Transfer

CE 431: Solid Waste Management

Transfer Stations

- Transfer stations are the sites on which transfer of waste is carried out, placed on small and then larger vehicles for transportation over long distances directly to the processing or final disposal site. At their simplest they can consist of open ground where waste is unloaded from one vehicle and subsequently picked up by other vehicles for long-range transport
- The main reason for waste transfer is to optimize the productivity of vehicles and collection crews as they remain closer to routes, while larger vehicles make the longer trip to processing and disposal sites, and reduce overall system costs

Benefits of Transfer Stations

- Minimize collection vehicle routing complexities
- Provide an opportunity to increase waste density
- Minimize illegal waste dumping.
- Can serve as a controlled place for sorting and processing the waste
- Minimize traffic congestion
- Reduce maintenance costs of collection vehicles
- Improve waste dumping efficiency at final disposal site

Problems with Transfer Stations

- increased traffic volume, noise and air pollution in the surrounding areas, and
- unless they are properly maintained there is a potential for environmental damage (leachate, odour, disease carriers, aesthetic and similar problems) in the surrounding area.

Factors to consider

- location – governed by the proximity of the collection routes, access to the major haulage routes, isolation from the community
- quantity of waste to be transferred/handled
- types and number of primary and secondary vehicles served
- types of transfer operations
- equipment requirements
- waste characteristics
- climate
- sanitation provision
- costs.

