What if Technical Assistance Really Works?

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The Tool of Technical Assistance

Most people don't seem to know very much about the advent of technical assistance as a tool of environmental governance, unless they have sophisticated knowledge of environmental policy and programs, or they have received such assistance. But these programs have become a vital part of our system of environmental protection. Starting in the 1980's, state after state began developing technical assistance programs for pollution prevention (at that time, more commonly called "source reduction", or "waste minimization"). In 1990, every state in the Union had a program to help businesses reduce pollution by preventing it, rather than addressing it after the fact. In the beginning, these programs typically focused on hazardous waste but soon grew to address the use of toxics and how reducing that use can reduce air emissions, wastewater discharges, workplace exposures, transportation accidents, and toxics in products. In the 21st century, technical assistance programs usually comprise assistance in environmental management systems, water conservation, energy efficiency and clean sources of energy, solid waste reduction, other aspects of environmental sustainability, as well as pollution prevention or toxics use reduction.

What most people also don't seem to know is that these programs have been very successful. The association that represents professionals in this field, the National Pollution Prevention Roundtable, (NPPR), has estimated that perhaps 167 billion pounds of pollution has been prevented through the efforts of these really quite small agencies (often only a handful of staff)[1].

Integrated Strategies

Our view of the job of environmental agencies is still primarily that of enforcement.[2] Many in environmental policy, however, have envisioned a different approach, one of combining carrots and sticks. EPA's Office of Enforcement and Compliance Assurance (OECA), formally recognized the importance of assistance when it created a federal advisory committee on compliance assistance in the late 1990's and asked it for advice on how to coordinate assistance and enforcement. Many regions have experimented with various models. One notable example is EPA Region One's invitation to colleges and universities to work with EPA on a cooperative and voluntary basis, while noting the possibility of enforcement actions if necessitated. At the April 2004 Environmental Assistance Summit hosted by NPPR and EPA, OECA presented a framework for integrating strategies for addressing environmental problems that clearly recognized the value of relying not just on enforcement, but of using all the tools at one's disposal – including assistance.[3]

One useful image is that of "two-handed" environmental governance. This is a personal, relational way of sorting out the issue of how enforcement and assistance are best coordinated. Imagine officials from a government agency approaching you. They have their hand out, offering a handshake. They want to work with you. They have their other hand in reserve, the one that might give you a penalty slap. They don't lead with that, or you might learn to avoid their presence. (Leading with enforcement, however, might be necessary when it is foolish to lead with the outstretched hand, such as when there are persistent, knowing violations).

A sensible plan for integrating and coordinating assistance and enforcement avoids the downside of promoting assistance – which is that some have seen it as a replacement for enforcement. This use of the assistance and voluntary program is essentially deregulatory, and the association of assistance with deregulation is unfortunate. It is exacerbated by the fact that this tool has developed during a time of serious reductions in funding for traditional environmental enforcement.

This paper, which asserts that technical assistance has played a major role in recent progress, places it squarely in the context of enforcement. The Massachusetts program discussed herein has also been a complement to enforcement, and has depended on the existence of a strong enforcement program for its own success. The results seen here would not likely have been achieved if the assistance had not been provided against a backdrop of potential enforcement actions[4]. Those of us who have worked in assistance know that companies are most often willing to take our good advice when they recognize that there could be serious consequences for poor performance in the environmental arena.

If technical assistance really works, our next move must not be to shift resources from enforcement. It is, rather, cause to design programs that make good use of both tools – an approach to environmental governance that uses a "fully equipped" toolbox.

The Importance of the Massachusetts Data

But does technical assistance really work? How effective can a voluntary effort really be? The 1989 Massachusetts Toxics Use Reduction Act (TURA) provides dramatic evidence that technical assistance for pollution prevention can be very effective. And what is seen in Massachusetts is very possibly true for many, if not all, of the other programs that have conducted similar activities.

