Chapter 8

Collection of Solid Waste

Collection accounts for 50-90% of the budget of a MSW management system!

Collection of MSW

- ***Collection*** includes not only the ***gathering*** or ***picking up*** of SW from various sources, but also the ***hauling*** to the location where the contents of the collection vehicles are emptied.
- The unloading of collection vehicle is also considered part of the collection operation.
- Activities associated with ***hauling*** and ***unloading*** are similar for most collection systems.
- ***Gathering*** or ***picking up*** of SW will vary with the characteristics of facilities, activities, or locations where wastes are generated and the methods used for onsite storage of accumulated wastes between collections.

Collection of commingled MSW

Curbside Collection
(manual)

Curbside Collection
(mechanized)

From low-rise detached dwellings

- Types of residential collection services
  - Curb – in front of house on the curb
  - Alley – one or two containers in the alley
  - Setout-Setback – forth and back to the house
  - Setout – forth but not back to the house

- Manual methods
  - Direct lifting and carrying of loaded containers
  - Rolling of loaded containers
  - Use of small lifts for rolling loaded containers

From low-and medium-rise apartments

- Transporting the container to the street for curbside collection by manual or mechanical means

From high-rise apartments

- Emptying mechanically using collection vehicles equipped with unloading mechanism
- Hauling to an off-site location

From commercial-industrial facilities

- Both manual and mechanical means
- Using ***movable containers*** to large ***stationary compactors***
- Using ***large open-top containers***
- To avoid traffic congestion during the day, solid wastes from commercial establishments in many large cities are collected in late evening and early morning hours.

From commercial-industrial facilities

- Using private haulers or city crew
- In some cities, ***cardboard*** is ***bundled*** and left at curbside where its collected separately.
- In large commercial facilities ***baling equipment*** may be used for the ***paper and cardboard***, and ***crushers*** are used for the ***aluminum cans*** and ***plastics***.

Collection of separated MSW

- Waste materials that have been separated at the source must be collected or gathered together before they can be recycled.
- The principal methods now used for the collection of these materials include curbside collection.

Curbside Collection

Vechiles used for separate collection

- Standard trucks
- Compactor trucks
- Mobile container system
- Modified flatbed truck
- Open-bin recycling truck
- Closed-body recycling truck

Collection System Types

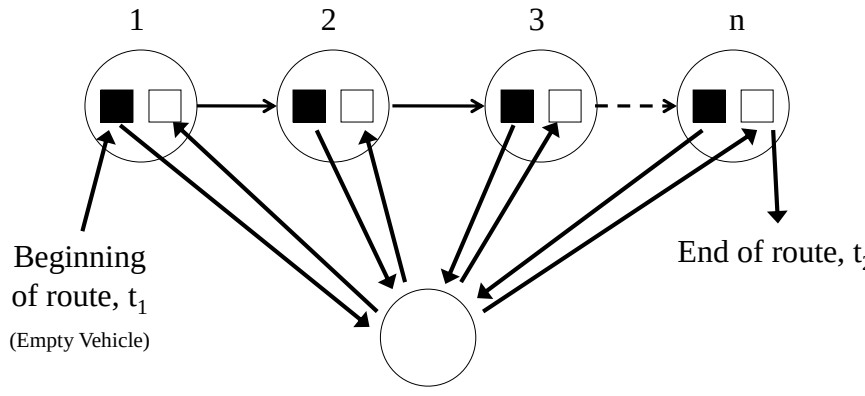
- Hauled Container System (HCS)
  - Container is moved to disposal site
  - Used for construction & demolition waste
  - High generation rates (open markets)
  - One drive and frequent trips
- Stationary Container System (SCS)
  - Container remains at site (residential and commercial)
  - May be manually or mechanically loaded
  - Container size and utilization are important

Hauled Container System (HCS)

