tooling and Production*, May 1994.

Degreasing Conversion Costs

The total net present value (NPV) of the nine potential conversions ranges from a loss of $0.8 million in the worst-case scenario, to a savings of $2.5 million under the best-case scenario. The savings estimated for the best-case scenario accrue because the initial costs of converting can, in most cases, be offset by operating savings within a few years. Savings from avoided TCE purchases account for 80 to 95 percent of the total operating savings from conversion. In the best-case scenarios, all companies analyzed had a positive NPV for the potential conversions. In the worst-case scenario, five of the nine companies had a negative NPV for their potential conversion. These results were driven primarily by the cost of capital equipment, and the relationship between this cost and the quantity of TCE purchases avoided. All but one of the companies with a negative NPV had a worst-case capital equipment cost at least five times their avoided annual TCE cost.

Surprisingly, the best-case NPV estimates are higher for high technology degreasing than for general applications. This is attributable to these facilities' higher TCE usage rates prior to conversion and the resulting greater savings from avoiding TCE purchases. The average annual savings from eliminating TCE range from $0.20 million to $0.58 million for high technology companies, compared to only $0.07 million to $0.15 million for general degreasers. In contrast, the NPV estimates for the worst-case potential conversions are lower for the high technology applications, indicating a greater potential loss for those companies. The large difference between best and worst case scenarios for the high technology applications is attributable to the wide spread between estimated capital costs, ranging from $27,000 to $1,250,000.[1] In the worst-case scenario, all high technology capital equipment costs are estimated to exceed $100,000. In contrast, only three general degreasing companies had worst-case capital cost estimates exceeding $100,000.

The higher capital costs estimated for high technology applications are partially attributable to their TCE usage rates, because capital costs obtained from case studies were scaled by TCE usage to estimate costs for the converting company.[2] In addition, the trade press indicates that capital investment required for conversion tends to be greater for high technology applications because of their special functional needs. These special needs can require ancillary equipment, such as full immersion baths and ultrasonic equipment, which

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[1]The estimate of $1,250,000 for capital equipment was obtained from one of the companies being analyzed, and reflects the cost of converting four production units.

[2]A case study was identified to match the degreasing characteristics of each potentially converting company. In some cases, the converting company had larger degreasing operations than the case study facility. A ratio of the TCE usage rates (between the converting company and the case study) was computed to reflect this difference. This ratio was used, along with commonly used scaling factors, to estimate the costs for the converting facilities. A scaling factor of 0.6 was used for capital, water treatment, alternative cleaning fluids, and utilities. A scaling factor of 0.2 was used for maintenance. These scaling factors are referenced in *Plant Design and Economics for Engineers* by Max Peters and Kaus Timmerhaus, 1958 and 1968.

results in capital costs as high as $250,000 per production unit.[1] The special needs of high technology degreasers are discussed in greater detail below.

In both the best and worst case scenarios, all companies experience conversion-related savings in annual operating costs. The primary determinant of this result is the difference between the cost of TCE and the alternative cleaning fluid, though differences in waste disposal costs and avoided regulatory costs, such as TURA fees, waste fees, testing and manifesting, and safety

TABLE 4.2 COSTS AND SAVINGS FROM POTENTIAL SUBSTITUTIONS IN DEGREASING APPLICATIONS (in thousands of 1994 dollars)

	High Technology[1]		General[2]	
	Worst	Best	Worst	Best
Total NPV of Conversion (All Facilities)	($649)	$1,503	($132)	$1,026
Average NPV of Conversion/Facility	($216)	$501	($22)	$171
Total Initial Costs (All Facilities)	$1,552	$588	$612	$192
Average Initial Cost/Facility	$517	$196	$102	$32
Total Annual Operating Savings (per year savings)	$147	$341	$78	$198
Average Annual Operating Savings/Facility	$49	$114	$13	$33

1 Three facilities classified as high technology were analyzed.
2 Six facilities classified as general degreasers were analyzed.

Sources: Derived from tables in Appendix C.

training, play a role. Maintenance costs (i.e., the labor needed to keep the system operating) tend to be higher for the alternative systems than for TCE use. Nevertheless, using the maintenance hours and wage rates in the case studies, scaled by TCE usage, does not result in incremental maintenance costs of a magnitude to offset the savings provided by avoiding TCE purchases.

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[1]J. Lorincz, "Clearing the Air (and Water) on Metal Cleaning," *Tooling and Production*, May 1993.

As discussed above, capital costs and operating savings resulting from eliminating TCE usage are the two primary components driving the results summarized in Table 4.2. Potential variations in the cost of capital equipment over time were considered to be sufficiently accounted for in the base analysis. However, the base analysis does not account for potential increases in the price of TCE above the rate of inflation. A sensitivity analysis was conducted to assess the influence of potential TCE price increases. Suppliers of TCE may increase prices as demand falls in order to maintain their level of revenue, despite decreased capacity utilization. For the sensitivity analysis, the TCE price assumptions of $0.50 and $1.00 per pound were increased by five percent a year over the ten year study period. These prices were then averaged, resulting in prices of $0.63 and $1.26 per pound.

A sensitivity analysis was performed on TCE prices to determine how changes in TCE price would effect the NPV (see Appendix C). The sensitivity analysis reveals that the cost analysis is quite sensitive to changes in TCE price. In the sensitivity analysis, the total NPV of conversion increased for the high technology companies by 30 to 35 percent, and for the general degreasers by 22 to 87 percent. The increase in general degreasers' worst-case cost is highest, in percentage terms, at 87 percent over the base case. However, the high technology worst-case experiences a larger NPV increase in absolute dollars (increasing by $0.2 to $0.5 million), due to these facilities' high TCE usage rates prior to the potential conversion. The implication of this sensitivity analysis is that as the price of TCE rises substituting to alternative processes or chemistries becomes economically more attractive.

While the best-case scenario indicates that substantial savings may be achieved by conversions from TCE, it is important to note that a number of degreasing performance factors could not be quantitatively evaluated. These factors were part of the reason several companies are not planning to eliminate TCE use by 1998. These companies have researched and tested alternative degreasing systems, yet have not identified alternatives that provide the desired functional performance.

When quantitative and qualitative factors are jointly considered, the difficulty of substituting away from TCE appears clearly greater for companies with high technology applications, even though under the best-case scenario the estimated NPV of switching is greater for those applications. The qualitative factors indicate that the specific material to be degreased, its configuration, and the processing system of which it is a part have to be considered in identifying alternatives that provide equivalent functional performance. A number of companies stated that satisfactory alternatives are not available for their applications at this time.

4.2.5.2 Adhesives

The three adhesive applications for TCE in Massachusetts are: 1) production of adhesive accelerators (i.e., curing agents); 2) production of contact adhesives; and 3) utilization of adhesives in the lamination of two-part fabrics. In each case, TCE serves as both a solvent and a carrier. Note that although the three adhesives-related companies are grouped together, they are substantially different with respect to potential substitutes and replacement technologies. In fact, one of the companies indicated that their application of TCE may be unique throughout the country.[1]

In contrast to degreasing applications, where most companies are moving away from TCE, none of the firms in the adhesives category currently plan to discontinue using TCE. This is not to say that these companies have not searched for substitutes. Two of the three companies indicate that they have spent, and are continuing to spend, considerable resources in examining alternatives.[2] While these companies have not yet identified acceptable substitutes, general categories of alternatives are known, including: biological solutions such as terpenes, water-based adhesives, and 100-percent solid adhesives (hot melts).

Adhesives Conversion Costs

Different costs are associated with switching to the three alternative kinds of adhesives. Replacing TCE with a biological solution may require redesign of the delivery system. This could be as simple as changing the gasket material or as complex as redesigning all the equipment with pumps. The latter would constitute a significant capital investment. However, some savings might be gained with the change, since the operational costs of a biological substitute may be cheaper than buying TCE.[3]

Two additional costs are associated with the water-based adhesives option. The first involves equipment changes that may be necessary, such as installment of stainless steel mixing tanks and a new sprayhead, or other application equipment. The second cost is the energy (heat) required to dry the adhesive, which could be considerable. Some savings may accrue from the change, however. For example, inventory requirements may be reduced, and water-based adhesives may be stored in cheaper plastic containers.[4]

The most consistently expensive option for conversion is the 100-percent solid adhesives option, which generally requires completely new capital equipment for both production and application. However, savings may be realized in the following areas: lower space requirements; lower energy requirements; no pre-mixing cost; and lower costs for raw materials, transportation, storage, and disposal because neither the feedstocks nor products are regulated as hazardous.[5]

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[1]Personal communication with a representative of a Massachusetts company using TCE in adhesives.

[2]Personal communication with representatives of the three TURA submitters that use TCE for adhesive applications in Massachusetts, October, 1994.

[3]ibid.

[4]UNEP 1991.

[5]Nard, Wallace D., "Production Update: Solventless Lamination Answers Green Challenges," *Paper Film and Foil Converter*, V66n4. April 1992.

An important consideration is the increased process time associated with two of the options. Both biological solutions and water-based adhesives do not dry as quickly as TCE-based adhesives, thus increasing the time necessary for production. Currently, this problem can be solved by redesigning the layout of the physical production process. In the future, industry analysts expect attempts to decrease the drying time of non-solvent adhesives to be increasingly successful.[1]

Quantitative information on the capital cost of converting TCE-based adhesive applications is difficult to obtain because the equipment required must be tailored to the specific application. However, some general cost information is available for hot melt capital equipment. A simple small hand-held sprayer costs between $5,000 and $10,000, while a more complex system (involving many spray guns or roll coating equipment) costs between $50,000 and $100,000.[2] Conversion data for water-based adhesives is also scarce, though data from one company indicates that the process change can be accomplished for approximately $13,000.[3]

Adhesives Companies' Likely Reactions to a TCE Use Restriction

Based on available data, the three companies currently using TCE in adhesive applications are unlikely to voluntarily switch to an alternative in the near future (though one is expected to reduce its usage rate below the TURA reporting threshold). This is primarily because the companies have not identified substitutes for TCE that they consider acceptable. If a TCE use restriction were enacted in Massachusetts and these companies could identify alternatives with the properties needed for their products, they seem willing to incur the costs of converting to new systems. For the two companies whose use will continue to exceed the TURA threshold, it is estimated that these conversion costs would range from approximately $13,000 to over $100,000. If functionally equivalent formulations are not discovered in time, however, the two companies would consider relocating to avoid the restriction. (This possibility is discussed further in Section 4.4) In the absence of a use restriction, the companies have chosen to invest in emission reduction technology, as opposed to substitution, to comply with current environmental regulations. They believe that reducing emissions is more feasible and less costly than reformulating TCE-based adhesive processes.[4] The trade press implies that discontinuing usage of TCE in adhesive applications may become more feasible in coming years, however, as new technologies are established and existing ones are further developed. Thus, the outlook for conversions over a ten-year period appears encouraging.

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[1] "Novel Laminating Adhesives," *European Adhesives & Sealants*, December 1992.

[2] Personal communication with Christian Bernadette, of Nordson Corporation, and David Dunn of Dexus Adhesives, December 1994.

[3] "Cabinet Makers Switch to Waterborne Cement and Reduce VOC Hazards," *Adhesives Age*, V36n9, pp. 15-16, August 1993.

[4] Personal communication with representatives of Massachusetts companies using TCE in adhesives.

4.2.5.3 Repackagers

Five companies in Massachusetts repackaged TCE for sale in 1992. One has since gone out of business. The remaining companies buy tanker truck loads of TCE and repackage it in 55 gallon drums and other smaller packages. These drums and packages are sold to smaller volume TCE users, such as companies with medium to small degreasing operations. One company indicated that they also mix TCE with other chemicals before reselling it.

Because these companies do not actually use TCE, no attempt has been made to identify potential alternatives that these companies could substitute for TCE. Instead, this analysis assesses the potential economic impact that a TCE use restriction would have on these repackagers' revenues.

While TCE sales may increase in the next few years due to TCA replacement, repackagers can anticipate declining TCE sales in the long run, given the national regulatory environment for chlorinated solvents.[1] Industry experts expect the increase in TCE sales related to TCA's elimination to have peaked by the year 2000.[2] As a result, a use restriction applicable after the year 2000 would primarily speed an on-going decline of TCE as a portion of the repackagers' business. Since repackagers sales of TCE depend on the pattern of use, the present analysis examines potential future demand for TCE as a basis for estimating the probable impact of a use restriction on repackagers.

Table 4.3 presents an estimate of the potential value of sales and profits that Massachusetts repackagers could lose because of a use restriction on TCE. The potential sales loss from a use restriction on TCE is estimated to range from approximately three to six percent for Massachusetts repackagers. While the overall impact of a use restriction seems limited for the group of repackagers as a whole, sales losses at two individual facilities could be more significant, e.g., as much as 11 to 16 percent. The range of potential profit losses, based on assumed profit rates of 10 and 30 percent for the best and worst impact cases, respectively, is from $0.15 to $0.90 million per year. The net present value of these potential profit losses over a ten year period, at a ten percent discount rate, is $0.92 and $5.53 million for the best and worst cases, respectively.

The best-case scenario estimate of potential profit losses, $0.9 million, is based on supplying the total annual usage rate for twelve non-switching Massachusetts companies (nine degreasing and three adhesives-related applications). Without a TCE use restriction, these companies are expected to purchase approximately one million pounds of TCE in 1998, the latest year for which estimates are available.[3] A use restriction might force those companies

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[1] "Planning for 1,1,1's Demise," *Chemical Marketing Reporter*, November 1993.

[2] Personal communication with Peter Gallerani, November 1994.

[3] The quantity of TCE expected to be purchased in 1998 is heavily influenced by one company with plans to more than triple their TCE use. If this company were excluded TCE purchases in 1998 could be approximately half the quantity reported above.

to convert, and remove that potentially remaining business from the repackagers. This estimate is based on the total volume of TCE that these repackagers shipped as product in 1992. Currently available data indicate that 1992 was the peak of TCE sales by these repackagers. The 1992 sales volume is used as the high sales estimate, assuming that repackagers successfully acquire new customers in other states to maintain their 1992 sales volume. In addition, some use reductions planned for the period between 1992 and 1998 might not actually be accomplished.

Two TCE prices are used for this analysis, $1.00/lb. and $1.26/lb. The former is the base price included in the best-case scenario for TCE substitutions, and the latter is the price used in the best-case scenario for the degreasers' sensitivity analysis, representing potential price increases that may be encountered over the next 10 years. Sales are assumed to remain at the levels included in recent Dun and Bradstreet reports, approximately $53 million, for lack of better data.

The potential sales loss from a use restriction on TCE could be offset if the repackagers are able to capture some of the market for TCE substitutes, such as aqueous cleaners. However, repackagers will need to offer multiple cleaning solutions to replace TCE, since no one product seems to work in all the different degreasing operations.