That we don't see reports from other states such as that described herein is due to the fact that they do not impose requirements on companies to report toxics use. Massachusetts does. It is this that has enabled Massachusetts to show the results of its efforts. The only other thing unique about Massachusetts is that the assistance program is a bit larger than most – during the 1990's the MA Office of Technical Assistance (OTA) had from 20 to 30 employees, most of them engineers who visited companies. The state also has a companion program, the Toxics Use Reduction Institute (TURI), which does not have as a primary function providing direct, one-on-one assistance to companies as does OTA, but which does educate toxics users. TURI's assistance efforts for companies has been massive, including several annual training events, publications, and notably, laboratory services that companies can use to test out safer alternatives to toxic solvents. The state also has a well-developed toxics use reduction planning requirement, and large quantity toxics users must also pay a fee for their chemical use. All of these elements combined have made for a very strong state program. The data discussed below provides indications that this suite of tools has reduced more than a half-billion pounds of toxics.[5] The focus of the study reported in this article, however, is on what the TURA data tells us about OTA's one-on-one, direct, technical assistance.

OTA's staff visit companies on a voluntary basis, to help them review their chemical use, to help them come up with alternative chemicals, or ways to use less of what they use. The staff point out compliance issues if they note them, and assist the company in understanding their options about changes in processes, equipment, or materials. OTA helps companies to identify where the chemicals spill, leak, evaporate, or otherwise get lost or become waste. The office works with the companies to help them become more efficient in their operations.

It is possible to be skeptical, and people often are, that such a program could work. Why, you might say, would a company continue operating with wasteful practices, if they could save money – or stop costly losses – by changing them? And how, you might ask, could someone who doesn't even work in the industry, know what changes could be made, in a cost-effective way?

These are legitimate and compelling questions. However, those in the field, who have worked with companies in this voluntary way, have shared through the years, through NPPR and other venues, innumerable anecdotes about how well the approach has worked. See, for example, the websites of the pollution prevention assistance programs of – pick any state. They are filled with case studies and success stories. In each case, helpful, friendly people from the government, or government-supported organizations (perhaps out of the state university), have visited companies and found implementable options that have not just reduced pollution and toxic risk, but have also saved the companies some good money. These are not in short supply, and OTA is not very different in its methods or results from dozens of other programs all over the United States. What is in short supply is information that is other than anecdotal. Those who are tempted to be skeptical can always claim that these are inflated examples, or unusual, or that in some way our method of examination is selective and not representative or even particularly meaningful.

Because the Massachusetts data provides an objective way of looking at the effectiveness of one technical assistance program, perhaps we can see that as a representative example. If we discern a result there, perhaps we can understand that it might be a good indication that the success stories of other programs are meaningful signposts. The answer to the question of effectiveness should be of great importance to those who want our environmental programs to work. If confidential, business-friendly, pollution prevention and compliance-oriented one-on-one onsite technical assistance visits can dramatically reduce toxics use, should we not give more serious consideration to investments in this available tool for environmental progress?

Mass Balance Measurement

Large quantity toxics users in Massachusetts are required to report their use of toxic chemicals, as well as their byproduct – that which does not go into useful product. This provides a mass balance measurement. This is a very useful and far more accurate and precise method of measuring pollution prevention than tracking releases or waste generation. Those latter methods are simply output – just one side of what is really an input/output equation. The Massachusetts data gives you the whole picture, as well as production level data (a relative, not an absolute measure) that may be used for adjustment of the chemical use/byproduct numbers. (This production ratio is considered more reliable than the federal Toxics Release Inventory (TRI) production ratio, because in Massachusetts there are specific requirements that it be measured relative to the reported chemical use, extensive guidance has been provided, and a quality assurance effort has been implemented).

Therefore we can look at the chemicals used by each large quantity toxics user (Massachusetts Toxics Use Reduction Act thresholds are very similar to the thresholds for reporting to the TRI[6]) and determine, with a specificity impossible in no other state (except for New Jersey), that the chemical is now being used with more or less efficiency.

OTA has visited well over a thousand facilities, about half of them covered by TURA. But because OTA works confidentially and one-on-one with companies, few know what it has been able to achieve, beyond the case studies it has posted on its website, and the stories that have been told at its conferences and workshops. When budgetary cuts threatened the office, and the dedicated fund for its continued operation was eliminated, OTA realized it had to provide some assessment of whether or not it had been effective. Thus it embarked upon the analysis reported herein.