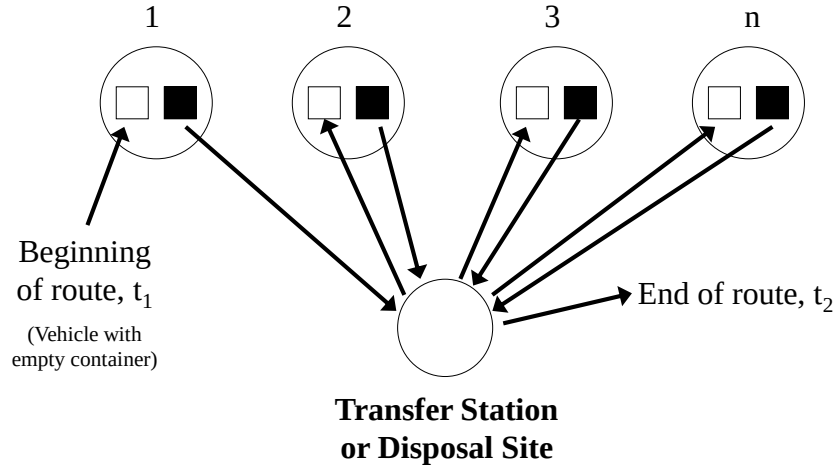
- Ideally suited for the removal of wastes from sources where the rate of generation is high
- The container is picked up and hauled off to the disposal area where the container is emptied and returned to the original location (conventional mode).
- The container is carried by the truck.
- A variation (exchange container mode) is start with an empty container.

Hauled Container System (HCS)

HCS: Conventional mode



HCS: Exchange container mode



Hauled Container System (HCS)

Advantages:

- Useful when generation rate is high and containers are large
- May eliminate spillage associated with multiple smaller containers
- Flexible. Need more capacity, use a larger container

Disadvantage:

- If the containers are not filled, low utilization rate.

Stationary container system (SCS)

- SCS can be used for the collection of all types of wastes
- The waste container remains in the vicinity of where the waste is generated.
- The waste is unloaded into a bigger truck. A large container is an integral part of the truck.
- When fully loaded from multiple waste containers, the truck travels to and from the landfill as opposed to the waste container.

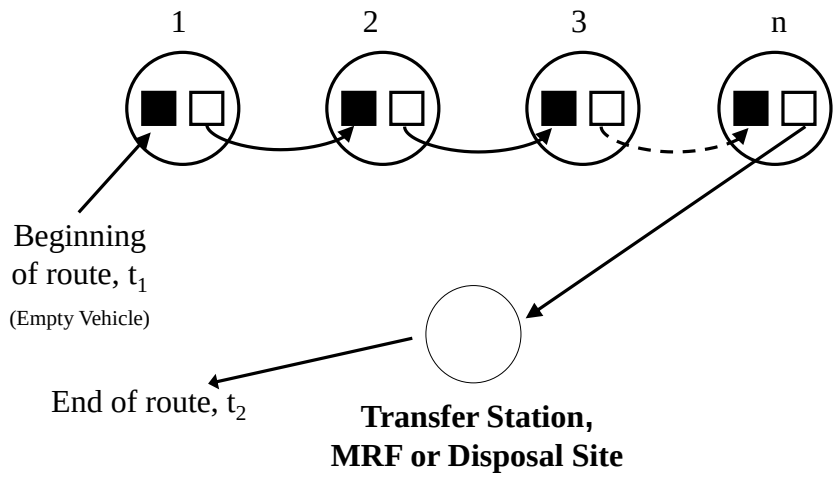
Stationary container system (SCS)

Types:

- Manually loaded: Small containers, residential pickup.
- Mechanically loaded: Larger containers, wheeled residential pickup and commercial pickup

- Almost all vehicles contain internal compaction equipment

Operational Sequence of SCS



Stationary container system (SCS)

- *Advantages*:
  - Major advantage is that vehicle does not travel to disposal area until it is full yielding higher utilization rates
- *Disadvantages*:
  - System is not flexible in terms of picking up bulky goods
  - Wastes e.g. demolition, that make damage the relatively delicate mechanisms
  - Large volume generations may not have room for storing large containers

Analysis of Collection Systems

To determine

- Capacity of vehicle
- # of vehicle required
- Crew size
- Labor required
- Length of workday/week

Look at: (divide collection into specific tasks)

- Pick up time
- Haul time
- At site time
- Off route time
- Container capacity,waste volume generated
- Vehicle compaction factor

Analysis of Collection Systems

- The activities involved in the collection of solid wastes can be resolved into four unit operations