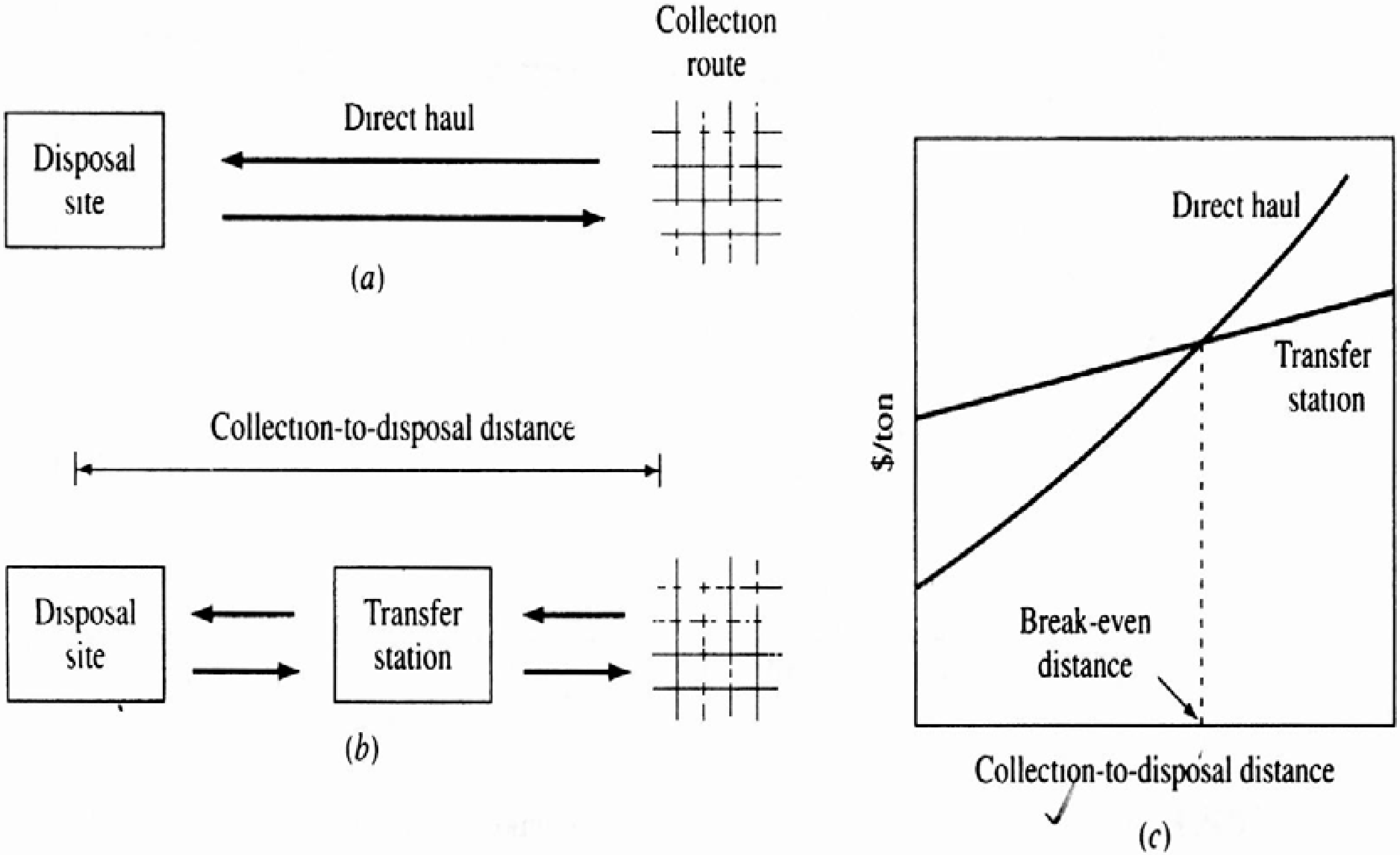


FIGURE 9.17 The cost curve for a direct-haul system (*a*) starts lower but rises more steeply than the cost curve when a transfer station is included (*b*). At some distance, where the curves cross, the transfer station option becomes more cost effective (*c*).

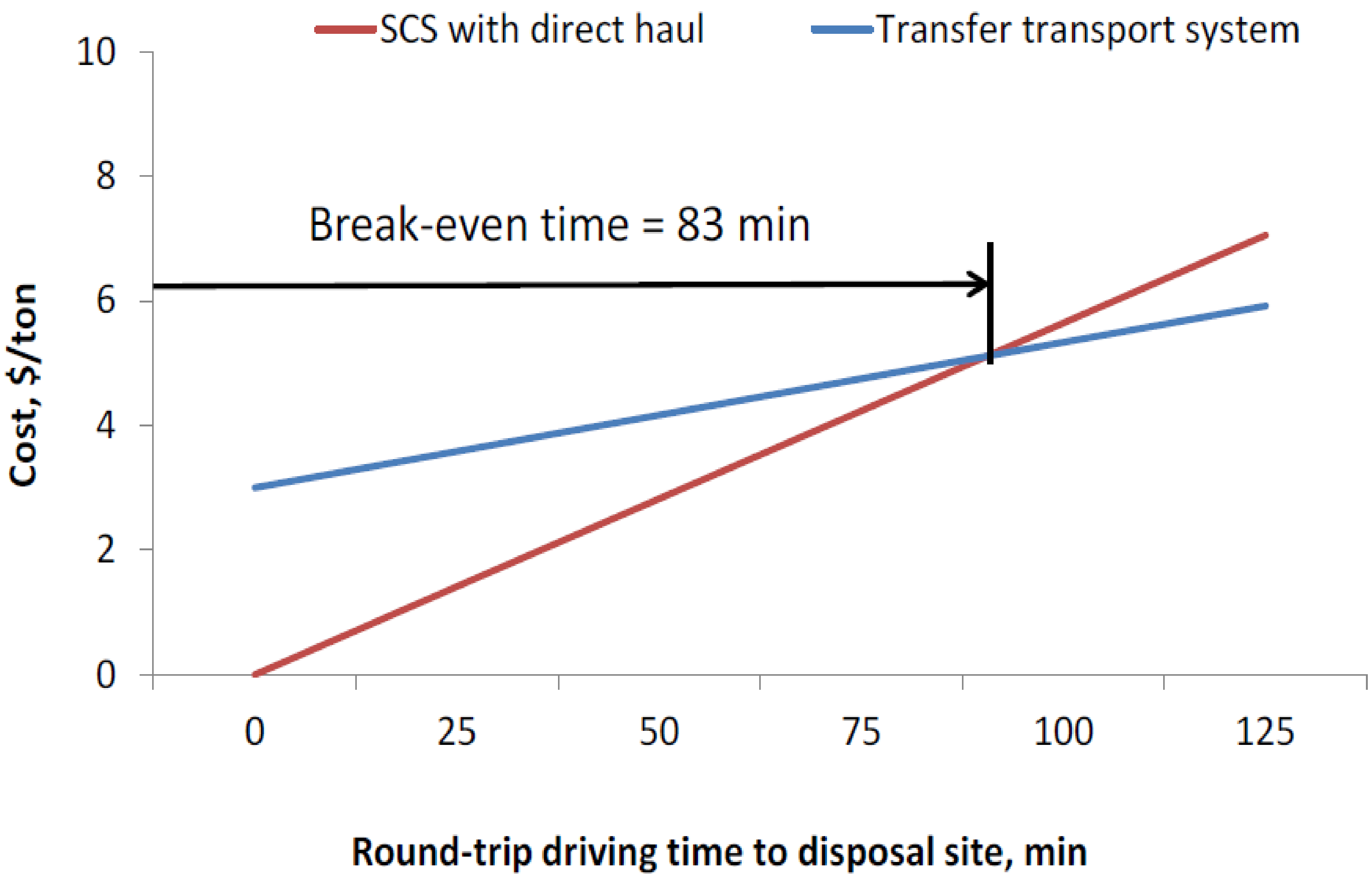
Comparison of SCS and Transfer & Transport System

