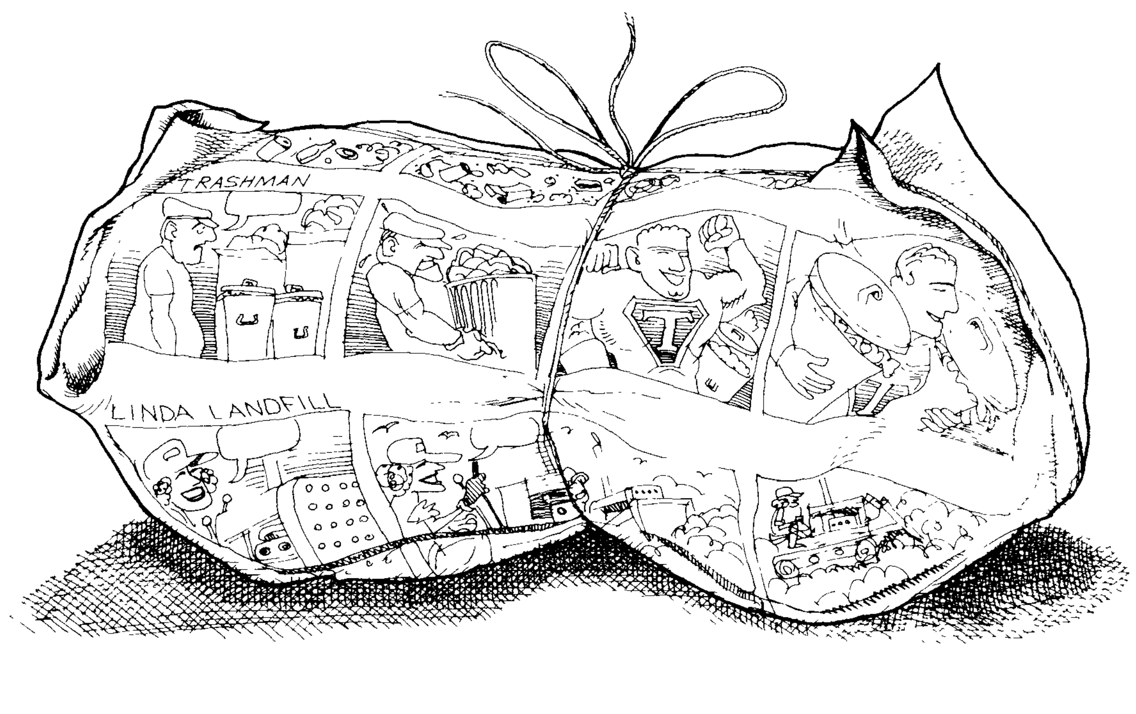
SW548

WRAPPING UP THE SOLID WASTE MANAGEMENT PROBLEM:

A Model for Regional Solid Waste Management Planning



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FOREWORD

According to a 1973 survey conducted by the National League of Cities, municipal officials across the country feel that solid waste management is the most critical issue facing their administrations. And a recent Environmental Protection Agency Report to Congress on Resource Recovery and Waste Reduction states that the amount of municipal solid waste disposed annually will increase by 30 million tons in the next 10 years.

States, regions, counties, cities and towns across the country are facing critical questions about what to do with solid waste. How can we plan systems that dispose of these wastes? Which of the many disposal options is the best? Which will meet environmental objectives as well as provide the least expensive solution? These questions are particularly difficult to answer when a plan must be developed for a region consisting of a number of municipalities, a large area, and a complex transportation network.

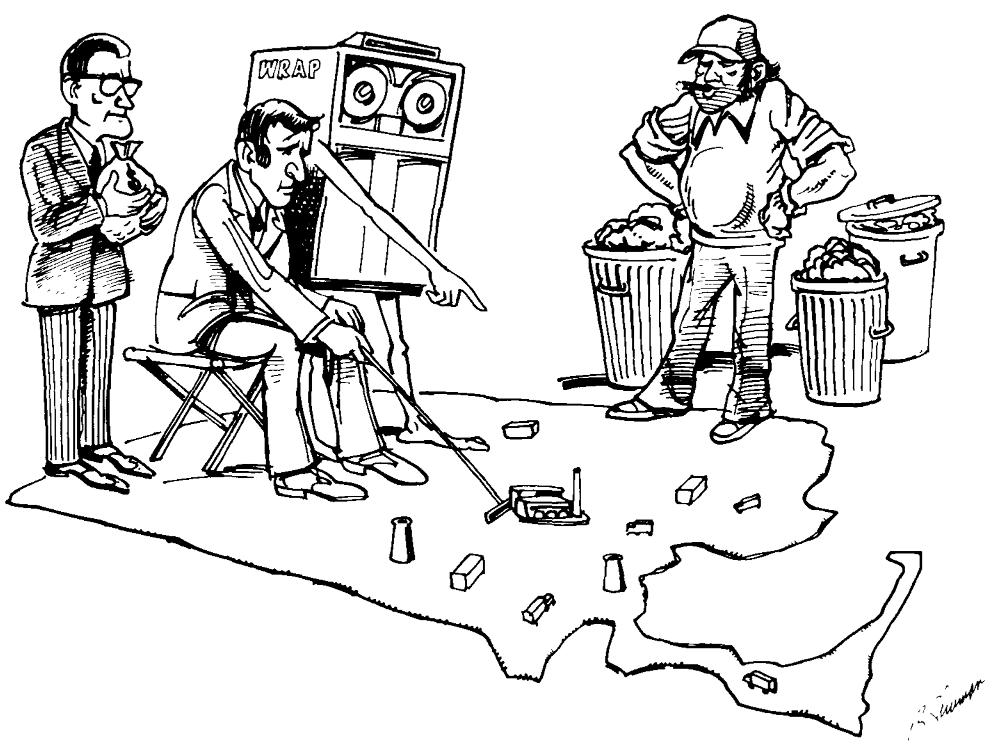
In order to assist decision makers with these and other complex questions, a computer model called WRAP (Waste Resources Allocation Program) has been developed. The model enables its users to quickly sort out all the various options and generate and calculate the cost of a number of solid waste management plans.