Pickup

P_{HCS}

- time spent driving to the next container
- the time spent picking up the loaded container
- time required to re-deposit the container after it has been emptied

P_{SCS}

- time spent loading the vehicle, beginning with the first container and ending when the last container has been loaded

Analysis of Collection Systems

Haul (h)

- HCS- The time required to reach the location where the waste will be emptied
- SCS - The time required to reach the location where the full vehicle will be emptied and continuing until the truck arrives at the location

At-site (s)

- The time spent at the site (landfill, transfer station) where the system is unloaded (including waiting time)

Off-Site (W)

- Non-productive activities (Check in, check out, meeting, breaks)
- Typically 15%

Collection Vehicles (avg. life 5-7 years)

Side loader

Front loader

Rear loader

Collection Vehicles (avg. life 5-7 years)

Crane truck for 'igloo' containers

Truck with tilt frame for hauled containers

Hoist truck for hauled container

Collection Routes

Path established by

- Trial and error
- Computer
- Heuristic methods (common sense)

Steps

- Define collection area
- Assign disposal sites if more than one
- Establish daily collection zones - collection area divided into sections for daily service established based on compacted volume

Collection Routes

Steps

- Balance daily vehicle assignments (districting)
- Route vehicles within daily districts
  - Location maps with pertinent info; sources, volume, containers
  - Layout preliminary routes

Rules

- Begin and end near arterial streets
- Start at top of hills
- Work toward disposal site
- Work in congested areas during non-rush hours
- Large quantities first

Example 8.2 Determination of haul-speed constants

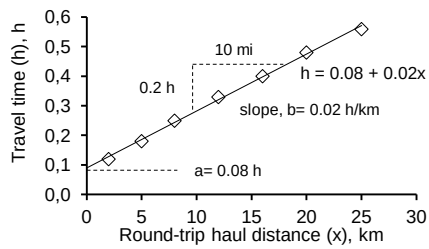
The following average speeds were obtained for various round-trip distances to a disposal site. Find the hauled speed contants a and b and the round-trip haul time for site that is located 11 km away.

Round-trip distance (x), km	Average haul speed (y), km/h	Total time (h=x/y), h
2	17	2/17=0.12
5	28	0.18
8	32	0.25
12	36	0.33
16	40	0.40
20	42	0.48
25	45	0.56

Example 8.2 Determination of haul-speed constants

Solution

Plot x/y, which is the total haul travel time versus the round-trip distance as shown below.



The round-trip haul time for the site that is located 11 km away.

Round-trip distance, x = 2 (11 km) = 22 km

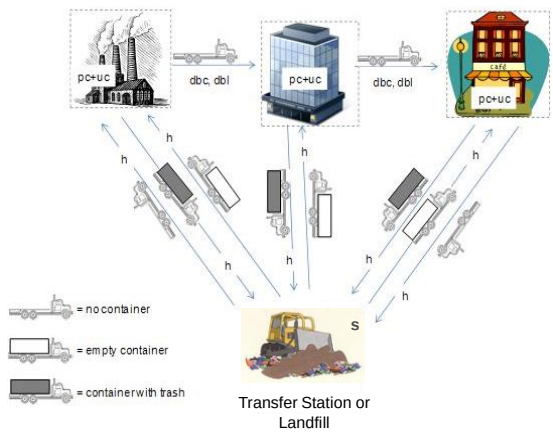
Round-trip haul time, h = a + bx = 0.080 h + (0.020 h/km) (22 km)

= 0.52 h

Example 8.3 Analysis of a hauled container system

- Solid waste from a new industrial park is to be collected in large containers, some of which will be used in conjunction with stationary compactors.
- Based on traffic studies at similar parks, it is estimated that the average time to drive from garage to the first container location (t1) and from the last container location (t2) to the garage each day will be 15 and 20 min, respectively.
- If the average time required to drive between containers is 6 min and the one-way distance to the disposal site is 15.5 mi (speed limit: 55 mi/h → a = 0.016 h/trip b = 0.018 h/trip), determine the number of containers that can be emptied per day, based on an 8-h workday.
- Assume the off-route factor, W, is equal to 0.15.