Determine the break-even time for a stationary container system with a separate transfer and transport system for transporting wastes collected from a municipal area to a landfill site. Assume the following data while calculating:

Transportation cost:
Stationary container system using an 18 m^3 compactor: $20/ hr
Tractor-trailer transport unit with a capacity of 120 m^3: $25/ hr

Other costs:
Transfer station operating cost: $ 0.40/m^3
Extra cost for unloading facilities: $ 0.05/m^3
Other data:
Density of wastes in compactor = 325 kg/ m^3
Density of wastes in transport unit = 150 kg/ m^3

Comparison of SCS and Transfer & Transport System



Comparison of SCS and Transfer & Transport System

- Before the break-even time, SCS seems to be more economic
- At break-even time, two systems are indifferent.
- After the break-even time, transfer transport system seems to be more economic

Collection Vehicles

General Considerations:

- Territory
- Access road
- Transport Regulations
- Travel Distance
- Integration
- Performance
- Type of Properties
- Storage Facilities
- Type and density of collection points

Collection Vehicles

General Considerations:

- quantity of waste – rate of generation and frequency of collection
- waste characteristics – constituents, abrasive, dense, low-density
- traffic levels – vehicles should be harmonious with existing traffic
- standardization – minimize overall maintenance costs
- payload capacity – the amount of waste that can be carried depends on the body weight of vehicles (that is, vehicles with lower body weight can carry more waste
- size of cab – often it is overlooked although it does not cost much
- technical know-how – availability of skilled labor for operation and maintenance
- cost – capital, operation and maintenance cost.

Improved Collection and Transfer: Industrialized vs developing countries

Labor Productivity and Waste collection system design

The objective of improved collection is defined in Habitat (undated) as:

- development and use of, as far as possible, relevant, efficient, indigenous
- equipment that requires the least cost per ton to operate,
- optimization of labor and equipment requirements, such that productivity is ensured for labor and equipment, and
- minimization of vehicle round-trip and out-of-service time.

Choice of Collection Vehicles

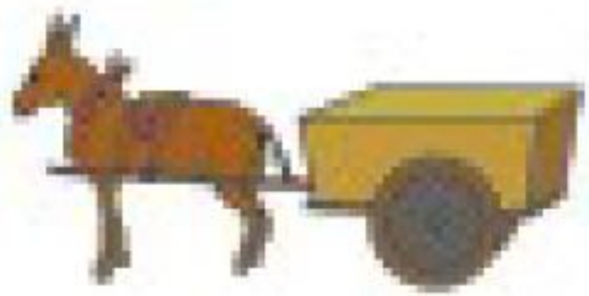
- Human and Animal powered Vehicles
- Motorized Vehicles

Human and Animal Powered Vehicles

- Human-powered vehicles generally include handcarts and three-wheeled pedal carts.
- Animal-powered vehicles mostly include animal panniers (bags or buckets carried over the back of the animal) and animal carts.
- The carrying capacities of these vehicles range from 70 gallons for human carts to about 500 gallons for animal carts.
- The operational radius often varies from about 1km for human carts to about 3km for animal carts

Human handcart

Animal cart



Human pedaldcart

Table 4.4: Characteristics of typical human- and animal-powered collection vehicles

Human-powered	Animal-powered
Handcarts [Figure 4.1 (a)]	**Panniers**
• carrying capacity up to 250kg • widely used in developing countries • low capital and maintenance costs • pollution (noise and air) free • suitable for small haulage (up to 1km) • unsuitable for very hilly areas or poor roads	• carried over the back of animals • used in an area unsuitable for wheeled vehicles • limited speed and capacity
Tricycles [Figure 4.1(a)]	**Carts [Figure 4.1(a)]**
• carrying capacity up to 130 gal • widely used in developing countries • low capital and maintenance costs • pollution (noise and air) free • suitable for haulage up to 3km • can operate poorly surfaced roads • unsuitable for very hilly areas	• carrying capacity up to 500 gal • widely used in developing countries • low maintenance costs • suitable for haulage up to 3km • can operate on poorly surfaced roads • cause considerable traffic obstruction • unsuitable for very hilly areas