However, even if the repackagers, or other Massachusetts companies, capture the market for alternative cleaners, the total revenue earned would be smaller than that currently derived from TCE sales. Since the alternative cleaners are usually mixed with water, degreasers do not need to buy as much of the alternatives as they did TCE. The nine degreasing companies analyzed in Section 4.3.1 of this chapter would be expected to purchase approximately 5,000 gallons of cleaner a year after converting their systems. Even with efficiency improvements and recycling taken into account, the companies are projected to purchase six times as much TCE if they do not convert. Thus, the repackagers or other firms would be expected to earn only 5 to 15 percent as much supplying alternative cleaners as they would from TCE.

TABLE 4.3 POTENTIAL IMPACT OF A TCE USE RESTRICTION ON ANNUAL SALES REVENUE FOR REPACKAGERS

	Best Case	Worst Case
Assumed TCE Price	$1.00[1]	$1.26[2]
Projected TCE Demand in MA	1.5 M lb.[3]	2.4 M lb.[4]
Potential Revenue Lost Annually	$1.5 M	$3.0 M
Total Companies Sales[5]	$53 M	$53 M
Percent Lost Sales	2.8%	5.7%
Assumed Percent Profit	10%	30%
Potential Annual Profit Loss	$0.15M	$0.90M

1. Based on TCE substitution case studies and recent prices for TCE in 55-gallon drums and other small containers supplied by repackagers.
2. Based on inflating the low estimate by five percent per year for ten years and taking the arithmetic average. It is intended to represent potential TCE price increases, above inflation, that could occur as use is reduced.
3. Based on 1992 usage rates and usage changes reported in TUR Plan summaries. Represents how much TCE Massachusetts companies expect to purchase in 1998. On-site TCE recycling is taken into account.
4. Based on the quantity of TCE "shipped in/as product" by repackagers in 1992, their peak year for TCE sales based on available TURA data.
5. Based on 1992 and 1993 estimates from Dun and Bradstreet reports. Analysis assumes that total sales remain constant.

4.2.6 Potential Effects of a TCE Use Restriction

Sixteen companies would be affected by a Massachusetts restriction on TCE use greater than 10,000 pounds per year. However, for some of these companies, such as those using TCE for adhesives or high technology degreasing applications, the restriction could have serious implications because these companies have not identified substitutes with equivalent functional properties. In other cases, such as more generic degreasing applications, a use restriction might require companies to make a conversion that could save them money in the long run. Finally, a use restriction could cause certain companies, such as those who repackage TCE, to lose a portion of their current business, though that loss could be offset by opportunities in the market for TCE replacement chemicals.

4.3 Cadmium Case Study

Concentrated deposits of cadmium naturally found in metallic ores and fossil fuels are dispersed into the environment through a variety of human activities. Cadmium in the environment is of concern because of its acute and chronic toxicity and tendency to bioaccumulate in humans and animals. It has been estimated that concentrations of cadmium in human kidneys--the target organ for cadmium toxicity--increased by a factor of 47 from the first part of the century.[1]

4.3.1 The Potential for Cadmium Exposure

While small amounts of cadmium enter the environment from natural weathering of minerals, most is released by human activities. Cadmium is released into air from mining and refining operations and through combustion of oil and coal and cadmium-containing household waste. Cadmium is released into water from industrial and household wastewater discharges. Phosphate fertilizer and wastewater treatment sludge used as a fertilizer transport cadmium to the soil as do spills and leaks from hazardous waste sites. Airborne cadmium may travel a long way before returning to earth as dust or in rain and snow. Once deposited on land or in water cadmium can move between soil and water. It is estimated that between 8,020-14,700 kilograms/year of cadmium is released into Massachusetts Bays; approximately one third originates from permitted industrial wastewater dischargers, another third from runoff, and another third from atmospheric inputs. [2]

Food and cigarette smoke are the largest sources of cadmium exposure in the general human population. The average American ingests 30 micrograms of cadmium per day from food, of which 1-3 micrograms are absorbed into the body (the rest is excreted). Smokers absorb an additional 1-3 micrograms per day from cigarettes. Why is cadmium found in food and tobacco? Cadmium in phosphate and sewage sludge fertilizers and from the deposition of cadmium-laden airborne particles increase the concentration of cadmium in soil. Plants take-up cadmium from soil through their roots and collect cadmium-laden dust on their leaves. Cadmium is concentrated (or bioaccumulated) in the liver and kidneys of animals that eat plants. When humans ingest cadmium-containing plant and meat foods or smoke tobacco they in turn ingest or inhale the cadmium that these sources contain.[3]

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[1]G.A. Drasch, "An Increase of Cadmium Body Burden for this Century--An Investigation on Human Tissues," *The Science of the Total Environment*, Elsevier Scientific Publishing Company, Vol. 26, 1983, pp. 111-119.

[2]The Massachusetts Audubon Society, "Turning the Tide: Toward a Livable Coast in Massachusetts," January 12, 1993.

[3]Agency for Toxic Substances and Disease, "Toxicological Profile of Cadmium." April, 1993.

Workplace cadmium inhalation may exceed environmental inhalation in the smelting, welding, soldering, electroplating and cadmium powders and pigments industries. Occupational inhalation is of great concern since cadmium dust is a probable human carcinogen. In 1992, the Occupational Safety and Health Administration lowered the permissible exposure limit[1] for cadmium from 100 (fume) - 200 (dust) micrograms/cubic meter to 5 micrograms/cubic meter in recognition of the weight of evidence demonstrating adverse human health impacts of cadmium exposure.[2]

4.3.2 Health and Ecological Effects of Cadmium Exposure

Cadmium has no known positive effects on human health. There is widespread evidence that the kidney is the primary target organ for cadmium toxicity following chronic exposure by inhalation or ingestion. Breathing lower levels of cadmium for many years causes a build-up of cadmium in the kidneys that can cause kidney disease. Human evidence has shown that long-term cadmium inhalation can cause lung damage and fragile bones, and tests on rats have shown that cadmium can increase risk of lung cancer.
Eating lower levels of cadmium over a long period of time leads to a build-up of cadmium in the kidneys, which may cause kidney damage. Painful bone disorders have been observed in some humans chronically exposed to cadmium in food. Scientists believe that this effect is secondary to a disruption in the kidney's ability to regulate vitamin D metabolism and calcium absorption and excretion. The Department of Health and Human Services and the International Agency for Research on Cancer have labelled cadmium a likely carcinogen; EPA has labelled cadmium a probable human carcinogen by inhalation.[3]

Cadmium is readily accumulated by many organisms, particularly microorganisms and mollusks where bioconcentration factors are in the order of thousands. Cadmium is toxic to soil microorganisms (particularly fungi), to sensitive aquatic animals, and to plants at concentrations exceeding 5 milligrams/kilogram (particularly in acidic soil environments).[4,5] Since cadmium is a non-essential element to plants and animals, its build-up in soils, water, and plant and animal tissues poses an unpredictable risk.

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[1]Eight hour time weighted average.

[2]Based on OSHA's best estimate of kidney dysfunction risks, the new standard is expected to prevent from 68-112 cases out of a total of 97-160 cases (Federal Register, Vol. 57, No. 178, Sept. 14, 1992).

[3]Agency for Toxic Substances and Disease, U.S. Department of Health and Human Services, "Toxicological Profile of Cadmium" (PB93-182418), April, 1993.

[4]International Programme on Chemical Safety, "Environmental Criteria 135, Cadmium-Environmental Aspects," World Health Organization, 1992.

[5]M. Stoeppler, "Cadmium," *Metals and their Compounds in the Environment* Weinheim Publishers, 1990.

4.3.3 The Benefits of Restricting Cadmium Use

The reduction of cadmium levels in the environment, in the workplace, and in the human food chain would benefit the health of humans and terrestrial and aquatic ecosystems. By reducing or eliminating the use of cadmium in Massachusetts firms, worker and public health exposure stemming from these uses would be reduced. It is difficult to determine the exact magnitude of worker health benefits and associated manufacturing savings in insurance rates, health care expenditures, and sick day productivity losses. These reductions may be low for firms that are in compliance with the new Occupational Safety and Health Administration (OSHA) worker exposure limit which appears to be reasonably protective of worker health.[1] However, if these firms can find suitable substitutes for cadmium, they stand to eliminate the costly worker protection equipment required by the new OSHA standard.

As stated previously, four out of the five TURA filers using cadmium compounds do so in plastics-related applications, either producing or using a cadmium-based pigment or heat stabilizer. Sixteen states (including Connecticut, Rhode Island, Main, New Jersey, New Hampshire and Vermont) have passed legislation (originating with the Coalition of Northeast Governors) that bans the use of cadmium, lead, hexavalent chromium and mercury in plastic and other types of packaging. The legislation is aimed at preventing toxic substances from leaching out of landfills and blowing out of incinerator stacks. Massachusetts has not adopted the legislation. Consequently, a cadmium use restriction would bring Massachusetts plastic packaging manufacturers in line with many of its New England neighbors.

Beyond the elimination of cadmium emissions from the manufacturing plant, it is important to consider the benefits of a cadmium use restriction "up-stream" and "down-stream" of the industrial user. In the US, cadmium metal is supplied by zinc ore refineries (cadmium is a component of zinc ore), recovered from flue gases from primary copper and lead smelting, and from nickel-cadmium battery recyclers. It is unlikely that the production levels and associated environmental and health impacts of the first two operations will be effected by a reduction in cadmium demand (since they are primarily driven by the demand for zinc, lead, and copper). However, a reduction in the demand for cadmium compounds would reduce emissions from a variety of intermediate processes that take the raw metal and convert it into intermediate materials for cadmium pigment, stabilizer, and battery production.

Many consumer products used and disposed of in Massachusetts are not made in the Commonwealth and the emissions from use and disposal of these products would not be affected by a Massachusetts-based restriction on cadmium use in manufacturing. Furthermore, many non-manufacturing, cadmium-emitting activities (e.g., oil combustion and

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[1]Based on exposure assessments conducted by OSHA for its 1992 rulemaking on cadmium, several of the Massachusetts firms characterized in Section 4.3.4 fall into categories of relatively high worker exposure, including the production of cadmium pigments and stabilizers and mixing cadmium-containing chemicals (Federal Register, Vol. 57, No. 178, Sept. 14, 1992.)

phosphate fertilizer applications) would continue to disperse cadmium into the Massachusetts environment.

4.3.4 Cadmium Usage Trends in Massachusetts

The TURA chemical list includes elemental cadmium and cadmium compounds, and both were analyzed. As shown in Table 4.4, three companies reported using elemental cadmium in 1992. The total quantity of elemental cadmium used was approximately 113,000 pounds. The cadmium was used in three different applications: 1) making electrical contacts, 2) electroplating, and 3) fabricating metal parts. Use of cadmium in Massachusetts has declined since 1992, primarily because the largest user closed its Massachusetts facility in 1992 (application #3). Cadmium use is expected to continue declining because one of the two remaining users has reported plans to substitute away from cadmium by 1995 (application #2). The final cadmium user (application #1) is exploring alternatives, but did not commit to eliminating cadmium in their 1994 TUR plan summary.

Five companies reported using cadmium compounds in 1992, for a state-wide usage of approximately 206,000 pounds. Four of these companies used cadmium compounds in plastics-related applications as a pigment or heat stabilizer. Approximately 95 percent of the total quantity of cadmium compounds reported in 1992 was used in these plastics-related applications. The remaining five percent was used in producing metal parts with special electrical properties, similar to electrical contacts. All four of the companies with plastics applications indicated in their TUR plan summaries that they will eliminate their use of cadmium-compounds by 1995. One of the four has already substituted an unregulated chemical. The fifth user of cadmium compounds expects to reduce, but not eliminate, their use of these chemicals.

4.3.5 Potential Effects of a Cadmium Use Restriction

As described above, only two companies expect to continue using cadmium after 1998. One company is using elemental cadmium; the other is using cadmium compounds. Both companies indicated in their TUR plans that their use of cadmium will be below the TURA threshold by 1998. Thus, if a use restriction did not regulate uses below 10,000 pounds per year, these companies would not be affected.

TABLE 4.4 ANTICIPATED USE REDUCTIONS FOR CADMIUM AND CADMIUM COMPOUNDS

	1992		Eliminated by 1994		Below Threshold by 1995		Eliminated by 1995		Eliminated by 1998		Not Substituting[1]	
Chemical	firms	lbs	firms	lbs	firms	lbs	firms	lbs	firms	lbs	firms	lbs
Cadmium	3	113,000	1[2]	77,000	0	0	1[4]	22,000	0	0	1[5]	14,000
Cadmium Compounds	5	206,000	1[3]	35,000	0	0	3[3]	160,000	0	0	1[5]	11,000
Total	8	319,000	2	112,000	0	0	4	182,000	0	0	2	25,000

Source: 1992 TURA submissions, 1994 TUR plans and phone conversations.

1 In both cases, these companies expect to reduce use below the TURA threshold by 1998. However, 1992 use estimates are shown in all columns for consistency.
2 This company used cadmium in the fabrication of metal parts.
3 These companies used cadmium compounds in production of plastics additives.
4 This company used cadmium for plating applications.
5 These companies used cadmium or cadmium compounds in the production of parts with special electrical properties.

No functional equivalents have been identified for either cadmium application. For this reason, no attempt was made to assess the costs that would be incurred should one or both of the companies attempt to convert to another material. In one application, cadmium is used to make metal strips for electrical contacts, such as those used in high voltage motor starters. Cadmium plays an important role by preventing the contacts from welding together under extreme heat. Another benefit of cadmium is that it works for all electrical contacts, while potential substitutes are expected to be effective for only a subset of these contacts. The second cadmium application also involves providing a connection in electrical equipment. Cadmium compounds are used in on/off switches that must withstand high voltage without welding to the connecting parts. No other alternatives have been identified for this cadmium application. This use was excluded from the European Economic Community's proposed ban of cadmium.[1]

Based on TRI data and conversations with the users, environmental releases from these two uses of cadmium appear to be relatively low, and are anticipated to become lower still. In 1992, neither of these two companies' cadmium releases were reported to TRI because their use was below the threshold. Releases can be expected to further decline because one of the two companies is currently building an automated process line that is expected to virtually eliminate all spills and air emissions. Given that the usage rates of these two applications are expected to fall below the TURA threshold, the lack of substitutes considered functionally equivalent by the companies, and the limited environmental releases from these two uses of cadmium, a use restriction might exempt these applications.

