4 ❖ COLLECTION AND TRANSFER

Efficient, sanitary, and customer-responsive collection of solid wastes is at the heart of a well-run waste management system. Collection services are provided to residents in virtually all urban and suburban areas in the United States, as well as some rural areas, either by private haulers or by municipal governments.

The types of collection services have expanded in many communities in recent years to include the special collection or handling of recyclables and yard wastes. Even though disposal costs continue to grow rapidly across the United States, the costs of collecting wastes continue to outpace disposal as a percentage of overall service costs for most communities.

This chapter addresses issues to consider when planning a new collection system or when evaluating changes to an existing system.

From: Decision Maker's Guide to Solid Waste Management, Volume II, (EPA 530-R-95-023), 1995. Project Co-Directors: Philip R. O'Leary and Patrick W. Walsh, Solid and Hazardous Waste Education Center, University of Wisconsin-Madison/Extension. This document was supported in part by the Office of Solid Waste (5306), Municipal and Industrial Solid Waste Division, U.S. Environmental Protection Agency under grant number CX-817119-01. The material in this document has been subject to Agency technical and policy review and approved for publication as an EPA report. Mention of trade names, products, or services does not convey, and should not be interpreted as conveying, official EPA approval, endorsement, or recommendation.

4 ❖ HIGHLIGHTS

The community should define its goals and constraints. (p. 4-5 — 4-6)	Each community should clearly define the goals for its collection system, periodically review the system's performance in meeting those goals, and regularly review and adjust the system's goals to conform to the community's changing needs. To define collection system goals, consider the following issues: • the level/quality of service your community needs • the roles to be played by the public and private sectors • the community's long-term waste management and source reduction goals • preferences for and constraints on available funding mechanisms • existing labor/service contracts that may affect decision making.
Both public and private operation should be considered and evaluated. (p. 4-6 — 4-7)	The municipality should determine appropriate roles for the public and private sectors. The collection system may be operated by (1) a municipal department, (2) a contracted private firm or firms, or (3) a combination of public and private haulers. Regardless of the management options chosen, a clear organizational structure and management plan should be developed.
Explore alternative funding methods to determine which is appropriate. (p. 4-7 — 4-10)	Explore alternative mechanisms for funding collection services. The two most common funding methods are property taxes and special solid waste service fees. However, communities are turning more to user-based fees, which can stimulate waste reduction efforts and reduce tax burdens. Economic incentives can be used to reduce waste generation by charging according to the amount of waste set out. When selecting a funding method, considering waste reduction and management goals is important. Table 4-2 lists advantages/disadvantages of alternative funding mechanisms.
Waste preparation and collection procedures should be coordinated. (p. 4-10 — 4-13)	Decisions about how residents prepare waste for pickup and which methods are used to collect it affect each other and must be coordinated to achieve an efficient, effective system. Decisions about the following must be made: • *Solid waste set-out requirements:* guidelines and ordinances specify how residents should prepare solid waste and recyclables for collection should be developed. • *Point and frequency of collection*: how often to collect waste and from what points (curbside, backyard, etc.) must be decided.
Collection equipment must be carefully chosen. (p. 4-13 — 4-15)	Numerous types of collection vehicles and optional features are available. For specific equipment design information, contact equipment vendors and review existing equipment needs. Table 4-4 presents criteria for choosing the most appropriate equipment. Cost information and expected service life should be gathered and evaluated.

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Is a transfer facility appropriate for your community?

(p. 4-16)

To determine if a transfer system is appropriate for your community, compare the costs and savings associated with the construction and operation of a transfer facility.

Benefits:

- lower collection costs
- reduced fuel and maintenance costs for collection vehicles
- increased flexibility in selecting disposal facilities
- the option to separate and recover recyclables or compostables at the transfer site
- the opportunity to shred or bale wastes before disposal.

Possible drawbacks:

- difficulty with siting and permitting, particularly in urban areas
- construction and operation costs may make them undesirable for some communities (especially for communities *less than* 10 or 15 miles from the disposal site).

Consider these crucial factors when selecting a collection and transfer alternative.

(p. 4-28 — 4-30)

The following factors are usually important to public officials when evaluating collection and transfer alternatives:

- costs of required new equipment and ability of community to obtain financing for it
- costs to operate collection system and transfer facilities
- compatibility of total costs with budget available for solid waste services
- differences in levels of service provided by alternative systems
- ability of system to meet public's demands or expectations for service
- proposed methods for financing system costs and public acceptability of those methods
- the system's effects on efforts to meet the community's waste reduction and management goals
- compatibility of proposed roles for public and private sectors with political support for them
- public's interest or disinterest in changing present arrangements for collecting solid waste and recyclables.

Developing efficient routes and schedules decreases costs.

(p. 4-30 — 4-32)

Detailed route configurations and collection schedules should be developed for the selected collection system. Efficient routing and rerouting of solid waste collection vehicles can decrease labor, equipment, and fuel costs.

4 ❖ HIGHLIGHTS (continued)

Implementing the collection and transfer system involves several steps. (p. 4-32)	Implementing a collection and transfer system involves the following activities: • finalizing and modifying the system management plan • purchasing and managing collection and transfer equipment • hiring and training personnel • developing and managing contracts with labor unions and private collection companies • providing information to the public • constructing and operating transfer, administrative, and maintenance facilities.
Good personnel management is crucial. (p. 4-34 — 4-36)	As in all organizations, good personnel management is essential to an efficient, high-quality waste collection system; hiring and keeping well-qualified personnel is crucial. Because collection jobs are physically demanding, carefully assess each applicant's physical condition. To retain employees, management should provide a safe working environment that emphasizes career advancement, participatory problem solving, and worker incentives.
Safety is a crucial concern. (p. 4-34 — 4-35)	Safety is especially important because waste collection employees encounter many hazards during each workday. As a result of poor safety records, insurance costs for many collection services are high. Frequently encountered hazards include: • busy roads and heavy traffic • rough- and sharp-edged containers that can cause cuts and infections • exposure to injury from powerful loading machinery • heavy containers that can cause back injuries • household hazardous wastes such as herbicides, pesticides, solvents, fuels, batteries, and swimming pool chemicals.
Maintaining good public communication is crucial. (p. 4-36 — 4-37)	Maintaining good communications with the public is important to a well-run collection system. Residents can greatly affect the performance of the collection system by co-operating with set-out (how waste is presented for collection) and separation require-ments, and by keeping undesirable materials, such as used oil, from entering the col-lected waste stream.
Successful management requires monitoring the system's costs and performance. (p. 4-37)	Collection and transfer facilities should develop and maintain an effective system for cost and performance monitoring. Just as the goals of a collection program guide its overall directions, a monitoring system provides the short-term feedback neces-sary to identify the course corrections needed to achieve those goals.

4 COLLECTION AND TRANSFER

DEVELOPING A SOLID WASTE COLLECTION AND TRANSFER SYSTEM

This chapter presents an 11-component process (see Table 4-1) for developing a collection system to meet a community's needs.

Collection programs in different communities vary greatly depending on the waste types collected, the characteristics of the community, and the preferences of its residents. Often, different collection equipment, methods, or service providers are required in the same community to serve different customers (single-family, multi-family and commercial) or to collect different materials (solid waste and recyclables) from the same customers.

Collection and transfer systems are often complex and difficult to design because many factors must be considered and a wide range of collection and transfer options are available. To simplify system design and modifications, this section presents an 11-component process for developing or modifying a collection system to best meet a community's needs. Table 4-1 provides an outline of the process, which can be adapted to meet a community's specific needs. Suggested procedures for completing each step is provided in the following sections.

Table 4-1

Key Steps in Developing or Modifying a Waste Collection and Transfer System

1. Define community goals and constraints.
2. Characterize waste generation and service area.
3. Determine public and private collection and transfer options.
4. Determine system funding structure.
5. Identify waste preparation and collection procedures.
6. Identify collection equipment and crew size requirements.
7. Evaluate transfer needs and options.
8. Evaluate collection and transfer alternatives.
9. Develop collection routes and schedules.
10. Implement the collection system.
11. Monitor system performance; adjust as necessary.

Source: W. Pferdehirt, University of Wisconsin–Madison Solid and Hazardous Waste Education Center, 1994

DEFINING COMMUNITY GOALS AND CONSTRAINTS

Each community should clearly define the goals for its collection system, periodically review the system's performance in meeting those goals, and regularly review and adjust the system's goals to conform to changes in the community's needs. Similarly, constraints should be identified and incorporated in the decision-making process. Some constraints, such as funding, can possibly be adjusted to meet changing needs.

Identifying goals, objectives, and constraints can help guide the planning process. Issues that should be considered include the following:

Evaluating program goals and constraints is an ongoing process influenced by many issues.

- **Level of service:** What level of services is required to meet the community's needs? What materials need to be collected and what are the requirements for separate collection of these materials? What needs and expectations exist with respect to the frequency of pickup and the convenience of set-out requirements for residents?
- **Roles for the public and private sectors:** Is there a policy preference regarding the roles of the public and private sectors in providing collection services for wastes and recyclables? If collection is to be performed by private haulers, should the municipality license, franchise, or contract with haulers?
- **Waste reduction goals:** What are the community's waste reduction goals and what strategies are necessary or helpful in achieving those goals? For example, source reduction and recycling can be facilitated by charging customers according to the volume of wastes discarded, by providing convenient collection of recyclables, and by providing only limited collection of other materials such as yard trimmings and tires.
- **System funding:** What preferences or constraints are attached to available funding mechanisms? Are there limits on the cost of service based on local precedence, tax limits, or the cost of service from alternative sources?
- **Labor contracts:** Are there any conditions in existing contracts with labor unions that would affect the types of collection equipment or operations that can be considered for use? How significant are such constraints and how difficult would they be to modify?

CHARACTERIZING WASTE TYPES, VOLUMES, AND THE SERVICE AREA

Gather data to determine your community's collection needs.

Data concerning waste generator types, volumes of wastes generated, and waste composition should be gathered so that community collection needs can be determined. Estimates of generation and composition can usually be developed through a combination of (1) historical data for the community in question, (2) data from similar communities, and (3) published "typical" values. Adjust data as necessary to correspond as closely as possible to local and current circumstances. See Chapter 3 for further discussion of techniques for estimating waste generation.

City street and block maps should also be obtained to determine information on specific block and street configurations, including number of houses, location of one-way and dead-end streets, and traffic patterns.

PUBLIC AND PRIVATE COLLECTION/TRANSFER: DETERMINING OPTIONS

Study alternative roles for the public and private sectors.

Before or while the technical aspects of the solid waste collection and transfer system are being developed, a municipality should evaluate alternative roles for the public and private sectors in providing collection services. The collection system may be operated by a municipal department, a contracted private firm, one or more competing private firms, or a combination of public and private haulers.

The following terms are commonly used when referring to these different collection systems:

- **Municipal collection:** A municipal agency uses its own employees and equipment to collect solid waste.

- **Contract collection:** A municipal agency contracts with a private collection firm to collect waste. Larger communities may issue multiple collection contracts, each for a different geographic area, type of customer (single-family versus multi-family units), or material collected (recyclables versus refuse).
- **Private collection:** Residents directly engage the services of private collection firms. Some communities using this approach give residents the complete freedom to choose haulers and the level of service provided; some require that all haulers obtain a license to operate from the municipality. This system relies on competition to control prices and quality of service. Other communities, wishing to reduce truck traffic and the costs of service through eliminating duplication of service, allow haulers to competitively bid to provide a specified level of service to residents within a defined "franchise" area. Residents then contract directly with the designated hauler for their area for the price and level of service specified in the hauler's franchise agreement with the municipality.

Each community should carefully evaluate which type of collection system, or combination of systems, will best meet their needs.

The collection system that is most appropriate for a particular community depends on the needs of the community and availability of qualified private collection firms. No single system type is best for all communities. In fact, one community may wish to consider the use of different systems for different customer types or different areas of the community. For example, many municipalities provide municipal service to single-family residences, small apartment buildings and small commercial customers, but require that larger apartment buildings and commercial and industrial customers arrange separately for their collection services.