Each plan indicates the selection, location and capacity of sites and processes, and the flow of waste throughout the region's transportation network. Total annual cost of the system and cost per ton are computed. One of the most important features of the model is that it can be used to guide the decision-making problem in the selection of alternative systems and to translate the impact of this selection into cost figures.

What WRAP can do to help decision makers, and how it can do it, are the subjects of this document.

This report has been prepared by the MITRE Corporation, Bedford, Massachusetts, (Contract No. 68-01-2976) for the Systems Management Division of the Office of Solid Waste, U.S. Environmental Protection Agency, under the direction of Ms. Donna M. Krabbe.

–SHELDON MEYERS
Deputy Assistant Administrator for the
Office of Solid Waste



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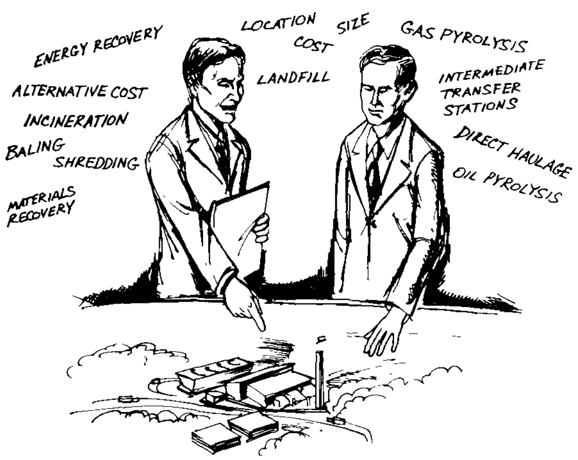
INTRODUCTION: THE SOLID WASTE MANAGEMENT PROBLEM

The millions of tons of solid waste produced annually create difficult decisions that must be made at local levels. City councils, mayors, town managers, public works officials, and state solid waste agencies must decide today how to dispose of the solid waste generated within their jurisdictions. The decisions were once rather straightforward: engineering firms were contracted to upgrade existing incinerators or, build new ones, or new landfill sites were located.

But today, officials are confronted with a complex and confusing array of alternatives and constraints.



Local landfills have traditionally been the least expensive method of disposal, but today land is becoming difficult to find. Incinerators designed to comply with environmental regulations are increaingly expensive. Similarly, the newly emerging resource recovery technologies offer environmentally sound waste disposal, but are generally too expensive for single communities to own and operate. Thus there are strong pressures toward regionalization of solid waste management functions.

Regionalization, however, gives rise to two fundamental problems:

- complexity of the regional system design; and
- obtaining a political consensus amongst the participants.

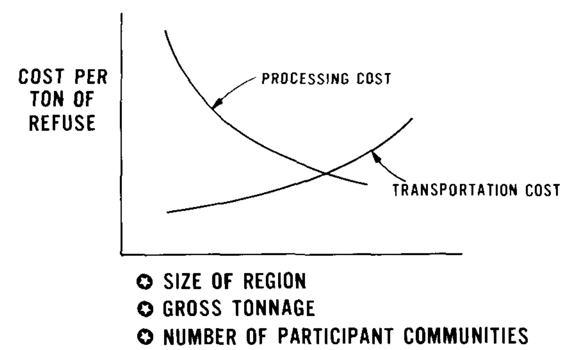
These issues can best be addressed by developing and clearly presenting technical and economic data about the consequences of various regional approaches.

Selection and implementation of a regional solid waste management plan can be viewed as one of economic choice in which decision makers must seek the least expensive solution that meets environmental and political constraints. In this context, solid waste management planning is sensitive to a number of important conditions.

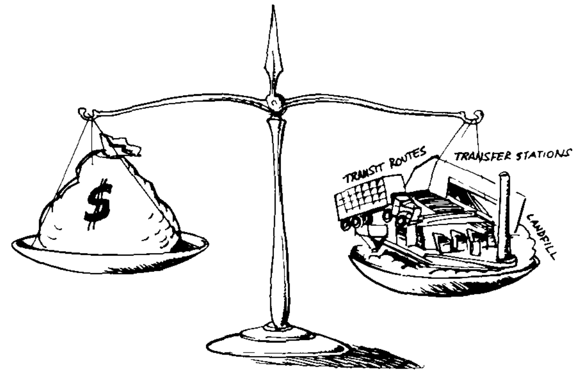
First, there are important variations in conditions found in different regions. The quantity of waste generated may vary considerably: from a very few tons per day to many thousands of tons per day. Regions differ in the prices obtainable for recovered materials and in the transportation costs necessary to realize those prices. They also differ in the availability and proximity of land for landfill. Therefore, the system that is right for one region is not necessarily right for another.