4.4 Summary and Conclusions

Many companies in Massachusetts are reducing their use of TCE and cadmium, even without specific regulations requiring them to do so. Data from TUR plan summaries indicate that chemical substitutions will reduce use of TCE by 15 percent between 1992 and 1998, and cadmium and cadmium compound use by 90 percent over the same period. When efficiency improvements and recycling efforts are considered, TCE usage could decline by an additional 35 percent from 1992 levels, while cadmium use could decline by an additional five percent.[2]

Several factors are driving the declines in use of TCE and cadmium. Many of the factors motivating the movement away from TCE stem from the 1990 Clean Air Act Amendments. In particular, the phase out of ozone-depleting chemicals, with its increasing tax on 1,1,1-trichloroethane and CFC-113, has heightened awareness of the problems associated with chlorinated solvents, even though the phase-out does not directly affect TCE. The operating permit program and the upcoming air toxics regulation for degreasers have also contributed to companies' desires to move away from regulated substances. For the adhesives industry,

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[1] "EC Cadmium Bans Approved," *Metal Bulletin*, June 24, 1994, p. 10.

[2] By 1998, TCE use would be expected to fall to only 40 percent of 1992 levels except that one company plans to increase its usage rate significantly, offsetting the decline from other companies.

the reporting and recordkeeping requirements in right-to-know legislation and VOC regulations have been cited as a factor motivating the move away from solvent-based technologies. In addition, industry data indicate that some companies will move away from solvents because new technologies are more competitive economically.[1] As new technologies are developed, these advantages will be extended to a broader range of processes.

For cadmium, a growing awareness of the health effects associated with heavy metals has developed, accelerated in Massachusetts by the media and public attention given to lead.[2] The most significant factor motivating replacement of cadmium, however, is a series of state regulations banning cadmium in food packaging. These regulations, referred to as the CONEG rules because they were initiated by the Coalition of Northeastern Governors, have been essentially replicated in 16 states, although not in Massachusetts.[3]

In addition to the direct impact of legislation on firms' behavior, the growing list of legislation affects public perception, which translates into another source of pressure on firms using TCE and cadmium.[4]

While some regulations have encouraged use reductions by limiting emissions, charging fees or, in the case of other states, banning uses in certain applications, no regulation specifically limits the use of either TCE or cadmium in Massachusetts. As a result of these essentially voluntary use reductions, the 1992-level of TCE use is expected to drop by 50 percent and cadmium use by 95 percent among TURA submitters by 1998. A state regulation limiting the use of these chemicals to less than 10,000 pounds at any single TURA submitting facility could further reduce the use of TCE by approximately 1.8 million pounds per year. The use of cadmium would probably not be reduced by such a regulation, however, because the companies currently using cadmium expect to be below the TURA threshold or to have completely eliminated cadmium use by 1998.

Tables 4.5 and 4.6 summarize the potential impacts of use restrictions for TCE and cadmium if the policies were imposed as of the year 2000. In most cases, the impact of a use restriction would be the cost of converting to a substitute, and potentially some minor

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[1]Ellerhorst 1982 as cited in 1991 UNEP Solvents, Coatings, and Adhesives Technical Options Report, December 1991, p. 254.

[2]"Environmentalism Alters Metal Plating," *Chemical Marketing Reporter*, April 1993; and Jim Callari, "Environmental Pressures Force Widespread Change," *Plastics World*, November 1992.

[3]"Laws Force Hunt for Pigment Alternatives," *Packaging*, May 1993. States that have enacted restrictions include: Connecticut, Georgia, Illinois, Iowa, Maine, Maryland, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Washington.

[4]Personal communication with a representative from a company using TCE in adhesives.

product quality losses. For example, in essentially all of the general degreasing applications, the possibility of implementing functionally equivalent substitutes is promising. However, for high technology and adhesives-related applications, some possibility exists that functionally equivalent substitutes may not be identified, even by the year 2000. As a result, even if restrictions were not applicable until 2000, they could potentially cause some companies to leave Massachusetts. The analysis indicates that between one and four companies could relocate, or simply close a portion of their operations because of a TCE use restriction.

The four companies that might relocate to avoid a TCE use restriction employ approximately 4,400 people at Massachusetts facilities. Sales information is available for only three. Together these three companies had sales of over $300 million in 1994, with one of the companies accounting for nearly 90 percent of that value. Available data do not reveal what portion of the operations run by these companies would be affected by a TCE use restriction. Thus, it is difficult to estimate whether these companies would consider relocating their entire facilities or only certain TCE related activities. Some company representatives have indicated that they would consider relocating their entire production process because of the inefficiency of separating different components. Others have stated that only a certain percentage of their operations would be closed or relocated, while the rest remained intact.

In summary, a TCE use restriction would create costs or savings on a statewide basis that are estimated to fall within the ranges presented in Table 4.5.[1] In the worst case, substitutions for all the uses affected (general and high technology degreasing, adhesives, and repackaging) would cause companies to incur net costs. The net present value for the worst case would be a cost of approximately $6.5 million for degreasers, repackagers, and companies with adhesives-related applications, though the estimate for this third group of companies is speculative. In the best case, degreasers' avoided cost of TCE purchases is sufficiently great to lead to a net statewide savings. As a result, despite adhesives-related conversion costs and repackagers' potential sales losses, the net percent value of the best case results in an aggregate savings of $1.7 million. These estimates are of course subject to numerous assumptions and the validity of case study data, as described in the TCE section of this chapter. The actual estimates should be viewed less as a precise indication of the potential costs of a use restriction than as an indication of the range of impacts that such a policy could create.

A cadmium use restriction, on the other hand, would not be expected to influence Massachusetts companies who have submitted TURA reports, unless it limits use to less than 10,000 pounds per year. For most of the companies analyzed, the impacts of a complete chemical ban are the same as those predicted for a restriction to use of less than 10,000 pounds. However, as summarized in Table 4.6, the two companies who expect to remain using cadmium in 1998 will have reduced their use to a rate of less than 10,000 pounds per year. As a result, a 10,000 pound use restriction would not influence their operations, while a complete ban would cause them to consider relocation.

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[1]The substitution costs and savings data were projected over ten years and discounted at 10%.

TABLE 4.5 SUMMARY OF POTENTIAL IMPACTS OF A USE RESTRICTION IN 2000 FOR TCE

Activity	Number of Companies	Best Case	Worst Case
General Degreasing	21	• Six companies could be forced to substitute alternative cleaners for TCE, potentially saving $1 million.	• Six companies could be forced to substitute to alternative cleaners, potentially costing $0.1 million.
High Technology Degreasing	7	• Three companies could be forced to substitute to alternative cleaners, potentially saving $1.5 million. • Functionally equivalent substitutes are being developed, so there should not be a loss of product quality.	• Three companies could be forced to substitute to alternative cleaners, potentially costing $0.6 million. • Functional equivalents might not be discovered – in this case, product quality could suffer or production units could be moved out of state.
Adhesives	3	• Functionally equivalent alternatives, such as terpenes, water-based adhesives and hot melts, are developed to meet companies' needs. • Three companies would incur costs of converting to these alternative products, ranging from approximately $13,000 to more than $100,000 per company.	• Functionally equivalent alternative adhesives might not be discovered. Two companies could relocate. The third plans to reduce usage rates below the TURA reporting threshold and thus might not be affected.
Repackaging	5	• Potential loss of approximately 1.5 million pounds of TCE sales and $0.9 million dollars in profits. However, these or other Massachusetts companies may be able to offset five to 15 percent of the decreased TCE sales by supplying alternative products.	• Potential loss of approximately 2.4 million pounds of TCE sales and $5.5 million dollars in profits. The repackagers themselves may have limited ability to offset reduced TCE sales by supplying alternatives. Other Massachusetts companies may increase revenues by approximately $24,000 as they provide alternative cleaners.
TOTAL TCE	36	• Companies can adapt to the restriction without major complications; some even save money.	• All companies incur costs, and quality may suffer for high technology degreasers and adhesives manufacturers. Quality concerns may cause some companies to relocate all or parts of their facilities.

TABLE 4.6 SUMMARY OF POTENTIAL IMPACTS OF A USE RESTRICTION IN 2000 FOR CADMIUM*

Activity	Number of Companies	Best Case	Worst Case
Plated Parts Fabrication	2	• All companies are expected to have virtually eliminated cadmium use by 2000, so the restriction would have no impact.	• All companies are expected to have virtually eliminated cadmium use by 2000, so the restriction would have no impact.
Plastics	4	• All companies are expected to have virtually eliminated cadmium use by 2000, so the restriction would have no impact.	• All companies are expected to have virtually eliminated cadmium use by 2000, so the restriction would have no impact.
Electrical Parts Production	2	• A functionally equivalent alternative could be discovered, though one is not currently available. If so, the restriction would have little or no impact.	• Both companies are expected to reduce use below 10,000 pounds per year, but not to eliminated use because no adequate substitute is available. • Both companies could relocate if faced with a total ban of cadmium.
Total Cadmium	8	• Very limited impact because all but two companies will have virtually eliminated use for other reasons. The two companies who do not plan to eliminate use of cadmium might be able to develop adequate substitutes by 2000.	• Impact generally considered limited because all but two companies will have virtually eliminated use for other reasons. However, the two companies who do not plan to eliminate use of cadmium might not be able to develop adequate substitutes by 2000, and could relocate to avoid a complete ban of cadmium use.

* Elemental cadmium and cadmium compounds are presented together.

CHAPTER 5 EXISTING MODELS FOR CHEMICAL RESTRICTIONS

The Institute's first state report on chemical restrictions described an array of policy tools that are potentially applicable to restricting toxic chemicals in Massachusetts in Chapters 4 and 8. Chapter 4 described most voluntary, economic, and mandatory policies that could be used to promote and/or implement restriction policies in the state. Chapter 8 briefly described and evaluated three existing models for restricting toxic chemicals -- the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), Toxic Substances Control Act (TSCA), and Swedish sunsetting program -- and concluded that the sunsetting/phase-out concept was the "most attractive for state adoption."[1] One outcome of the Institute's policy analysis was the development of the "Toxic Chemical Transition Process" concept (Chapter 9), which proposed that a combination of voluntary, economic, and mandatory policies be used to promote and implement cleaner production processes for a few target toxic chemicals.

Comments received at the public hearings held on the Institute's chemical restrictions report emphasized the need to work within the existing chemical restrictions framework provided under the federal law, TSCA, and to examine in more detail the effectiveness of other existing phase-out legislation.[2] To develop a more comprehensive understanding of the principal opportunities and models available to the State for restricting toxic chemicals, this chapter examines in more detail (than in *Toxic Chemical Management in Massachusetts*) TSCA, the Swedish sunsetting program, and the Montreal Protocol phase-out of ozone depleting chemicals.

5.1 The Federal Toxic Substances Control Act (TSCA)

When the federal Toxics Substances Control Act (TSCA) was enacted in 1976 it added significant new authorities to the U.S. Environmental Protection Agency (EPA) for regulating industrial toxic chemicals. The Congressional committee hearings reveal that TSCA was drafted to meet several objectives: a) to assure that chemicals would be evaluated before use, b) to guarantee that existing chemicals pose no unreasonable risk to human or environmental

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[1]Rossi and Geiser, *Toxic Chemical Management in Massachusetts*, 1993, p. 138.

[2]Mark Rossi and Ken Geiser, *Summary of Responses: TURI Further Chemical Restriction Policies Report* (Lowell, Massachusetts: Toxics Use Reduction Institute), 1993.

health, and c) to restrict chemicals already on the market that do pose unreasonable health risks. Key provisions of the law are:

1. to screen all new chemicals to assess whether they pose an unreasonable risk,
2. to require testing of existing chemicals identified as posing unreasonable risks,
3. to gather information on existing chemicals, and
4. to control chemicals proven to pose an unreasonable risk.

Within the context of the Massachusetts debate on toxic chemical restrictions, the most important aspect of TSCA is the control of existing chemicals (Section 6 of TSCA). For this reason, the role of TSCA in evaluating new chemicals is not addressed in this section.

Section 6(a) of TSCA authorizes the EPA to regulate toxic chemicals:

> If the Administrator [of the EPA] finds that there is a reasonable basis to conclude that the manufacture, processing, distributing in commerce, use, or disposal of a chemical substance ... presents or will present an unreasonable risk of injury to health or the environment, the Administrator shall ... protect adequately against such risk using the least burdensome requirements [regulations].[1]

Through Section 6 of TSCA the EPA can engage in a wide range of chemical restrictions involving chemicals or products that pose an unreasonable risk to human or environmental health:

- prohibit or limit the manufacturing, processing, or distribution in commerce of the target chemical/product,

- prohibit or limit particular uses or concentrations of the manufacturing, processing, or distribution in commerce of the target chemical/product,

- require that the chemical/product be labeled regarding the instructions for use and disposal, and the dangers of the product,

- require that manufacturers and processors of the chemical/product make and retain records of the processes used to manufacture or process such substances and to monitor or conduct tests to assure compliance,

- prohibit or otherwise regulate any manner or method of commercial use of such substance or mixture,

- prohibit or otherwise regulate the disposal of the chemical/product, or

[1]15 U.S.C. 2605(a).

- require that manufacturers or processors "give notice" of unreasonable risk or injury distributors in commerce.[1]

To implement regulations for existing chemicals under TSCA the Agency must prove that a chemical poses "unreasonable risk of injury to health or the environment". This is the same standard found in the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) except that the phrase "presents or will present" precedes the standard. This phrase was added to clarify that risk did not mean a certainty of harm. Despite the concept of unreasonable risk being central to decision making under TSCA, it is never formally defined in the legislation.[2] However, Section 2(c) of TSCA does state what it means to implement the act in a "reasonable" manner:

> It is the intent of Congress that the Administrator shall carry out this Act in a reasonable and prudent manner, and that the Administrator shall consider the environmental, economic, and social impact of any action the Administrator takes or proposes to take under this Act.

Therefore, to determine whether or not the manufacture, processing, distributing in commerce, use, or disposal of a chemical substance chemical poses unreasonable risks the EPA must identify and evaluate the environmental and social impacts of that chemical and the economic consequences of regulating it.

The regulations for implementing Section 6 emphasize a flexible approach rather than strict adherence to the Administrative Procedures Act such that the Agency is directed to find the least burdensome approaches to the regulation of a targeted chemical.[3] It is clear from these regulations that the actual phase out of production or use is intended to be employed only when less burdensome policy instruments will not effectively protect human health or the environment.

Relevant to toxic chemical restrictions in Massachusetts is the effectiveness of EPA's efforts to evaluate the risks posed by toxic chemicals and the Agency's ability to regulate or restrict them. As required by TSCA, the EPA developed an inventory list of all chemicals in commerce. The initial list developed by the Agency included 43,000 unique chemical formulations.[4] As of 1989, the chemical inventory included roughly 68,000 chemicals, with 15,000 believed not to be in commerce and 19,000 being polymers (generally of low

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[1]Excerpted in part from Rossi and Geiser, *Toxic Chemical Management in Massachusetts*, 1993, pp. 68-69.