In addition, municipalities may wish to explore options for working with other nearby communities to provide collection service on a regional basis. Development of a regional collection system can be particularly cost-effective if several small communities are located close to each other and use the same disposal site.

DETERMINING THE SYSTEM FUNDING STRUCTURE

Selecting the method of funding is a key step in developing a solid waste collection system. The goal of a funding plan is to generate the money necessary to pay for collection services. In addition, a well-designed funding method can also help a community achieve its waste reduction and management goals.

Selecting the funding method is a key step.

The three principal alternatives for funding solid waste services are (1) property tax revenues, (2) flat fees, and (3) variable-rate fees. These three methods and their relative advantages and disadvantages are summarized in Table 4-2.

- **Property taxes:** A traditional way of funding solid waste collection is through property taxes, especially in communities where collection has been performed by municipal workers. A principal attraction of this method is its administrative simplicity; no separate system is necessary to bill and collect payments, since funds are derived from moneys received from collection of personal and corporate property taxes.

  Despite its ease of administration, however, communities are increasingly moving away from this funding method, at least as their sole funding source. Many municipalities have shifted to covering part or all of their costs through user fees, largely because of statutorily or politically imposed caps on property tax increases. In addition, municipal officials realize that funding from property taxes provides no incentives to residents to reduce wastes through recycling and source reduction.

Table 4-2

Advantages and Disadvantages of Alternative Funding Mechanisms

Property Taxes

Under this approach, a portion of property tax revenues is used to fund waste collection. Although the tax revenues are collected by the municipality, the funded collection services may be provided by either municipal crews or by a private hauler under contract.

Advantages

- Collection of funds is relatively easy to administer; collected as part of taxes.
- Everyone pays for the system; less incentive for improper disposal by dumping wastes along roadsides or in other people's containers.
- Can be argued that costs are generally distributed according to ability to pay, since owners of expensive properties pay most.

Disadvantages

- Generators have no direct incentive for waste reduction.
- Revenues are hard to adjust to unexpected budget increases, for example, to cover higher tipping fees or fuel costs.
- Generators are unable to reduce their cost of service through waste reduction.
- Actual, total costs of waste services may be difficult to track because personnel, equipment and facilities funded from property taxes may be used for multiple purposes. Often results in understatement of actual costs, and perhaps demand for higher level of service than if costs were apparent.
- Can lead to equity-related objections if commercial and large, multi-family properties are not served by municipal waste collection, but are levied taxes to support it. Similar concerns may arise if tax- exempt property owners receive municipal waste collection.

Flat-Fee Systems

Under flat-fee systems, residents pay a set monthly fee for waste collection. The fee may be collected by the municipality or by a private hauler.

Advantages

- Relatively easy to administer; same fee for all.
- Usually easier to adjust fees than change tax assessments.
- If collection is by private sector, local government does not need to get involved in collection of service fees.
- Cost of waste collection is not counted against property tax limits.

Disadvantages

- Fees are often earmarked for a separate fund used exclusively for solid waste services. Moneys in such funds are less often subject to re-appropriation by elected officials than property tax revenues.
- If fees are set to recover full cost of waste services, elected officials and the public can make more informed choices about services to be provided.
- Some residents may try to evade cost of service by dumping wastes along roads, streams, alleys, etc.
- Fees can be more difficult than taxes to collect.
- Flat fees do not reward waste reduction.
- Fee-based systems generally require poorer residents to pay more than they would under systems funded by property taxes.

Variable-Rate Systems

Under a variable-rate system, residents are charged on a sliding scale, depending on how much waste they set out for collection. Charges can vary by the week, depending on the amount set out by a resident for that particular collection day, or residents can "subscribe" for a selected level of service (e.g., one 30-gallon can per week).

Advantages

- Provide direct economic incentives that motivate residents to generate less waste.
- Let generators choose the amount of service they purchase.
- Usually increase participation rates and collected quantities for recycling collection programs.
- Usually lead to greater level of awareness among residents when making purchasing decisions that affect waste generation.
- Typically result in more on-site management of yard trimmings through composting and leaving clippings on lawns.
- Except for relative ease of administration, have all other advantages of flat-fee systems.

Disadvantages

- Can be complicated to administer; must have method of computing charges, or distributing bags or stickers.
- When rates are based on volume customers sometimes compact wastes excessively, which can cause overweight containers and higher bag breakage.
- Contaminants in recyclables can increase as residents try to minimize waste collection charges. Recycling workers should diligently prevent wastes from being collected with recyclables.
- Often require enforcement programs, at least initially, to prevent illegal dumping.
- Can be difficult to project anticipated revenues; if contracting with a hauler for service, municipality may need to guarantee minimum level of revenues from fees.
- Under a pure variable-rate system, large families will typically pay more than under flat fee or property-tax-funded systems. Can be especially hard on poorer, large families. Effects can be decreased through a payment assistance plan or through a hybrid funding approach that covers part of collection costs from taxes or a flat fee.

Hybrid Funding Methods

Hybrid approaches use a combination of the above methods to fund collection services. For example, variable-rate systems often pay for a portion of costs through a base rate or taxes. Advantages and disadvantages depend on the specific components of the selected funding approach.

Source: W. Pferdehirt, University of Wisconsin–Madison Solid and Hazardous Waste Education Center, 1994

Whereas this was generally tolerated when disposal was relatively cheap, the increased cost to properly manage wastes has caused many communities to find ways to give meaningful pricing signals and incentives to residents.

- **Flat fees:** Flat fees are a common method for funding collection in many communities served by private haulers and in many municipalities where a separate authority or special purpose fund is used for solid waste services. Although this method does a better job than property taxes in communicating the real cost of solid waste services, it still does not provide an incentive for reducing wastes.
- **Variable-rate fees:** With a variable-rate fee system, generators pay in proportion to the amount of wastes they set out for collection. Variable rates are also called unit rates and volume-based rates. Variable-rate systems typically require that residents purchase special bags or stickers, or they offer generators a range of service subscription levels. When bags or stickers are used, their purchase price is set high enough to cover most or all program costs, including costs for bags and stickers and for an accounting system.

  Systems that offer generators a range and choice of subscription levels have less administrative complexity than systems that use bags and stickers. However, when generators use bags and stickers, they may be more aware of how much waste they are producing and, therefore, have more incentive to reduce it. In addition, by using smaller or fewer bags or fewer stickers, generators can realize savings from their source reduction efforts immediately.

Communities can combine elements from different funding methods to meet their specific needs.

Sometimes communities combine various elements of the above funding methods to form a hybrid system specially tailored for their communities. Many variable-rate programs are adapted to mute the potential negative impacts of such systems. For example, a basic level of service offering a certain number of bags or one can per week could be provided to all residents and paid for from property taxes. Generators could then be required to place any additional wastes in special bags sold by the municipality.

Municipalities that choose to provide collection, either on their own or through a municipal contract with a hauler, might find it advantageous to segregate solid waste funds in an enterprise account. With this method, costs and revenues for solid waste services are kept separate from other municipal functions, and mangers are given authority and responsibility to operate with more financial independence than when traditional general revenue departments are used. Some local governments have found that this approach increases the accountability and cost-effectiveness of their solid waste operations.

Accurately tracking the full costs of waste collection services is crucial.

The importance of accurately tracking the full costs of waste collection services cannot be overstated. For most communities, the costs of collecting wastes or recyclables are significantly higher than the costs of disposal or processing. Accurate cost accounting can provide managers with the information necessary to compare performance with other similar communities and the private sector and to identify opportunities for improving efficiency. Some states, including Florida, Indiana, and Georgia, have enacted laws requiring “full-cost accounting” of waste services by municipalities. Full-cost accounting provides residents and decision makers with more complete information on waste collection by including indirect costs, such as administration, billing, and legal services along with such direct costs as labor, equipment, tipping fees, and supplies. In communities where garbage collection is funded from property taxes, this information helps residents understand that “free” garbage collection is, in reality, not possible. Using full-cost accounting, many communities have demonstrated that the costs of recycling collection and processing are less than those for solid waste collection and disposal. However, even when the costs of recycling are shown to be greater, the information helps communities better understand and weigh the cost / benefit tradeoffs of the alternative systems being considered.

IDENTIFYING WASTE PREPARATION AND COLLECTION PROCEDURES

Decisions about how residents prepare waste for pickup and which methods are used to collect it affect each other and must be coordinated to achieve an efficient, effective system. For example, a community may decide to use self-loading compactor trucks in certain neighborhoods. As a result, residents will have to prepare wastes by placing them in containers that fit the trucks' container-lifting mechanisms. These decisions about vehicle and container types would affect the selection of crew size, allowing a smaller crew than manual systems would.

Solid Waste Set-Out Requirements

How residents prepare waste for collection affects program costs. Table 4-3 describes different set-out options.

To establish uniform and efficient collection, communities normally develop guidelines and enact ordinances that specify how residents must prepare solid waste and recyclables for collection. Although the requirements vary from one community to another, set-out requirements usually address the types of containers to be used, separation of recyclables or other wastes for separate collection, how frequently materials are collected, and where residents are to set materials out for collection.

Storage Container Specifications

Many municipalities enact ordinances that require using certain solid waste storage containers. Most important, containers should be functional for the amount and types of materials they must hold and the collection vehicles used. Containers should also be durable, easy to handle, and economical, as well as resistant to corrosion, weather, and animals.

In residential areas where refuse is collected manually, either plastic bags or standard-sized metal or plastic containers are typically required for waste storage. Many cities prohibit the use of other containers, such as cardboard boxes or 55-gallon drums, because they are difficult to handle and increase the chance of worker injury.

If cans are acceptable, they should be weatherproof, wider at the top than bottom, fitted with handles and a tightly fitting lid, and maintained in good condition. Many municipalities limit cans to 30-35 gallons or to a maximum specified total weight. Some municipalities also limit the total number of containers that will be collected under normal service; sometimes additional fees are charged for additional containers.

If plastic bags are acceptable, they must be in good condition and tied tightly. Some communities require that bags meet a specified minimum thickness (for example, 2 mils) to reduce the propensity for tearing during handling. Some programs require the use of bags because they do not have to be emptied and returned to the curb or backyard and are therefore quicker to collect than cans.

Some communities require that residents purchase metered bags or stickers so that residents pay fees on a per-container basis. The price of the bags or stickers usually includes costs for waste collection and disposal services. A related option is to charge different rates for various sizes of cans or other containers. Communities that also collect recyclables usually do so at no, or reduced, cost to residents as a financial incentive for recycling instead of disposal.

When automatic or semiautomatic collection systems are used, solid waste containers must be specifically designed to fit the truck-mounted loading mechanisms. Waste-storage containers used in such systems typically range from 1 to 30 cubic yards in size. Automatically loading compactor trucks are commonly used to pick up waste from apartment buildings and commercial establishments.

Automatic and semiautomatic collection systems are also being used increasingly in single-family neighborhoods to reduce costs. For example, the community of Sarasota, Florida switched from manual collection to semiautomatic collection. Under the manual collection system, the city provided backyard and curbside service using 8-cubic-yard packer bodies, which were emptied at a transfer station. Under the new semiautomatic system, the community provides customers with 90-gallon carts which they wheel to the curb. The carts are then emptied automatically into 17-cubic-yard trucks. The trucks transport wastes directly to the disposal site; this eliminates the need for a transfer station. As a result of this process modification, Sarasota has reduced the number of crew members per truck from 3 to 2 and the total number of routes from 14 to 11.

Solid Waste Separation Requirements

Recycling programs usually require residents to separate waste for collection.

Communities may wish to collect some portions of solid waste separately, which requires that residents separate wastes before the collection. As more communities implement recycling programs, mandatory separation of recyclable materials such as paper, cardboard, glass, aluminum, tin, and plastic is also increasing. Communities may also require residents to separate yard trimmings, bulky items, and household hazardous wastes for separate collection or drop-off by residents. Bulky items are usually placed at the same point of collection as other solid wastes. Recently, some U.S. communities have begun to test wet / dry collection systems, in which “wet” organic wastes acceptable for composting are collected separately from “dry” wastes, which will be sorted for the recovery of recyclables. Phoenix, Arizona is the first large U.S. city to experiment with a city-wide wet / dry collection system.