Secondly, there is a tradeoff on haulage costs versus processing costs – that varies among technologies – which is represented by the choice between central or dispersed locations for processing facilities. Larger facilities can generally process a ton of refuse at a lower cost than smaller facilities. Thus, the decision to choose a centralized processing center makes available economies of scale in processing, but at the expense of higher haulage costs to achieve the required volume of waste. On the other hand, a system of dispersed processing will offer lower haulage costs at the sacrifice of economies of scale in processing.

THE ECONOMIC TRADEOFF IN REGIONAL DESIGN



Finally, a proper economic analysis of choice should not only identify which alternative solid waste management plan is preferred but also the comparative costs of other "good" alternatives. This information assists decision makers in their search for the best "politically acceptable" alternative.



THE WRAP MODEL: A DECISION MAKING TOOL

Faced with an array of available alternatives and considerations, decision makers are confronted with the recognition that although regionalizing solid waste management functions has economic advantages, regionalization itself gives rise to some questions: Where should the disposal facility be located? What is the preferred technology? Who should it serve? How large should it be? Should participating communities haul their refuse directly to the facility, or through intermediate transfer stations? What size and where should the transfer stations be? What will a system that meets all the objectives cost? What are good alternatives and what will they cost? In sum, what is the most economically preferred regional system design and what are the costs associated with changing that design?

In order to assist those faced with these complex issues, the U.S. Environmental Protection Agency has sponsored the development of a computer model called the Waste Resources Allocation Program, WRAP. It specifically evaluates the economic trade-offs within the entire processing and disposal systems, including haul costs of collection vehicles to a disposal facility, capital and operating costs of transfer stations, resource recovery facilities and landfills, transfer haul costs, and revenues available from materials and energy recovery. It helps to sort out all the various options within a specific region by indicating a preferred solution that identifies the minimum cost regional solid waste management plan that meets all the objectives determined by its users. Use of the model enables officials to study and analyze the costs and implications of all available alternatives.

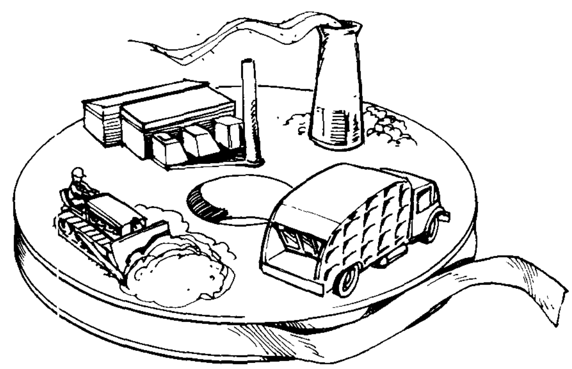
How WRAP Can Help

- **AIDS IN STRUCTURING THE ANALYSIS**
  - The decision maker.
    - defines issues to be examined
    - defines all processing and disposal alternatives
  - WRAP provides for uniform data definition
- **OBJECTIVE ECONOMIC ANALYSIS**
  - WRAP
    - evaluates all options presented
    - selects lowest cost regional plan
    - identifies physical plan behind lowest cost solution
- **EFFECTIVE DECISION-MAKING**
  - The decision-maker.
    - uses WRAP to generate a set of alternative plans
    - evaluates these alternative plans
    - considers the economic impact of choosing among alternatives

WHAT IS A MODEL?

A model is an abstract representation of a system (which can be a real thing or an idea) that is being studied or examined. Although a model is never more than a partial representation of reality, its use allows one to adequately predict the effect of changes in the system on that system's overall effectiveness or cost.

The use of models is not new to modern man. From the beginning of history, models have been used to represent objects or ideas in an effort to express meanings. Physical models are perhaps the most familiar; however, mathematical models (models in which the system is represented by a set of equations which can be manipulated mathematically) form the basis of the scientific disciplines.

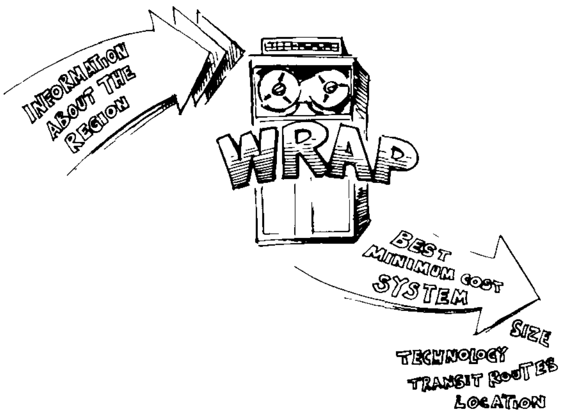


Increasingly, computerized mathematical models have been used as aids in management planning. These are simply sets of mathematical equations expressed or written according to a particular set of rules so that they can be processed by the computer. The advent of the computer has proven invaluable in modeling, as it frees its users from time consuming and cumbersome calculations.

