SPECIAL NEWS & VIEWS REPORT:

Integrated Waste Management (IWM) Model

December 2002

Computer model helps cities weigh their waste opportunities

There is no single right way to manage municipal wastes responsibly. One community running out of landfill space is making a major investment in recycling. Another is investigating energy recovery options. And a third has made a serious commitment to expanded composting programs. Each hopes to adopt a practical, affordable and environmentally sound treatment alternative to solve a local waste disposal problem.

What is the right mix of waste recycling, reduction and recovery options? How do you balance the economic, environmental, technical and regulatory factors with the expectations of local ratepayers? How can you fairly compare the full environmental implications — both the benefits and the costs — of one treatment option with another?

The Integrated Waste Management (IWM) Model for municipalities is a tool for evaluating the life cycle environmental and economic effects of waste management decisions. The easy-to-use, computer-based program comes from a partnership between the Environment and Plastics Industry Council (EPIC), Corporations Supporting Recycling (CSR), and Environment Canada. The model focuses on the major components of residential waste — paper, glass, plastic, aluminum, ferrous metals, food and yard wastes — and reviews each in terms of the available waste management options, including recycling, composting, land application, energy recovery and landfilling. In the near future, a new module dealing with anaerobic digestion will be added to the model.

The goal of the IWM Model is to give municipalities a broad indication of the environmental effects and economic implications of waste management decisions, and to point to strategies that can potentially improve the environmental performance of their waste management systems.

Plug in the required data about your community's waste stream, together with operating details of the current collection and treatment infrastructure, and the model generates solid environmental performance data. The model tracks materials in the waste stream from the time they are collected curbside to the point they have finally decomposed in a landfill, combusted in an incinerator, or the recyclable material, usable compost or recovered energy is delivered to the market. And based on this data, it can tell you the amount of greenhouse and acid gases generated, the releases of heavy metals and other toxic chemicals, the air pollutants that contribute to urban smog, and so on through the whole gamut of environmental impacts.

The IWM Model is just one part of a broader strategy to move planners and municipalities

What is integrated waste management?

The recognition that there is no best or preferred way to handle waste has given rise to the concept of integrated solid waste management. The philosophy considers the full range of waste streams to be managed and views the available waste management practices as a menu of options from which waste managers can select the preferred option, based on site-specific environmental, economic and social considerations. The environmental analysis model uses life cycle methodology to quantify the energy consumed and the emissions released from a specified waste management system.

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Computer model:

Every situation is unique

What is life cycle analysis?

Life cycle assessment (LCA), which is used to assess the environmental impacts of products from cradle to grave, is increasingly being applied to the evaluation of waste management strategies. The life cycle of a waste starts when a material is discarded into the waste stream and ends when the waste material has either been converted into a resource (such as recycled material or recovered energy) or, when it has been finally disposed.

toward an integrated approach to waste management. It's proving to be a valuable tool to help quantify the environmental impacts of waste management decisions, one of the pillars of sustainability. This makes it possible to marry environmental factors with economic considerations.

Every situation is unique

The model doesn't tell municipalities what they SHOULD do with their wastes. Instead, it provides information on the environmental and economic impacts of the various available options so that users can make a more informed decision. The model is unbiased and scientifically credible, and the emissions and other impact data were peer-reviewed by environmentalists, industry experts and academics. The results it supplies depend entirely on the information you feed in and the questions you ask. Research into the environmental effects of waste management practices has shown that the "preferred" options for waste management depend upon a number of site-specific factors, including:

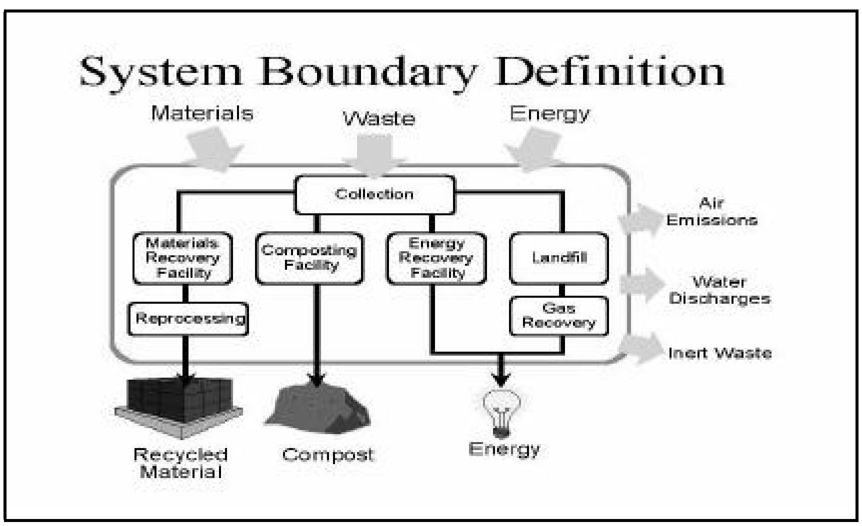
- the characteristics of the waste;
- the efficiency of the waste collection and processing systems;
- the availability and proximity of markets for recovered materials;
- the end-use of the materials recovered from the waste stream;
- the emission standards to which waste management facilities are designed and operated;
- the cost-effectiveness of the environmental protection obtained by different waste management practices; and
- the social preferences of the community.

The IWM Model helps the user assess and compare the various treatment options that are suited to each of the materials in the waste stream, taking into account the environmental implications, geographic considerations, and economic conditions. It also allows you to test different treatment scenarios and see how you could tweak your existing waste management system to improve its environmental performance. Based, in part, on this information, a municipality can craft a system that best meets its needs and expectations. The results could also be used in a state of the environment report to document municipal contributions to improving environmental performance.

The IWM Model provides valid, quantifiable reasons for looking at other treatment options that may offer a better environmental pay-off. It's a very powerful tool; millions of dollars can be wasted and, even worse, years lost by backing an impractical work-plan or abandoning a more effective alternative too soon. The IWM Model will provide the rationale for a sustainable, integrated approach to waste management.

Six years in the making

Both EPIC and CSR, two of the original partners in funding the basic research and developing the IWM Model, are committed to helping municipalities adopt an integrated approach to waste management. The two industry associations have spearheaded the development of the IWM Model to advance implementation of waste manage-



Computer model:

How the model works

ment systems that make both environmental and economic sense. The development and management of the model has been carried out under the auspices of a steering committee comprised of EPIC, CSR, Environment Canada, Procter & Gamble, municipalities and others.

The consulting firm Proctor and Redfern (now known as Earthtech) was commissioned to construct the model in the fall of 1996. Three years later, the full team was involved in field testing the model and had assembled an expert panel to review its scientific underpinnings. From the very beginning, Environment Canada has been very supportive of the work, providing funding to increase the number of modules and upgrade the model's databases.

Dr. Murray Haight, an urban planning professor with the University of Waterloo's Faculty of Environmental Studies, first chaired the panel that was asked to peer review the model and ensure that it was scientifically defensible. Today, he serves as the IWM coordinator, overseeing the on-going maintenance, promotion and distribution of the model. Dr. Haight is a waste management specialist, and has long been involved in life cycle analysis and life cycle inventory studies.

Life cycle analysis offers a way of thinking about the entire waste management system in a comprehensive manner. A number of universities now use the IWM model in their environment courses and have found it to be a very useful planning tool. While it stresses the environmental component, the model shows you can't escape the economic consequences. The model also allows you to test drive a treatment option and review the environmental ramifications without making a huge investment in time or money implementing pilot programs.

How the model works

Environmental scientists have become more sophisticated and accurate in their ability to quantify the repercussions of various management options. Life cycle analysis (LCA) has grown from an interesting theory to a rigorous scientific discipline. By identifying the various inputs — energy, water and raw materials — and the intentional and unintentional outputs — products and by-products, as well as air and water pollutants, solid wastes, lost heat and fugitive emissions — you can map the environmental footprint of a particular treatment option. LCA can reveal the environmental burden of transporting a truckload of refillable bottles across the province, or landfilling tonnes of food waste every week, or collecting materials curbside for recycling.