Two Kinds of Toxics Use Efficiency

We can look at two basic kinds of efficiency. Is more or less of the toxic chemical being used to make the same amount of product (Input efficiency)? Is more or less waste byproduct being produced for each pound of chemical used (Byproduct/use efficiency)? The first kind measures whether companies are able to substitute or use less of the chemical to make the same amount of product. In other words, if the company is using less of chemical X because it is making less of the product that contains chemical X, no reduction will show up. Only if the company is using less per unit of product made, will a reduction be measured.[7]

The second kind measures whether companies are able to use the chemical with more or less waste per pound used. It is independent of the production level.

Eliminating Distortions for Group Comparisons

Using the two measures of chemical use efficiency described above, OTA compared the performance of the companies with which it had worked, before and after it began working with them. It also compared the performance of the visited group with those who had never worked with OTA. The office used very simple methods of measurement, and then subjected the data to extensive review, and gave it to independent researchers to perform alternative, econometric analysis.

To avoid distortions from unreliable data, we did not use the data generated during the first years of the program, when a great many mistakes in reporting were made (This had the drawback of failing to capture the improvements OTA may have helped companies to make when the concepts of pollution prevention were new to them and there was much "low-hanging fruit". However, this simply makes our findings conservative estimates). During the examined period, 1993 to 2002, 612 facilities were in the not-visited group, and 443 had been visited (This is 90% of the 1172 companies reporting during the period 1990 – 2002, the entire period for which TURA data existed at the time of the study). The companies visited had entered 2699 chemical reports, and the companies not visited had entered 2216.

We multiplied the base year of reported chemical use – the first year the company reported use of the chemical – by the subsequent annual production ratios self-reported by the company. This generated an expected quantity of chemical use. These "expected pounds" were compared to the actual number of pounds of chemicals used in the examined year. This calculation is a best estimate, not a precise measurement of what toxics use has been avoided.

Chemicals no longer reported (used in amounts below the threshold for reporting) were counted by using the amount reported in the base year, the first year the chemical was reported by that facility. Some would say that a chemical eliminated in one year is a recurring annual reduction in all subsequent years. We employed a more conservative method and one better suited to comparing performance over time and among groups: counting reductions only in the year they occurred.

Dropouts (companies no longer reporting) that were not due to chemical reductions, but to changes in regulatory coverage, were not counted: chemicals and chemical categories that have been delisted from the TURA list were eliminated. Electrical utilities (38 companies in SIC category 49) were also eliminated, because reviewers felt utilities have qualitatively different chemical use patterns and requirements, and their quantities can be extremely high and act to skew the results.

Because variations from group to group could be dependent on the composition of that group, we developed percentage reduction measures. For example: the average pound reductions of a group with a lot of companies having small successes, but with very large amounts, could be much higher than those of a group with many companies having dramatic reductions, but who on average use much smaller amounts. We divided the use reductions in each year by the expected use in that year to produce a percentage reduction.

There were two groups of companies not visited by OTA: those never visited by OTA during the entire time frame examined, and those who would be visited later but had not yet been visited in the examined year. One could surmise that the willingness of a company to invite OTA in for a visit – and not the assistance provided - could account for differences in performance between visited and not visited companies. To correct for this, we compared already visited companies to those who would be visited later – (the "not yets") - both groups containing the kind of company that would ask for a visit.

We used "skew limits" to avoid measuring the performance of a tiny handful instead of the performance of the larger group of more typical population members (This is a problem when measuring average total pounds, and not when using the measures that are independent of size: percentage reductions, advancer/decliner ratios, and byproduct/use ratios). For example, we kicked out toxics users who reported over 10 million pounds of use.

We estimated the importance of the shut-down effect, which occurs when companies have dropped out of the system not because they are making their products without a toxic chemical, but because they have closed their doors. We researched every visited company that reported chemical dropouts. We estimated that the maximum percentage of reduced pounds of toxics use that could be due to this was no more than one-sixth of reductions. We also calculated how the "just-below threshold" effect, where a company is no longer reporting but has not eliminated use – it is still using the chemical in quantities below the threshold for reporting. Assuming that the amount is "just below" provides the worst case scenario. We found that in most years the maximum of this effect was less than five percent.