WHAT IS THE WRAP MODEL?

WRAP is such a computer model. It can be used as a tool by decision makers who are seeking a solid waste management plan that most economically meets environmental and political criteria. The model reviews information about the region and from this provides a minimum cost regional solid waste management plan.

A key capability of WRAP is its ability to balance the economies of scale achievable through centralization of processing at one location against the additional haul costs required for centralization. This makes it possible to determine what levels of centralization make the most economic sense.



WRAP consists of a series of equations which consider the sources of solid waste generation over a given planning region, a set of possible sites, and processes to be considered at those sites, as well as various site and process capacity constraints. The processes can be transfer stations, resource recovery processes (including the extraction of recoverable resources to be marketed), secondary processes (which receive the residue of primary processes as input) and various disposal processes. WRAP further considers many transportation route alternatives from sources of waste generation to sites, and from sites to sites, and allows for site traffic constraints.

Processing costs are input to WRAP so as to reflect the economies of scale available for each process, and the revenues from the marketing of recovered materials. Haul costs are included, which increase directly with both tonnage and travel time.

WRAP has three essential components:

structure – which assures that each alternative considered is feasible in the sense that all wastes generated are entered into transportation, that all wastes arriving at a site are processed, that all residues generated are processed at the site or entered into transportation, and that no process exceeds the indicated tonnage maximums;

cost – which assures that each alternative is properly costed, including economies of scale where appropriate; and

procedure – an organized mathematical procedure which allows those options which improve the solution to be separated from those that make it worse, and indicates when the procedure has identified the least cost solution.

WHY SHOULD DECISION MAKERS USE THE MODEL?

When planning a regional system, decision makers should consider many different siting, process, capacity and transportation alternatives. Designing the minimum cost plan could involve hundreds of time consuming and cumbersome calculations. The WRAP model should be used because it allows its users to make these calculations in a relatively brief period of time, thereby permitting a continuous planning and decision process. The model makes it practical to examine many more questions and alternatives than would be possible without its use.

Because the model mathematically analyzes the economic advantages and disadvantages of each of the alternatives, it avoids the potential errors of decision based purely on intuition.

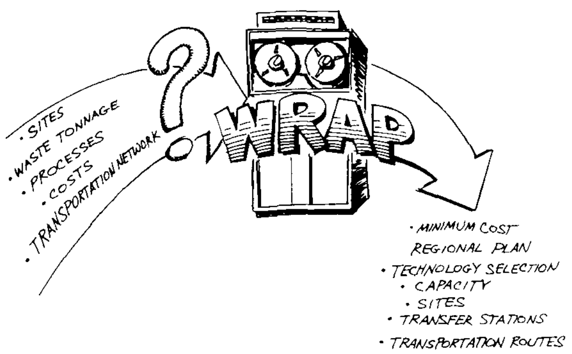
HOW IS THE WRAP MODEL USED?

To use the WRAP model, data and information about the region are structured in a set of model runs. Each run examines specific issues and questions that decision makers wish to address. The lowest cost solution for each alternative being examined is generated by the model, as well as a regional system plan for each alternative. Decision makers can then use the model to calculate the incremental costs of moving from one alternative to another, and in particular, the costs of moving from less political acceptability to greater acceptability. In any given planning region, for example, WRAP can be used to quantify the system cost difference in a regional system compared with a county by county solution; or the system cost impact of the political acceptability or technical availability of certain resource recovery or disposal processes; or the system cost impact of alternative revenues for marketing recovered materials and energy.

Each plan generated by WRAP indicates what kinds of waste disposal technologies would be best for the region based upon differing assumptions, where to locate the facilities for processing and disposal as well as transfer stations, how much capacity to install at each site, and the transportation network to link the elements of the system together to achieve the minimum cost solution.

WHAT IS NEEDED TO USE WRAP?

Users need four things to apply the WRAP model: a sense of the kinds of questions for which answers are wanted; access to analytical skills; the use of or access to a computer; and data.



Questions To Be Asked

In order to sort out the various alternatives and options, as well as to illuminate potential political issues, users should have some feeling for the kinds of questions for which they desire answers. For example,

- where should transfer stations be located?
- is resource recovery viable? or
- what is the cost impact of locating an element of the system in one place versus another?

On the other hand, time and budget should be allowed to answer additional questions, for it has usually been the case that the first few runs in answering a question have suggested additional questions.

Analytical Skills

Model users either need to have, or have access to, persons with analytical skills (for example, regional planners) who are capable of examining the situation and identifying and structuring issues which WRAP will address. In addition, persons with technical skills, who can actually use the model, are necessary. The nature and extent of the skills needed can be determined by reading the supporting information available about the WRAP Model, or by inquiring of EPA's Systems Management Division staff.

Computer

It is necessary to have access to a computer, the actual size requirement of which may vary according to the dimensions of the problem being addressed. WRAP has been designed to operate on an IBM 370/165 system.

