COLLECTION OF SOLID WASTE

- The types of collection services provided
- The types of collection systems and some of the equipment now used as well as the associated labor requirements
- An analysis of collection system, including the component relationships that can be used to quantify collection operations
- The general methodology involved in setting up collection routes

PRINCIPLE TYPES OF COLLECTION SERVICES USED FOR UNSEPARATED WASTE

1. From Low-Rise Detached Dwellings

   a. Curb

   b. Alley

   c. Setout-Setback

   d. Setout

   e. Backyard

a. Curb side collection

- Homeowner or resident is responsible for placing the containers to be emptied at the curb on collection day at specified time and returning the empty containers to their storage location until the next collection
- Curb collection - Containers are emptied by collection crew
- Poor aesthetics – Spillage and litter problem

b. Alley side collection

- The containers are placed at the alley line from where they are picked up by workmen from refuse vehicle and he places back the empty container
- Doesn't require scheduled service for homeowner cooperation

c. Set-out, Set-back service

Set-out men go to individual houses, collect the containers and empty them in the solid waste collection vehicle. Another group of persons return them to house owner's yard.

d. Set-out service

The workers of solid waste collection vehicles collect the containers from individual houses and empty them in the collection vehicles. The house owner is required to take back the empty containers.

e. Backyard service

Solid waste workers carry a bin, handcart or sack or cloth to the yard and empty the solid waste container in it. The handcart or bin is subsequently taken to solid waste collection vehicles where it is emptied.

2. From Low and Medium –Rise Apartments

- Curbside collection service is common
- Maintenance staff is responsible for transporting the containers to the street (manual or mechanical)
- If containers are large- mechanically emptied using collection vehicles equipped with unloading mechanisms

3. From High Rise Apartments

- Typically large containers are used
- Depending on the size and type of containers used, the waste emptied mechanically using collection vehicles
- Some containers are hauled to an off-site location

TYPES OF COLLECTION SYSTEMS

Collection systems have been classified into two categories :

1. Hauled container systems (HCS)
2. Stationary container systems (SCS)

1. Hauled container systems (HCS)

- The containers used for storage of wastes are transported to processing, transfer or disposal site, emptied and returned to either their original location or some other location
- HCS are ideally suited for the removal of wastes from sources where the rate of generation is high
- The collector/driver is responsible for driving the vehicle, loading the full containers and unloading the empty containers and emptying the contents of the containers at the site
- HCS requires only one truck and driver to accomplish the collection cycle but in some cases, for safety reasons, both a driver and helper are used
- There are three types of HCS's a) Hoist truck b) Tilt-frame container and c) trash -trailer

a) Hoist Truck systems

- These trucks were widely used with containers varying in size from 2 to 12 cubic yard
- With the advent of large capacity mechanically loaded collection vehicles, however this system appears to be applicable in only a limited number of cases as follows:
- Wastes from small operation or only from few pickups and where purchase of newer equipment cannot be justified economically
- For the collection of bulky items and wastes that are not suitable for collection with compaction vehicles

b) Tilt-frame container

- Often called drop or debris boxes
- Ideal for collection of all types of solid waste and rubbish from locations use large containers
- Open top containers are used at warehouses and construction sites
- Large containers with stationary compactors are common in apartments
- Because of large volume that can be hauled, their uses has become widespread, especially among private collectors servicing commercial accounts

c) Trash –trailer systems

- Application is similar to tilt-frame system
- Better for the collection of heavy rubbish, such as sand, timber and metal scrap
- Collection construction and demolition wastes from construction sites


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2. Stationary container systems (SCS)

- Collection systems in which containers used for the storage of wastes remain at the point of waste generation
- Used for the collection of all types of wastes
- There are two types:

  a) Systems in which mechanically loaded collection vehicles are used

  b) Systems in which manually loaded collection vehicles are used
- All the collection vehicles are equipped with internal compaction mechanisms
- Manual methods are used for the collection where movement of vehicle is difficult


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Let us segregate the waste
&
save our environment
PMSPL


SURAT MUNICIPAL
CORPORATION
WEST ZONE.
DOOR
TO
DOOR.
GARBEAGE
COLLECTION
HELP-LINE.
NO.0261-6455527.
STOP
Signal.
GJ-5-AZ
680

ANALYSIS OF COLLECTION SYSTEM

- To establish vehicle and labor requirements for the various collection systems
- Helps to determine unit time required to perform each task
- Collection activities are separated into unit operations – helps to develop design data and relationships that can be used universally
- To evaluate both variables associated with collection activities and particular location