Frequency of Collection

Communities can select the level of services they wish to provide by choosing how often to collect materials and the point from which materials will be collected at each residence. The greater the level of service, the more costly the collection system will be to operate.

Many factors together determine the appropriate frequency of collection for each community.

Factors to consider when setting collection frequency include the cost, customer expectations, storage limitations, and climate. Most municipalities offer collection once or twice a week, with collection once a week being prevalent. Crews collecting once per week can collect more tons of waste per hour, but are able to make fewer stops per hour than their twice-a-week counterparts. A USEPA study found that once-a-week systems collect 25 percent more waste per collection hour, while serving 33 percent fewer homes during that period. Personnel and equipment requirements were 50 percent higher for once-a-week collection (USEPA 1974a). Some communities with hot, humid climates maintain twice-a-week service because of health and odor concerns.

Pick-up Points for Collection

In urban and suburban areas, refuse is generally collected using curbside or alley pickup. Backyard service, which was more common in the past, is still used by some communities. Table 4-3 describes these collection methods and the advantages and disadvantages of each.

As shown in the table, curbside / alley service is more economical but requires greater resident participation than backyard service. In fact, according to Hickman (1986), the productivity of backyard systems is about one-half that of curbside or alley systems. Therefore, as municipal budgets have tightened and service costs increased, most municipalities have chosen or switched to

Table 4-3
Advantages and Disadvantages of Alternative Pick-Up Points for Collecting Solid Wastes

Curb-side/Alley Collection

Residents place containers to be emptied at curb or in alley on collection day. Collection crew empties containers into collection vehicle. Resident returns containers to their storage location until next scheduled collection time.

Advantages:

- Crew can move quickly.
- Crew does not enter private property, so fewer accidents and trespassing complaints arise.
- This method is less costly than backyard collection because it generally requires less time and fewer crew members.
- Adaptable to automated and semi-automated collection equipment.

Disadvantages:

- On collection days, waste containers are visible from street.
- Collection days must be scheduled.
- Residents are responsible for placing containers at the proper collection point.

Backyard Set Out - Set Back Collection

Containers are carried from backyard to curb by a special crew and emptied by the collection crew. The special crew then transports the containers back to their original storage location.

Advantages:

- Collection days need not be scheduled.
- Waste containers are not usually visible from street.
- Use of additional crew members reduces loading time as compared to backyard carry method.

Disadvantages

- Because crews enter private property, more injuries and trespassing complaints are likely.
- The method is more time-consuming.
- Residents are not involved and requires more crew members than curb-side/alley collection.
- This is more costly than curb-side/alley collection because additional crews are required.

Backyard Carry Collection

In this method, collection crews enter property to collect refuse. Containers may be transported to the truck, emptied and returned to their original storage location, or emptied into a tub or cart and transported to the vehicle so that only one trip is required.

Advantages:

- Collection days need not be scheduled.
- Waste containers are not usually visible from street.
- Residents are not involved with container setout or movement.
- This method requires fewer crew members than set out/ set back method.

Disadvantages:

- Because crew enters private property, more injuries and trespassing complaints are likely.
- This approach is more time-consuming than curb-side/alley or set back method.
- Spills may occur where waste is transferred.

Drop Off at Specified Collection Point

Residents transport waste to a specified point. This point may be a transfer station or the disposal site.

Advantages:

- Drop-off is the least expensive of methods.
- Offers reasonable strategy for low population densities.
- This method involves low staffing requirements.

Disadvantages:

- Residents are inconvenienced.
- There is increased risk of injury to residents.
- If drop-off site is unstaffed, illegal dumping may occur.

Source: American Public Works Association, Institute for Solid Wastes. 1975. *Solid Waste Collection Practice*. 4th ed., Chicago curbside / alley collection. However, some municipalities have traditionally offered backyard service to residents and decide to continue offering this service.

Pick-up strategies must be carefully planned.

Rural areas face special challenges because of low population densities and limited budgets for solid waste operations. When pick-up service is offered in rural areas, residents usually are required to place bags or containers of wastes near their mailboxes or other designated pick-up points along major routes. Other municipalities prefer a drop-off arrangement, such as that described in Table 4-3. In such cases, wastes are dropped off at a smaller transfer station (described below). Drop-off service is much less expensive than a collection service but also less convenient for residents.

Some municipalities also offer collection service to larger apartment buildings and commercial establishments. In other communities, service to these customers is provided by private collection companies. In general, wastes from such buildings are stored in dumpsters or roll-off containers and collected using either front-loading compactors or roll-off hoist trucks, respectively.

DETERMINING COLLECTION EQUIPMENT AND CREW SIZE

Selecting Collection Equipment

Equipment Types

Numerous types of collection vehicles and optional features are available. Manufacturers are continually refining and redesigning collection equipment to meet changing needs and to apply advances in technology. Trends in the collection vehicle industry include increased use of computer-aided equipment and electronic controls. Now, some trucks even have onboard computers for monitoring truck performance and collection operations.

Regulations, crew preferences, and many other factors must be considered.

Truck chassis and bodies are usually purchased separately and can be combined in a variety of ways. When selecting truck chassis and bodies, municipalities must consider regulations regarding truck size and weight. An important objective in truck selection is to maximize the amount of wastes that can be collected while remaining within legal weights for the overall vehicle and as distributed over individual axles. Also, because they are familiar with equipment, collection crews and drivers should be consulted when selecting equipment that they will be using.

Compactor trucks are by far the most prevalent refuse collection vehicles in use. Widely used for residential collection service, they are equipped with hydraulically powered rams that compact wastes to increase payload and then push the wastes out of the truck at the disposal or transfer facility. These trucks vary in size from 10 to 45 cubic yards, depending on the service application. Compactor trucks are commonly classified as front-loading, side-loading, or rear-loading, depending on where containers are emptied into the truck.

Before compactor trucks were developed, open and closed noncompacting trucks were used to collect solid waste. Although these trucks are relatively inexpensive to purchase and maintain, they are inefficient for most collection application because they carry a relatively small amount of waste, and workers must lift waste containers high to dump the contents into the truck. Noncompacting trucks are still used for collecting bulky items like furniture and appliances or other materials that are collected separately, such as yard trimmings and recyclable materials. Noncompacting trucks can also be appropriate for small communities or in rural areas. Recently, many new types of noncompacting trucks have been designed specifically for collecting recyclable materials.

Waste set-out requirements, waste quantities, and the physical characteristics of the collection routes are likely to be key considerations in the selection of collection vehicles. For example, suburban areas with wide streets and little on-street parking may be ideally suited to side-loading automatic collection systems. Conversely, urban areas with narrow alleys and tight corners may require rear loaders and shorter wheelbases.

For large apartment buildings and complexes, and for commercial and industrial applications, hauled-container systems are often used. The roll-off containers used with these systems have capacities of up to 50 cubic yards. They are placed on the waste generator's property, and when full, are transported directly to the transfer / disposal site. Special hoisting trucks and a cable winch or hydraulic arm are required to load the containers.

Criteria for Equipment Selection

Establishing written criteria makes selecting appropriate equipment easier.

To determine specific equipment design information, hauling companies or departments should contact vendors and review existing equipment records. Table 4-4 provides criteria that should be used to determine the most appropriate collection equipment. Municipalities can use these criteria to outline the requirements that equipment must meet and select general equipment types that will be considered.

In addition to the technical requirements listed in Table 4-4, the following cost data should be compared for each truck being considered: initial capital cost, annual maintenance and operation costs, and expected service life. Life-cycle costs should be computed using this information to compare total ownership costs over the expected life of the required vehicles.

Crew Size

The optimum crew size for a community depends on labor and equipment costs, collection methods and route characteristics. Crew sizes must also reflect conditions in contracts with labor unions. As previously mentioned, crew size can have a great effect on overall collection costs.

As collection costs have risen, there has been a trend toward (1) decreasing frequency of collection, (2) increasing requirements on residents to sort materials and transport them to the curb, and (3) increasing the degree of automation used in collection. These three factors have resulted in smaller crews in recent years. Generally, a one-person crew can spend a greater portion of its time in the productive collection of wastes than a two- or three-person crew can. Multiple-person crews tend to have a greater amount of nonproductive time than do single-person crews because nondriving members of the crew may be idle or not fully productive during the haul to the unloading point. Some communities address this problem by requiring that nondrivers perform other duties, such as cleaning alleys, while the driver hauls collected wastes to the disposal or transfer facility.

Crew size greatly affects program costs. Optimum crew size depends on

- *labor/equipment costs*
- *collection methods/routes*
- *labor union contracts.*

Although the one-person crew has the greatest percentage of productive time, many municipalities use larger crews, mainly for three reasons: some trucks (for example, rear-loading packers) do not readily support use of a single-person crew, the municipality wants to provide a higher level of service than one-person crews can provide, or labor contract provisions require more than one person on each crew. These multi-person crews can be efficient if properly trained and provided with suitable performance incentives. In more efficient multiple-person crews, the driver helps with waste loading and the crew carries some containers to the truck instead of driving to each pick-up location.

EVALUATING TRANSFER NEEDS AND OPTIONS

Sometimes, for efficiency or convenience, municipalities find it desirable to transfer waste from collection trucks or stationary containers to larger vehicles

Table 4-4

Factors to Consider in Selecting or Specifying Solid Waste Collection Equipment

Loading Location

Compactor trucks are loaded in either the side, back, or front. Front-loading compactors are often used with self-loading mechanisms and dumpsters. Rear loaders are often used for both self and manual loading. Side loaders are more likely to be used for manual loading and are often considered more efficient than back-loaders when the driver does some or all of the loading.

Truck Body or Container Capacity

Compactor capacities range from 10 to 45 cubic yards. Containers associated with hauled systems generally have a capacity range of 6 to 50 cubic yards. To select the optimum capacity for a particular community, the best tradeoff between labor and equipment costs should be determined. Larger capacity bodies may have higher capital, operating, and maintenance costs. Heavier trucks may increase wear and tear, and corresponding maintenance costs for residential streets and alleys.

Design Considerations:

- The loading speed of the crew and collection method used.
- Road width and weight limits (consider weight of both waste and vehicle).
- Capacity should be related to the quantity of wastes collected on each route. Ideally, capacity should be an integral number of full loads.
- Travel time to transfer station or disposal site, and the probable life of that facility.
- Relative costs of labor and capital.

Chassis Selection

Chassis are similar for all collection bodies and materials collected.

Design Considerations:

- Size of truck body. Important for chassis to be large enough to hold truck body filled with solid waste.
- Road width and weight limitations (also need to consider waste and truck body weight).
- Air emissions control regulations.
- Desired design features to address harsh treatment (e.g., driving slowly, frequent starting and stopping, heavy traffic and heavy loads) include the following: high torque engine, balanced weight distribution, good brakes, good visibility, heavy duty transmission, and power brakes and steering.

Loading Height

The lower the loading height, the more easily solid waste can be loaded into the truck. If the truck loading height is too high, the time required for loading and the potential of injuries to crew members will increase because of strain and fatigue.

Design Considerations:

- Weight of full solid waste containers.
- If higher loading height is being considered, consider an automatic loading mechanism.

Loading and Unloading Mechanisms

Loading mechanisms should be considered for commercial and industrial applications, and for residences when municipalities wish to minimize labor costs over capital costs. A variety of unloading mechanisms are available.

Design Considerations—Loading:

- Labor costs of collection crew.
- Time required for loading.
- Interference from overhead obstructions such as telephone and power lines.
- Weight of waste containers.

Design Considerations—Unloading:

- Height of truck in unloading position. Especially important when trucks will be unloaded in a building.
- Reliability and maintenance requirements of hydraulic unloading system device.

Truck Turning Radius

Radius should be as short as possible, especially when part of route includes cul-de-sacs or alleys. Short wheelbase chassis are available when tight turning areas will be encountered.

Watertightness

Truck body must be watertight so that liquids from waste do not escape.

Safety and Comfort

Vehicles should be designed to minimize the danger to solid waste collection crews.