Motorized Vehicles

- Motorized (road) vehicles used in solid waste collection have a much larger range than human- and animal-driven transport.
- In developing countries, along with purpose-made vehicles, small (open or closed body) trucks and motor tricycles (small two-stroke, three-wheeled vehicles) have also been used.
- In general, motorized trucks tend to have both a higher capital cost and higher maintenance costs, particularly in developing countries, than the other modes of transportation discussed.

Types of Motorized Vehicles

Waste collection and transportation equipment (mostly used in industrialized countries), depending on the types of collection bodies adapted and available with a compaction mechanism, can be divided into 4 general categories:

- Compaction vehicle
- Semi-compaction vehicle
- Non-compaction vehicle
- Container handling systems

Compaction Vehicle

- Widely used in industrialized countries to compact waste before long-range transportation, and in many cases this is done during collection.
- The heavy weight of the body a compacting mechanism (in the range of 3-5 tons) reduces the payload capacity of the vehicle and thus increases operation and maintenance costs.

Non-Compaction Vehicles

- Solid waste in developing countries is typically of higher density, so pay full load of waste collection vehicles can be obtained without any compaction mechanism.
- In many industrialized countries , these vehicles are also used to carry specific waste(large bulky items, furniture etc).
- However , non-compaction collection vehicles generally require a larger body than compaction vehicles to attain their full payload.

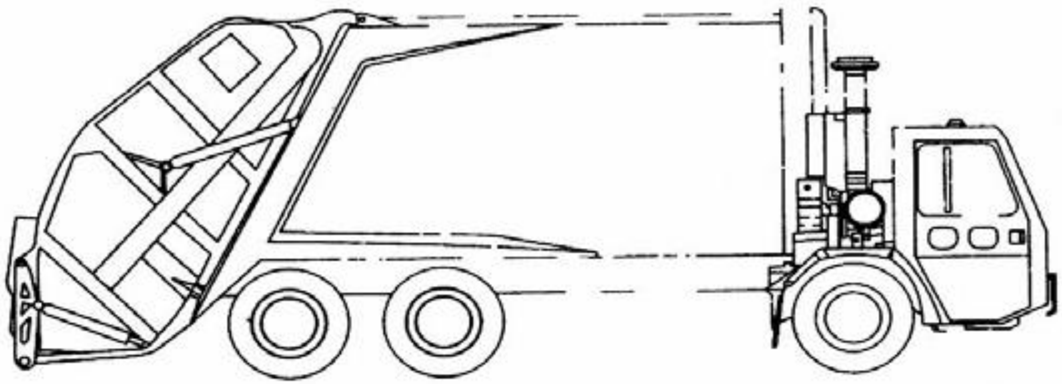
Semi-Compaction Vehicles

- It represents a halfway between compaction and non-compaction vehicles.

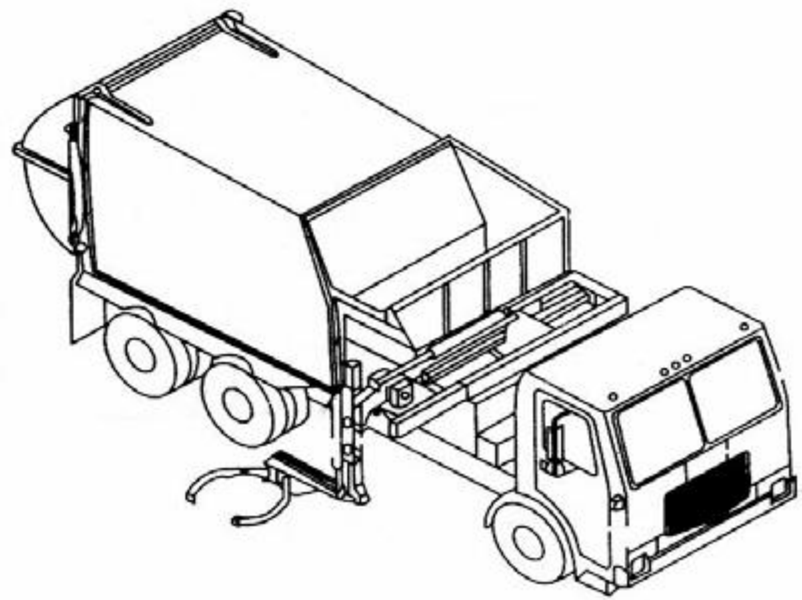
- Some reduction in waste volume is achieved