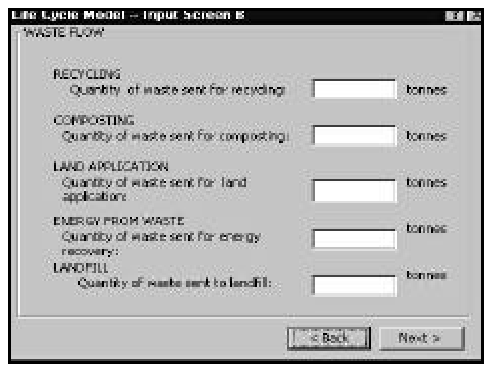
The environmental impacts of each treatment option is determined by the model's life cycle inventory (LCI) module, while the economic implications are ascertained by an economic analysis module. These modules can be used together or independently to evaluate changes in the municipality's waste management system.

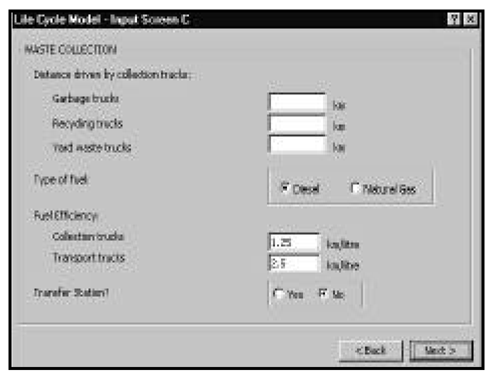
Using the LCI module

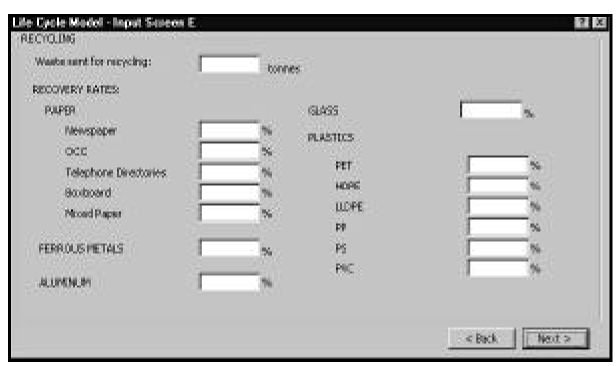
The model is very simple to use. A municipality merely inputs the required data, utilizing an easy-to-use "Visual Basic" interface, into a series of ten on-screen boxes. These boxes cover:

1. the quantity and composition of the municipality's solid waste streams;
2. waste flow data that describes where the waste is currently being directed;
3. waste collection

Screen inputs







Computer model:

Operating modules

and transport data, which covers the distance traveled, fuel efficiencies, transfer station operations, etc.;

4. electric grid selection data, which describes, by province, how the power is generated (nuclear, hydro, coal-fired, etc.);
5. recycling operations;
6. materials recovery facility (MRF) operations, including energy consumption, residue management, and so on;
7. composting operations;
8. land application;
9. energy-from-waste (EFW) facilities; and
10. landfilling.

Once this information is entered into the computer program, it is evaluated through seven separate modules in terms of the specific environmental burdens (the amount of energy consumed, the emissions to air and water, etc.) associated with each waste management option. By so doing, municipalities will be able to learn the environmental profile of their current system, in terms of:

- energy consumption, as an indicator of resource depletion;
- greenhouse gas emissions (carbon dioxide and methane), as indicators of climate change;
- emissions of acid gases (nitrogen oxides, sulfur oxides and hydrogen chloride), as indicators of acid precipitation;
- emissions of smog precursors (nitrogen oxides, inhalable particulates and non-methane volatile organic compounds), as indicators of smog formation;
- air emissions of lead, cadmium, mercury and trace organics (dioxins), as indicators of health risk;
- water emissions of heavy metals, dioxins and biological oxygen demand (BOD), as indicators of the impact on water quality; and
- residual solid waste, as an indicator of land use disruption.