[2]Michael Shapiro, "Toxic Substances Policy", in Paul R. Portney, ed. *Public Policies for Environmental Protection* (Washington, DC: Resources for the Future), 1990, p. 211.

[3]40 C.F.R. Part 750, December 2, 1977.

[4]Walter A. Rosenbaum, *Environmental Politics and Policy* (Washington, DC: Congressional Quarterly, Inc.), 1985, p. 205.

toxicity). This leaves roughly 34,000 chemicals most of which have had little to no health or environmental effects testing.[1]

To assist the EPA in setting testing priorities, TSCA created the Interagency Testing Committee (ITC). The ITC submits semi-annual reports to the EPA recommending which chemicals should be given priority consideration for testing. As of 1991, the EPA was "supervising testing programs for 151 chemicals, which included 68 chemicals recommended from sources other than ITC."[2] By 1991, EPA had compiled complete test data for sixteen chemicals.[3]

Concerning the implementation of regulations under TSCA (Section 6), the EPA has regulated four chemicals:

- banned poly chlorinated biphenyls (PCBs), 1976 (the EPA was mandated to restrict PCBs by TSCA);
- banned chlorofluorocarbons (CFCs) in aerosol propellants, 1978;
- promulgated dioxin disposal regulations, 1980 (since transferred to RCRA in 1988); and
- promulgated asbestos-in-schools regulations, 1987, and banned almost all asbestos-containing products over the next seven years, 1989.[4]

The 1989 ban of most asbestos-containing products was struck down by the Fifth Circuit Court of Appeals in 1991 (*Corrosion Proof Fitting v. EPA*) and the Appeals Court decision was later upheld by the federal Supreme Court.

Despite a full-plate of 34,000 largely unstudied chemicals the EPA has moved quite slowly in testing and regulating existing chemicals. A variety of explanations have been offered for the slow pace of implementing TSCA:

- political interference in the early 1980s under Administrator Anne Gorsuch[5];

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[1]Nicholas A. Ashford and Charles C. Caldart, *Technology, Law, and the Working Environment* (New York: Van Nostrand Reinhold), 1991, p. 198.

[2]United States General Accounting Office, *Toxic Substances: Status of EPA's Reviews of Chemicals Under the Chemical Testing Program* (Washington, DC: US GAO, "GAO/RCED-92-31FS"), 1991, p. 9.

[3]US GAO, *Toxic Substances*, p. 3.

[4]Nicholas A. Ashford and Charles C. Caldart, *Technology, Law, and the Working Environment* (New York: Van Nostrand Reinhold), 1991, p. 196.

[5]Ashford and Caldart, p. 199.

- delays caused by a "methodical progression from risk assessment (based on testing) to risk management (regulations)"[1];
- delays in developing testing protocols[2];
- little intra-agency coordination on TSCA action;
- the exclusive focus on chemicals of environmental concern, leaving all occupational hazards to OSHA[3];
- the initial focus on putting the program in place: "organizing and staffing the new office, meeting statutory deadlines for promulgating test rules, compiling the TSCA inventory, and putting the new chemical review program into place"[4];
- the "basic difficulty of making unreasonable risk determinations in the face of the data limitations and uncertainties"[5]; and
- "burdened by delays and complications arising from the difficulty in obtaining technical information and resolving scientific conflicts over the program objectives"[6].

Two authors, Michael Shapiro and Walter Rosenbaum, note the difficulty of reconciling the issue of proving unreasonable risk with limiting the economic consequences of restricting or regulating industrial toxic chemical use:

Rosenbaum:

> ... legislation containing a multiplicity of different, often inconsistent statutory criteria for determining acceptable risk in regulation--the norm for most environmental legislation, as illustrated by the Toxic Substances Control Act--forces administrators to adopt balancing formulas among scientific, economic, and political criteria in which scientific considerations are often subordinate or the relative weight of differing criteria is obscured.[7]

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[1]Ashford and Caldart, p. 199.

[2]Ashford and Caldart, p. 199.

[3]Ashford and Caldart, p. 199.

[4]Michael Shapiro, "Toxic Substances Policy", infrom Paul R. Portney, ed. *Public Policies for Environmental Protection* (Washington, DC: Resources for the Future), 1990, p. 225.

[5]Shapiro, p. 225.

[6]Walter A. Rosenbaum, *Environmental Politics and Policy* (Washington, DC: Congressional Quarterly, Inc.), 1985, p. 205.

[7]Walter A. Rosenbaum, "The Bureaucracy and Environmental Policy" (from James P. Lester, ed. *Environmental Politics and Policy: Theories and Evidence*. Durham, North Carolina: Duke University Press), 1989, p. 222.

Shapiro:

> Formaldehyde provides an excellent example of the difficulties involved when a major existing chemical product is being considered for regulation on the basis of a chronic toxic effect such as cancer. With the economic stakes as high as they are for a chemical like formaldehyde, the many uncertainties associated with the assessment of chronic hazards are subject to intense scrutiny and debate.[1]

The efforts of the EPA to regulate or restrict chemicals under the TSCA framework became even more complex when the Fifth Circuit Court of Appeals ruling against the asbestos ban was upheld by the Supreme Court.

> [In that case, *Corrosion Proof Fittings v. EPA*,] the court asserted that the agency had neither fully evaluated and rejected less burdensome regulatory measures, nor fully evaluated the relative safety of known alternatives to asbestos. The court put a significant burden on the agency by requiring it to compare, for instance, the benefits of a ban with the benefits of requiring increased worker protection equipment and product labelling. Moreover, the court interpreted Sections 1-5 of TSCA as a hierarchy, that is, limiting the amount of substance that can be produced cannot be done unless labelling has already been tried, regardless of the harm. Further, even though it is widely acknowledged that banning a substance may encourage technological innovation towards substitutes, the court held that U.S. EPA erred in failing to fully review the relative hazards posed by existing asbestos substitutes such as PVC (polyvinyl chloride) pipe and the safety of automotive brakes made without asbestos.[2]

Prior to the asbestos decision, the EPA was having severe problems in meeting the goal of TSCA of regulating existing toxic chemicals. Without an adequate database on toxic chemical health effects, and a clear mandate of what constitutes unreasonable risk and how health and economic effects should be balanced, the EPA has acted and continues to act at a glacial pace in testing and regulating existing toxic chemicals under TSCA.

5.2 Swedish Sunsetting Program

The most aggressive toxic chemical restriction program being implemented in the international arena is in Sweden. As of 1991, Sweden had severely restricted or banned 70 pesticides and 62 industrial chemicals. However, it is important to note that the Swedish approach to toxic chemical restrictions operates on a variety of policy levels in addition to toxic chemical bans. The public policy tools used in Sweden include promoting voluntary efforts, requiring product labeling, and phasing-out toxic chemicals.

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[1]Shapiro, p. 227.

[2]Rossi and Geiser, *Toxic Chemical Management in Massachusetts*, 1993, p. 138.

Sweden promotes voluntary restrictions by stimulating the in-house work of companies to voluntarily replace hazardous substances and products. For example, in Sweden manufacturers of paints and varnishes are voluntarily phasing-out the use of lead in these products.[1]

In a similar vein, Sweden has enacted a mandatory labeling law, the Swedish Product Damages Act:

> This law requires companies to provide information on their products' characteristics and composition. For example, products containing allergenic or carcinogenic substances, or substances which may cause reproductive system or immune system disturbances must be labeled so.[2]

The law requires no changes in the manufacturing process; any changes that a company makes to their manufacturing process is voluntary. However, the incentive of removing negative human health labeling from a product through safer substitution is clearly a large inducement for a manufacturer to change the chemical inputs.

Most uniquely, Sweden is coupling voluntary restrictions with mandatory restrictions and phase-outs. In the area of mandatory restrictions, Sweden has implemented three primary initiatives.

First, in 1990 the Swedish Government amended the Act on Chemical Products to require "those who import, manufacture or otherwise handle a chemical product ... to avoid such products that may be replaced by less hazardous ones"[3] (i.e., substitute hazardous products with less hazardous ones).

Second, the Swedish Work Environment Act regulates chemicals used in the workplace and the agency administering the Act has banned fourteen substances found to be carcinogenic.[4]

Third, in 1989 the Swedish government charged the Swedish National Chemicals Inspectorate (KemI) and the Swedish Environmental Protection Agency (SNV) with the task of developing action plans for sunsetting the use of chemicals that have particularly harmful effects on

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[1]The Swedish National Chemicals Inspectorate and the Swedish Environmental Protection Agency, *Risk Reduction of Chemicals: A Government Commission Report* (Stockholm: Swedish National Chemicals Inspectorate), 1991, p. 17.

[2]Rossi and Geiser, *Toxic Chemical Management in Massachusetts*, 1993, p. 66.

[3]The Swedish National Chemicals Inspectorate, p. 27.

[4]Rossi and Geiser, *Toxic Chemical Management in Massachusetts*, 1993, p. 136.

humans or the environment.[1] In 1991, the Swedish Parliament approved the action plans for sunsetting 13 chemicals.[2] The chemicals covered are:

- arsenic
- brominated flame retardants
- cadmium
- chloroparaffins
- creosote
- lead
- mercury
- methylene chloride
- nonyl-phenol-ethoxylates
- organotin compounds
- phthalates
- tetrachloroethylene (perchloroethylene)
- trichloroethylene

A review of the proposed action plans[3] reveals that Sweden is not sunsetting all 13 chemicals. The action plans for the 13 chemicals range from merely collecting information to mandating complete sunsets (see Table 5.1). The action plans as a whole recommend the use of a broad array of policy tools to promote and require the reduction in the use of the chemicals. The policies include (see Appendix D for further details on the action plans):

- working with industrial organizations to voluntarily phase-out chemical uses,
- promoting international phase-outs,
- taxes to promote changes in use,
- product labeling requirements,
- information reporting requirements,
- technological assistance in the development and implementation of safer substitutes,
- bans of specific chemical uses, and
- staged phase-outs of chemicals.

Sweden is phasing-out the use of some toxic chemicals. Where information is inadequate on uses or health effects of a chemical more data are sought. Where information is sufficient and alternatives available for a chemical's use, the phase-out time frame is short. Where information is sufficient and alternatives uncertain for a chemical's use, longer phase-out time frames are provided with assistance from the state to develop alternatives or to promote their development. Cost-benefit analyses play a small role at this point in the Swedish "sunsetting" process because the chemicals have already been identified as high risk chemicals either in Sweden or internationally.

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[1]The Swedish National Chemicals Inspectorate, p. 7.

[2]Draft, Pollution Probe, *Toxic Chemical Sunsets* (Toronto: Pollution Probe), 1993.

[3]The finalized action plans have not been attained from Sweden.

TABLE 5.1 SUMMARY OF SWEDISH GOALS FOR THEIR "SUNSET" CHEMICALS

Stated Goal	Chemicals Targeted for the Goal
Phase-out all uses within ten years	methylene chloride, trichloroethylene, perchloroethylene, and chlorinated paraffins
Phase-out most uses by the year 2000	nonyl-phenol-ethoxylates
Phase-out most or all uses in the long-term	lead, mercury
Reduce use in wood-preserving agents	arsenic compounds and creosote
Reduce some uses and phase-out other uses	cadmium and organotin compounds
Reduce environmental releases through toxics use reduction	brominated flame retardants and phthalates

Source: Swedish National Chemicals Inspectorate and Environmental Protection Agency, *Risk Reduction of Chemicals*, 1991.

The Swedish commitment to reducing the human and environmental health risks posed by certain chemicals is further reinforced by their current effort to identify "multiproblem chemicals" and to target these chemicals for risk reduction through their "Sunset Project". The Sunset Project is currently in the process of identifying risk reduction candidates and will then propose and implement measures for reducing the risks. Through the Sunset Project 100 multiproblem chemicals have been identified. Additional data will be collected on the health and environmental hazards of the 100 multiproblem chemicals. Use patterns will then be examined. Finally, a group of multiproblem chemicals will be identified for risk reduction. Risk reduction measures to be considered include:

- banning or phasing-out uses that cannot be adequately controlled,
- restricting uses,
- limiting releases, and
- disseminating information to stimulate manufacturers or users to take voluntary measures[1].

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[1]Swedish National Chemicals Inspectorate, *Selecting Multiproblem Chemicals for Risk Reduction*, (Stockholm: National Chemicals Inspectorate), 1993.

5.3 The Montreal Protocol

A detailed case study on the Montreal Protocol was included in the first state chemical restrictions report. This section on the Montreal Protocol seeks to summarize data presented in the case study and to shed light on its effectiveness.

The Montreal Protocol contains the most comprehensive chemical restriction policy to be enacted either nationally or internationally. The Protocol is actually an annex to the Vienna Convention for the Protection of the Ozone Layer first drafted under the sponsorship of the United Nations Environment Program in 1985. The Protocol provides for an international phase-out of the following ozone depleting chemicals:

- carbon tetrachloride,
- chlorofluorocarbons (CFCs),
- halons, and
- 1,1,1-trichloroethane.

The Protocol was signed in Montreal in September 1987 and was activated in early 1989 after 11 nations, representing two-thirds of global CFC consumption, ratified it. The significance of the Montreal Protocol is that it represents agreement among countries to a "system of international regulation that would affect powerful commercial interests and products widely used in everyday life."[1] The initial agreement along with amendments made in London in 1990 set specific timetables for the phase-out of the above ozone depleting chemicals. The phase-out time schedules call for carbon tetrachloride, CFCs, and halons (with minor exceptions) to be phased-out by 2000 and for 1,1,1-trichloroethane to be phased-out by 2005.

Nations that have ratified the Montreal Protocol have moved at varying paces to enact its provisions into national law. Sweden and Germany moved quickly. Germany, for instance passed legislation in 1989 to ban all production and use of chlorofluorocarbons by 1995.

Implementation of the Montreal Protocol in the US has resulted in an array of policy initiatives designed to facilitate the ultimate phase-out of ozone depleting chemicals. Rather than relying solely on the threat of a ban by the year 2000, the US is using many policy initiatives to facilitate the phase-out; similar to the methodology being employed in Sweden to sunset multiproblem chemicals.

In order to deter the use and production of CFCs in the US, Congress included in the Omnibus Budget Reconciliation Act of 1989 an annually increasing tax on the sales of CFCs and halons. In 1990, shortly after the London meeting and amendments to the Montreal Protocol, Congress passed amendments to the 1977 Clean Air Act that established a phase out process for eliminating ozone depleting substances. The amendments created two classes of regulated substances. Class I substances (those on the Montreal Protocol list) were to be

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[1]Hilary F. French, "Strengthening Global Environmental Governance," in Lester Brown, et. al., *State of the World, 1992*, (New York: W.W. Norton & Company), 1992, p. 160.

phased out by 2000, while the Class II substances that included many chemical substitutes were to be heavily regulated until "safe substitutes" could be developed. In 1992 this schedule was shortened as President Bush announced a ban on all further production and use of CFCs by 1995.