Container Handling Systems

- Container handling systems are used in attempt to reduce the loading time, and hence maximize the productivity of the vehicles.
- The containers can be placed just about anywhere that space allows ; for example , at a transfer station or throughout residential areas as communal bins.
- They are filled with waste while not attached to the vehicles and subsequently either emptied into a vehicle on site, or collected and taken (in case of hauled-container systems) to the final disposal site for emptying.



Rear-loading packer truck



Automated side-loader packer

FIGURE 9.13 Examples of a rear-loading packer truck and a side-loading truck with an automated arm to pick up trash containers.

Maintenance of Collection Vehicles

The overall productivity of a vehicle depends on the total amount of time the vehicle remains operational during its productive life. Although a substantial amount of money is spent in the acquisition of vehicles for solid waste management, it is evident from Coad (1997) that the operation and maintenance costs of collection vehicles are often not considered in vehicle procurement processes.

Generally vehicle maintenance is being carried out in the following two ways:

- preventive maintenance: and
- breakdown maintenance.

Maintenance of Collection Vehicles

Preventive maintenance:
Preventive maintenance in the service of vehicle that occurs when they seems to be working efficiently in order to identify problems before they occur. Preventive maintenance should be carried out at regular intervals that are generally based on distance of a vehicle travelled or hours of operation. Minor preventive maintenance activities should be carried out daily or weekly.

Breakdown maintenance:
Breakdown or crisis maintenance is the repair of the vehicle once problem have already occurred. In the developing countries, this is the only sort of maintenance that occurs. It is easy to plan and works to simply as a response to problems as they occur. However, it may lead to long down times (the length of time that the vehicle is out of operation).

Collection Vehicle Routing

- The selection of proper collection routes is important to maximize the productivity of collection vehicles to reduce waste collection costs. The principal approaches to design the
- collection routes may be broadly classified as:

1. Heuristic
2. Deterministic

<u>Heuristic:</u>
This is an old system of assigning routes which mainly based on experience and intuition and therefore depends on the experience of the users

<u>Deterministic:</u>
The deterministic approach attempts to detect the optimum solution through developing mathematical models with the input of local data.