For byproduct reductions, TURA reporting combines all kinds of waste - all nonproduct output - into one byproduct number, which includes the chemical that is emitted to air, discharged to water, or shipped in a drum – everything that is neither destroyed nor converted in process nor incorporated into product.[8] We calculated a "byproduct/use ratio" for each chemical, for each year. We compiled the byproduct/use ratios for all visited companies up to the examined year and compared the results to the performance of nonvisited groups in the same years. In order to measure how much change took place among the typical population members, we removed chemical reports that had zero or 100% byproduct in both the base and examined years, so that we could obtain a more accurate picture of the dynamic population, where change occurred.[9] When reducing input is not technically or economically feasible, the byproduct/use measure becomes the critical efficiency measure.

At the time of the analysis, information was available concerning 613 companies that had dropped out of the TURA system (A company can become a "drop out" by ceasing to have above threshold quantities of chemicals, by closing up shop or going to less than 10 employees, or because a chemical has been delisted).

The dropout population consisted of 179 companies visited by OTA and 434 that were not visited. To gain another indication of how visited companies performed relative to nonvisited, we compared the rates at which they dropped out because of TUR.

Close-in-time Analysis

In one phase of our analysis, we looked at performance in the three years surrounding the visit year. Looking at the changes that occurred in the discrete time frame surrounding the visit reduced the potential impact, inherent in a longer time-series evaluation, of other intervening factors. Also, OTA's recommendations are often practical solutions that can be implemented within a reasonable business time frame. The average changes in pounds reduced, and the average percent changes, were developed for both visited and not visited companies, and compared. As another comparative indicator of how groups fared, we looked at how many members of each group did better or worse. We called those who reduced their use more than in previous years *advancers*, and those who used more of the toxic chemical than before, (to make the same amount or less product than before), *decliners*. The ratio of advancers to decliners was calculated for each group, as well as the percentages that advanced and declined.

Before and After Analysis

Percent reductions were also calculated for all years for all companies, from 1994 to 2002 (the data included 1993, but it takes two years to develop an estimate of reductions, so performance results are recorded from 1994 on). All the performance measurements for visited companies were grouped into one large "before" and one large "after" population, and the average of each group was compared. The statistical test, analysis of variance (ANOVA), was applied to determine if the difference found in the average performance of these groups was significant.

To dilute the effect of potential factors occurring at a certain time, we grouped all the performance measurements in categories of numbers of years before and after being visited, and calculated the average performance of each time category. This reduced the importance of competing factors to which causation could reasonably be attributed.

Results

Being covered by TURA is associated with TUR improvements. Out of 4189 chemical reports, toxics use was reduced in 76.9% of reported chemicals - the ratio of advancers to decliners for all TURA chemicals was high - 3.75 to one. If the companies covered under TURA had continued to use chemicals at the same rate as when they began reporting to the public on such use, they would have used an additional 559 million pounds.

Tables 1a and b compare how much toxics use reduction the average visited companies accomplished in the year before being visited, to the year visited, and the performance in the year after being visited to previous performance. The year-to-year changes in amounts of chemicals reduced are comparative measures, not total amounts of reductions, and they are averages for each group (visited, never visited, not-yet visited). *OTA companies performed better after being visited than they were performing before being visited*. The year of the visit, an average of 20.5% more pounds than before, were reduced. The year after the visit, the average change was 15% more pounds reduced. These numbers are from 3 to 5 times higher than the comparable advances by the not visited groups in those same time frames.

The average change in terms of pounds was about the same magnitude higher for visited companies. In the year of the visit, companies reduced 5,114 pounds more than the year before. At the same time, those never visited only reduced 1,513, and those who would be visited later, but had not yet been visited, reduced 1,980. The year after being visited these differences are very similar: the pattern holds.

Looking at the ratio of advancers to decliners in each group, companies visited by OTA had 63.8% advancing the year of the visit, and 66.5% the year after.

Companies never visited had a ratio of 55.2% and 55.3% in the same time frames, respectively. Companies visited later (the "not-yet visited") had 56.9% and 55.8% advancers/decliners in those same years. *More visited companies showed improvements than those not visited.* See Fig. 1.