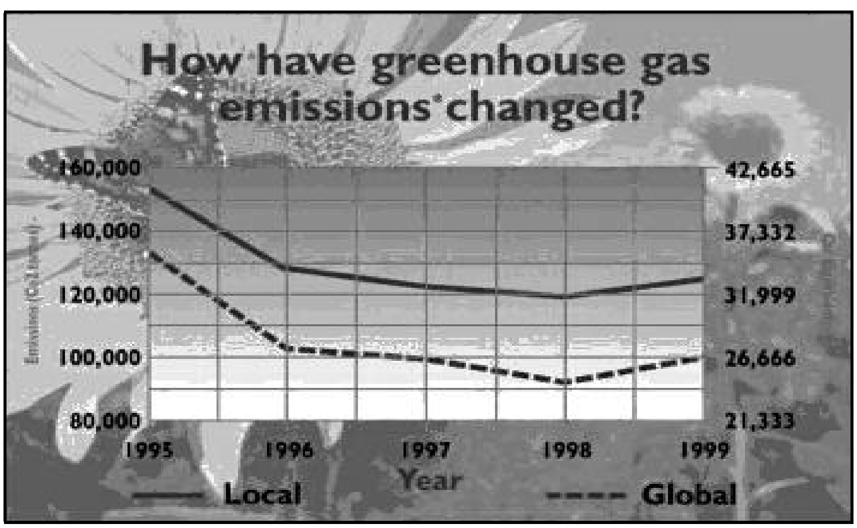
The model itself has been designed for the user to input municipality-specific data, but it also provides default quantities (wherever possible). The LCI data have been derived from a variety of sources, including Environment Canada, the U.S. Environmental Protection Agency (EPA) and the Canadian Raw Material Database, and represent the best data currently available. As refinements to these values are developed, they are incorporated into the model. A full list of data sources appears in the IWM instruction manual, while the raw material database can be accessed on-line at <http://crmd.uwaterloo.ca>.

The first of the seven modules that comprise the environmental analysis is the energy module, which estimates the environmental burdens resulting from the production, delivery and use of the different forms of energy used within the waste management system. This module accounts for any energy that is consumed during the transportation, material handling and processing of the waste material.

The second module addresses transportation. It calculates the environmental burdens that are created as the waste material is transported throughout the waste man-

London embraces IWM philosophy

The City of London, Ontario, worked very closely with EPIC and CSR to provide data that could be used in sample runs for the integrated waste management tool. The data were run through both the environmental and economic modules to obtain profiles of the London system. These showed how changes in existing collection schedules would effect greenhouse gas emissions and affect the number of full-time jobs. The City has continued to further develop the model through its direct application in London's Continuous Improvement System.



Computer model:

Free registration

agement system. Stages include: the collection of recyclables, compostables and garbage; the transportation of materials from a materials recovery facility to the end markets; the transportation of residues from the MRF and compost plant to either the landfill or EFW facility; and, in the case of the latter, the transportation of the ash to the landfill.

The MRF module reviews the environmental burdens associated with MRF activities, which are essentially a result of the energy consumed by MRF operations that, in turn, depends upon the level of mechanization. Next, the materials reprocessing component looks at the environmental burdens involved in processing recovered materials. Then, the composting module analyzes the environmental burdens in terms of composting organic wastes. Although this module covers both windrow and in-vessel composting technologies, the study makes note of the limited data currently available on pollutants in air emissions and waste water effluents from composting processes.

Energy recovery and landfill are the sixth and seventh modules. The former allows for facility-specific air emissions data and the quantities of ash generated to be entered by the user or estimated based on waste composition and default air emission data. Greenhouse gas allocation is based on carbon content, while energy production figures are based on heat content. Heavy metals and dioxins are allocated according to weight. The landfill module uses waste composition, landfill design parameters and the amount of energy consumed to determine the environmental burdens.

The impact equivalency component is a unique part of the IWM Model. It allows the user to take complicated expressions of environmental benefits and translate them into a common currency people can readily understand. For example, the energy consumed in various waste management processes is compared to the amount of electricity used by the average Canadian home for a year. And emissions of GHGs can be expressed in terms of the number of passenger vehicles emitting an equivalent amount of pollutants in a year. This feature also makes the model an effective tool for public education.

Economic analysis module

The economic cost analysis module allows the user to view two different scenarios simultaneously: the current system costs and the costs that would be associated with a system change. It allows the user to enter the operational parameters and costs of up to three or four different components (for example, curbside collection, depot systems, etc.). The module is based on the same structure as the Recycling Cost Collection Model and Processing Cost Model developed jointly by EPIC and the Ontario Ministry of the Environment.

A number of factors can be varied to determine the number of collection vehicles required under any given scenario. These may include frequency of collection, demographics, and the size of the vehicle used. Collection, processing and administration costs are entered by the user. The manual provides default values for processing costs associated with recycling, composting, EFW and landfill facilities, based upon the size of facility and other factors.