Data

Two basic groups of data are required: those that are tailored to the specific planning region; and those that are generally applicable throughout the country. The former group must be provided by the users; the latter group is available from earlier runs but should be reviewed before use. A brief description of the specific kinds of data required is provided here. However, all of these data and potential sources are described in greater detail in supporting volumes of the WRAP model designed for its users.

Data to be provided include estimates of waste generation volumes, possible sites being considered for the location of transfer stations, primary and secondary solid waste processing facilities, and landfills; data on the local transportation network in terms of transit times between the sources of waste generation and each site, and among sites; and estimates of revenues from the sale of recovered energy and materials, representing local market conditions.

Other data required which are perhaps the most difficult to obtain are the costs of the various solid waste disposal processes being considered as well as the estimated costs per ton-minute of transporting the refuse in packer and transfer vehicles. The costs of all solid waste disposal processes being considered need to be provided as input to the model.

WHO SHOULD USE THE WRAP MODEL?

The WRAP model has been developed to assist a wide range of decision makers who must make choices concerning the future direction of solid waste management. This includes officials within various regional or county agencies, state agencies which are responsible for this function, and city agencies or officials, who are contemplating regional systems.

Because the model has been developed to assist in regional solutions, it should not be used unless there are large enough geographical areas to warrant investigation of economic tradeoffs.

WHEN SHOULD THE WRAP MODEL BE USED?

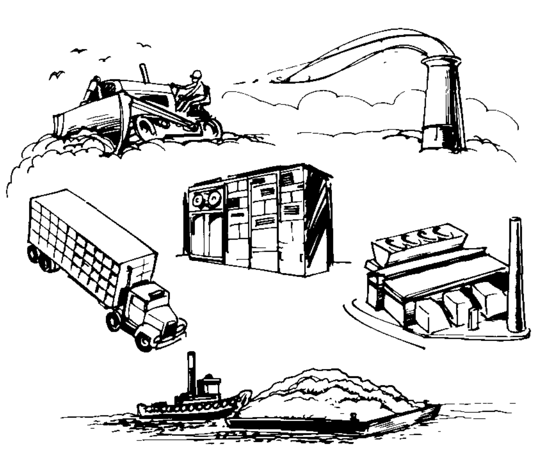
The WRAP Model should be used by decision makers who are faced with situations in which local solid waste disposal options are no longer available, and regional solutions must be considered.

For example, the model can be used in the early regional planning stages to identify how large the region should be and which communities should participate. It can determine which technology is most appropriate and where it and subscribing transfer stations should be located to produce the minimum system cost to the communities. The model can be used to determine the economic feasibility of a system proposed for the region, the economic effects of alternative volumes of waste, and the effects of variations in revenues from recovered materials.

During the early stages of planning, data, especially concerning process costs and markets are necessarily estimates. The quality of the model's solutions are, of course, only as good as the data supplied to it. As the planning process progresses and better data becomes available, WRAP should be used to verify earlier plans or to evaluate any changes which might be indicated.

WHERE HAS THE WRAP MODEL BEEN USED?

The WRAP model has been used in Northeast



Massachusetts and Greater St. Louis, and is currently being used in other areas.

For the Commonwealth of Massachusetts, the model was applied to a region encompassing 63 communities in Northeast Massachusetts and New Hampshire in an effort to assist the Commonwealth in the initial planning stages of a regional solid waste management plan. The Commonwealth's plan emphasizes the implementation of regional resource recovery systems throughout the State, and it desired assistance in identifying the most efficient regional system design for the first region.

Under EPA sponsorship, the model was applied to identify and illuminate issues in Greater St. Louis, where the Union Electric Co. is proposing to install an 8,000 ton-per-day resource recovery system using the shredded fuel process developed by them. The proposed system included the marketing of the recovered fuel to Union Electric's power generating stations within Greater St. Louis. A local regional planning agency, the East-West Gateway Coordinating Council, requested EPA to fund an application of the model to provide further insights into the advantages to the communities of participating in such a plan.

WHAT KINDS OF QUESTIONS HAS THE MODEL ANSWERED?

Use of the WRAP model by the Commonwealth of Massachusetts provided significant information concerning the elements and makeup of the state's first regional resource recovery system.

In response to a request from five communities in the Merrimack Valley region who were faced with critical disposal problems, the Commonwealth agreed to sponsor the implementation of a regional resource recovery system that would provide comprehensive, full scale disposal services to those communities. Recognizing that there would be clear economic advantages to creating a larger region, the Commonwealth used the model to determine:

- Which of the many technologies would produce the minimum cost solution?
- How large an area should the system serve in order to minimize the cost?
- Where should the facility be located and what size should it be?
- Which communities should participate in transfer stations, and where and what size should those transfer stations be?
- What will be the overall system costs of alternative system designs?

The model indicated that with all options available, gas pyrolysis facilities at two sites in the region would provide the minimum cost solution at $4.40 per ton. Because gas pyrolysis is in the developmental stages and not available for implementation, the model was asked to provide the "next best" solution, and selected sanitary landfill in six locations throughout the region, at an incremental cost of around $3 per ton. Recognizing that landfills are of questionable political acceptability in Massachusetts the model was asked to pick the next best system, and selected the dry shredded fuel process at a single location for an incremental cost of $4 per ton over the original solution. (A later analysis showed that the markets for shredded fuel at that time were weak, thus a different technology was finally recommended.) The selected system in each case indicated which communities should participate, the location and size of transfer stations and the secondary resource recovery facility, as well as the most economical transportation routes for communities to utilize in reaching the facility.