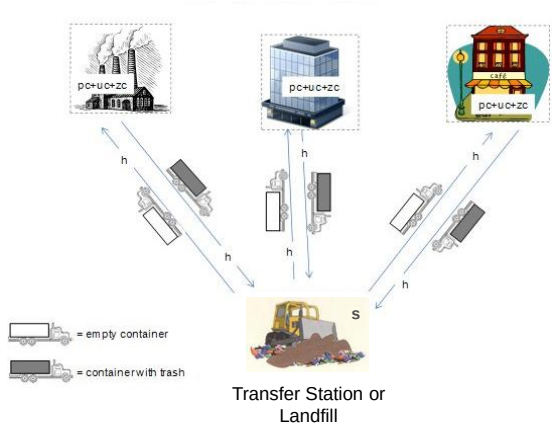
HCS: Conventional mode



A round trip *starting from the time the truck arrives at a waste generation site would be*:

- pickup the container, **pc**
- drive to the disposal site with the used container, **h**
- empty the container at the disposal site, **s**
- drive to the generation site with the empty container, **h**
- return the empty container to the pickup location in Step 1, **uc**
- drive to the next pickup location with an empty truck (no container), **dbc**

HCS: Exchange container mode



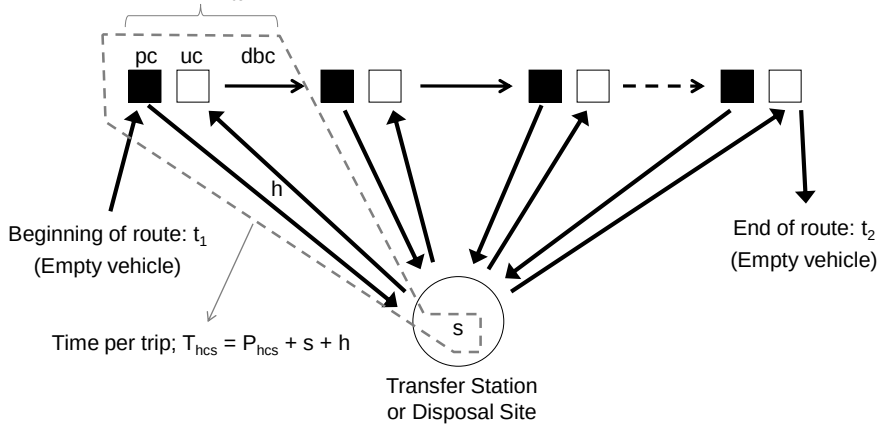
A round trip starting from the time the truck leaves the disposal site would be:

- drive to the pickup location with an empty container on truck, h
- unload the empty container, pickup the used container, reposition the empty container, (uc+pc+zc)
- drive to the disposal site, h
- empty the container at the disposal site, s

Round trip sequence is now complete. After at-site time, vehicle will start the round trip sequence again and drive to next site.

Example 8.3 Analysis of a hauled container system

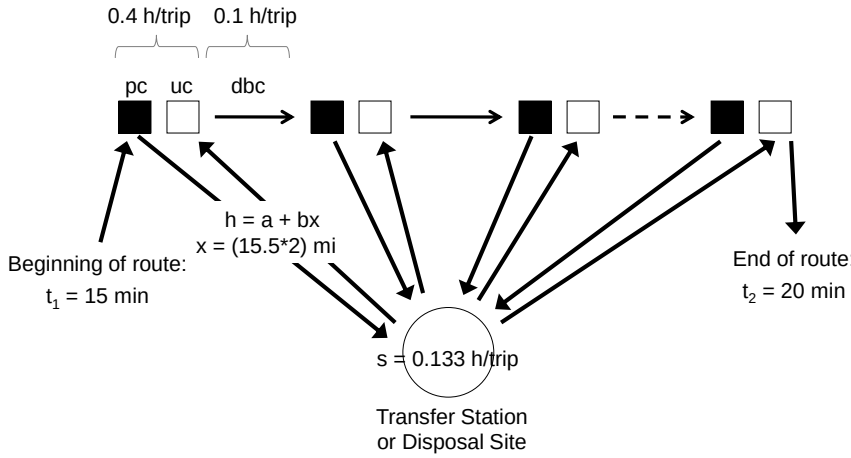
Pickup time per trip; P_{hcs} = pc + uc +dbc