Other policy initiatives being employed in the US include:

- funding and performance of research and development for safer alternatives;
- publishing data on available substitutes;
- labeling requirements on products sold that contain or used ozone depleting chemicals in their manufacture; and
- identifying of non-ozone depleting alternatives through the US EPA's Safe New Alternatives Program.

The implementation of the Montreal Protocol in the US has met with many successes and a few drawbacks. Successes include the formation of the International Clearinghouse on Ozone Layer Protection (ICOLP) by the electronics industry to distribute information on alternatives to ozone depleting chemicals, the quick exit of the electronics industry out of ozone depleting chemicals, the development of clearly safer alternatives such as no clean low-solid fluxes, and the generally quick development of alternatives for the vast majority of cleaning operations. The principal drawback to the implementation of the Montreal Protocol has been in developing technically effective and economically viable alternative refrigerants. The difficulty surrounding refrigerant alternatives is highlighted by the US EPA asking DuPont to continue production of CFCs for automobile air conditioners.

The Montreal Protocol is generally regarded as a successful example of the phasing-out of toxic chemicals in the US. The cost of the phase-out is offset because all nations incur the same costs. Interestingly, the legal authority for phasing-out ozone depleting chemicals was vested in the Clean Air Act Amendments of 1990 and not in TSCA.

5.4 Summary

Based on the ability to restrict toxic chemicals of concern, the Swedish model for restricting toxic chemicals stands in contrast to TSCA. Sweden is restricting, banning, and phasing-out industrial "multiproblem" chemicals. The United States is not doing the same. The information presented in the section on TSCA points primarily to problems in the legal design of TSCA--it is too complicated and too ill-directed. But of greater importance is the significant reluctance that the American government has demonstrated in promoting the use of TSCA to phase out the production or use of toxic chemicals. The analysis of the Swedish experience points to strong government support for reducing risks through chemical restrictions.

Explanations for the differences in government approach point to a polarization over the issue in the US and a more cooperative environment in Sweden. In Sweden restrictions are a central component of an overall risk reduction program. There are a few, rare examples of the use of TSCA to restrict the production and use of toxic chemicals, but, in general, in the US chemical restrictions are not a component of an overall risk reduction program.

In contrast to the US's limited use of TSCA for restricting toxic chemical use, the US has moved quickly and effectively to phase-out ozone depleting chemicals through the Clean Air Act. In the case of ozone depleting chemicals, the US has taken an integrated policy approach -- using a series of policy measures quite similar to the Swedish approach -- to sunsetting chemicals. This approach is proving, with the exception of refrigeration/air conditioning, to be an effective one. The international scope of the Montreal Protocol does make ozone depleting chemicals a unique case. The success of the Montreal Protocol makes it a compelling model. Still the uniqueness of the Montreal Protocol leaves unanswered the question whether this is a historical aberration or a new trend in multiproblem toxic chemical management unanswered.

CHAPTER 6 POLICY OPTIONS FOR MASSACHUSETTS

The existing legal framework for the Commonwealth to restrict toxic chemical usage in Massachusetts remains fraught with ambiguities. The capacity of the state agencies to systematically identify priority chemicals and plan for and implement programs to convert users to safer substitutes remains clouded.

Experience with TURA has significantly raised government and industry attention to the use of toxic chemicals and developed a much more sophisticated array of resources at the state level for working with industry to reduce the use and byproducts generated by the use of those chemicals.

As demonstrated in Chapter 3 the generation of toxic chemical byproducts has decreased significantly while the total use of toxic chemicals has declined, but more gradually.

If the state wishes to go beyond toxics use reduction (i.e., byproduct reduction) and hasten the decline in the total use of toxic chemicals, there remain several options. The state may choose to do nothing more; it may seek more aggressive action from the federal level; or it may attempt to implement further chemical restriction policies. Each of these options is detailed in the following sections.

6.1 Do Nothing More

In policy analysis it is always useful to consider the option of doing nothing. The Commonwealth of Massachusetts has established an array of policies concerning the proper management of toxic chemicals and the state's nationally recognized toxics use reduction law is only five years old. It can be argued that the current policies are adequate or that it is still too early to assess the effectiveness of the current policies.

Doing nothing more could mean:

- holding off on any further state initiative until 1997 when TURA will be more fully assessed evaluated, or

- planning to do nothing more until some critical event or popular concern compels the state legislature to enact new legislation on chemical restrictions.

The value of doing nothing more is that neither industry nor the state will be required to take further actions. This would permit those firms where management is motivated to reduce or eliminate the use of some toxic chemicals to do so voluntarily. The evidence from the TURA program suggests that some firms have already done so, are doing so now, or plan to do so in the near future. Of course, doing nothing more will not motivate firms that currently have no incentive for reducing or eliminating the use of toxic chemicals.

As identified in the first report, the option of doing nothing more would generate some potentially undesirable consequences for the state. Doing nothing more will leave the state fairly unprepared for responding to sudden and unpredictable public sentiment to address a particular toxic chemical and will provide no state system for prioritizing toxic chemicals of high concern.

The opening chapter of the first state report on chemical restrictions attempted to document the current problems posed by toxic chemicals in Massachusetts. Doing nothing more could leave these problems much as they are today or subject them to the (potentially corrective) accumulated effects of existing laws and regulations, in particular TURA.

During the past year two reports from the environmental advocacy community have sought to use TURA data to further describe the risks that toxic chemicals pose in Massachusetts.[1] While these data are not universally accepted as evidence that toxic chemicals are worthy of further restrictions they do suggest that there will continue to be advocacy for doing something more.

6.2 Promote Federal Initiatives

Faced with the consequences of doing nothing more, but unwilling to commit the Commonwealth to inaction, the state could use its powers to promote and assist changes at the federal level. Pressing for changes at the national level is attractive for at least two reasons:

1. Chemical markets are much more national, even international, than they are bounded within one state. A more comprehensive and industry-wide approach to toxic chemical management could be achieved by addressing the need for toxic chemical restrictions at the federal level.

2. Seeking more aggressive federal action on chemical restrictions would eliminate the business community's concerns that Massachusetts was staking out too independent a position on chemical restrictions and, therefore, jeopardizing the state's "business

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[1]See Environmental Lobby of Massachusetts, *The Carcinogens Around Us: Chemical Use in Massachusetts, 1990-1992*, Boston, MA, August, 1994; and JSI Center for Environmental Health Studies, *Toxics Use in Massachusetts: Implications for Public Health*, Boston, MA, 1994.

climate" and placing some Massachusetts firms at a competitive disadvantage with firms in states that did not have similarly aggressive chemical restriction policies.

The Commonwealth could seek to promote chemical restrictions at the federal level in two ways: by encouraging its Congressional delegation to seek changes in federal legislation, or by directing its executive agencies to promote changes in federal environmental regulations and programs.

Legislative changes could be effected through new legislation or through modifications to existing media-specific pollution control laws (the Clean Air Act, the Clean Water Act, the Resource Conservation and Recovery Act, etc.) or the substance-focused commodity control laws (the Federal Insecticide, Fungicide, Rodenticide Act, the Consumer Product Safety Act, the Toxics Substances Control Act, etc.)

The most obvious federal statute would be the Toxic Substances Control Act (TSCA) because it so directly focuses on toxic chemical management and because it already contains some of the most far reaching federal authority to restrict the use of toxic chemicals.

Chapter 5 noted some of the current limits with TSCA and many policy advocates argue that TSCA has not met the expectations with which it was enacted and that TSCA needs to be brought before the US Congress for reconsideration. During 1994 two hearings were held by the Senate Subcommittee on Toxic Substances, Research and Development to assess alternative directions for re-drafting TSCA.

Testimony from those hearings revealed many problems with TSCA including slowness and weaknesses in the testing program for existing chemicals, the glacial-like progress of reviewing even the agencies short list of 16,000 individual chemicals, the limits on states and the general public to chemical composition and health data due to the over use by industry of confidential business claims, and the weak enforcement powers in the act.[1]

In terms of chemical restrictions several improvements could be made. These include a more effective multi-stakeholder process for prioritizing existing chemicals for phase-out, more of a focus on classes of chemicals than on specific substances, more attention to the processes of converting from targeted chemicals to safer substances, and more direct support for the development of safer and more ecologically sound new chemicals.

A state initiative to promote the reform of TSCA might be well received, but it would certainly be unique. In general state knowledge of and interaction with TSCA has been limited. A recent National Conference of State Legislatures survey of state needs in regards to toxic chemical management found that 45 per cent of state agency respondents were not

[1]See testimony by Lynn Goldman, Roger Kavanaugh and Kenneth Geiser, U.S. Senate, Subcommittee on Toxic Substances, Research and Development. Committee on Environment and Public Works, Washington, D.C., July 13, 1994

familiar with TSCA and 85 per cent were not aware of what facilities in their states were regulated under TSCA.[1]

Massachusetts could become more actively involved in the emerging efforts to re-authorize TSCA in order to promote processes for chemical restrictions that would reduce the need for such initiative at the state level. In so doing, the state might seek some of the following:

- better coordination and integration of state and federal efforts to manage toxic chemicals

- establish a process for working cooperatively with industry to restrict toxic chemicals

- develop an integrated risk reduction strategy that uses restrictions as one of many policy measures

- improved state access to TSCA data, cooperative data exchange procedures between state and federal data bases, and a less liberal system for masking chemical characterization and health effects information behind confidential business claims

- authority to transfer state developed chemical restrictions petitions for federal review, further testing, risk assessment, cost analysis and the development of effective control strategies

- the development of joint federal-state programs to promote reductions in production and use of priority toxic chemicals

6.3 State Toxic Chemical Restrictions Processes

If the state was interested in implementing toxic chemical restrictions, two options have been proposed in the past few years, which are available for consideration.

The Toxic Chemical Transition Process, which was developed by the Institute in its first report on chemical restrictions remains a candidate. The Toxic Chemical Transition Process proposed by the Institute is a fairly lengthy four step process that would assist the state in prioritizing toxic chemicals and working with industry in the promotion of reductions first through voluntary measures, then through required plans, and finally through mandatory eliminations. This process would create a more coordinated and comprehensive state approach to toxic chemical management that would unite the best resources of the state and industry in a mission oriented conversion from the most dangerous materials to more benign processes and alternatives.

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[1]U.S. Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances, Forum on State and Tribal Action, *The State Toxics Needs Assessment*, prepared by the National Conference of State Legislatures, unpublished report, Washington, D.C., June, 1994.

In general, both the business community and the public interest community found fault with the Institute's proposed process. While the two different groups approached the process with quite different motivations, both groups found the process too lengthy, too complex and, ultimately, too costly. Perhaps a more streamlined version of the Institute's proposal would find a better reception.

The Swedish program to sunset multi-problem chemicals offers a more streamlined model of a chemical restriction program. After substantial study the Swedish Chemical Inspectorate and the Swedish National Environmental Protection Agency promulgated a list of 13 chemicals. Following a relatively brief period of consultation with industry the Swedish government then published plans with target dates for the phase out of the use of these 13 substances. This process did not involve a long period of public participation or prolonged risk assessment procedures. This more streamlined approach may be more attractive because:

- it is relatively speedy
- it is not encumbered by significant government investments of time and effort
- it provides a clear message to industry and the general public
- it focuses directly on planning and implementing the conversion process without a long preparatory period

A even more streamlined process was proposed in a bill submitted to the legislature last year by the Massachusetts Public Interest Research Group (MassPIRG). As a response to the Institute's proposed process the MassPIRG filed a restriction bill in the 1994 legislative session, titled "To Restrict the Use, Manufacture or Sale of Chlorinated Solvents."[1] This bill focused singularly on four common industrial solvents: methylene chloride, perchloroethylene, trichloroethylene and methyl chloroform. Instead of a set of procedural steps based on studies and programs, this bill simply created a schedule for the phasing-out of specified uses of the solvents. The bill did include a requirement that prohibited the substitution of known high risk chemicals for the targeted chemicals and did encourage the Institute and the Office of Technical Assistance to provide specific technical assistance, research and technology transfer services.

This bill and the general consensus of testimony in the public hearings suggests that there may be grounds for further discussion on a more streamlined toxic chemical transition process. In order for such a process to be acceptable to those stakeholders that testified at the hearings the process would need to be more easily initiated, less burdensome in terms of time and procedure, and more tightly limited to permit only the most serious of chemicals to proceed towards phase out.

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[1]Massachusetts General Court, "An Act to Restrict the Use, Manufacture or Sale of Chlorinated Solvents", House Bill #1905, Boston, MA, 1994.

CHAPTER 7 CONCLUSIONS

In the first state report, the Institute attempted to document some of the problems caused by the release of toxic chemicals in Massachusetts. The report examined the current condition of the Commonwealth's capacity to respond and examined a broad range of potential policy instruments ranging from voluntary to mandatory tools. Following a lengthy review of case studies on chemical phase outs and recent government programs to restrict the use of toxic chemicals, the report went on to propose a four step, multi-instrument process that could be adopted in Massachusetts to create a rational toxic chemical transition process.

In this report, the Institute has attempted to use data from the state toxics use reduction program to assess industrial experience in using the toxics use reduction program to restrict the use of toxic chemicals. In addition, this report has used two case chemicals--trichloroethylene and cadmium--as examples of chemicals that might be given high priority for restriction and attempted to examine the economic effects that might be derived from their restriction. Finally, this report has examined in more detail three current approaches to toxic chemical phase outs.

What can be drawn from these two reports and the comments received at public hearings on the first report is that:

- the management of toxic chemicals at the state level is characterized by a fragmented and ad hoc approach that remains little capable of setting priorities or responding in a planned, preventive or pro-active manner,
- the state yet lacks a priority list of toxic chemicals of concern or a means of setting those priorities,
- there is wide divergence of opinion among state business and environmental leaders about the need to develop further state authority for toxic chemical restrictions,
- the toxics use reduction program is being effectively pursued by both industry and government and there are many compelling anecdotal examples of firms reducing the use of toxic chemicals (and achieving cost savings),
- qualitative data on the rates of byproduct reduction suggest that many firms are implementing toxics use reduction programs,

- quantitative data on toxic chemical use and byproduct generation over the four year period in which TURA has been in effect indicates a decline in both total use and byproduct generation, although the decline in byproduct generation is the more substantial of the two,

- a review of sixteen toxic chemicals rated as priority chemicals by other governments reveals that there has been a decrease in both the use and byproduct generation for most chemical over the past four years,

- among these sixteen chemicals those with largest reductions in use and byproduct are those targeted for phase out by the international Montreal Protocol,

- among the sixteen chemicals byproduct generation of dichloromethane and xylene has increased and both byproduct and total use of lead have increased over these four years,

- an analysis of the costs and benefits of further restrictions on two illustrative toxic chemical reveals that in the best case the firms using those chemicals can find effective substitutes that are cost competitive and in some cases these conversions could lead to additional cost savings,

- this analysis also reveals in the worst case that a few facilities would endure serious burdens and either change products or leave the state.