Design Considerations:

- Carefully designed safety devices associated with compactor should include quick-stop buttons. In addition, they should be easy to operate and convenient.
- Truck should have platforms and good handholds so that crew members can ride safely on the vehicle.
- Cabs should have room for crew members and their belongings.
- Racks for tools and other equipment should be supplied.
- Safety equipment requirements should be met.
- Trucks should include audible back-up warning device.
- Larger trucks with impeded back view should have video camera and cab-mounted monitor screen.

Speed

Vehicles should perform well at a wide range of speeds.

Design Considerations:

- Distance to disposal site.
- Population and traffic density of area.
- Road conditions and speed limits of routes that will be used.

Adaptability to Other Uses

Municipalities may wish to use solid waste collection equipment for other purposes such as snow removal.

Source: W. Pferdehirt, University of Wisconsin–Madison Solid and Hazardous Waste Education Center, 1994

before transporting it to the disposal site. This section discusses how to decide if a transfer facility is necessary to serve the waste collection needs of a community. The section also discusses factors to consider when designing a transfer station and selecting equipment for it.

Communities that provide curbside collection of recyclables may find it necessary to develop a material recovery facility (MRF) to sort and densify materials before they are shipped to markets. MRF siting and design requirements are discussed in Chapter 6.

Evaluating Local Needs for Waste Transfer

Transfer station cost-effectiveness depends on distance of disposal site from the generation area.

10-15 miles is usually the minimum cost-effective distance.

To determine whether a transfer system is appropriate for a particular community, decision makers should compare the costs and savings associated with the construction and operation of a transfer facility. Benefits that a transfer station can offer include lower collection costs because crews waste less time traveling to the site, reduced fuel and maintenance costs for collection vehicles, increased flexibility in selection of disposal facilities, the opportunity to recover recyclables or compostables at the transfer site, and the opportunity to shred or bale wastes prior to disposal. These benefits must be weighed against the costs to develop and operate the facility. Also, transfer facilities can be difficult to site and permit, particularly in urban areas.

Obviously, the farther the ultimate disposal site is from the collection area, the greater the savings that can be realized from use of a transfer station. The minimum distance at which use of a transfer station becomes economical depends on local economic conditions. However, most experts agree that the disposal site must be at least 10 to 15 miles from the generation area before a transfer station can be economically justified. Transfer stations are sometimes used for shorter hauls to accomplish other objectives, such as to facilitate sorting or to allow the optional shipment of wastes to more distant landfills.

Types of Transfer Stations

Many factors influence transfer station design.

The type of station that will be feasible for a community depends on the following design variables:

- required capacity and amount of waste storage desired
- types of wastes received
- processes required to recover material from wastes or prepare it (e.g., shred or bale) for shipment
- types of collection vehicles using the facility
- types of transfer vehicles that can be accommodated at the disposal facilities
- site topography and access.

Following is a brief description of the types of stations typically used for three size ranges:

- small capacity (less than 100 tons/day)
- medium capacity (100 to 500 tons/day)
- large capacity (more than 500 tons/day).

Small to Medium Transfer Stations

Typically, small to medium transfer stations are direct-discharge stations that provide no intermediate waste storage area. These stations usually have drop-off areas for use by the general public to accompany the principal operating areas dedicated to municipal and private refuse collection trucks. Depending on weather, site aesthetics, and environmental concerns, transfer operations of this size may be located either indoors or outdoors.

The type of station determines operator needs.

More complex small transfer stations are usually attended during hours of operation and may include some simple waste and materials processing facilities. For example, the station might include a recyclable materials separation and processing center. Usually, direct-discharge stations have two operating floors. On the lower level, a compactor or open-top container is located. Station users dump wastes into hoppers connected to these containers from the top level.

Smaller transfer stations used in rural areas often have a simple design and are often left unattended. These stations, used with the drop-off collection method, consist of a series of open-top containers that are filled by station users. These containers are then emptied into a larger vehicle at the station or hauled to the disposal site and emptied. The required overall station capacity (i.e., number and size of containers) depends on the size and population density of the area served and the frequency of collection. For ease of loading, a simple retaining wall will allow containers to be at a lower level so that the tops of the containers are at or slightly above ground level in the loading area.

Larger Transfer Stations

Larger transfer stations are designed for heavy commercial use by private and municipal collection vehicles. In some cases, the public has access to part of the station. If the public will have access, the necessary facilities should be included in the design. The typical operational procedure for a larger station is as follows:

1. When collection vehicles arrive at the site, they are checked in for billing, weighed, and directed to the appropriate dumping area. The check-in and weighing procedures are often automated for regular users.
2. Collection vehicles travel to the dumping area and empty wastes into a waiting trailer, a pit, or onto a platform.
3. After unloading, the collection vehicle leaves the site. There is no need to weigh the departing vehicle if its tare (empty) weight is known.
4. Transfer vehicles are weighed either during or after loading. If weighed during loading, trailers can be more consistently loaded to just under maximum legal weights; this maximizes payloads and minimizes weight violations.

The advantages and disadvantages of transfer station types are provided in Table 4-5.

Several different designs for larger transfer operations are common, depending on the transfer distance and vehicle type. Most designs fall into one of the following three categories: (1) direct-discharge noncompaction stations, (2) platform / pit noncompaction stations, or (3) compaction stations. The following paragraphs provide information about each type, and Table 4-5 presents the advantages and disadvantages of each.

Direct-Discharge Noncompaction Stations

Direct-discharge noncompaction stations are generally designed with two main operating floors. In the transfer operation, wastes are dumped directly from collection vehicles (on the top floor), through a hopper, and into open-top trailers on the lower floor. The trailers are often positioned on scales so that dumping can be stopped when the maximum payload is reached. A stationary knuckleboom crane with a clamshell bucket is often used to distribute the waste in the trailer. After loading, a cover or tarpaulin is placed over the trailer top. These stations are efficient because waste is handled only once. However, some provision for waste storage during peak time or system interruptions should be developed. For example, excess waste may be emptied and temporarily stored on part of the tipping floor. Facility permits often restrict how long wastes may be stored on the tipping floor (usually 24 hours or less).

Platform/Pit Noncompaction Stations

In platform or pit stations, collection vehicles dump their wastes onto a floor or area where wastes can be temporarily stored, and, if desired, picked through for recyclables or unacceptable materials. The waste is then pushed into open-top trailers, usually by front-end loaders. Like direct discharge stations, platform stations have two levels. If a pit is used, the station has three levels. A major advantage of these stations is that they provide temporary storage, which allows peak inflow of wastes to be leveled out over a longer period. Although construction costs for this type of facility are usually higher because of the increased floor space, the ability to temporarily store wastes al-

Table 4-5

Advantages and Disadvantages of Transfer Station Types

Direct Dump Stations

Waste is dumped directly from collection vehicles into waiting transfer trailers.

Advantages:

- Because little hydraulic equipment is used, a shutdown is unlikely.
- Minimizes handling of wastes.
- Relatively inexpensive construction costs.
- Drive-through arrangement of transfer vehicles can be easily provided.
- Higher payloads than compactor trailers.

Disadvantages:

- Requires larger trailers than compaction station.
- Dropping bulky items directly into trailers can damage trailers.
- Minimizes opportunity to recover materials.
- Number and availability of stalls may not be adequate to allow direct dumping during peak periods.
- Requires bi-level construction.

Pit or Platform Noncompaction Stations

Waste is dumped into a pit or onto a platform and then loaded into trailers using waste handling equipment.

Advantages:

- Convenient and efficient waste storage area is provided.
- Uncompacted waste can be crushed by bulldozer in pit or on platform.
- Top-loading trailers are less expensive than compaction trailers.
- Peak loads can be handled easily.
- Drive-through arrangement of transfer vehicles can be easily provided.
- Simplicity of operation and equipment minimizes potential for station shutdown.
- Can allow recovery of materials.

Disadvantages:

- Higher capital cost, compared to other alternatives, for structure and equipment.
- Increased floor area to maintain.
- Requires larger trailers than compaction station.

Hopper Compaction Station

Waste is unloaded from the collection truck, through a hopper, and loaded into an enclosed trailer through a compactor.

Advantages:

- Uses smaller trailers than non-compaction stations uncompacted.
- Extrusion/"log" compactors can maximize payloads in lighter trailers.
- Some compactors can be installed in a manner that eliminates the need for a separate, lower level for trailers.

Disadvantages:

- If compactor fails, there is no other way to load trailers.
- Weight of ejection system and reinforced trailer reduces legal payload.
- Capital costs are higher for compaction trailers.
- Compactor capacity may not be adequate for peak inflow.
- Cost to operate and maintain compactors may be high.

Push Pit Compaction Station

Waste is unloaded from the collection truck into a push pit, and then loaded into an enclosed trailer through a compactor.

Advantages:

- Pit provides waste storage during peak periods.
- Increased opportunity for recovery of materials.
- All advantages of hopper compaction stations.

Disadvantages:

- Capital costs for pit equipment are significant.
- All other disadvantages of hopper compaction stations.

Source: W. Pferdehirt, University of Wisconsin–Madison Solid and Hazardous Waste Education Center, 1994

lows the purchase of fewer trucks and trailers, and can also enable facility operators to haul at night or other slow traffic periods. These stations are usually designed to have a storage capacity of one-half to two days' inflow.

Compaction Stations

Compaction transfer stations use mechanical equipment to densify wastes before they are transferred. The most common type of compaction station uses a hydraulically powered compactor to compress wastes. Wastes are fed into the compactor through a chute, either directly from collection trucks or after intermediate use of a pit. The hydraulically powered ram of the compactor pushes waste into the transfer trailer, which is usually mechanically linked to the compactor.

Other types of equipment can be used to compact wastes. For example, wastes can be baled for shipment to a balefill or other disposal facility. Baling is occasionally used for long-distance rail or truck hauling. Alternatively, some newer compactors produce an extruded, continuous "log" of wastes, which can be cut to any length. Bales or extruded wastes can be hauled with a flat-bed truck or a trailer of lighter construction because, unlike with a traditional compactor, the side walls of the trailer do not need to restrain the wastes as the hydraulic ram pushes them.

Compaction stations are used when (1) wastes must be baled for shipment (e.g., rail haul) or for delivery to a balefill, (2) open-top trailers cannot be used because of size restrictions such as viaduct clearances, and (3) site topography or layout does not accommodate a multi-level building conducive to loading open-top trailers. The main disadvantage to a compaction facility is that the facility's ability to process wastes is directly dependent on the operability of the compactor. Selection of a quality compactor, regular preventive maintenance of the equipment, and prompt availability of service personnel and parts are essential to reliable operation.

Transfer Station Design Considerations

This section discusses factors that should be considered during station design. In general, these factors were developed for designing large stations, but many also apply to smaller transfer stations.

The main objective in designing a transfer station should be to facilitate efficient operations. The operating scheme should be as simple as possible; it should require a minimum of waste handling, while offering the flexibility to modify the facility when needed. Equipment and building durability are essential to ensure reliability and minimize maintenance costs. With modification, the facility should be capable of handling all types of wastes.

Goals of transfer station design should include:

- *efficient waste handling*
- *equipment and building durability*
- *simple operating scheme*
- *flexibility to modify facility.*

Table 4-6 provides transfer station design considerations.

Site Location and Design Criteria

Local residents are most likely to accept the facility if the site is carefully selected, the buildings are designed appropriately for the site, and landscaping and other appropriate site improvements are made. These design features should be accompanied by a thorough plan of operations. When selecting a site, municipalities should consider the following factors:

- **Proximity to waste collection area:** Proximity to the collection area helps to maximize savings from reduced hauling time and distance.
- **Accessibility of haul routes to disposal facilities:** It should be easy for transfer trucks to enter expressways or other major truck routes, which reduces haul times and potential impacts on nearby residences and businesses. When considering sites, determine if local road improvements will be necessary, and if so, whether they will be economically and technically feasible. Accessibility to rail lines and waterways may allow use of rail cars or barges for transfer to disposal facilities.