RATIO OF ADVANCERS TO DECLINERS IN EACH GROUP – CHEMICAL USE

Figure 1. The ratio, in each group, of those who had more reductions ("advancers") in subsequent years, than before, to those who increased toxics use ("decliners"), compared to previous performance.

The total before and after analysis (1321 data points) showed that after being visited, 61% of companies were advancers, averaging 6.95% reductions in use. Before being visited, only 56% were advancers, and the population showed an average increase in toxics use of 2.49%. The statistical test confirmed that *the 9.44 percentage point difference was significant*, with a very high degree of confidence[10].

Of the nonvisited dropouts, 115 cited TUR as the dropout reason. This is 26% of the nonvisited dropout population. Of the visited dropouts, 83 cited TUR as the dropout reason. This is 46% of the visited dropout population. Adding in the dropouts for which we didn't have information on the cause of dropping out, the total is a possible 76% for visited companies who could have dropped out because of TUR. The maximum for the nonvisited is 45%.

The companies visited by OTA also had lower byproduct/use ratios in every year examined, than the groups not visited. In most years, the visited companies averaged less than half of what the other groups attained. Over all the examined years, an average of 10.3 pounds of every 100 pounds of chemicals used by the visited companies became nonproduct waste (10.3%). For those companies never visited, the average was 20.9%, and for those companies who would be visited by OTA but were not yet visited in the year examined, the average was 22.2%. See Fig. 2.

Independent Boston University researchers examined 25 chemicals for which there was a sufficient population of reporting companies in both visited and nonvisited populations. OTA visits were associated with a statistically significant decline in usage for eight of the chemicals[11] and in byproduct for two chemicals.[12]

The predominance of findings reveals a pattern of post-visit improvements, higher than the performance of unvisited companies, within the same time frame. Over all years, visited companies have consistently generated less waste per pound of chemical input than those not visited, and they get out of the program by doing TUR at a higher rate than those not visited. On all measures, the visited companies performed much better than those who would be visited later. Companies also had better performance after being visited, compared to their own past performance.

COMPARISON OF HOW MUCH USE BECAME WASTE BYPRODUCT

Figure 2. Average byproduct/use ratios for all three groups, for all companies up to the year examined.

In addition to finding this result in a variety of perspectives, the independent econometric analysis provided confirmation of the proposition that OTA's visits are associated with significant toxics use efficiency performance improvements.

The meaning of these results

What does it mean to avoid some significant amount of toxics in a state of 6.5 million people? An examination of the value of this result would have to account for the reduced likelihood that each of these inhabitants will be exposed to toxic chemicals. Their water and soil, their air, will be cleaner. There will be fewer accidents on the roads of the state. There will be fewer toxics in products, less hazardous waste to manage, and less toxic solid waste when the products are disposed. The costs to businesses to manage their compliance matters will be reduced. The potential liabilities for businesses, for accidents, toxic torts, end-of-life product disposition, and workplace exposures will all be reduced. The costs to government for managing the toxics use by businesses would be reduced as well – the costs of monitoring air pollution, wastewater discharges, hazardous waste movements, right-to-know, and enforcement for noncompliance: all reduced, because toxics use is at the root of all of these problems.

Perhaps the most difficult aspect to quantify, however, is the improvement in the way companies conduct business that often occurs when companies benefit from a pair of fresh eyes. The assistance programs provide this service. When someone from the outside takes a walk through a facility, and asks questions from the perspective of reducing unnecessary material use or waste, (or, as is now done, other resources such as energy and water), new ideas often emerge. The evidence of this is anecdotal, but it provides powerful suggestions of the value of technical assistance.