These findings would suggest several conclusions.

First, there remains an unfulfilled need for additional state initiative to design and implement a more comprehensive and preventive approach to toxic chemical management.

Second, while this analysis suggests that there is a general decline in toxic chemical use and byproduct generation, there is not enough data or data analysis from the toxics use reduction program to draw telling conclusions upon that program's effectiveness.

Third, it is too early to assess the overall effectiveness of the toxics use reduction program or to conclude from that experience that further chemical restrictions are warranted.

Finally, because there is not enough evidence to suggest that the toxics use reduction program will effectively reduce the problems caused by high priority toxic chemicals and because the state may need to pursue further chemical restriction policies in the future either through appeal to the federal government or through its own initiative, it would be prudent for the Institute to identify a short list of toxic chemicals for further study in terms of both economic and health and environmental effects.

Selection of these chemicals is rather straight forward. They should be chemicals used in significant volume in Massachusetts and chemicals identified as possible candidates for phase out should the Commonwealth ever wish to implement such a program. Chapter 3 identified a list of priority chemicals derived from priority lists of other governments. Thus the selection criteria are:

- the substances are included on other government priority lists including the EPA "33/50" list, the Swedish government list of multi-problem chemicals, and the list of ozone depleting substances as determined by the international Montreal Protocol, and

- the substances are used in high volume in Massachusetts.

In Chapter 3 these criteria were used to identify the following sixteen chemicals:

- arsenic compounds
- cadmium and cadmium compounds
- chlororfluorocarbons (CFCs)
- chromium and chromium compounds
- cyanide compounds
- dichloromethane
- lead and lead compounds
- methyl ethyl ketone
- methyl isobutyl ketone
- nickel and nickel compounds
- phthalates
- tetrachloroethylene
- 1,1,1-trichloroethane
- trichloroethylene
- toluene
- xylene

This report has examined the effects of restricting the use of two of these sixteen chemicals: trichloroethylene and cadmium.

During the next two years the Institute, with assistance from the Science Advisory Board, will examine in more detail the health and environmental risks of these sixteen substances, consider the social and economic effects of eliminating the use of these substances, and monitor the performance of those facilities currently using these chemicals. The Institute will include a report on this work in the evaluation of the state toxics use reduction program due in 1997.

APPENDIX A. NORMALIZATION METHODOLOGIES

The purpose of data normalization is to adjust for changes in production in order to provide a clearer picture of quantitative extent of toxics use reduction (TUR) activities. Adjusting data for production can be important because it reduces the likelihood that increases in production mask TUR implementation or decreases in production overstate TUR implementation.

Three potential methodologies for normalizing TURA data are: 1) linking the data to one or more general indicators of production activity -- such as employment, value-added by manufacturer, value of shipments, or wages of production employees; 2) applying the "activity index" from the federal Toxics Release Inventory (TRI) database to the TURA data; and 3) calculating "facility-wide, and then state-wide reductions using either actual quantity reduction or a weighted average of byproduct reduction indices".[1] Unfortunately none of these normalization methodologies is an ideal fit with the TURA data.

The general indicator used for normalization in this analysis was employment. Employment was selected as the general indicator because it was the only indicator that met the following four criteria:

1) available at the 4 digit SIC code for all industries which are required to file TURA data
2) available publicly on an annual basis and in a timely manner
3) available for Massachusetts
4) high quality

Employment data for Massachusetts are available through the Bureau of Labor Statistics (BLS) at the four-digit SIC code level on an annual basis. These data, which are compiled for the Covered Employment and Wages program, are derived from tax reports submitted by employers subject to State unemployment insurance laws and from Federal agencies subject to Unemployment Compensation for Federal Employees program. As of 1972, all facilities employing at least one worker were required to submit information. Excluded from these reporting requirements are a portion of all agricultural workers, self-employed farmers, self-employed non-agricultural workers, domestic workers, unpaid family workers, members of the Armed Forces stationed in the United States, State and local government workers, and railroad workers covered by a different unemployment system.

Employment data are compiled from quarterly tax reports on monthly employment (based on all covered workers who received pay for a period including the 12th day of the month), including persons on paid sick leave, paid holiday, and paid vacation. The Bureau of Labor

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[1]Elizabeth Harriman, et al, *Measuring Progress in Toxics Use Reduction* (Medford, Massachusetts: Tufts University, Hazardous Materials Management Program), 1991, p. ES-3.

Statistics withholds the publication of industry data for confidentiality purposes when one of the following criteria is met:

- the industry level consists of fewer than three establishments
- a single establishment accounts for at least 80% of the industry's employment

While employment data are available and reliable, they also have limitations, including: the increasing productivity of workers, lag times in hiring/firing, and the inconsistent relationship between number of non-production employees and actual facility production level. Some additional data are available to correct for these factors, but they did not meet the four selection criteria. For example, changes in worker productivity are available for only some four-digit SIC codes and only on a national basis.

All other sources of general indicators of production levels -- e.g., value-added by manufacturer, value of shipments, or wages of production employees -- failed to meet the four data criteria listed above. For example, in the case of value added data, incompatibility problems included:

- only available for the manufacturing SIC codes (i.e., SIC codes 20-39)
- value added data are not available for all 4-digit SIC codes because of confidentiality constraints[1]
- data are reported too infrequently: the most recent value added data available are reported from the 1987 Census of Manufacturers[2] and the 1992 data are not expected until June 1995

The second normalization methodology (the TRI activity index) was not used for this analysis because of its focus on whole facility production levels -- rather than on SIC-specific activity -- and because of uncertainty regarding the quality of the indices. The TRI database reports four-digit SIC codes at the facility level, rather than TURA's production unit level, and activity indices are reported for the whole facility. In addition, because a number of facilities did not report an index, or reported zero, it would be necessary to hand check each index and make necessary adjustments.

The third normalization methodology, using a facility-wide BRI as the basis of normalization,[3] at first glance seems like the most appropriate methodology. But, it relies on data not reported in the Form S: a facility-wide byproduct reduction index. Because BRI's are reported at the production unit level and chemical quantities are reported at the

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[1]When a few facilities comprise the majority of firms in a particular SIC code, data for that SIC code are omitted.

[2]Published by the U.S. Department of Commerce, Bureau of the Census.

[3]This normalization methodology was developed by a group of Tufts University graduate students for DEP, see Harriman, et al, *Measuring Progress in Toxics Use Reduction* (Hazardous Materials Management Program, Tufts University), 1991.

facility level, it is not possible to determine what portion of a facility's chemical use was responsible for each BRI. It is, therefore, not possible to aggregate BRI's unless there is only one production unit associated with a particular chemical.

Data normalization is a complex and difficult task within the context of measuring progress in TUR, in large part because it cannot be performed using data obtained solely from the Form S. Introducing additional data to act as a proxy for level of production invariably results in inconsistencies and introduces new sources of error. Given all the previously mentioned advantages and limitations, state-wide four-digit SIC code employment data were chosen to be used as a proxy for level of production in the normalization analysis.

Application of the Employment Normalization Methodology to Four Industry Sectors

To develop an understanding of how the employment normalization methodology works it was applied to four four-digit manufacturing SIC codes:

- 2672 Paper Coated and Laminated, not elsewhere classified
- 2821 Plastic Materials and Resins
- 3471 Metal Plating and Polishing
- 3679 Electronic Components, not elsewhere classified

These four industry sectors were chosen because they each manufacture different types of products and include significant users of toxic chemicals over all use categories, excepting manufactured chemicals.[1] In some cases these SIC codes are in the top three of a chemical category:[2]

- 2821 is number one in processed chemicals, total use, and releases and transfers[3]
- 2821 is number two in shipped in or as byproduct
- 2672 is number one in byproduct generation
- 2672 is number two in otherwise used

In Table A.1 the byproduct generation of these four industry sectors is listed for the three years 1990-1992. In Table A.1 the list of chemicals was held constant using the 1990 list. What Table A.1 reveals is that byproduct generation over the three year period decreased for SIC codes 2672 and 2821 and increased for SIC codes 3471 and 3679. The changes in

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[1]Manufactured chemicals were not considered because of the high percentage of manufactured chemicals claimed as trade secret.

[2]Donald LaTourette, *Toxics Use and Emissions in Massachusetts: An Analysis* (Lowell, Massachusetts: Toxics Use Reduction Institute), Research Fellow Report, 1994.

[3]"Releases and transfers" refers to the total of releases and transfers, not as two separate categories.

byproduct generation ranged from moderate decreases (12-22%) to moderate increases (15-20%).

TABLE A.1 BYPRODUCT GENERATION BY SIC CODE, CHEMICALS HELD CONSTANT AT 1990

SIC Code	1990 (million lbs)	1991 (million lbs)	1992 (million lbs)	Percent Change
2672	22.3	19.5	17.3	-22
2821	8.2	4.9	7.2	-12
3471	6.8	10.2	7.8	15
3679	6.9	5.9	8.3	20

In an effort to understand the effects of changes in the production levels of facilities upon toxic chemical byproduct generation, employment figures were used as a proxy for changes in production levels. Table A.2 lists the number of employees for the four SIC codes. For all four industry sectors employment declined or remained steady over the 1990-1992 period. If employment is an accurate proxy of industry sector production levels, then four of the industry sectors examined in this report are in a period of contraction, especially the "plastic materials and resins" industry (SIC code 2821), which experienced a 12 percent decline in employment during this period.

Two key assumptions are made in interpreting the normalized byproduct results:

- changes in employment roughly mirror changes in facility-level production
- in the absence of TUR, changes in pounds of byproduct roughly mirror changes in facility-level production

All other factors being equal, the changes in employment shown in Table A.2 mean that byproduct generation should have declined for SIC codes 2821, 3471, and 3679, and remained roughly the same for SIC code 2676. Table A.3 lists byproduct generation and byproduct generation normalized by employment. In general, actual byproduct generation by SIC code differs from what would be expected if byproduct generation rose and fell with employment (assuming all other factors remain equal). Table A.4 summarizes the changes in employment and byproduct generation over the three year period, 1990-1992.

The one industry sector where there seems to be an association between employment and byproduct generation is SIC code 2821. In this case employment decreased by 12 percent and byproduct generation also decreased by 12 percent between 1990 and 1992. These two trends seem to indicate that the decline in byproduct generation is due to changes in industry sector productivity rather than due to implementing TUR techniques.

For SIC code 2672, employment remained steady over the three years and byproduct generation dropped by 22 percent. These trends seem to indicate that TUR techniques were implemented in SIC code 2672 to produce the reduction in byproduct generation; as opposed to achieving byproduct generation through reduced production.

For SIC codes 3471 and 3679 the employment trends and byproduct trends are running in opposite directions: employment is declining while byproduct is increasing. If the byproduct data is accurate, one plausible explanation for the trend is: these industry sectors are just beginning to emerge from an economic downturn, production is increasing but workers are still being laid off, and worker productivity is increasing because workers are working longer hours. It is also possible that production processes become less efficient during this time period.

TABLE A.2 MASSACHUSETTS EMPLOYMENT BY SIC CODE

SIC Code	Employment Category	1990	1991	1992
2672	number of employees	1,337	1,326	1,328
	% change from base yr		-1	-1
2821	number of employees	3,772	3,490	3,324
	% change from base yr		-7	-12
3471	number of employees	2,420	2,244	2,325
	% change from base yr		-7	-4
3679	number of employees	6,621	6,311	6,142
	% change from base yr		-5	-7

Source: Bureau of Labor Statistics

TABLE A.3 BYPRODUCT GENERATION: AGGREGATE DATA AND NORMALIZED DATA BY SIC CODE

SIC Code	Byproduct Generation Category	1990	1991	1992
2672	byproduct (million lbs)	22.3	19.5	17.3
	% change from base yr		-13	-22
	byproduct (normalized by employment)	16,709	14,736	13,023
	% change from base yr		-12	-22
2821	byproduct (million lbs)	8.2	4.9	7.2
	% change from base yr		-40	-12
	byproduct (normalized by employment)	2,161	1,411	2,172
	% change from base yr		-35	1
3471	byproduct (million lbs)	6.8	10.2	7.8
	% change from base yr		50	15
	byproduct (normalized by employment)	2,811	4,555	3,365
	% change from base yr		62	20
3679	byproduct (million lbs)	6.8	5.9	8.3
	% change from base yr		-13	22
	byproduct (normalized by employment)	1,036	941	1,358
	% change from base yr		-9	31

TABLE A.4 SUMMARY OF CHANGES IN EMPLOYMENT AND BYPRODUCT GENERATION BY SIC CODE (1990-1992)

SIC Code	Change in Employment	Change in Byproduct Generation
2672	decrease = -1%	decrease = -22%
2821	decrease = -12%	decrease = -12%
3471	decrease = -4%	increase = 15%
3679	decrease = -7%	increase = 22%

APPENDIX B. THE INCOMPATIBILITY OF THE TRI DATABASE IN MEASURING PROGRESS IN BYPRODUCT GENERATION

The Toxics Release Inventory (TRI) data is occasionally used as an indicator of progress in reducing byproduct generation. In the aggregate (total toxic chemical releases and transfers for all reporting facilities in Massachusetts), the TRI data reveal a dramatic decrease in releases over the period 1987 - 1992 (years for which data are publicly available, see Table B.1). The TRI data reveal that:

- between 1987 and 1992 toxic chemical releases declined steadily, by over 50 percent, from 33 to 14 million pounds
- toxic chemical transfers declined in a similar fashion until 1991, when the definition of transfers was expanded, causing transfers of toxic chemicals to rise sharply
- total releases and transfers declined from 75 million pounds in 1987 to 55 million pounds in 1992

The decline in toxic chemical releases and transfers represents progress in managing toxic chemicals in Massachusetts. This decline in TRI releases and transfers is undoubtedly environmental progress. The question under consideration here, however, is not whether Massachusetts is better off because of reduced toxic chemical releases and transfers. Rather the question is to what extent can this data be used to show progress in reducing byproduct generation.

The difficulty in using TRI data to show progress in byproduct generation is that the TRI database covers only toxic chemical releases and transfers, not byproduct generation. "Releases" are defined as: fugitive air emissions, stack air emissions, surface water discharges, underground injection, and releases to land. "Transfers" are defined transfers to recycling, energy recovery, treatment, publicly owned treatment works (POTWs), disposal, and other off-site transfers.