- **Visual impacts:** The transfer station should be oriented so that transfer operations and vehicle traffic are not readily visible to area residents. To a great extent, visibility can be restricted if the site is large enough. The area required will depend on vehicle traffic and storage needs, necessary buffer areas, and station layout and capacity.
- **Site zoning and design requirements:** Municipalities should confirm that the proposed use meets the site zoning requirements. In addition, the local site plan ordinance should be reviewed to identify restrictions that could affect design, such as building height and setback, and required parking spaces.
- **Proximity to utility tie-ins:** The transfer station may require the following utility services: electricity and gas, water (for domestic use and fire fighting), telephone, and sanitary and storm sewers. Station designers should determine the cost of connecting to these utilities and the continuing service charges associated with them.

In some cases, municipalities may wish to consider the construction of more than one transfer station. For example, two transfer stations may be economically preferable if travel times from one side of the city to the other are excessive.

Site permitting for a transfer station can be time-consuming—begin the process as soon as a site is selected.

One of the most time-consuming aspects of transfer facility design is site permitting. The permitting process should, therefore, be started as soon as a suitable site is selected.

States usually require permits, and some local governments may require them as well. The project team should work closely with regulatory agency staff to determine design and operating requirements, and to be sure that all submittal requirements and review processes are understood. Table 4-6 summarizes additional considerations for site design.

Building Design

Whenever putrescible wastes are being handled, larger transfer stations should be enclosed. Typically, transfer station buildings are constructed of concrete, masonry or metal. Wood is not generally desirable because it is difficult to clean, is less durable, and is more susceptible to fire damage. Key considerations in building design include durability of construction, adequate size for tipping and processing requirements, minimization of column and overhead obstructions to trucks, and flexibility and expandability of layout. Table 4-7 provides a summary of factors that should be considered as part of the building design.

Transfer Station Sizing

The transfer station should have a large enough capacity to manage the wastes that are expected to be handled at the facility throughout its operating life. Factors that should be considered in determining the appropriate size of a transfer facility include:

- capacity of collection vehicles using the facility
- desired number of days of storage space on tipping floor
- time required to unload collection vehicles
- number of vehicles that will use the station and their expected days and hours of arrival (design to accommodate *peak* requirements)
- waste sorting or processing to be accomplished at the facility
- transfer trailer capacity
- hours of station operation
- availability of transfer trailers waiting for loading

Table 4-6
Transfer Station Site Design Considerations

Office Facilities

- Space should be adequate for files, employee records, and operation and maintenance information.
- Office may be in same or different building than transfer operation.
- Additional space needed if collection and transfer billing services included.

Employee Facilities

- Facilities including lunchroom, lockers, and showers should be considered for both transfer station and vehicle personnel.

Weighing Station

- Scales should be provided to weigh inbound and outbound collection vehicles and transfer vehicles as they are being loaded or after loading.
- Number of scales depends on traffic volume. Volume handled by one scale depends on administrative transaction time, type of equipment installed, and efficiency of personnel. A rough rule-of-thumb estimate for collection vehicle scales is about 500 tons/day. Another estimate that can be used for design purposes is a weighing time of 60 to 90 seconds/vehicle.
- Length and capacity of scales should be adequate for longest, heaviest vehicle. Different scales can be used for collection and transfer vehicles. Typical scale lengths are 60 to 70 feet. Typical capacities are 120,000 to 140,000 pounds.
- Computerized scale controls and data-recording packages are becoming increasingly common. Computerized weighing systems record tare weight of vehicle and all necessary billing information.

On-site Roads and Vehicle Staging

- If the public will use the site, separate the associated car traffic from the collection and transfer truck traffic
- Site roads should be designed to accommodate vehicle speed and turning characteristics. For example, pavement should be wider on curves than in straight lanes and have bypass provision on operational areas.
- Ramp slopes should be less than 10 percent (preferably 6 percent max. for up-ramp) and have provisions for de-icing, if necessary.
- The road surface should be designed for heavy traffic.
- Minimize intersections and cross-traffic. Use one-way traffic flow where possible.
- Assure adequate queue space. For design purposes, assume that 25 to 30 percent of vehicles will arrive during each of two peak hours, but check against observed traffic data for existing facilities.

Site Drainage and Earth Retaining Structures

- Drainage structures should be sized to handle peak flow with no disruption in station operation.
- Provide reliable drainage at bottom of depressed ramps.
- For most transfer station designs, earth retaining structures will be required. Elevation differences will vary depending on station design.

Site Access Control

- A chain-link fence, often with barbed wire strands on top, is usually required for security and litter control.
- Consider installing remote video cameras and monitoring screens to watch access gates.
- A single gate is best for controlling security and site access.
- Signs stating facility name, materials accepted, rates, and hours of operation are usually desirable and often required. Ordinances may specify the size of such signs.

Buffer and Landscaping Areas

- Landscaped barriers (berms or shrub buffers) provide noise and visual buffers, and are often required by local ordinance.
- Fast-growing trees that require minimal maintenance are the best choice. Evergreens provide screening throughout the year. Design berms and plantings to meet site-specific screening requirements.

Fuel Supply Facilities

- Fuel storage and dispensing facilities are often located at transfer stations.
- Adequate space to accommodate transfer vehicles is very important.

Water Supply and Sanitary Sewer Facilities

- Water must generally be supplied to meet the following needs: fire protection, dust control, potable water, sanitary facilities use, irrigation for landscaping.
- Fire protection needs usually determine the maximum flow.
- Sanitary sewer services are usually required for sanitary facilities and wash-down water.
- A sump or trap may be required to remove large solids from wash-down water.

.Electricity and Natural Gas

- Electricity is necessary to operate maintenance shop, process and other auxiliary equipment and provide building and yard lighting.
- Natural gas is often required for building heat.

Source: Adapted, in part, from Peluso et al., 1989

- time required, if necessary, to attach and disconnect trailers from tractors, or to attach and disconnect trailers from compactors
- time required to load trailers.

Consider tradeoffs between capital and operating costs.

Table 4-8 provides formulas for estimating the required capacity of various types of transfer stations. These formulas should be adapted as necessary for specific applications. The formulas in Table 4-8 do not reflect the effects of using the tipping floor to store wastes.

When selecting the design capacity of a transfer station, decision makers should consider tradeoffs between the capital costs associated with the station and equipment and the operational costs. The optimum capacity will often be a compromise between the capital costs associated with increased capacity and the costs associated with various operational parameters (for example, collection crew waiting time and hours of operation).

Facility designers should also plan adequate space for waste storage and, if necessary, waste processing. Transfer stations are usually designed to have one-half to two days of storage capacity. The collection vehicle unloading area is usually the waste storage area and sometimes a waste sorting area.

When planning the unloading area, designers should allow adequate space for vehicle and equipment maneuvering. To minimize the space required, the facility should be designed so that collection vehicles back into the unloading position. For safety purposes, traffic flow should be such that trucks back to the left (driver's side). Adequate space should also be available for offices, employee facilities, and other facility-related activities.

Table 4-7

Transfer Station Building Components: Design Considerations

Building Construction

- Usually constructed of concrete masonry or metal.
- If prefabricated metal, building will typically be constructed of multiples of 20- to 25-foot bays.
- Clear-span construction is desirable so that vehicles and equipment do not need to maneuver around columns. Typically, frame will be steel for smaller buildings and steel truss for larger ones.
- Collection vehicles must be able to unload within the building. Generally, most vehicles require 25 to 30 feet clearance. More than 25 to 30 feet may be required for dump trailers.
- Design for flexibility and expendability.

Doors

- Number of openings depends on number of trucks unloading per hour at a peak or compromise time.
- Door placement should minimize effects of wind in contributing to litter and odor problems. Door placement should also minimize visual exposure of tipping operations to neighbors and passersby.
- Door supports should be protected by bollards.
- If possible, doors should be high enough that trucks can be driven through door openings while in full-unloading position. Typically, this requires 25 feet or more of vertical clearance. If damage is possible, provide driver-warning mechanism (e.g., hanging pipe that will hit truck before door).
- Wide doors (min. 16 ft.) improve operations and limit damage to door jambs.
- To eliminate door damage, leave one side of building open.

Floors

- Floors receive considerable wear from various transfer operations.
- To control wear, floors are often topped with a granolithic topping (1 to 2 inches). A less expensive, but less durable option is to use a shake-on metallic hardener for the concrete floor.

Material Recovery

- Include space and equipment for recovery of recyclables.
- Address needs for receiving and storing special materials like household hazardous wastes, appliances, used oil, or tires.

Dust Control

- Dust control should be provided.
- Typical systems include wet-spray systems, dust collection equipment and good ventilation.

Safety Equipment

The necessary safety equipment, equipment shut-off switches, and emergency exit signs should be included.

Maintenance and Clean Up Access

Provide high-pressure hoses for wash-down. Drains should have screens that can be easily cleaned.

Source: Adapted partially from Peluso et al., 1989

Additional Processing Requirements

Solid waste transfer facilities can be designed to include additional waste processing requirements. Such processes can include waste shredding or baling, or the recovery of recyclable or compostable materials.

At a minimum, transfer facilities should provide a sufficient area for the dump-and-pick recovery of targeted recyclables. For example, haulers servicing businesses usually reserve an area of the floor where loads rich in old corrugated containers can be deposited. Laborers then pick through the materials to remove the corrugated containers for recycling. Dump-and-pick operations are a low-capital way to begin the recovery of recyclables, but they are hard on workers' backs and inefficient for processing large volumes of materials.

Waste transfer stations can include additional functions, including

- *waste shredding and baling*
- *recovery of recyclable and compostable materials.*

Newer transfer facilities often include mechanically assisted systems to facilitate the recovery of recyclables. Some facilities use only conveyors to move the materials past a line of workers who pick designated materials from the conveyor and drop the sorted material into a bin or onto another conveyor. Other facilities use mechanical methods to recover certain materials; for example, a magnetic drum or belt can be used to recover tin cans and other ferrous metals, and eddy current separators can be used to remove aluminum.

Shredders or balers are sometimes used to reduce the volume of wastes requiring shipment or to meet the requirements of a particular landfill where wastes are being sent. Shredders are sometimes used for certain bulky wastes like tree trunks and furniture. Solid waste facilities using shredders must take special precautions to protect personnel and structures from explosions caused by residual material in fuel cans and gas cylinders. Commonly used measures include inspecting wastes before shredding, explosion suppression systems, wall or roof panels that blow out to relieve pressure, and restricted access to the shredder area. If considering a combined recyclable material processing and transfer station, municipalities should also refer to Chapter 6.

Table 4-8

Formulas for Determining Transfer Station Capacity

Pit Stations

Based on rate at which wastes can be unloaded from collection vehicles:

$C = P_c \times (L/W) \times (60 \times H_w/T_c) \times F$

Based on rate at which transfer trailers are loaded:

$C = (P_t \times N \times 60 \times H_t)/(T_t + B)$

Direct Dump Stations

$C = (N_n \times P_t \times F \times 60 \times H_w)/ [((P_t/P_c) \times (W/L_n)) \times T_c + B]$

Hopper Compaction Stations

$C = (N_n \times P_t \times F \times 60 \times H_w)/[(P_t/P_c \times T_c) + B]$

Push Pit Compaction Station

$C = (N_p \times P_t \times F \times 60 \times H_w)/[(P_t/P_c \times W/L_p \times T_c) + B_c + B]$

where:

C	=	Station capacity (tons/day)
P_c	=	Collection vehicle payload (tons)
L	=	Total length of dumping space (feet)
W	=	Width of each dumping space (feet)
H_w	=	Hours per day that waste is delivered
T_c	=	Time to unload each collection vehicle (minutes)
F	=	Peaking factor (ratio of number of collection vehicles received during an average 30-minute period to the number received during a peak 30-minute period)
P_t	=	Transfer trailer payload (tons)
N	=	Number of transfer trailers loading simultaneously
H_t	=	Hours per day used to load trailers (empty trailers must be available)
B	=	Time to remove and replace each loaded trailer (minutes)
T_t	=	Time to load each transfer trailer (minutes)
N_n	=	Number of hoppers
L_n	=	Length of each hopper (feet)
L_p	=	Length of push pit (feet)
N_p	=	Number of push pits
B_c	=	Total cycle time for clearing each push pit and compacting waste into trailer

Source: Schaper, 1986

Transfer Vehicles

Although most transfer systems use tractor trailers for hauling wastes, other types of vehicles are sometimes used. For example, in collection systems that use small satellite vehicles for residential waste collection, the transfer (or "mother") vehicle could simply be a large compactor truck. At the other extreme, some communities transport large quantities of wastes using piggyback trailers, rail cars, or barges.