Calgary shows wise waste management can cut greenhouse gases

The City of Calgary, Alberta, used the IWM model to evaluate how its waste management practices contributed to greenhouse gas (GHG) emissions. Waste managers also tested five hypothetical scenarios to see if they could cut the release of GHGs. The model showed that collecting landfill gas and investing in energy recovery would reduce GHG emissions by an amount equivalent to that generated by 63,000 cars in the course of one year. Recycling and composting programs could also provide significant benefits.

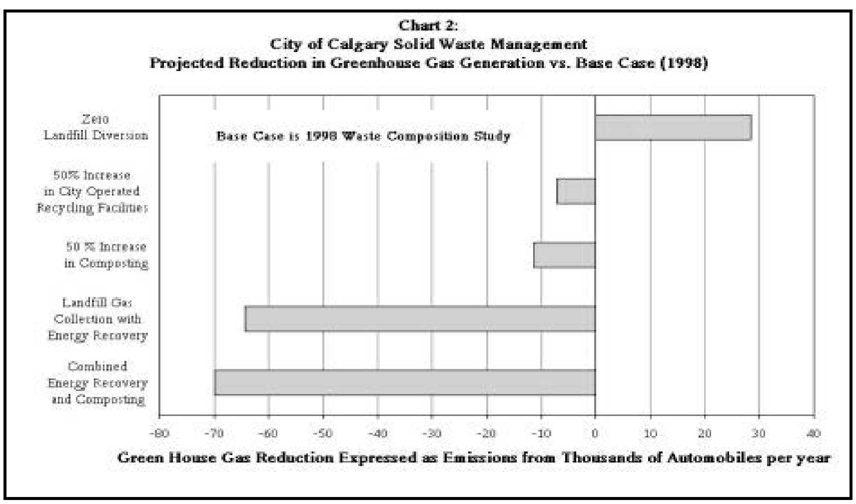


Chart 2:
City of Calgary Solid Waste Management
Projected Reduction in Greenhouse Gas Generation vs. Base Case (1998)

Computer model:

Incorporating change

Capital Region of B.C. uses model to gauge past efforts and test possible refinements

Authorities used the IWM model to assess the environmental performance of the existing waste management system, as well as a number of different scenarios that could be implemented in the future. The model showed that the Region would save the most energy by capturing up to 50% of the landfill gases currently vented to the atmosphere, while composting up to 80% of the residential food and yard waste would achieve the greatest reduction in greenhouse gas (GHG) emissions. The energy savings would offer even greater environmental benefit if B.C. didn't derive most of its electricity from clean hydro-electric plants. The model was also able to show that the waste reduction and recycling activities undertaken over the last ten years had cut GHG emissions by 253.2 kt of carbon dioxide, equivalent to the pollution emitted by 62,000 cars in a year.

Registration is easy AND free

There is no charge for using the model. All you have to do is register on-line and you will be issued a pass code that gives you access to the model, the user manuals, case studies and a Help line. Then it's entirely up to you to use the model as you wish. If possible, users are asked to forward a report of their major findings, although that's not always possible. Currently, the IWM website contains descriptive case studies detailing how the cities of Calgary, Alberta, and London, Ontario, have used the model to their advantage. A case study prepared by the Capital Region of British Columbia is expected to be posted soon.

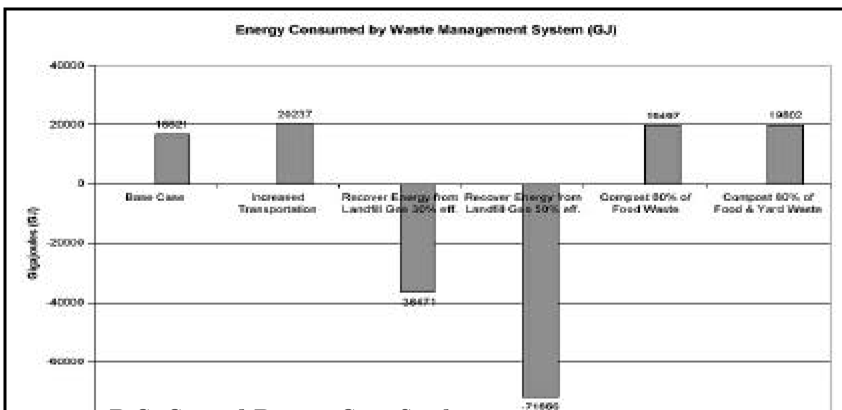
There are currently just under 150 registered users, primarily municipalities, and three or four new applications are being processed every week. Two years ago, the user manuals were translated and the model completely reformatted for French-language users. There was a big jump in user numbers as soon as the model became bilingual. The Quebec government requires municipalities to prepare and file waste management plans, and our IWM Model was recommended as a particularly useful resource for doing this.