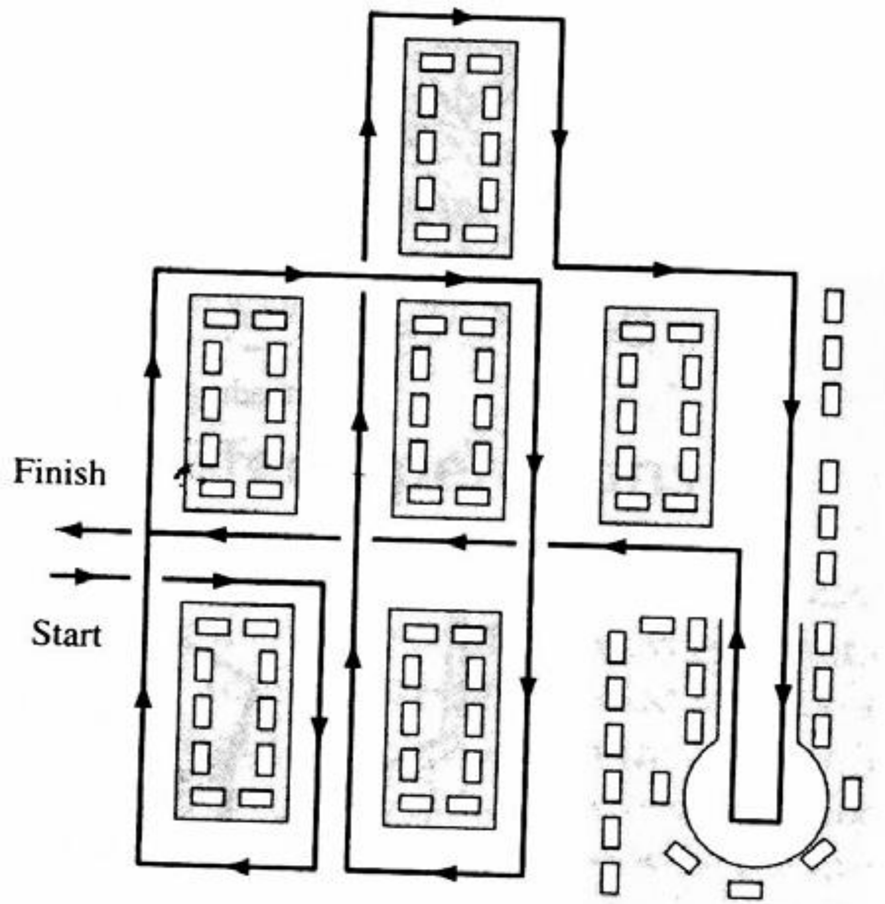


FIGURE 9.14 A heuristic route emphasizing right turns and a minimum amount of deadheading.

Economics of Solid Waste Collection

The economic costs of solid waste collection includes:

- planning and design
- procurement, operation and maintenance of waste collection equipment (vehicles, storage container, as well as cost of workshop/garage facilities and auxiliary civil works)
- skilled and unskilled labour, and drivers involved directly in collection services
- a percentage of administrative costs
- resource recovery (if there is a resource recovery system not at source but in the collection stream).

Economics of Solid Waste Collection

- To decide on the truck size that would provide the cheapest waste transport, we need to know the annual cost of owning and operating trucks, including the cost of the crew that makes the pickups.

- Finding the annualized cost of each truck involves using an engineering economy calculation in which capital cost, amortized over the lifetime of the vehicle, is added to the estimated annual maintenance and fuel costs.

Economics of Solid Waste Collection

The relationship between the purchase price of capital equipment, such as trucks and the amortized yearly cost is given by:

$$A = P\left[\frac{i\left(1+i\right)^{n}}{\left(1+i\right)^{n}-1}\right]$$

where, A = annual cost ($/yr)

P = purchase price, ($)

i = interest rate, discount rate (yr^{-1})

n = amortization period (yr)

$[i(1+i)^n \;/\; \{(1+i)^n - 1\}]$ = Capital Recovery Factor (CRF)

Economics of Solid Waste Collection

- The annualized cost of a vehicle will depend on its size and usage. One approach to analyzing its economics is to use a simple linear model as follows:

$$\textbf{Annualized cost (\$/yr)} = \alpha + \beta V$$

- where, α and β are empirically determined estimates based on a survey of available vehicles,
- V = truck volume

Economics of Solid Waste Collection

Problem: An Economic Analysis of Refuse Collection

Suppose the annualized cost of purchasing, fueling and maintaining a compactor truck is given by the following expression:

Annualized cost ($/yr) = 25000 + 4000V

Where, V is the truck volume in cubic yards.

Suppose these trucks require two person crews, with labor charged at $24 per hr each (including benefits). Perform an economic analysis of the collection system, in which a 14.4 yd^3 truck collects refuse from 340 households each day. Each household generates 60 lbs of refuse per week. The trucks and crew work 5 days per week and curb-side pickup is provided once a week for each house. What is the cost per ton of refuse collected and what is the cost per household?

Economics of Solid Waste Collection

TABLE 9.17

Comparison of Costs for Trucks Making One, Two, or Three Trips Per Day to a Disposal Site

Number of Trips Per Day	Houses Served Per Truck	Minimum Truck Size (yd^3)	Annualized Costs: Truck ($/yr)	Annualized Costs: Labor ($/yr)	Cost Per Ton ($/ton)	Cost Per Household ($/yr)
1	2,061	34.9	164,556	99,840	$82.25	$128.31
2	1,702	14.4	82,643	99,840	$68.80	$107.32
3	1,344	7.6	55,338	99,840	$74.02	$115.47

- Under the assumptions made in the analysis mentioned above, mid-sized trucks are optimum.
- Larger trucks make fewer runs to the disposal site, but their capital cost is too high.
- On the other hand, use of smaller trucks holds their capital cost down, but the extra time spent driving back and forth reduces the number of customers served, which more than offsets that advantage.