The following discussion presents information on truck and rail transfer vehicles. Although smaller vehicles may also be used for transfer, their use is more typically limited to collection.

Trucks and Semitrailers

Trucks and semitrailers are often used to carry wastes from transfer stations to disposal sites. They are flexible and effective waste transport vehicles because they can be adapted to serve the needs of individual communities. Truck and trailer systems should be designed to meet the following requirements:

Carefully consider the community's needs when selecting transfer vehicles.

- Wastes should be transported at minimum cost.
- Wastes must be covered during transport.
- The vehicles should be designed to operate effectively and safely in the traffic conditions encountered on the hauling routes.
- Truck capacity should be designed so that road weight limits are not exceeded.
- Unloading methods should be simple and dependable, not subject to frequent breakdown.
- Truck design should prevent leakage of liquids during hauling.
- The materials used to make the trailers and the design of sidewalls, floor systems, and suspension systems should be able to withstand the abusive loads innate to the handling and hauling of municipal solid wastes.
- The number of required tractors and trailers depends on peak inflow, storage at the facility, trailer capacity, and number of hauling hours. Most direct-discharge stations have more trailers than tractors because empty trailers must be available to continue loading, but loaded trailers can, if necessary, be temporarily parked and hauled later.

It is important to select vehicles that are compatible with the transfer station. There are two types of trailers used to haul wastes: compaction and noncompaction trailers. Noncompaction trailers are used with pit or direct-dump stations, and compaction trailers are used with compaction stations. Noncompaction trailers can usually haul higher payloads than compaction trailers because the former do not require an ejection blade for unloading. Based on a maximum gross weight of 80,000 pounds, legal payloads for compaction trailers are typically 16-20 tons, while legal payloads for open-top live-bottom trailers are 20-22 tons. Possum-belly trailers (which must be tilted by special unloaders at the disposal site) can have legal payloads up to 25 tons.

Transfer vehicles should be able to negotiate the rough and muddy conditions of landfill access roads and should not conflict with vertical clearance restrictions on the hauling route. Table 4-9 discusses additional factors to consider when selecting a transfer trailer.

Rail Cars

Railroads carry only about five percent of transferred wastes in the U.S. (Lueck, 1990). However, as the distance between sanitary landfills and urban areas in-

The use of rail haul is increasing.

creases, the importance of railroads in transporting wastes to distant sites also grows. Rail transfer is an option that should be considered, especially when a rail service is available for both the transfer station and the disposal facility, and when fairly long hauling distances are required (50 miles or more). Cities that have recently developed rail transfer systems include Seattle, Washington; Portland, Oregon; and the southeastern Massachusetts region.

Rail transfer stations are usually more expensive than similarly sized truck transfer stations because of costs for constructing rail lines, installing special equipment to remove and replace roofs of rail cars for loading or to bale wastes, and installing special equipment to unload rail cars at the disposal facility. Transfer trailers, however, can usually transport a payload of only 20-25 tons of waste, whereas a 60-foot boxcar can transport approximately 90 tons of waste. Rail transfer becomes more economically attractive as hauling distances increase, but some communities, such as Cape Cod, Massachusetts, have found short-haul dedicated rail transfer to be economically viable.

Wastes can be transported via rail using either dedicated boxcars or containerized freight systems. Most facilities use boxcars to transport baled wastes. Rail cars with removable roofs can be directly loaded in a rail direct-discharge station. This latter arrangement, which is used at a transfer station

Table 4-9
Transfer Truck and Trailer Systems: Design Considerations

Trailer Type

Trailers are classified as either compaction or noncompaction. Typically, compaction trailers are rear-loading, enclosed and equipped with a push-out blade for unloading. In noncompaction trailers, the entire top is usually open for loading. After loading, top doors or tarps cover waste.

Design Considerations:

- Transfer station design usually determines whether to use a compaction or noncompaction trailer.
- Compaction trailers must endure the pressure of the compaction process; therefore they are usually enclosed and reinforced. As a result, they are often heavier than noncompaction trailers.
- Noncompaction trailers are larger and lighter than compaction trailers. They are usually made of steel or aluminum. These trailers usually have a walking floor or a conveyor floor, or they are tipped by a hydraulic platform at the disposal facility.

Trailer Capacity

Typically, capacities range 65 cubic yards for compaction trailers to 125 cubic yards for noncompaction trailers.

Design Considerations:

- Waste densities are usually 400 to 600 pound/cubic yard for compacted wastes, and 275 to 400 pounds/cubic yard for noncompacted wastes.
- Trailers are typically sized to meet legal payload and dimension requirements. Specific requirements vary depending on local regulations.
- Weight depends on degree of compaction and composition of the material.
- Trailers are often sized to be higher than legal height requirements when empty, but lower when full.

Unloading Mechanisms

Some trailers are self-emptying, and others require additional equipment to help with the unloading process. The most common mechanisms are the following:

Push-Out Blade

- Push-out blades are usually used in compaction trailers and sometimes used in noncompaction trailers.
- In compaction trailers, the same blade that is used to compact wastes is used to eject them.
- The blade is relatively simple to operate and can be powered by tractor hydraulic system or by a separate engine. However, items such as tree limbs can wedge under the blade, causing it to jam.

Moving Floor

- Moving floors are common in noncompaction trailers.
- Floor usually has two or more movable sections that extend across the entire width of the trailer; therefore, even if one section breaks, another can empty wastes.
- Floor can typically empty wastes in 6 to 10 minutes.
- Rear of trailer may be larger to expedite unloading.

Hydraulic Lift

- A lift located at the disposal site tips the trailer to an angle that allows discharge of the wastes.
- Time required for unloading operation is about 6 minutes.
- One disadvantage is a possible wait for use of lift. Breakdown of lift seriously impedes ability to receive wastes.

Pull-Off System

- A movable blade or cable slings are placed in front of the load. To empty load, auxiliary equipment (e.g., landfill dozer) pulls the waste out of the trailer.
- The system may require more time than self-unloading trailers because there may be a wait for auxiliary equipment.

Source: W. Pferdehirt, University of Wisconsin–Madison Solid and Hazardous Waste Education Center, 1994

in Yarmouth, Massachusetts, requires special equipment to lift and rotate the rail car at the unloading facility. Containerized systems require double-handling of wastes because wastes must first be loaded into the containers and the containers then loaded onto rail cars; this process must be reversed at the destination. Therefore, handling costs usually prohibit the use of containerized shipment unless the transfer station or disposal facility is not accessible by rail. If the transfer facility or disposal facility is not served by rail, trucks must be used to transport either containers or noncontainerized bales. In this situation, containers are usually less expensive to handle than are bales; also, bales become susceptible to breakage with increased handling.

When evaluating a potential rail transfer system, decision makers should consider environmental impacts and potential opposition from towns between the transfer facility and the disposal facility. Rail cars should be covered and kept clean, and shipment should be scheduled to minimize en-route delays.

EVALUATING COLLECTION AND TRANSFER ALTERNATIVES

Defining System Alternatives

After options are identified, further evaluation of system-wide alternatives is needed.

After appropriate options for collection, equipment, and transfer have been identified, various combinations of these elements should be examined to define system-wide alternatives for further analysis. Each alternative should be a unique configuration of all collection and transfer elements. For example, a proposed system might consist of the following elements:

- A weekly collection of mixed solid wastes using 30-cubic-yard rear-loading compactors and two-person crews. Wastes would be transported directly to the disposal site.
- A monthly collection of bulky items using an open truck and a one-person crew. Collection would be the same day as regular waste collection.
- A weekly curbside collection of mixed recyclables (newspaper, tin cans, plastic, glass, and aluminum) on the same day as regular waste collection. Materials would be collected in a noncompacting truck by a one-person crew and transported to a recycling facility for separation and processing.
- A drop-off facility for collection of tires, used motor oil and batteries.

Comparing Alternative Strategies

Decision makers should evaluate each candidate for its ability to achieve the identified goals for the collection program. Economic analysis will usually be a central focus of the system evaluations. However, to the extent that the alternatives differ in their level of service or other performance parameters, it is important to note such differences so that decision makers understand the economic tradeoffs involved. This initial evaluation will lead to several iterations, with the differences between the alternatives under consideration becoming more narrowly focused with each round of evaluations.

Analyzing Crew and Truck Requirements

The community can use the number of houses per block or route, along with waste density and quantity information, to determine an average quantity of waste generated (in pounds or cubic yards) for all or portions of the service area. This average waste quantity can be used to estimate the number of stops to be serviced per vehicle load (N) as shown in Table 4-10, item 1. The number of services per load and other block configuration data will be used to develop collection routes and schedules. Seasonal variations in generation rates should be considered when estimating staff and equipment needs.

Estimating Time Requirements

Loading Time Requirements

Making accurate time estimates is essential.

For each collection method and crew size being considered, a loading time should be estimated using data from another, similarly configured system, or, if necessary, using a time study of proposed collection procedures. Time studies are usually performed only if historic data is not available for comparable systems and when the potential cost impacts of the decisions at hand warrant the cost of a time study. Table 4-11 lists procedures for a time study. Estimates of the loading time and average generation per household can be used to determine the average time required to fill a truck (see Table 4-10, item 2).

If distances between stops vary significantly, different loading times and total vehicle filling times should be estimated for each area. These estimates and block configuration data are used to determine collection routes.

Hauling Time and Other Travel Time Requirements

To estimate hauling times for collection vehicles, consider the following:

- travel time from the garage to the route at beginning of day

Table 4-10
Calculations for Waste Collection System Design

1. Number of Services/Vehicle Load (N)

   N = (C x D)/W; where,

   C = Vehicle Capacity (cubic yards)

   D = Waste Density (pounds/cubic yard)

   W = Waste Generation/Residence (pounds/service)

2. Time Required to Collect One Load (E)

   E = N x L; where,

   L = Loading Time/Residence, including on-route travel

3. Number of Loads/Crew/Day (n)

   The number of loads (n) that each crew can collect in a day can be estimated based in the workday length (T), and the time spent on administration and breaks (T1), hauling and other travel (T2), and collection routes (T3).

   A) Administrative and Break Time (T1):

   T1 = A + B; where,

   A = Administrative Time (i.e., for meetings, paperwork, unspecified slack time)

   B = Time for Breaks and Lunch

   B) Hauling and Other Travel Time (T2):

   T2 = (n x H) - f + G + J; where,

   n = Number of Loads/Crew/Day

   H = Time to travel to disposal site, empty truck, and return to route

   f = Time to return from site to route

   G = Time to travel from staging garage to route

   J = Time to return from disposal site to garage

   C) Time Spent on Collection Route (T3):

   T3 = n x E

   where variables have been previously defined.

   D) Length of Workday (T):

   T = T1 + T2 +T3

   where T is defined by work rules or policy and equations A through D are solved to find n.

4. Calculation of Number of Vehicles and Crews (K)

   K = (S x F)/(N x n x M); where,

   S = Total number of services in the collection area

   F = Frequency of collection (numbers/week)

   M = Number of workdays/week

5. Calculation of Annual Vehicle and Labor Costs

   Vehicle Costs = Depreciation + Maintenance + Consumables + Overhead + License + Fees + Insurance

   Labor Costs = Driver Salary + Crew Salaries + Fringe Benefits + Indirect Labor + Supplies + Overhead

Source: Adapted from Tchobanoglous et al., 1977

- travel time from the route to the disposal site (include daily traffic fluctuations)
- time spent queuing, weighing, and tipping at the disposal / transfer site
- travel time to the collection route from the site
- travel time returning to the garage at end of day.

To the extent that different alternatives being considered affect collection or transfer time requirements, the impacts on labor, equipment and operating costs should be quantified. Detailed delineation of individual collection routes can wait until after the specific alternative system is selected.