For example, one company visited by OTA was asked in 1990 if it had calculated the full costs of managing the toxic solvent cleaner it was using. These costs included the time spent on manifesting the waste and the cost of disposal; the time and cost of complying with air permit reporting, and with OSHA and Right-to-Know requirements; the energy used to ventilate the area where it was used; emergency planning; and the insurance necessary in the event of accidents and cleanups. When the company estimated how much it was spending for all of this labor, even without any serious mishaps, it decided it was actually cheaper to switch to a less-hazardous cleaner that cost more to purchase – but didn't have all those other ancillary costs. OTA recently revisited the company and found that it has continued to implement pollution prevention projects, using a life-cycle full cost approach.[13] The advice given in 1990 changed the way the company does its business, and it recently estimated that it has saved about $2 million over ten years as a result.[14]

Other examples involve changes that produced economic benefits far beyond the environmental cost avoidance. A printing company switched to ultraviolet-cured inks and didn't just avoid volatile emissions, but increased its available production time by 33%.[15] A metallic product company started regenerating instead of discharging its acids, and saved six jobs.[16] An electronics firm switched from ozone-depleting cleaners to an alcohol-based cleaner and found that its products were cleaned better than ever before.[17] Companies that take a new look at their materials and processes are reexamining assumptions that may need revising, and when they find new and better approaches, they often have lower reject rates, faster production times, or higher product quality. When they clear the air in the workplace, they often have more productive output. Company staff have limited time to do all the things they have to do. It is easy to miss these opportunities during the press of events, because they are usually not immediately evident, and often not directly relevant to the corporate mission. But what the many assistance program success stories show is that even when the importance is indirect, the results may still be very powerful for both the bottom line and the environmental and workplace contexts.

Social Intellectual Capital

A fully-implemented pollution prevention program, with expert assistance, is an investment by society in a very important intangible resource: it creates a common pool of shared knowledge. What technical assistance professionals observe on site helps them to help others, and design research and educational tools and events that help ever larger populations.

The social intellectual capital that results from assistance programs may be the positive outcome that is most difficult to quantify. The case studies, the guidance, the fact sheets and outreach developed by pollution prevention assistance programs all across the country are all visible indications that the pool of shared knowledge for developing a better and safer economy is growing. The analysis described above shows that the anecdotal information about pollution prevented by one assistance program is a true indicator that the program is indeed reducing toxics at the source. What course of action is thus most sensible, if the many programs producing success stories are likely also having a similar effect? Should we wait until they, too, can prove their efficacy, even though they don't possess the information to duplicate this analysis? Or should we surmise that all such programs likely merit closer consideration as key tools for effective environmental governance?

THREE YEAR COMPARISON – CHEMICAL USE REDUCTIONS

	Year of Visit	Year After
Visited in 1995	11.50	11.30
Never Visited	4.60	7.70
Not Yet Visited in 95	4.00	3.20
Visited in 1996	13.20	6.04
Never Visited	5.50	6.60
Not Yet Visited in 96	10.60	6.90
Visited in 1997	12.50	21.60
Never Visited	3.30	6.60
Not Yet Visited in 97	2.00	5.10
Visited in 1998	34.60	7.40
Never Visited	5.80	4.70
Not Yet Visited in 98	5.40	9.40
Visited in 1999	37.66	27.87
Never Visited	4.20	2.80
Not Yet Visited in 99	14.30	7.40
Visited in 2000	13.60	16.20
Never Visited	2.20	4.20
Not Yet Visited in 2000	0.70	-5.90
average, all years, visited	20.51	15.07
average, all years, never	4.27	5.43
average, all years, not yet	6.17	4.35

1a Percent Reduction

	Year of Visit	Year After
Visited in 1995	2,929	4,549
Never Visited	2,412	3,121
Not Yet Visited in 1995	1,028	545
Visited in 1996	4,459	2,278
Never Visited	2,093	2,808
Not Yet Visited in 1996	3,680	2,483
Visited in 1997	5,304	4,979
Never Visited	894	1,696
Not Yet Visited in 1997	1,095	1,418
Visited in 1998	5,255	4,805
Never Visited	983	789
Not Yet Visited in 1998	1,209	2,811
Visited in 1999	5,793	8,108
Never Visited	1,199	1,125
Not Yet Visited in 1999	4,150	1,787
Visited in 2000	6,945	6,943
Never Visited	1,496	1,315
Not Yet Visited in 2000	717	-3,554
average, all years, visited	5,114	5,277
average, all years, never	1,513	1,809
average, all years, not yet	1,980	915

1b Pounds Reduced

Tables 1a and b. Both tables compare the year of the visit and the year after the visit to previous performance. Successful reductions result in positive numbers. Negative numbers mean toxics use has increased. Table 1a compares the average percent change in use, and Table 1b shows the average number of pounds reduced. For example: for companies visited in 1995, the average percent change is 11.5, and 2,929 more pounds of toxics use were reduced, on average, than the year before the visit. The year after, the average percent change 11.3, and 4,549 more pounds were reduced.