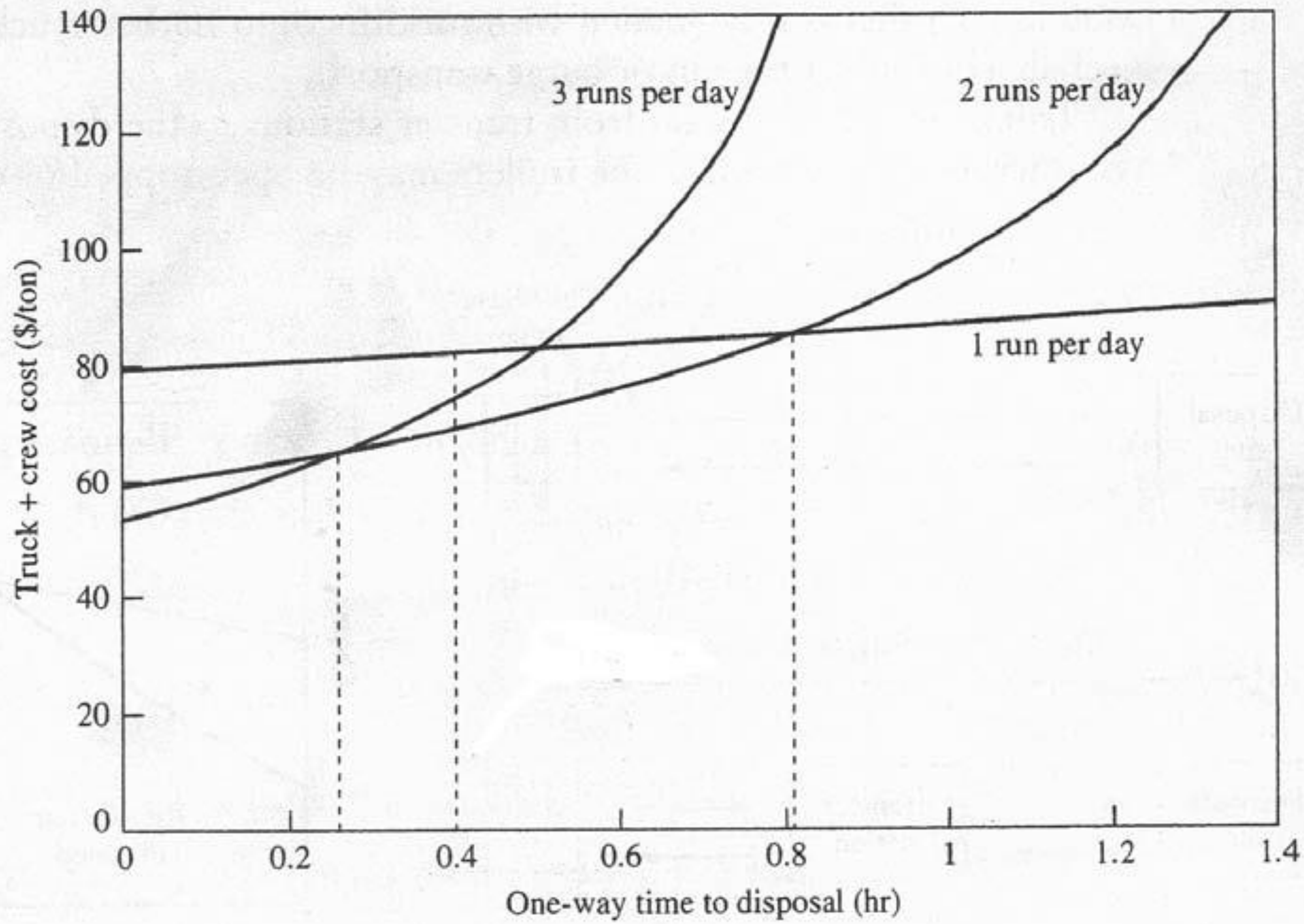


FIGURE 9.16 The optimum number of trips to make per day to the disposal site is sensitive to the time needed to make the drive. For short distances, smaller trucks making more trips are optimum. For long distances, large trucks that can collect all day long before disposal become more cost effective. This figure is based on assumptions in Examples 9.6 and 9.7.