Overall Time Requirements

Time estimates for each option should be computed.

The loading and hauling times can be used to calculate the number of loads that each crew can collect per day. To make this calculation, managers will need to estimate administrative and break time, hauling route and other travel time, and actual collection time. Table 4-10, item 3, presents methods for estimating these times.

Labor and equipment costs should be estimated for each collection system being considered. First, using the total quantity of waste that will be generated and number of loads that can be collected each day, collection managers should calculate the number of vehicles and crews that will be required to collect waste (see Table 4-10, item 4). Then, these numbers, along with equipment and cost information, can be used to calculate the annual cost of each collection alternative (see Table 4-10, item 5).

Analyzing Transfer Elements

For alternatives that include a transfer component, waste transfer costs should be analyzed and included as part of the overall system costs. Table 4-12 presents a list of capital and operating and maintenance costs for transfer systems.

Alternatives that include transfer systems should show reduced collection costs to offset some or all of the transfer costs. There are several ways to reduce collection costs; three examples are given below:

- Vehicle operating costs can be reduced if collection vehicles travel fewer miles to empty wastes.
- Nonproductive time during hauls and personnel costs can be reduced if crews spend more time on collection routes; this may also reduce the number of collection crews required.
- Vehicle maintenance costs from flat tires and damage to axles and other undercarriage parts can be reduced if vehicles deliver wastes to a transfer facility rather than directly to a landfill.

Selecting A Collection and Transfer Alternative

Decision makers must carefully consider many factors.

Appropriate public officials must eventually select a preferred system for implementation. Usually the authority for final approval rests with a body of elected officials, such as town board, city council, or county board. The type of solid waste collection services provided and their associated costs usually evoke considerable debate when establishing a new service or modifying an existing service. Issues that are usually important to elected officials in evaluating collection and transfer alternatives, and which staff should be prepared to address in their recommendations, include the following:

- costs of required new equipment and ability of community to obtain financing for it
- costs to operate collection system and transfer facilities

Table 4-11
Steps for Conducting a Time Study

1. Select crew(s) representative of average level and skill level.
2. Determine the best method (series of movements) for conducting the work.
3. Set up a data sheet that can be used to record the following information: date, name of crew members and time recorder, type of collection method and equipment (including loading mechanism), specific area of municipality, and distance between collection points.
4. Divide loading activity into elements that are appropriate for the type of collection service. For example, the following elements might be appropriate for a study of residential collection loading times:
   - time to travel from last loading point to next one
   - time to get out of vehicle and carry container to the loading area
   - time to load vehicle
   - time to return container to the collection point and return to the vehicle.
5. Using a stop watch, record the time required to complete each element for a representative number of repetitions. Time may be measured using one of the following two methods:
   - Snapback method: The time recorder records the time after each element and then resets watch to zero for measurement of the next element.
   - Continuous method: The time recorder records the time after each element but does not reset the watch so that it moves continuously until the last element is completed.

   Because the continuous method requires the time recorder to perform fewer movements and no time is lost for watch resetting, the continuous method is usually recommended.

   The number of repetitions that will be representative depends on the time required to complete the overall activity (cycle). The following numbers of repetitions have been suggested as sufficient :*

Number of Repetitions	Minutes Per Cycle	Number of Repetitions	Minutes Per Cycle
60	0.50	20	2.0
40	0.75	15	5.0
30	1.00	10	10.5

6. Determine the average time recorded (T_o) and adjust it for "normal" conditions.

   In the case of waste collection, adjustments should be made for delays and for crew fatigue. These adjustments are typically in terms of the percent of time spent in a workday. The delay allowance (D) should include time for traffic conditions, equipment failures and other uncontrollable delays. Crew fatigue allowance (F) should include adequate rest time for recovery from heavy lifting, extreme hot and cold weather conditions, and other circumstances encountered in waste collection. The allowance factors (D and F) along with the average observed time (T_o), can be used to estimate the "normal" time (T_n):

   $$T_n = (T_o) \times [1 + (F + D)/100]$$

   This "normal" time is the loading time required for the particular area, and collection system.

   For other activities, adjustments are also made for personal time (bathroom breaks). In this case, adjustment for personal time is made when calculating the number of loads/crew/day.

Sources: (1) Miller and Schmidt, 1984; *(2) These values only, from Presgrave, 1944

- compatibility of total costs with budget available for solid waste services
- differences in levels of service provided by alternative systems
- ability of system to meet public's demands or expectations for service
- proposed methods for financing system costs and public acceptability of those methods
- the system's effects on efforts to meet the community's waste reduction goals
- compatibility of proposed roles for public and private sectors with political support for them
- public's interest or disinterest in changing present arrangements for collecting solid waste and recyclables.

DEVELOPING COLLECTION ROUTES AND SCHEDULES

Detailed route configurations and collection schedules should be developed for the selected collection system. Efficient routing and rerouting of solid waste collection vehicles can decrease costs by reducing the labor expended for collection. Routing procedures usually consist of two separate components: microrouting and macrorouting.

Efficient routing decreases program costs by reducing labor expended in collection.

Macrorouting, also referred to as route balancing, consists of dividing the total collection area into routes sized so they represent one day's collection for one crew. The size of each route depends on the amount of waste collected per stop, distance between stops, loading time, and traffic conditions. Barriers, such as railroad embankments, rivers, and roads with heavy competing traffic, can be used to divide route territories. As much as possible, the size and shape of route areas should be balanced within the limits imposed by such barriers.

For large areas, macrorouting can be best accomplished by first dividing the total area into districts, each consisting of the complete area to be serviced by all crews on a given day. Then, each district can be divided into routes for individual crews.

Using the results of the macrorouting analysis, microrouting can define the specific path that each crew and collection vehicle will take each collection day. Results of microrouting analyses can then be used to readjust macrorouting decisions. Microrouting analyses should also include input and review by experienced collection drivers. Microrouting analyses and planning can do the following:

Table 4-12

Transfer System Costs

Capital Costs	Operating and Maintenance Costs
• Land	• Labor for station operation and vehicle hauling
• Buildings	• Utility service charges
• Utilities	• Station and vehicle maintenance
• Site development (on- and off-site)	• Insurance
• Material handling and processing equipment	• Taxes
• Transfer vehicles	• Vehicle license
• Design and permitting	• Facility permit
• Legal and financing fees	• Vehicle operation (tires, oil, fuel)
	• Host community benefits
	• Renewal and replacement
	• Reserve on contingencies

Source: W. Pferdehirt, University of Wisconsin–Madison Solid and Hazardous Waste

- increase the likelihood that all streets will be serviced equally and consistently
- help supervisors locate crews quickly because they know specific routes that will be taken
- provide theoretically optimal routes that can be tested against driver judgment and experience to provide the best actual routes.

Routes may need seasonal adjustments.

The method selected for microrouting must be simple enough to use for route rebalancing when system changes occur or to respond to seasonal variations in waste generation rates. For example, growth in parts of a community might necessitate overtime on several routes to complete them. Rebalancing can perhaps consolidate this need for increased service to a new route. Also, seasonal fluctuations in waste generation can be accommodated by providing fewer, larger routes during low-generation periods (typically winter) and increasing the number of routes during high-generation periods (typically spring and fall).

Heuristic Route Development: A Manual Approach

The heuristic route development process is a relatively simple manual (i.e., not computer-assisted) approach that applies specific routing patterns to block configurations. USEPA developed the method to promote efficient routing layout and to minimize the number of turns and dead space encountered (USEPA, 1974).

When using this approach, route planners can use tracing paper over a fairly large-scale block map. The map should show collection service garage locations, disposal or transfer sites, one-way streets, natural barriers, and areas of heavy traffic flow. Routes should then be traced onto the tracing paper using the rules presented in Table 4-13.

Table 4-13
Rules for Heuristic Routing

1. Routes should not be fragmented or overlapping. Each route should be compact, consisting of street segments clustered in the same geographical area.
2. Total collection plus hauling times should be reasonably constant for each route in the community (equalized workloads).
3. The collection route should be started as close to the garage or motor pool as possible, taking into account heavily traveled and one-way streets (see rules 4 and 5).
4. Heavily traveled streets should not be collected during rush hours.
5. In the case of one-way streets, it is best to start the route near the upper end of the street, working down it through the looping process.
6. Services on dead-end streets can be considered as services on the street segment that they intersect, since they can only be collected by passing down that street segment. To keep left turns at a minimum, collect the dead-end streets when they are to the right of the truck. They must be collected by walking down, backing down, or making a U-turn.
7. Waste on a steep hill should be collected, when practical, on both sides of the street while vehicle is moving downhill. This facilitates safety, ease, and speed of collection. It also lessens wear of vehicle and conserves gas and oil.
8. Higher elevations should be at the start of the route.
9. For collection from one side of the street at a time, it is generally best to route with many clockwise turns around blocks.

   Note: Heuristic rules 8 and 9 emphasize the development of a series of clockwise loops in order to minimize left turns, which generally are more difficult and time-consuming than right turns. Especially for right-hand-drive vehicles, right turns are safer.
10. For collection from both sides of the street at the same time, it is generally best to route with long, straight paths across the grid before looping clockwise.
11. For certain block configurations within the route, specific routing patterns should be applied.

Source: American Public Works Association, 1975

Computer-Assisted Routing

The use of computer-assisted routing is growing.

Computer programs can be helpful in route design, especially when routes are rebalanced on a periodic basis. Programs can be used to develop detailed microroutes or simpler rebalances of existing routes. To program detailed microroutes, planners require information similar to that needed for heuristic routing. This information might include block configurations, waste generation rates, distance between residences and between routes and disposal or transfer sites, topographical features, and loading times. Communities that already have a geographic information system (GIS) database are in an especially good position to take advantage of computerized route balancing.

Municipalities can also use computers to do simple route rebalancing. For example, the city of Wilmington, Delaware, used a spreadsheet program, average generation rates, and block configuration data to balance the weight of waste collected on each route. The city assumed that loading times were equal in all areas and altered the boundaries of existing routes. Specific collection vehicle paths were left to drivers. As a result of this simple rebalancing, the city was able to reduce its waste collection crew and save collection costs. For smaller communities, rebalancing can be accomplished using manual methods.

IMPLEMENTING THE COLLECTION AND TRANSFER SYSTEM

Implementing a collection and transfer system involves the following activities, which are described in more detail in the paragraphs below:

- finalizing and modifying the system management plan
- purchasing and managing collection and transfer equipment
- hiring and training personnel
- developing and managing contracts with labor unions and private collection companies
- providing public information
- constructing and operating transfer, administrative, and maintenance facilities.

Finalizing and Implementing the System Management Plan

The management plan should be concise, easy to follow, and well-organized.

Whether a municipality provides collection services or manages the efforts of a private or regional group, a clear organizational structure and management plan are needed. The management plan and structure should be reviewed periodically as implementation of collection services proceeds and continues.

The organizational structure should be simple, with a minimum of administrative and management layers between collection crews and top management. Structures should be clear, but kept sufficiently flexible to readily adapt to changing performance requirements. All workers in the department should clearly understand the department's mission and their own roles in achieving that mission. Through training, incentives, and reinforcement by management, workers should be encouraged to be customer-oriented and team contributors.

Details about system funding, accounting, billing, and performance monitoring should be developed and periodically reviewed. Feedback mechanisms to help crews review their performance and to help managers monitor the performance of crews, equipment, and the overall organization should be developed and used to achieve continuous improvement.

Purchasing and Managing Equipment

Equipment Purchasing

To purchase equipment most municipalities issue bid specifications, which are to be the basis of contractors' bids. Such specifications may either give detailed equipment requirements or be based on more general performance criteria. Detailed specifications include exact requirements for equipment sizes and capacities, power ratings, etc. Performance specifications often request that equipment be equivalent to certain available models, and meet standards for capacity, speed, maneuverability, etc.

Equipment Maintenance

A well-designed preventive maintenance program

- *keeps repair costs down*
- *makes vehicles more reliable.*

Municipalities may either perform equipment maintenance themselves, contract with a local garage, or in some cases, contract with the vehicle vendor at the time of purchase. Usually, municipal collection agencies elect to maintain vehicles using municipal facilities.