Rick Reibstein has been working at the MA Office of Technical Assistance, on and off, since before it began. He worked in a predecessor office, the Office of Safe Waste Management (OSWM), and helped develop the specific activities and practices of OTA when it began, based on the successful pilot projects of OSWM. He teaches environmental law and policy at Boston University (and will soon be teaching at Clark, as well). He has served as an enforcement attorney at U.S. Environmental Protection Agency Region 1, and briefly at the MA Department of Environmental Protection. Reibstein would like to acknowledge the excellent work of MA OTA staff, and its directors who supported this work, as well as the many reviewers who assisted in the evaluation effort described herein.

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1 *An Ounce of Pollution Prevention is Worth Over 167 Billion Pounds of Cure: A Decade of Pollution Prevention Results*, 1990- 2000, 2003 (http://www.p2.org/p2results/2418_historyfinal.pdf).

2 Personal observation of the author, having worked in assistance for twenty years, derived from the continuing surprise expressed when people learn what he does for a living.

3 Delivered by Karin Leff, OECA, April 19, 2004, at: http://www.p2.org/summit2004/documents/Presentations/Integrated%20Strategies%20Workshop-2.ppt

4 About half of the companies with which OTA has worked have also interacted with the MA DEP. Although none are required to work with OTA, or required to do toxics use reduction to come into compliance, results showing the success of technical assistance should be interpreted, to some significant degree, as the success of an integrated strategy.

5 *The Effect of Providing On-site Technical Assistance for Toxics Use Reduction*, The Massachusetts Executive Office of Environmental Affairs, July, 2006, p. 31. http://www.mass.gov/envir/ota/publications/pdf/ota_effectiveness_study_final_2006.pdf.

6 As with TRI, the thresholds are 25,000 pounds per year when the chemical is manufactured or processed, and 10,000 pounds per year when otherwise used, and there are lower thresholds that apply for Persistent, Bioaccumulating and Toxic chemicals (PBTs). (Until 2006, the triggering of a lower threshold by an 'otherwise used chemical' caused the 25,000 pounds threshold for manufacturing or processing to drop to 10,000 pounds for all chemicals at the reporting facility, but this was changed for the 2006 reporting year).

7 This is not to disparage the importance of absolute numbers, it just has limited utility for TUR performance comparison.

8 TURA would not count as byproduct that which is managed as a useful raw material – even if not the originally intended use - if used or sold as is, or recycled in an integral fashion.

9 A few chemical reports that exceeded 100% were also eliminated. Looking at both years meant that the only data removed were "static" situations where all of the chemical became byproduct, or none of it did, and that never changed.

10 Using a skew limit of 500% change.

11 Acetic acid, acetone, ammonia, ethylene glycol, methanol, sulfuric acid, toluene, and 1,1,1 trichoroethane.

12 An average reduction of 28% was found overall. The as yet unpublished paper can be obtained from the authors, Robert Kaufmann of Boston University, kaufmann@bu.edu, or Rick Reibstein, rick.reibstein@state.ma.us.

13 Such an approach does not have to be time-consuming in and of itself. Even rough, back-of-the napkin estimates, as opposed to a very detailed life-cycle analysis, should be much more useful than ignoring all but up-front purchasing costs.

14 *Technical Assistance Revisited: Lightolier, Elimination of Trichloroethylene*, OTA, 2007: http://www.mass.gov/envir/ota/publications/cases/lightolier_tar_final.pdf.

15 *TUR Case Study: Fit-to-Print, Conversion to UV Curing Reaps Benefits*, OTA, 1996: http://www.mass.gov/envir/ota/publications/cases/fit_to_print_case_study.pdf.

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17 *The Merrimack Project*, OTA, 1995, available from OTA.