The use of the model enabled the Commonwealth to determine the minimum cost regional system design, as well as the incremental costs of proceeding to a regional design of greater political acceptability.

In the Greater St. Louis area, the East-West Gateway Coordinating Council asked EPA to fund an application of the model to assist in the resolution of two issues of primary importance in that area. One was to determine the economic feasibility of community participation in a resource recovery system proposed by Union Electric compared to continued landfill operations. The second issue concerned the design of a resource recovery system, e.g., what design would produce the minimum cost to the participants?

Based upon the data inputs, the model solution indicated that the resource recovery system was indeed a viable, economically feasible solid waste management plan, and was in almost all cases the least cost system as compared to landfill. The generated solution included the location of the facilities and transfer stations.

The model was then asked to provide information relative to the incremental costs of changing that design. Specifically, what would be the incremental cost of prohibiting the flow of waste across the state boundaries of Missouri and Illinois; of losing a particular market or a portion of the tonnage; and, what would be the effect on the regional design and the cost of forcing the model to consider locating the facility in a particular location?

Although the cost of each of these solutions did not vary significantly, the result of these variations, both singly and together, changed the structure of the preferred solid waste plan. For example, prohibiting the interstate flow of waste altered the regional configuration by locating the shredded fuel processing facility farther away from the urban area, and deeper into the suburbs.

The application of the model provided significant information concerning the economic viability of resource recovery in comparison with landfill operations.

EXAMPLES OF MODEL USE

Examples of the kinds of issues which WRAP can address are provided here to illustrate its capabilities and versatility. These examples are drawn from actual model applications in St. Louis and Massachusetts.

Background

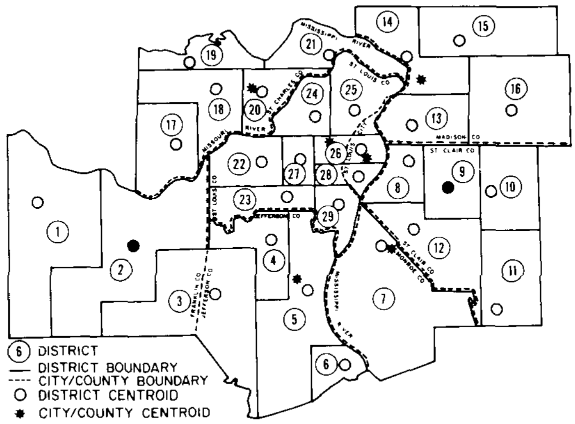
The WRAP model was used to analyze a 450 square mile area in Greater St. Louis, encompassing 185 municipalities, and roughly two and one-half million people, producing an estimated 8,000 tons per day of residential, commercial and industrial waste. One hundred eighty five landfills and dumps, and two incinerators currently provide inadequate disposal services to the area, often in violation of environmental regulations. The Union Electric Company is proposing a large resource recovery system using the shredded fuel process developed by the company, including the marketing of the fuel to Union Electric's steam generating stations within the region.

Data for the application was drawn from an earlier report prepared for the East-West Gateway Coordinating Council, one of the agencies concerned with the course of solid waste management in the region. The data comprised costs of the proposed Union Electric process, the Bureau of Mines residue recovery process, transfer stations, landfills, transfer haul and rail haul, revenues from the sale of recovered materials and energy, as well as waste generation tonnages and possible site locations.

In Massachusetts, the Commonwealth desired to provide solid waste disposal services for Northeastern Massachusetts communities faced with critical disposal problems. The WRAP model was used to analyze a 750 square mile region, encompassing 63 communities, with over one million people. Data for the Massachusetts application included costs of various disposal technologies, including pyrolysis, dry shredded fuel, landfill, residue recovery, transfer stations and transfer haul, as well as waste generation tonnages and possible sites.

Is Resource Recovery Economically Viable for a Planning Region Under Consideration? How Can WRAP Help in Determining the Answer?

The WRAP model was used in Greater St. Louis in an effort to determine the answer to one of the questions facing the region: Is it economically sensible for the region's communities to participate in the proposed Union Electric resource recovery system? Because the size of the region under consideration was extremely large, the seven-county area and the City of St. Louis were divided into 29 districts, in order to promote an effective and rapid manipulation of the data. The district boundaries consolidate smaller subdistricts of similar character. This classification was used for the analysis and presentation of data for areas larger than subdistricts, but smaller than counties.



GREATER ST. LOUIS

Estimates were used for 1980 waste generation tonnages for each of the 29 districts. Thirty-four sites throughout the region were identified as possible locations of transfer stations, primary and secondary processing facilities, and landfills.

Two initial model runs were made to answer the question of resource recovery viability based upon locally supplied data. When offered only resource recovery as an option (Run A), the WRAP model generated a minimum cost regional plan, at a cost of $1.253 per ton. When offered landfill as an option, only one-half of one percent of the waste flowed to landfill, while 99.5% entered resource recovery processing. Run B operated at a cost of $1.249 per ton, only four tenths of a cent less than Run A, as shown.