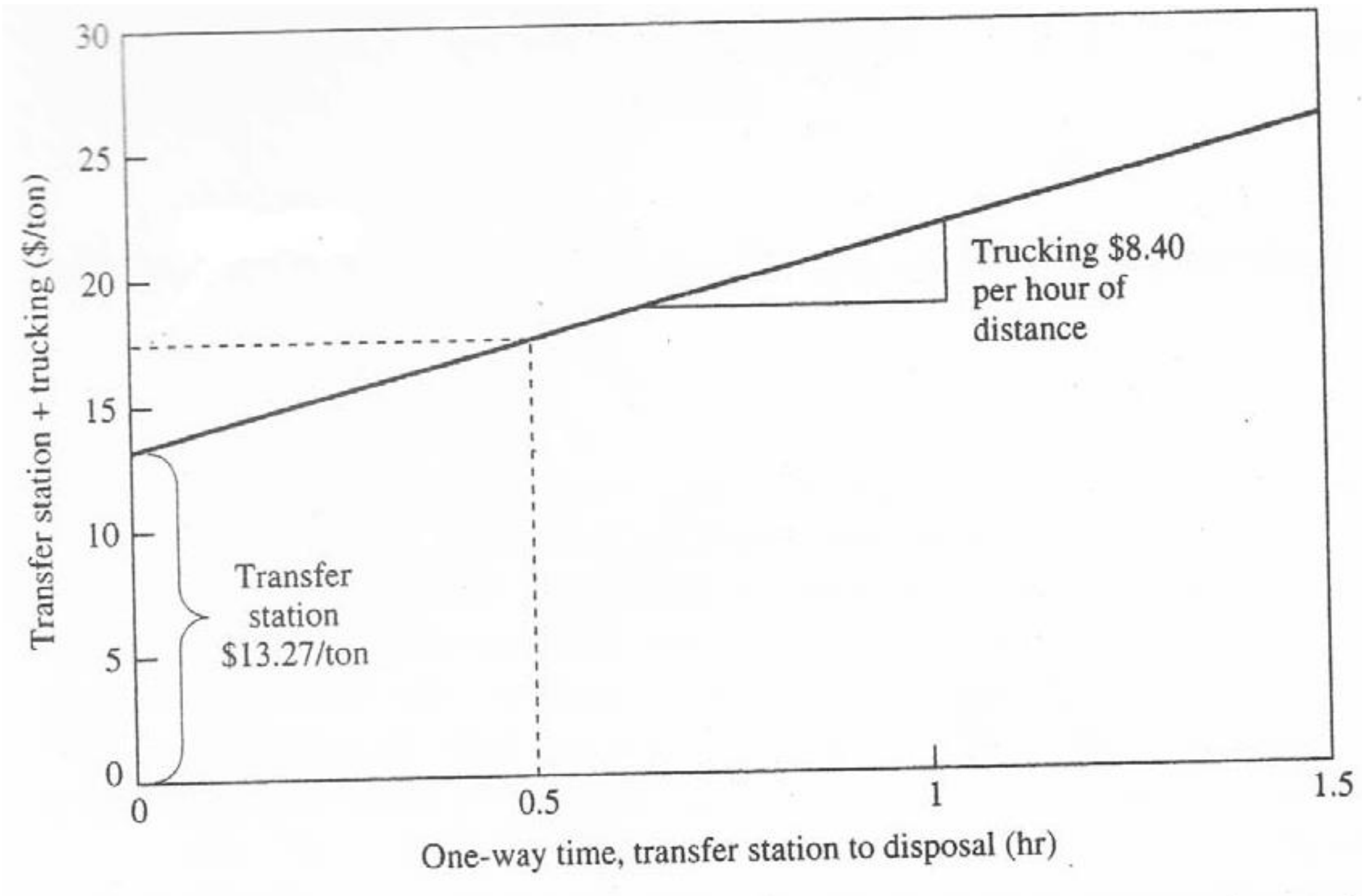
Economics of Solid Waste Collection

Problem: Costs of a Transfer Station and Its Vehicles

A transfer station handling 300 tons/day, 5 days per week, costs $5 million to build and $150000 per year to operate. An individual tractor-trailer costs $140000 and carries 15 tons/trip. Operation and maintenance costs (including fuel) of the truck are $50000/yr; the driver makes $40000 per year 9including benefits). The capital costs of the building and transfer trucks are to be amortized over a 10-yr period using a 12% discount factor.

Suppose, it takes 30 minutes to make a one-way trip from the transfer station to the disposal site and 7 round trips per day are made. Find the transfer station and hauling cost in dollars per ton.

Economics of Solid Waste Collection



Environmental Costs

- consumption of energy and generation of atmospheric emissions
- production storage facilities (e.g. bags, bins)
- maintenance of storage containers
- treatment (e.g. separation, home composting) of waste materials at
- sources
- environmental benefits.