The decline in toxic chemical releases and transfers indicates that Massachusetts industry is effectively collecting toxic chemicals prior to their release into the environment (i.e., stack emissions, fugitive emissions, direct discharges to water, underground injection, and releases to land). The principal plausible explanations for the decline in releases are 1) manufacturers are doing a better job of collecting pollutants prior to their release to the environment and transferring them off-site (i.e., better pollution control[1]), 2) manufacturers are implementing TUR techniques, which are resulting in less releases, 3) plants closed due to the economic downturn from 1989-1991, 4) plant production levels declined (thus less toxic chemicals were

[1]"Pollution control" is a term whose definition varies frequently with the perspective of the user. Pollution control in this report refers to all initiatives that are designed to reduce releases of pollutants through all non-TURA methods.

used and released into the environment), 5) "delisting" of chemicals,[1] and 6) facility waste accounting methods have changed.

The above list of explanations for decreases in toxic chemical releases can also be applied to transfers, with the exception of point #1 -- better pollution control (because chemicals used in the production process and listed as a "transfer" have already passed through pollution control technologies).

The extent to which decreases in releases and transfers is attributable to each cause cannot be determined. What is known is that the dramatic increase in transfers from 1990 to 1991 (from 20 to 36 million pounds) is due to the broader definition of a transfer. Two new categories of transfers -- transfers to recycling and energy recovery -- produced an additional 22.8 million pounds of toxic chemical transfers in 1991. Far offsetting the 5.8 million pounds of reduction in transfers to treatment and disposal that occurred in 1991.[2] However, without knowing the amount of transfers to recycling and energy recovery prior to 1991, it is difficult to gauge how much the reduction in TRI releases was due to pollution control, TUR, and/or a contracting economy.

No one factor can explain the trends in the TRI data. The three key factors seem to be pollution control (e.g., in 1992 transfers to recycling and energy recovery[3] accounted for over 28 million pounds of chemicals transferred[4]), the economic recession in Massachusetts,[5] and the implementation of TUR techniques at facilities. The TRI data demonstrate progress in protecting environmental and human health, the data cannot be used to show progress in TUR.

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[1]Over the 1987-1992 period, the US EPA has altered the universe of chemicals that facilities are required to report on by adding and removing (delisting) chemicals.

[2]US Environmental Protection Agency, *1992 Toxics Release Inventory Public Data Release* (Washington, DC: US EPA, EPA 745-R-94-001, 1994), pp. 198-199.

[3]These two categories were added to the TRI database in 1991.

[4]US EPA, *1992 Toxics Release Inventory Public Data Release*, 1994.

[5]Between 1984 and 1990 New England lost over 240,000 jobs, with almost all of this decline in manufacturing employment (Lynn E. Browne, "The Role of Services in New England's Rise and Fall: Engine of Growth or Along for the Ride?", *New England Economic Review*, July/August 1991).

TABLE B.1 MASSACHUSETTS TRI RELEASES AND TRANSFERS DATA, 1987-1992

YEAR	RELEASES (lbs)	TRANSFERS (lbs)	RELEASES & TRANSFERS (lbs)
1987	33,355,176	41,807,594	75,162,770
1988	29,356,961	38,644,146	68,001,107
1989	25,812,887	29,982,724	55,795,611
1990	20,819,818	20,315,090	41,134,908
1991	17,056,992	35,966,101	53,023,093
1992	14,359,448	40,986,601	55,346,049

APPENDIX C. BACKGROUND DATA TO THE COST ANALYSIS FOR THE TRICHLOROETHYLENE CASE STUDY

This appendix explains how the quantitative analysis for degreasing applications of trichloroethylene (TCE) was conducted. Best and worst case estimates from a converting company's perspective, were developed for two types of cost elements: the initial costs associated with converting from TCE to an alternative degreasing system, and the annual operating costs for degreasing. Operating costs for both a TCE-based system and an alternative system were estimated for each company, then compared to create an incremental operating cost for the substitution. The initial and operating costs were estimated for the nine companies expected to remain using TCE in 1998, according to their TUR plan summaries.[1] The costs were estimated using data from existing case studies, conversations with past and present TCE users, and articles in the trade press. Table C.1 presents the cost elements considered for degreasers. Table C.2 presents a summary of the data used for this analysis, as the numbers were reported in the case studies.[2] Table C.3 displays the data after accounting for inflation. Operating costs were assumed to remain constant for ten years, and discounted by 10 percent. For a detailed explanation of how the costing elements for converting companies were calculated, as summarized in the "Comments on Converting Companies' Cost Elements" column displayed in Table C.3, refer to the "Notes for Calculation of Converting Companies' Cost Elements" section at the back of this Appendix.

Initial Costs

Initial costs were estimated only for the alternative to TCE. Four different cost elements were considered for initial costs: alternative degreasing capital equipment, water treatment equipment, research and development efforts, and process or facility adjustments (see Table C.1). These four cost elements were determined primarily by examining the activities being performed and product characteristics at the facilities potentially being altered by a substitution. Every attempt was made to match the potential costs for each company with the characteristics of that company.

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[1] One industry contact suggested that the cost of switching for each company using TCE be estimated by multiplying the total amount of TCE used by the overall cost per pound for the most applicable case study. However, because there are some gaps in the case study data, it was determined that this methodology is not the most appropriate.

[2] To protect the privacy of those companies that supplied information, letters are used instead of names for some cases.

TABLE C.1. COST ELEMENTS FOR DEGREASING ANALYSIS

Costs for Both TCE Usage and Alternative System	
Regulatory Costs Paperwork and Permitting Costs Safety Training and Equipment Waste Testing, Fees and Manifesting	**Other Operating Costs** Maintenance Waste Disposal Utilities
Costs for TCE Usage Only	
Regulatory Costs TURA Fees	**Other Operating Costs** TCE Purchases
Costs for Alternative System Only	
Initial Costs Research & Development Capital Equipment Process Adjustments Water Treatment System	**Operating Costs** New Cleaning Fluid Purchases

Table C.4 presents the capital equipment cost estimates used for each of the nine companies analyzed. For two companies, the same capital equipment costs were used for both the best and worst cases, and were based on the most applicable case study. For six of the seven remaining companies, the best-case capital equipment costs were based on those of a case study company, adjusted for relative TCE usage rates using a scaling factor of 0.6.

Table C.2 ACTUAL DATA FROM CASE STUDIES

	Cost of Changing		Company A		Company B		Company C		Company D		NEWMOA 1		NEWMOA 2		NEWMOA 3		Company E	
Cost Element	TCE	NEW	TCE	NEW	TCE	NEW	TCE	NEW	TCE	NEW	TCE	NEW	TCE	NEW	TCE	NEW	TCE	NEW
INITIAL																		
Equipment																		
Purchase New		9,000		321,000		117,500		24,500		1,000				88,000		20,000		118,000
Waste Trt.				25,000		11,215				3,500								
R & D Hours										150		24						500
Adjustments		432		25,000		14,900		690		1,000		1,000						
TOTAL	0	9,432	0	371,000	0	143,615	0	25,190	0	5,650	0	1,024	0	88,000	0	20,000	0	118,500
OPERATING																		
TCE Purchases																		
Lbs	25,492				30,000		8,600		15,598		1,749				1,000		20,000	
Price/Lb	1.08				1.04		0.83										1.00	
Cost	27,531		65,123		31,200		7,138		3,800								20,000	
Waste Disposal																		
# of Drums	8						1										4	
Price	165						250										350	
Cost	1,320		9,225		3,120		250	870			10,600		11,000		550		1,400	
Wst Fees, Tests, & Manifesting			4,190	740	6,000													
Safety Training&Othr																		
Hours			66	36	30													
Wage			12.5-45	45	30													
Cost			2,285	1,620	900													
Equip. Cost			280															
TURA Fee	1,100		3,413	2,313	1,100				3,000									
Paperwork																		
Hours	15		280	194	195		10										5	
Wage	16		20-45	45	30		30										30	
Cost	240		10,700	8,750	5,850		300										150	
Permitting																		
Hours	4																	
Wage	16																	
Cost	56																	
Maintenance																		
Hours	7	36				66	2	5										
Wage	16	16				30	30	30										
Cost	112	576	42,420	104,020	20,000	1,980	60	135										
New Cleaner																		
Gallons/Yr		34																
Price		12.95																0.15
Cost		444				10,500		2,947										
Utilities ($)																		
Water		7	9,000	55,000														
Gas&Electric			10,305	9,000										10,000				
TOTAL	30,359	1,027	156,939	181,443	68,170	12,480	7,748	3,952	6,800	0	10,600	0	11,000	10,000	550	0	21,550	0

Table C.3 INFLATED DATA FROM CASE STUDIES

Cost Element	Cost of Changing TCE	Cost of Changing NEW	Company A TCE	Company A NEW	Company B TCE	Company B NEW	Company C TCE	Company C NEW	Company D TCE	Company D NEW	NEWMOA 1 TCE	NEWMOA 1 NEW	NEWMOA 2 TCE	NEWMOA 2 NEW	NEWMOA 3 TCE	NEWMOA 3 NEW	Company E TCE	Company E NEW	Comments on Converting Co.'s Cost Elements
INITIAL																			
Equipment																			
Purchase New		9,000		329,501		127,083		24,500		1,000				93,592		20,989		118,000	Scaled
Water Trt				25,662		12,130				3,500									Scaled
R & D Hours										150		24						500	$3,370 or $9,119
Adjustments		432		25,662		16,115		690		1,000		1,049							Scaled
TOTAL	0	9,432	0	380,825	0	155,328	0	25,190	0	5,650	0	1,073	0	93,592	0	20,989	0	118,500	
OPERATING																			
TCE Purchases																			
Lbs	25,492				30,000		8,600		15,598		1,749				1,000		20,000		TURA & TRI
Price/Lb	1.08				1.04		0.83										1.00		$0.50 or $1.00
Cost	27,531		65,123		31,200		7,138		3,800								20,000		
Waste Disposal																			
Lbs Waste																			TRI
Adjustment																			TUR Plan
# of Drums	8						1										4		Calculated
Price	165						250										350		$330
Cost	1,320		9,225		3,120		250	870			10,600		11,000		550		1,400		Calculated
Wst Fees, Taxes & Manifesting			4,190	740	6,000														TCE:$1132, New:$40
Safety Training&Othr																			
Hours			66	36	30														Average
Wage			12.5-45	46	34														$30
Cost			2,357	1,671	1,026														TCE:$1640, New:$540
Equip. Cost			287																$32
TURA Fee	1,100		3,413	2,313	1,100				3,000										$1,100
Paperwork																			
Hours	15		260	194	195		10										5		Average
Wage	16		20-45	46	34		30										30		$30
Cost	240		11,039	9,027	6,666		300										150		TCE:$2910, New:$1164
Permitting																			
Hours	* 4																		
Wage	16																		
Cost	56																		$56
Maintenance																			
Hours	7	36				66	2	3											
Wage	16	16				34	30	30											
Cost	112	576	43,763	107,314	22,790	2,256	60	135											Scaled
New Cleaner																			
Gallons/Yr		34																	
Price		12.95																0.15	
Cost		444				11,356		2,947											Scaled
Utilities ($)																			
Water		7	9,267	56,634															
Gas&Electric			10,609	9,267										10,833					Scaled
TOTAL	30,359	1,027	159,274	186,966	71,901	13,613	7,748	3,952	6,800	0	10,600	0	11,000	10,833	550	0	21,550	0	

Note: Costs are inflated to 1994 dollars.

Table C.4

CAPITAL COSTS FOR DEGREASERS

	Best Case		Worst Case	
High Technology	**Estimate**	**Source**	**Estimate**	**Source**
Company 1	26,889	Cost of Changing	125,000	"Tooling and Production"
Company 2[1]	500,000	"Tooling and Production"	1,250,000	"Tooling and Production" and Calls to Companies
Company 3	48,021	Company C Case	150,000	"Tooling and Production" and Calls to Companies
General				
Company 1	80,157	Company C Case	80,157	Company C Case
Company 2	9,000	Cost of Changing	118,000	Calls to Companies
Company 3	46,617	Company C Case	200,000	Calls to Companies
Company 4	9,000	Cost of Changing	9,000	Cost of Changing
Company 5	9,000	Cost of Changing	20,000	"Tooling and Production"
Company 6	9,000	Cost of Changing	160,000	Calls to Companies

[1] Four production units being converted.

[2] Tooling and Production is a trade journal. In two recent articles (May 1993 and 1994), the publication provided price estimates for various different types of aqueous and semi-aqueous degreasing systems.

For the seventh company, best-case capital equipment costs were based on estimates in the trade press. For the worst-case capital equipment estimates, four of the seven were based on information from the trade press, and three were based on information from companies with a similar degreasing operation.

Water treatment costs were included for companies in which the most relevant case study, the case being used as the basis for the capital costs, provided these costs. In such cases, the estimates provided were scaled by TCE usage, and applied to the best and worst cases.

The same estimate of research and development (R&D) costs was used for all general degreasing cost scenarios, as well as for the best-case scenario for the high technology degreasing applications. This estimate ($3,370) was developed by averaging the number of hours for R&D included in three of the case studies and applying a wage rate of $45.00 per hour. This R&D wage rate was identified in one of the case studies and appeared to be a representative hourly wage for R&D activity, which in smaller firms can be expected to be performed by the plant manager. For high technology degreasers in the worst-case scenario, two additional estimates of the costs incurred from R&D were incorporated into the calculation. These supplementary estimates were provided in telephone discussions with companies currently investigating degreasing alternatives for high technology applications. Using this additional data, the worst-case research and development cost for high technology degreasers was estimated to be $9,119.

The same case studies used as the basis for the capital cost estimates were used to estimate the adjustments in physical plant configurations necessary to accommodate the substitution. If no estimates for adjustments were made in a specific source, no estimate of adjustment cost was made in the analysis based on that source. This decision was made because the sources may have included the adjustment costs in their capital equipment cost figures.

Operating Costs

As with initial costs, most estimates of operating cost for converting companies were based on the case study data depicted in Exhibit A-2. However, as described below, the companies' TURA submissions, TUR plans, and TRI submissions also were used.

The cost of TCE purchases was estimated in the same way for all companies, multiplying quantity of TCE by price. The quantity of TCE reported in each company's 1992 TURA submission was used as a base, then adjusted to reflect both on-site recycling reported in the company's 1992 TRI submission and use reductions described in their TUR plan. After these adjustments, the results should reflect the quantity of TCE that each company can be expected to purchase in 1998 and beyond, assuming no further reductions in TCE usage occur. Two prices for TCE were used -- $0.50 and $1.00 per pound. The low estimate, used for the worst-case scenario, was based on the current price of TCE delivered by truckload. The higher estimate, used for the best-case scenario, was based on the case studies, and can be expected to better reflect the cost that smaller users pay, since they are likely to purchase TCE from repackagers.