Is Resource Recovery A Viable Option?

(A Comparison of the WRAP Model Runs in St Louis)

	Run	Cost $/ton	Landfill Selected
A	Resource Recovery	1.253	None
B	Landfill Added as Option	1 249	for 400 TPD (0 5% of total)

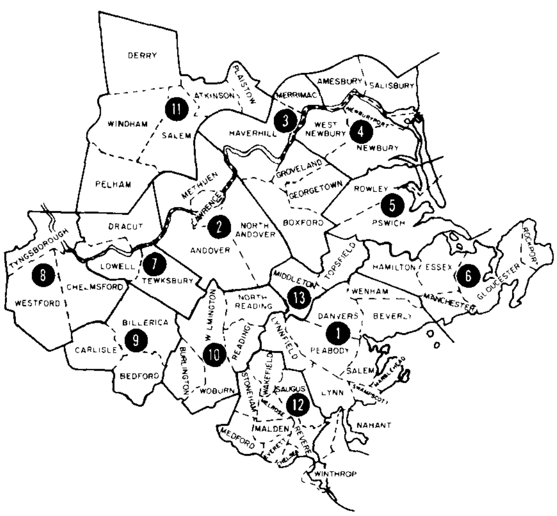
The model solution indicated that the resource recovery system proposed by St. Louis could indeed be competitive with landfill. The revenues for fuel and secondary materials proved too attractive to permit a regional system that relied on landfill.

Which of the Many Solid Waste Disposal Options Is Best for a Planning Region in Terms of Total

System Cost? What Are the Effects on the Regional System of the Unavailability or Political Unacceptability of Those Options Selected?

Three runs in the application of the WRAP model for the Commonwealth of Massachusetts provided the answers for these questions: Which of several solid waste processing and disposal options (pyrolysis, refuse-derived fuel, and landfill), is best for the region? If the selected option is not available, or is politically unacceptable, what are the effects on both the system cost and the regional design?

Input data was prepared in a fashion similar to that in St. Louis. The region was divided into 13 districts with centroid and waste generation identified in each district. Costs of transfer stations and truck haul, possible sites, and distances and times between those sites were determined. Costs for the three solid waste disposal options were input, as well as expected revenues from the sale of recovered products for the resource recovery technologies, and a residue recovery process. (It should be noted that the residue recovery process used in the model was that being planned at that time for the City of Lowell, under an EPA grant.)

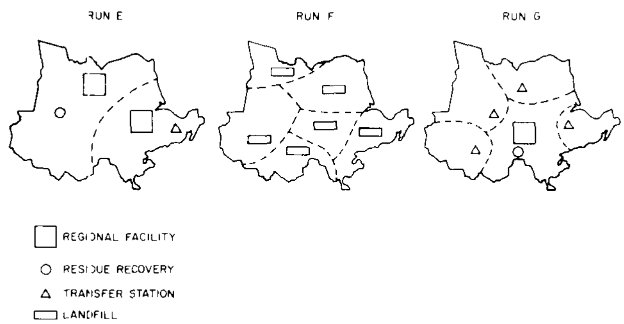


NORTHEASTERN MASSACHUSETTS PLANNING REGION

Three runs were made. The model solution indicated that with all the options available the minimum cost solution could be achieved through the selection of the gas pyrolysis technology at two locations within the 63 community region. The minimum cost solution included a single transfer station, and the residue recovery facility at a system cost of $4.38 per ton.

Runs (Options Available)	Structure of Run Solution
E Transfer Stations, Shredded Fuel, Gas Pyrolysis, Residue Recovery, Landfill	Two Pyrolysis Facilities One Transfer Station Residue Recovery $4.38/ton
F Transfer Stations, Shredded Fuel, Residue Recovery, Landfill	Six Landfills Residue Recovery $7.34/ton
G Transfer Stations, Shredded Fuel, Residue Recovery	One Shredded Fuel Facility Residue Recovery Four Transfer Stations $11.23/ton

Although the model selected the pyrolysis technology it was still in the developmental stages and not ready for implementation. Consequently, a second run was made, and the model was asked to provide the "next best" solution. The model selected landfill at six locations throughout the region at a cost of $7.34 per ton, or an incremental cost of about $3.00 per ton.



WHERE SHOULD THE ELEMENTS OF THE REGIONAL PLAN BE LOCATED IN ORDER TO ACHIEVE MINIMUM SYSTEM COST? (MASSACHUSETTS RUNS E,F&G)

Because landfill disposal is of questionable political acceptability in Massachusetts, Run G was made asking the model for the next best solution. The model determined that, given markets for the sale of the recovered products, the minimum cost solution consisted of a dry shredded fuel process in one location, with four subscribing transfer stations and the residue recovery facility. The cost for this system was $11.23 per ton, or an incremental cost of roughly $4.00 per ton.

The results of the WRAP application indicated to the Commonwealth which of the many solid waste disposal options would provide the minimum system cost while meeting all applicable criteria. Most importantly, the WRAP application gave the Commonwealth the incremental dollar costs of the unacceptability of another.