When equipment is maintained by the municipality, maintenance facilities may be under the authority of either a central municipal service or a specialized maintenance service for waste collection vehicles only. There is no consensus as to which form of organization is more effective. The advantages of a single-department maintenance service are that the maintenance facility is likely to be located closer to the garage or disposal facilities operated by the collection department, the maintenance personnel will usually be more responsive to the needs of collection department staff and vehicles, and the mechanics are likely to be better acquainted with the needs of the collection fleet's vehicles.

Centralization of all fleet services may allow a municipality to realize some cost savings by minimizing duplication of some costs for labor, buildings, equipment, and spare parts. Often smaller communities have combined municipal fleet services, and larger cities have multiple, specialized fleet services.

Regardless of the organizational location of the maintenance facility, its efficiency can be increased by developing a well-defined organizational structure and good reporting procedures. In many vehicle maintenance organizations it is most efficient to have a diagnostician and mechanics who specialize in certain areas such as routine maintenance, compaction equipment repair, etc.

A well-designed preventive maintenance program is essential to controlling repair costs and sustaining high reliability for fleet vehicles. Without an effective preventive maintenance program, vehicles are more likely to experience on-route breakdowns, which are particularly expensive because of towing costs, lost labor, and overtime. As part of the preventive maintenance program, the collection crew should check the vehicle chassis, tires, and body daily, and report any problems to maintenance managers. In addition, each vehicle should have an individual maintenance record that includes the following items:

- a preventive maintenance schedule
- a current list of specific engine or packer problems
- for each maintenance event, a description of repairs and a list including repair date, mechanic, cost, type and manufacturer of repair parts, and the length of time the truck was out of service.

Management personnel should periodically review this information to refine maintenance plans for individual vehicles and to identify improvements to the overall maintenance program.

Equipment Replacement

Plan for equipment replacement.

Some municipalities or hauling companies replace their trucks at a pre-specified mileage or time interval. Although this rule-of-thumb approach is easy to administer, it often results in "lemons" being kept longer than they should and some good trucks being replaced earlier than economically justifiable.

A truck replacement strategy that is based on the actual costs of owning and maintaining individual trucks is likely to result in a more effective use of resources. Using this approach, costs are tracked for each truck, and each truck is replaced as the costs of continuing to own that particular truck exceed the costs of purchasing and operating a replacement truck. Annual costs that should be tracked for existing trucks include the following:

- parts and labor for repair and maintenance
- costs for towing and lost crew time due to breakdowns
- capital loss based on actual decrease in resale value (not book depreciation)
- vehicle operating costs (fuel, insurance, tires, etc.).

Recorded costs should be compared with estimated costs for new trucks, and individual trucks replaced as their individual maintenance records warrant. Replacements of all trucks may nevertheless be required when changes to the entire fleet are needed to accommodate changes to collection procedures. Collection trucks retired from active service can either be used as standby vehicles, for replacement parts, or deployed for other types of service (for example, using old compactor trucks to collect yard materials).

Hiring and Training Personnel

As in all organizations, good personnel management is essential to an efficient, high-quality waste collection system. Management should therefore strive to hire and keep well-qualified personnel for solid waste management.

To hire qualified people, many municipalities use a civil service system. If a civil service system is not used, municipalities should develop a system that minimizes political favoritism in the hiring process. The recruitment program should assess applicants' abilities to perform the types of physical labor required for the collection equipment and methods used. To retain employees, management should provide a safe working environment that emphasizes career advancement, participatory problem solving, and worker incentives.

Safety

Concern for safety is crucial, and an ongoing safety program is a must.

Safety is especially important because waste collection employees encounter many hazards during each workday. As a result of poor safety records, insurance costs for many collection services are high. Collection personnel frequently encounter the following hazards:

- busy roads and heavy traffic
- rough- and sharp-edged containers that can cause cuts and infections
- exposure to injury from powerful loading machinery
- heavy containers that can cause back injuries
- dangers from discarded household hazardous wastes such as herbicides, pesticides, solvents, fuels, batteries, and swimming pool chemicals.

To minimize injuries, haulers should have an ongoing safety program. This program should outline safety procedures and ensure that all personnel are properly trained on safety issues. The safety program should include, at a minimum, the following items:

An adequate safety program includes

- *training*
- *record keeping*
- *protective clothing*
- *refresher sessions.*

- procedures and training in proper lifting methods, material handling, equipment operation, and safe driving practices
- a reporting and record-keeping procedure for accidents
- requirements for protective clothing such as hard hats, gloves, goggles, safety shoes, high-visibility vests, etc.
- frequent refresher sessions to remind workers of safe working habits and department requirements.

Collection managers should closely monitor worker accident and injury reports to try to identify conditions that warrant corrective or preventive measures. For example, some municipalities now offer their collection staff the use of lifting belts to help prevent lower-back injuries. Similarly, during hot weather some municipalities offer workers free beverages that replace electrolytes. The cost of an aggressive, preventive safety program is almost certain to be offset by savings from lost work time and injuries.

Comfort

Concern for employee comfort and providing worker incentives encourage safer work.

Appropriate work place comfort reduces the potential for injuries and enhances employee morale. To make working conditions comfortable, haulers should provide adequate equipment, clothing, and rest facilities. Many haulers furnish clean, comfortable uniforms for employees; doing so, they note, benefits employees and improves the public image of the hauler. In addition, many haulers furnish rain gear, boots, and other special clothing for inclement weather.

Haulers should also provide adequate facilities to meet employees' needs. These facilities should include nearby space for rest rooms, showers, lockers and lunchrooms.

Training

Haulers should develop an employee training program that helps employees improve and broaden the range of their job-related skills. Such training underscores the importance of each individual's contribution to the hauler's overall performance and helps foster a sense of professionalism. The haulers benefit from improved performance and increased flexibility in assigning work to staff.

Training opportunities should also be developed to address safety and liability concerns. Education should address such subjects as driving skills, first aid, safe lifting methods, identification of household hazardous wastes, avoidance of substance abuse, and stress management.

Worker Incentives

Incentives should be developed to recognize and reward outstanding performance by employees. Ways to accomplish motivation include merit-based compensation, awards programs, and a work structure that emphasizes task completion rather than "putting in your time."

Compensation should provide managers with flexibility to reward good performance. Feedback on employee performance should be regular and frequent, however, and not just at annual evaluation time. Award programs acknowledge an employee's accomplishments in the presence of his or her peers. Such programs can be internal (e.g., "employee of the month" award) or through professional organizations such as the Solid Waste Association of North America (SWANA) and the National Solid Waste Management Association (NSWMA).

To improve the efficiency of collection crews, many municipalities use a task system. Under this approach, crew members may go home after their daily collection responsibilities have been completed, rather than wait around until a specified quitting time. This approach provides a built-in motivation for crews to work efficiently and usually reduces the amount of overtime required.

Task system design must ensure a high quality of service; it must also ensure that crews do not compromise safety to complete their work. Routes should be carefully drawn up so that each represents a balanced and reasonable workday. Also, crews should be trained to work at a pace that discourages poor-quality service and minimizes safety hazards or injuries. However, if a task system is used, it is important to ensure that crews do not sacrifice safety or customer satisfaction in the interest of finishing early.

Customer complaints should be handled by crew supervisors, and crews should address the problems raised.

To encourage high-quality service, crew supervisors should field customer complaints and then have the crew receiving the complaint address problems associated with it. In some cities, a separate crew addresses complaints, but this system requires other feedback mechanisms to help crews learn from their mistakes.

Developing and Managing Contracts with Labor Unions and Private Collectors

Labor unions are common in much of the solid waste collection industry. It is therefore likely that municipal collection departments will be required to bargain collectively with labor unions. If this is the case, the department should usually designate a labor management relations group to handle collective bargaining. In addition, as part of the labor management relations process, the department should set a formal procedure for managing employee grievances. This procedure should be designed to allow employees to file grievances without concern of reprisal. Grievances should be handled quickly and fairly.

If a municipality decides to contract for collection services, selection of the contractor will usually require the issuance of service specifications and evaluation of contractors' bids. The municipal department responsible for overseeing collection should work with municipal purchasing groups to request, evaluate, and award bids for waste collection. The municipality should ensure that it has adequate resources to monitor the performance of collection contractors in meeting contract requirements.

Providing Public Information

Maintaining good communications with the public is important to a well-run collection system. Residents can greatly affect the performance of the collection system by cooperating with set-out and separation requirements, and by keeping undesirable materials, such as used oil, from entering the collected waste stream.

System managers must maintain effective communication with the public at every stage of the process.

Collection system managers should creatively use available communication methods and materials to remind customers of set-out requirements, inform them of changes to those requirements, provide them with names and telephone numbers of key contacts, and provide them with helpful feedback on system performance. Commonly used methods of communicating information include brochures, articles in community newsletters, newspaper articles, announcements and advertisements on radio and television, informational attachments to utility bills, and school handouts. These materials should be designed to communicate new information, but also to remind customers of service requirements; this is particularly important in communities with highly transient populations such as university students.

Communication materials should be used to help residents understand community solid waste management challenges and the community's progress in meeting them. For example, residents should be regularly updated on how well the community's recycling program is doing in meeting waste reduction goals and any recurring problems, such as contamination of materials set out for collection. Residents should also be kept informed about issues such as the availability and costs of landfill capacity so that they develop an understanding of the issues and a desire to help meet their community's solid waste management needs.

In San Diego, collection workers go door-to-door to explain new programs. This approach gives crews an opportunity to meet their customers and develop greater personal awareness and pride in meeting their customers' needs.

MONITORING SYSTEM COSTS AND PERFORMANCE

System costs and performance in light of program goals should be continually monitored.

Short-term feedback is necessary for accurate program evaluation and planning to meet new needs.

Collection and transfer facilities should develop and maintain an effective system for cost and performance reporting. Each collection crew should complete a daily report that includes the following information:

- total quantity hauled (tons or cubic yards)
- total distance and travel times to and from the disposal site
- amounts delivered to each disposal, transfer, or processing facility (if there is more than one site)
- waiting times at sites
- number of loads hauled
- vehicle or operational problems needing attention.

In addition, transfer stations should collect vehicle and weight information. If a scale is used at the transfer station, waste quantities, vehicle origins, and delivery times can be collected using a computerized logging system.

Collected data should be used to forecast workloads, track costs, identify changes in the generation of wastes and recyclables, trace the origin of problematic waste materials, and evaluate crew performance. Managers should use such information to identify changes in service needs and to evaluate the effectiveness of the collection system in meeting its goals and objectives. To be effectively used by managers for such purposes, reports must provide concise summaries that track the status of identified key performance parameters, while allowing optional access to more detailed data that can be used to more thoroughly investigate a particular problem or issue.

Just as the goals of a collection program set its overall directions, a monitoring system provides the short-term feedback necessary to identify the course corrections needed to achieve those goals.

REFERENCES

American Public Works Association, Institute for Solid Wastes. 1975. *Solid Waste Collection Practice*, 4th edition. Chicago, IL: APWA.

Hickman, H. L. 1986. "Collection of Residential Solid Waste." In *The Solid Waste Handbook: A Practical Guide*, ed. by W. D. Robinson. NY: John Wiley & Sons.

Lueck, G.W. 1990. "Elementary Lessons in Garbage Appreciation," *Waste Age* (September).

Peluso, R. A. and E. H. Ruckert, III. 1989. "Designing for Smooth Transfer Operations." *Waste Age*, April.

Presgrave, R. 1944. *The Dynamics of Time Study*. Toronto: Univ. of Toronto Press.

Schaper, L. T. 1986. "Transfer of Municipal Solid Waste." *The Solid Waste Handbook.* NY: John Wiley & Sons.

Tchobanoglous, G.; H. Theisen; and R. Eliassen. 1977. *Solid Wastes: Engineering Principles and Management Issues*. NY: McGraw-Hill.

USEPA. 1974. *Heuristic Routing for Solid Waste Collection Vehicles*. DSW / SW-1123.

USEPA. 1974a. *Residential Collection Systems, Volume 1: Report Summary*. SW-97c.1.