The cost of waste disposal for TCE was derived from TRI information and the case studies. For the best-case scenario, each company's 1992 TRI estimate of off-site waste transfers was converted from pounds to 55-gallon drums, then multiplied by a per-drum cost of $320. The cost per drum was derived from information in the case studies. Specifically, estimates in the case studies were averaged, then inflated by five percent per year. These inflated costs were then averaged to create a cost per drum that reflects the potential for cost increases over the next ten years. For the worst-case scenario, the cost of disposal was assumed to be negligible because TCE-containing waste may in some cases be recycled or used for energy. The waste disposal costs of the alternative degreasing systems were estimated using values in the most applicable case study, adjusted for TCE usage using a scaling factor of 0.6.

For both the TCE and alternative system scenarios, some costing elements are calculated using the same methodology. The cost for waste fees, tests, and manifesting is an average of the case study costs. The costs for safety training, safety equipment (for TCE usage scenario only), and paperwork were all calculated by averaging the number of hours for each activity reported in the case studies, then multiplying the average by a wage of $30 per hour. Although this rate is not the average wage from the case studies, it was the most prevalent wage for employees that are responsible for operating the degreasing equipment.

For the TURA fee on using TCE, the current cost of $1,100 was used for all companies. The costs for permitting associated with TCE were derived from a single case study because the others did not specifically delineate this cost element. While the cost of $50 per year is small relative to other costs, it was included to highlight that annual permitting is a requisite activity when TCE is used.

Maintenance costs for TCE usage and for the alternative system were based on the particular case study used to determine each company's potential capital cost. As with the capital costs, the maintenance costs from the applicable case study were scaled by TCE usage to better reflect the company being analyzed. While the scaling procedure was the same, the scaling factor was 0.6 for capital equipment and 0.2 for maintenance labor.

Two operating cost elements were analyzed only for the alternative degreasing systems -- cleaning fluid purchases and utilities. Each of these cost elements was estimated based on values in the most applicable case study, with scaling based on TCE usage using a scaling factor of 0.6.

Price Sensitivity Analysis

Table C.5 displays the results of the sensitivity analysis for TCE prices. In comparing these numbers to the base case results in Table 4.2, the sensitivity to TCE price becomes apparent. The total NPV of conversion increased for the high technology companies by 30 to 35 percent, and for the general degreasers by 22 to 87 percent. The increase in general degreasers' worst-case cost is highest, in percentage terms, at 87 percent over the base case. However, the high technology worst-case experiences a larger NPV increase in absolute dollars (increasing by $0.2 to $0.5 million), due to these facilities' high TCE usage rates prior to the potential conversion.

TABLE C.5 **TCE PRICE SENSITIVITY ANALYSIS: COSTS AND SAVINGS FROM POTENTIAL SUBSTITUTIONS IN DEGREASING APPLICATIONS (in thousands of 1994 dollars)**

	High Technology[2]		General[2]	
	Worst	Best	Worst	Best
Total NPV of Conversion (All Facilities)	($421)	$1,960	($17)	$1,256
Average NPV of Conversion/Facility	($140)	$653	($3)	$209
Total Initial Costs (All Facilities)	$1,552	$588	$612	$192
Average Initial Cost/Facility	$517	$196	$102	$32
Total Annual Operating Savings (per year savings)	$184	$415	$97	$236
Average Annual Operating Savings/Facility	$61	$138	$16	$39

[1] Three facilities classified as high technology were analyzed.
[2] Six facilities classified as general degreasers were analyzed.

Sources: Derived from Table C.2 and C.3.

NOTES FOR CALCULATION OF CONVERTING COMPANIES' COST ELEMENTS
(as summarized in Table C.3)

Calculation of Cost Elements

Capital Equipment: Cost from the most applicable case study was scaled by TCE usage, with a 0.6 scaling factor.[1]

Water Treatment: Cost from the most applicable case study was scaled by TCE usage, with a 0.6 scaling factor.

R&D: The numbers of hours spent on research and development, as specified in the case studies, were averaged (divided by 9, since a non-entry is interpreted as 0), then multiplied by a wage of 45.00.

For the worst-case, high-technology scenario, two additional estimates (555 and 1000 hours) obtained from phone conversations were included (and the new total was divided by 11).

Adjustments: Cost from the most applicable case study was scaled by TCE usage, with a 0.6 scaling factor.

TCE lbs.: The amount of TCE the case study company used. This figure was used as the basis for scaling.

TCE Price: The prices paid for TCE by case-study companies were combined with TCE prices from other sources to determine an appropriate range for TCE prices.

Waste Disposal

Quantity: TRI data were used to determine the quantity of TCE disposed by each firm.

Price: The three case-study waste disposal prices were averaged, the average was inflated by five percent for ten years, and an average price for the ten future years was calculated to obtain a single number reflecting potential price increases.

Waste Fees, Testing and Manifesting: Case study estimates were averaged (divided by 9).

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[1] All scaling factors were obtained from Plant Design and Economics for Chemical Engineers by Max Peters and Klaus Timmerhaus, 1958 and 1968. All scaling factors were used as the exponent to the ratio of the company's TCE usage to the case study's TCE usage.

Safety Training: Case study hours estimates were averaged (divided by 2) and multiplied by a wage of $30.00 per hour.

Safety Equipment: Case study estimates were averaged (divided by 9).

TURA Fee: A set fee of $1,100 (TURA's incremental fee for reporting additional chemicals) was used.

Paperwork: Hours were averaged (divided by 5), then multiplied by a wage of $30.00 per hour. For company A and E, the hours estimates were back calculated from the cost.

Permitting: The estimate of $50.00 per year, taken from the *Cost of Changing* case study, was used for all nine companies analyzed.

Maintenance: Cost from the most applicable case study was scaled by TCE usage. A scaling factor of 0.2 was used for labor.

New Cleaner: Cost from the most applicable case study was scaled by TCE usage, with a 0.6 scaling factor.

Utilities: Cost from the most applicable case study was scaled by TCE usage, with a 0.6 scaling factor.

Additional Comments

For three cost elements -- waste disposal price, safety training, and paperwork -- an average was calculated based on the number of data points reported, because all companies are likely to incur these types of costs. In essence, this calculation method assumes that the other cases did incur costs for these cost elements, but these costs were not explicitly reported. For three other cost elements -- R&D, waste fees, testing and manifesting, and safety equipment -- an average was calculated assuming no cost for the case studies that did not specifically report a cost (i.e., the sum of the available data was divided by nine, not by the number of data entries). This method was used because some companies might not incur these types of costs. However, since the available data were not sufficiently precise to delineate which companies are likely to incur these costs, the averaged cost was applied to all nine of the companies being analyzed. Since the present analysis is attempting to characterize state-wide costs, not the costs likely to be incurred by individual companies, this simplified approach should not have a significant impact on the results. The magnitude of the resulting averaged values are small (mostly below $2,500), when compared with other larger costs such as capital equipment, TCE purchases, and waste disposal.

Inflating Data from Case Studies

Table C.2 shows the case study data as reported. Because the data for five of the nine studies were not in current dollars, they were inflated to 1994 dollars (see Table C.3). The annual Marshall and Swift Equipment Cost Indexes from "Chemical Engineering", August and October 1994, were used to inflate all initial costs, the safety equipment costs, and the price of the new cleaning fluid. The annual Manufacturing Wages and Salaries Employment Cost Indexes from Economic Report of the President, February 1994, were used to inflate safety training, paperwork, and maintenance costs.[1] The annual Housing Fuel and Other Utilities Consumer Price Indexes from Economic Report of the President, February 1994, were used to inflate utilities.

Waste fees, testing, and manifesting, the TURA fee, and permitting costs were not inflated because they were to have remained constant over the life of the costing period. The waste disposal price was not inflated because the case studies for which we have data are in 1994 dollars. The TCE price for the case studies were not inflated because they were not explicitly used in the costing analysis for the converting companies. For TCE price, a low of $0.50/pound and a high of $1.00/pound were assumed for the base analysis. A TCE price sensitivity analysis was performed in which the base price assumptions were increased by 5 percent over the ten year costing period to account for shrinking TCE market demand. These increased prices were then averaged, resulting in prices of $0.63 and $1.26 per pound, which were used in the sensitivity analysis.

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[1] Because safety training and paper work costs for the converting companies are based on the average case study hours and a wage of $30 per hour, inflation of the case study costs does not impact the results of the converting companies.

APPENDIX D. SWEDISH ACTION PLANS FOR THE 13 "SUNSET" CHEMICALS[1]

ARSENIC

Goal: reduce the use of arsenic compounds in wood-preserving agents

Recommendations:

- perform in-depth review of wood-preserving agents, then decide whether or not to grant continued approval in 1993
- place an environmental charge on use of arsenic compounds in wood-preserving agents

BROMINATED FLAME RETARDANTS

Goal: reduce the use of brominated flame retardants

Recommendations:

- require manufacturers and importers of brominated flame retardants to report on the damage to health or the environment caused by their products by 1991
- based on the reports of brominated flame retardants develop "restrictive measures"

CADMIUM

Goal: reduce the use of cadmium

Sweden has already banned the use of cadmium for surface treatment, in plastics, and in dyes.

Recommendations:

- phase-out cadmium use in fertilizers (no date)
- place a charge on sealed nickel-cadmium batteries and permanently mounted nickel-cadmium batteries, as well as returnable deposits on nickel-cadmium batteries
- place a charge on cadmium in fertilizers

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[1]The source of information for this appendix is the Swedish National Chemicals Inspectorate and Swedish Environmental Protection Agency report, *Risk Reduction of Chemicals: A Government Commission Report*, 1991.

CHLORINATED PARAFFINS

Goal: phase-out all uses of chlorinated paraffins within ten years and phase-out the short-chained, highly chlorinated paraffins within 3-4 years

Recommendations

- work with importers and users of chlorinated paraffins to make them aware of the environmental hazards involved and of the substitutes available
- promote development of substitutes through the National Swedish Board for Technical Development

CREOSOTE

Goal: reduce the use of creosote in wood-preserving agents

Recommendation:

- perform in-depth review of wood-preserving agents, then decide whether or not to grant continued approval in 1993

LEAD

Goal: long-term cessation of lead use

Recommendations:

- implement tax on leaded gasoline that makes unleaded gasoline cheaper than leaded gasoline
- phase-out lead shot by 1996
- phase-out all lead batteries in the long term; promote development of alternatives through the National Board for Technical Development
- phase-out laying of new lead sheathed underground cables by 1995
- promote international lead-free crystal glass standards and cease production of lead crystal by 1992
- phase-out use of lead as a plastic additive (no date)
- monitor industry initiative to phase-out lead in paints and coatings
- phase-out lead soldered tin cans (no date)
- promote the cessation of lead in all other uses
- pursue efforts to reduce the risks associated with lead through the Organization for Economic Cooperation and Development's "Risk Reduction Project"

MERCURY

Goal: phase-out all uses of mercury in the long term

Recommendations:

- phase-out the sale of all mercury containing thermometers by 1993
- phase-out the use of all switches containing mercury by 1993
- phase-out the use of all mercury in strip lighting, mercury lamps, etc., in the long term. In the short term implement a labeling system.
- restrict uses of mercury in laboratories
- investigate the opportunities for phasing-out mercury as an amalgam in dental-filling material

METHYLENE CHLORIDE

Goal: phase-out all uses of methylene chloride within five-ten years

Recommendations:

- place an environmental charge on methylene chloride sales
- cease sales of methylene chloride in consumer packaging in the retail trade by 1992
- issue regulations that will reduce methylene chloride emissions from industrial degreasing and cleaning
- issue regulations that will limit the amounts of methylene chloride released in the production of pharmaceuticals and other health care products.
- pursue efforts to reduce the risks associated with methylene chloride through the OECD's "Risk Reduction Project"
- degreasing: phase-out over 5-10 years
- paint removal: phase-out over 5 years
- pharmaceuticals industry: cease use immediately if politically feasible (1990), otherwise within 10 years
- preparations: rapid phase-out if politically feasible by 1991, otherwise within 5 years

NONYL-PHENOL-ETHOXYLATES (NPES)

Goal: phase-out most uses by the year 2000

Recommendations:

- place an environmental charge on NPES sales
- reduction of 90% for all major industrial uses by 2000
- pursue international efforts to reduce the risks associated with phthalates through the OECD's "Risk Reduction Project" and the European Union

ORGANOTIN COMPOUNDS

Goal: cease environmentally hazardous uses of organotin compounds

Recommendations:

- require manufacturers and importers of tin-containing plastic stabilizers to report on the damage to health or the environment caused by their products by 1991
- based on the reports of tin-containing stabilizers develop "restrictive measures"
- phase-out use of organotin in boat bottom paints for all vessels plying the Baltic and the North Sea
- work with Baltic nations to ban all use of organotin compounds on vessel bottoms
- induce the paint and glue industries to implement their own measures to discontinue the use of triorganic tin compounds as preserving additives by 1991
- induce manufacturers and importers of chemical products not to sell triorganic tin compounds as preserving additives in water-based products, nor as biocidal cooling-water additives by 1991

PERCHLOROETHYLENE

Goal: phase-out all uses of perchloroethylene by the beginning of the 21st century.

Recommendations:

- place an environmental charge on perchloroethylene sales
- cease sales of perchloroethylene in consumer packaging in the retail trade by 1992
- phase-out all uses of perchloroethylene, with the exception of dry cleaning and industrial degreasing/cleaning, within five years
- issue regulations that will reduce perchloroethylene emissions in industrial degreasing and cleaning
- devise "general recommendations" on perchloroethylene in dry cleaning to assist county administration with their inspections and supervision of dry cleaners.

PHTHALATES

Goal: reduce discharge of phthalates into the environment

Recommendations:

- require manufacturers and importers of phthalate plastic stabilizers to report on the damage to health or the environment caused by their products by 1991
- based on the reports of phthalate plastic stabilizers develop "restrictive measures"
- pursue international efforts to reduce the risks associated with phthalates through the OECD's "Risk Reduction Project"

TRICHLOROETHYLENE

Goal: phase-out all uses of trichloroethylene within ten years

Recommendations:

- place an environmental charge on trichloroethylene sales
- Cease sales of trichloroethylene in consumer packaging in the retail trade by 1992
- issue regulations that will reduce TCE emissions from industrial degreasing and cleaning
- issue regulations that will reduce TCE emissions released in the production of pharmaceuticals and other health care products
- phase-out all uses of trichloroethylene, with the exception of industrial degreasing/cleaning and the production of pharmaceuticals and other health care products, within 5 years
- phase-out all uses of trichloroethylene in ten years