Where Should the Components of a Regional Solid Waste Management System Be Located in Order to Achieve the Least Cost System? How Large Should They Be? And Whom Should They Serve?

In the applications of WRAP previously discussed, a variety of questions were asked. In providing an answer to each, WRAP generated a system design which comprised the best regional design that would produce the minimum cost while answering the specific question. Each design indicated where the facilities should be located; how large and where the transfer stations should be; and how the system should be linked together.

The optimal region design generated by WRAP for Massachusetts is shown schematically in the figure above. The location and size of the system components for each plan varies according to which option was selected. In the regional design in which the gas pyrolysis technology (Run E) was selected, one processing facility handled 700 tons per day, and served 15 communities, while the other, at 1500 tons per day, served 34 communities. A single transfer station served one community with 90 tons per day.

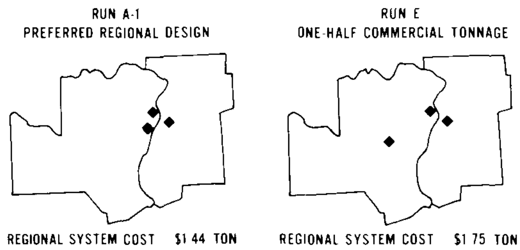
Run F generated a minimum cost design comprising six landfills, and no transfer stations. Run G generated a design consisting of a single dry shredded fuel facility to serve the entire region, with four transfer stations serving a total of 34 communities. The remaining 19 communities hauled their waste directly to the facility.

How Can WRAP Help in Determining the Effect on the Preferred Regional Design of Having More or Less Than the Expected Volume of Tonnage?

In both the St. Louis and Massachusetts applications, runs of the WRAP model were made to determine the effect on both the makeup of the regional system and the overall system cost of having more or less than the expected tonnage.

For St. Louis, Run E asked the model: What is the preferred regional design if the private haulers in the region, who are largely responsible for the haul and disposal of commercial waste, do not join the regional system? In order to determine this effect, Run E included only half the amount of commercial tonnage generated in the region. Since commercial tonnages tend to be concentrated in urban areas, the model generated a solution which caused primary processing to be relocated toward the suburbs. The cost impact of this change was relatively small. Based upon locally supplied data, the model generated a system cost of $1.75 per ton, or an incremental cost of $.31 per ton over the base case for that solution.

WHAT IS THE EFFECT ON THE REGIONAL DESIGN OF HAVING LESS THAN THE EXPECTED VOLUME OF TONNAGE?
(ST LOUIS RUN E)



Runs H and I were made to determine the effects of doubling the amount of tonnage in the region on both the design generated when all options were available (Run G). The purpose of these runs was to determine how sensitive the model solution was to radical changes in tonnage.

Run H generated a regional configuration that was identical to that of Run E but with two additional transfer stations. The effect on the system cost was a decrease from $4.38 per ton to $3.45 per ton.

Run I generated a somewhat different design from that generated by the earlier Run G. The addition of twice the amount of tonnage caused a relocation of the shredded fuel facility to a more northerly location, four transfer stations in slightly different locations, and the residue recovery facility in the northeastern part of the region. As in Run H, the system cost decreased from $11.23 per ton to $8.47 per ton.

Comparison of Massachusetts Runs E, G, H and I

Run	Structure	Solution Cost
E	All options available	$4.38/ton
G	Only shredded fuel available	$11.23/ton
H	Doubled tonnage, all options available	$3.45/ton
I	Doubled tonnage, only shredded fuel available	$8.47/ton

Use of the WRAP model in both Massachusetts and St. Louis provided its users with valuable information concerning the most economically preferred solution for those regions.

WHAT KINDS OF DOCUMENTATION ARE AVAILABLE ABOUT WRAP?

Comprehensive information that describes and documents the use of the WRAP model is available. This information comprises three documents: A User's Guide; A Programmer's Manual; and a full documentation of the model applications made for EPA.

The User's Guide (127 Pages)

This guide is addressed to the individual or group of individuals who are intending to use the WRAP model to assist in the decision-making process. The model is fully described in terms of its makeup and equation structure to familiarize the users with its capabilities. The guide contains a full description of the kinds of data required for its use, as well as how to prepare and utilize those data and how to interpret outputs. Examples of prepared data inputs are provided, as well as a guide to the design and operation of the model.

The Programmer's Manual (345 Pages)

Addressed to the data processing individual, this manual provides information about how the program is actually applied and how it is run. An overview of how the computer program is set up, and how information inside the program is stored is provided.

Operational and Exercise Runs (222 Pages)

This includes a full documentation of the model applications made for EPA in St. Louis and Massachusetts. It contains a detailed description of all data inputs and outputs used, where these were obtained, and the assumptions used. The document is addressed to any individual who desires to analyze and review the actual model application in an effort to more fully understand its capabilities.

HOW IS THE WRAP MODEL OBTAINED?

For further information about the WRAP model, call or write:

WRAP
Office of Solid Waste Management
U.S. Environmental Protection Agency
401 M Street S.W.
Washington, D.C. 20460
at (202) 755-9125

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