Number of trips; $N_d = [H(1-W)-(t_1+t_2)] / T_{hcs}$

H : length of work day, h/d
W : off-route factor, %

Example 8.3 Analysis of a hauled container system



Number of trips; $N_d = [H(1-W)-(t_1+t_2)] / T_{hcs}$ H = 8 h/d
W = 15%

Example 8.3 Analysis of a hauled container system

Solution

- Determine the pick-up time per trip: P_{hcs} = pc + uc + dbc
  - pc: time required to pick up loaded container, h/trip
  - uc: time required to unloaded empty container, h/trip
  - pc + uc = 0.4 h/trip (from Table 8-5)
  - dbc: time req. to drive between container locations = 6 min/trip = 0.1 h/trip
  - P_{hcs} = pc + uc + dbc = 0.4 + 0.1 = 0.5 h/trip
- Determine the time per trip: $T_{hcs} = P_{hcs} + s + h = P_{hcs} + s + a + bx$
  - s: at site time = 0.133 h/trip (from Table 8-5)
  - a = 0.016 h/trip b = 0.018 h/trip
  - T_{hcs} = 0.5 + 0.133 + 0.016 + 0.018(31) = 1.21 h/trip
- Determine the # of trips that can be made per day:
  - $N_d = (H(1-W)-(t1+t2))/T_{hcs}$
  - N_d = (8h/d (1-0.15)-(0.25h+0.33h))/1.21 h/trip
  - N_d = 5.14 trip/d ≈ 5 trips/d

Problem 8.8

- Because of a difference of opinion among city staff members, you have been retained as an outside consultant to evaluate the collection operation of the city of XXX. The basic question centers around the amount of time spent on off-route activities by the collectors. The collectors say that they spend less than 15% of each 8-h workday on off-route activities; management claims that the amount of the time spent is more than 15 percent. You are given the following information that has been verified by both the collectors and management:
- From this information, determine whether the truth is on the side of collectors or the management.

Problem 8.8

- A hauled container system is used.
- The avarage time spent driving from yard to the first container is 20 min, and off-route activities ocur.
- The avarage pick up time per container is 6 min.
- The avarage time to drive between containers is 6 min.
- The avarage time required to empty the container at the disposal site is 6 min.
- The avarage round trip distance to the disposal site is 10 mi/trip, and the haul equation (a+bx) constants are a: 0,004 h/trip and b=0,02 h/mi.
- The time required to redeposit a container after it has been emptied is 6 min.
- The avarage time spent driving from the last container to the Corporation yard is 15 min, and no off-route activities ocur.
- The number of containers emptied per day is 10.

Solution of Problem 8.8

- Determine the time spent on various tasks:

Pick up time= 10 cont x (6min/cont) = 60 min

Drop of time = 10 cont x (6 min/cont) = 60 min

Time spent btw containers = (10-1) cont x (6min/cont) = 54 min

Time spent at disposal site = 10 cont x (6min/cont) = 60 min

Time spent to and from 1st and last cont = (20+15) min = 35 min

Round-trip haul time = 10 x (0,004 h/trip + 0,02h/mi (10 mi/trip)) = 2,04 h

Total time spent = (60 +60 + 54 +60 +35) x (1/60min) + 2,04 h = 6,52 h

[(8-6,25)/8] x 100 =18,46% > 15%

Problem - SCS

A mechanically loaded stationary container system is operated with the following parameters:
Vehicle capacity = 21 m^3
Vehicle compaction factor =2
Time from dispatch to collection area = 10 min
Time from disposal site to dispatch site = 15 min
Ave. haul time (1-way) from collection area to disposal site = 25 min
At-site time = 20 min
Average number of containers per location = 1
Container size = 0.8 m^3; Container utilization factor = 0.9
Average drive between location time = 4 min
Container service time = 3.5 min/container
Length of work day = 10 hr
Off-route factor = 0.165
Determine (a) Number of locations one vehicle can service in a day.
(b) If there are 410 containers to be serviced each day, how many vehicles are required?