There's also been some international interest in the IWM Model. There are five or six similar programs operating in the United Kingdom and Europe, some of which charge substantial sign-up fees for potential users. Each program started independently, but we all share a common interest in integrated waste management modeling and work together as a group where we can.

Still, the IWM Model is specifically calibrated for the Canadian experience; all the default values reflect Canadian emission standards, the diesel fuel mixes used in this country, and similar parameters. For the last six years, we've been breaking scientific ground in the field of waste management modeling. And that success has spurred other jurisdictions to get into the game. While the Canadian-based IWM Model is the only computerized version currently operating in North America, the U.S. EPA is expected to unveil its own integrated model in the near future.

A growing, breathing thing

The IWM Model is a growing, breathing creation. It has undergone some tweaking since it was launched in 1999, and now boasts improved user-friendliness, as well as a more efficient Excel 2000 platform. Other improvements include a scenario comparison program built into the main



B.C. Capital Region Case Study

Computer model:

Making a difference

body of the model, and an easier way to save "current data". Future changes being planned include the addition of a help function and comment screens, and redesigning the system to support the use of multiple screens. We are committed to supporting the future use and distribution of the model and ensuring it remains user friendly and up-to-date.

In addition, as production methods and fuel mixes and pollution control technologies and regulatory standards change, we have to update the data that drives the model. This means checking and recalibrating some of the original background assumptions. As more is learned, new and more up-to-date data will be input to fine tune the model.

A support group, which consists of representatives from several organizations involved in the model's initial development and roll-out, is charged with the responsibility of making sure the model remains current and up-to-date. This includes deciding when to expand the model to incorporate new treatment options. Currently, a new module for anaerobic digestion (to complement the model's existing composting module) is being built, with financial support from Environment Canada. The module will use data relating to the collection of paper, yard and food wastes, and other organics from curbside through to the production of products. In turn, it will estimate the amount of energy consumed or produced, as well as the emissions to air, water and land. The anaerobic digestion module will round out the offerings of the IWM Model and increase its value as a resource for municipalities to use in evaluating their waste management options. The new module should be up and running by the end of 2002.

Adding a new treatment component is a complex and time-consuming matter. Before you plug a new option into the model, you need to compile accurate numbers on energy consumption, efficiency rates, air and water emissions, the quantity and quality of any by-products or residues produced, and so on. It takes time to set up pilot testing programs, generate useful data and have it all reviewed in the open scientific literature. The support team is currently looking at the promising gasification option for generating syngas from municipal wastes, but it will be some time before they are ready to incorporate it into the IWM Model.

Starting to make a difference

The IWM Model is really beginning to pay environmental dividends in municipalities across Ontario and across the country. The model has already won over a number of municipalities to the value of integrated waste management and is helping to counter ideological opposition to innovative waste treatment alternatives like anaerobic digestion and thermal treatment.

EPIC and CSR shared a vision and both contributed the initial funding to get the IWM Model up and running; we consider this work an integral part of our stewardship mandate. As citizens continue to hold waste planners ever more accountable for the way they spend tax dollars, municipalities are going to have to better quantify the benefits, environmental and otherwise, of the decisions they make. This is where the IWM Model becomes such an important planning resource and educational tool.

Of course, the model only supplies one part of the puzzle. The environmental benefits of any waste management option need to be integrated with, and weighed against, the potential technological limitations, societal expectations, and economic, market and geographic realities. More and more municipalities are discovering the IWM Model is an effective tool that politicians can use to make a more responsible decision on their waste management options and opportunities.

How to get involved

For more information on using the Integrated Waste Management model, visit the dedicated website, hosted by the University of Waterloo, at <www.iwm-model.uwaterloo.ca>, or contact the Environment and Plastics Industry Council (EPIC) or Corporations Supporting Recycling (CSR).

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INTEGRATED WASTE MANAGEMENT MODEL

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