DEFINITION OF TERMS

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

1. pickup
2. haul
3. at-site
4. off-route

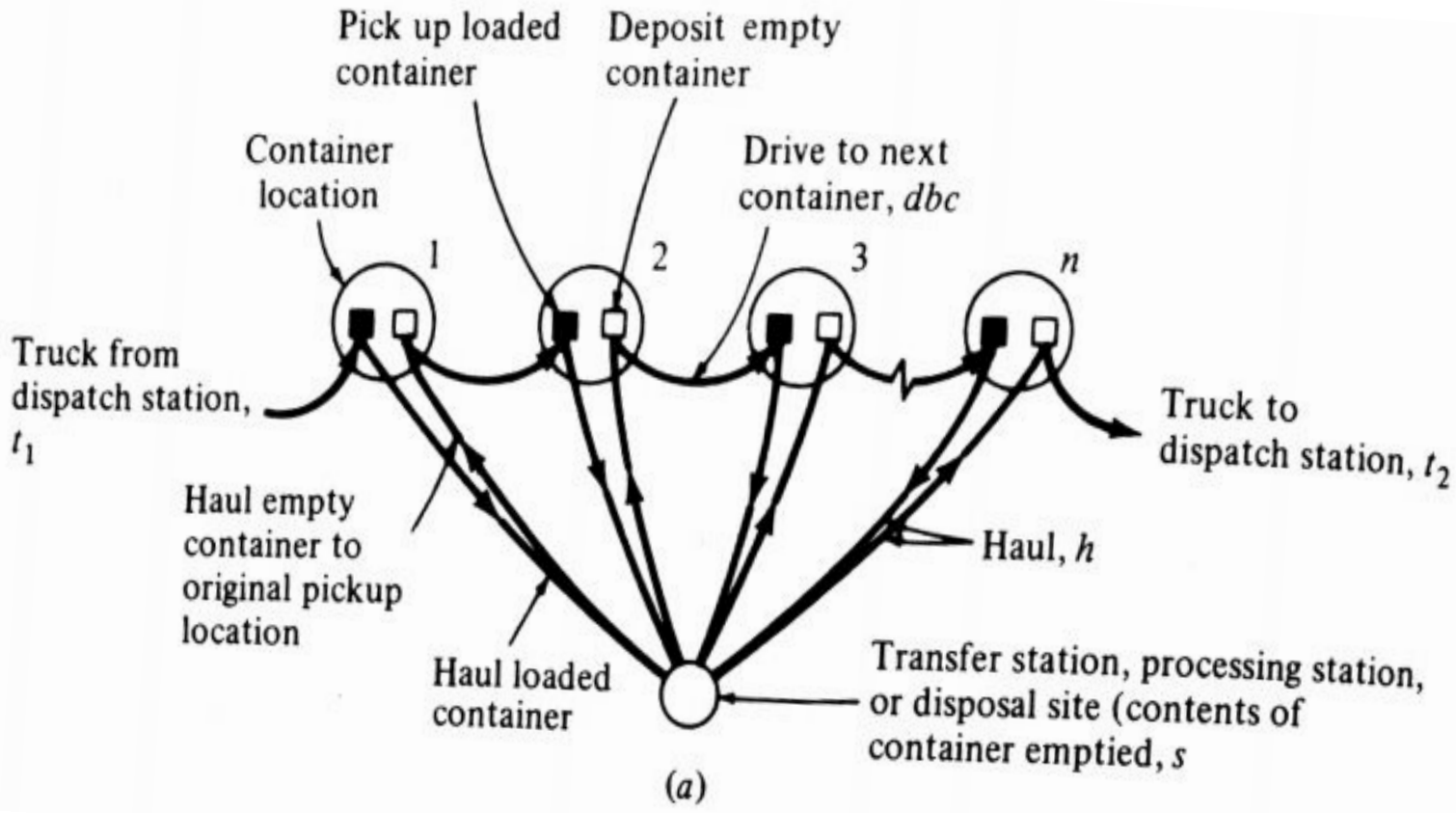

Figure: Schematic of operational sequence for hauled container system

Hauled container system (HCS) - Equation

The time required per trip, which also corresponds to the time required per container, is equal to the sum of pick-up, at-site and haul times and given by the following equation:

$$T_{hcs} = (P_{hcs} + s + h) \quad \ldots\ldots\ldots \quad \textit{Eq. 1}$$

Where,

T_{hcs} = time per trip for HCS, h/trip

P_{hcs} = pick-up time per trip for HCS, h/trip

s = at-site time per trip, h/trip

h = haul time per trip, h/trip

For hauled container system the pickup and at-site times are relatively constant, but the haul time depends on both haul speed and distance. From an analysis of a considerable amount of haul data for various types of collection vehicles, it has been found that the haul (h) time may be approximated by the following expression:

$$h = a + bx \quad \ldots\ldots\ldots \quad \textit{Eq. 2}$$

a = empirical haul –time constant, h/trip

b = empirical haul –time constant, h/mi or h/km

x = average round trip haul distance, mi/trip or km/trip

Substituting the Eq. 2 in Eq. 1 , the time per trip can be expressed as follows :

$$T_{hcs} = (P_{hcs} + s + a + bx) \ldots\ldots\ldots \quad Eq.\ 3$$

The pickup time per trip, P_{hcs} for the hauled container system is equal to

$$P_{hcs} = pc + uc + dbc \ldots\ldots\ldots \quad Eq.\ 4$$

Where,

pc = time required to pick up loaded container, h/trip

uc = time required to unload empty container, h/trip

dbc = average time required to drive between container location, h/trip

The number of trips that can be made per vehicle per day with a HCS, including a factor to account for off-route activities is determined using the following equation:

$$N_d = [(1-W)H - (t_1 + t_2)]/T_{hcs} \ldots\ldots\ldots \quad Eq.\ 5$$

Where,

N_d = number of trips per day, trip/day

W = off-route factor, expressed as a fraction ***(0.10-0.40)*** □ ***0.15***

H = length of workday, h/d

t_1 = time from garage to first container location, h

t_2 = time from last container location to garage, h

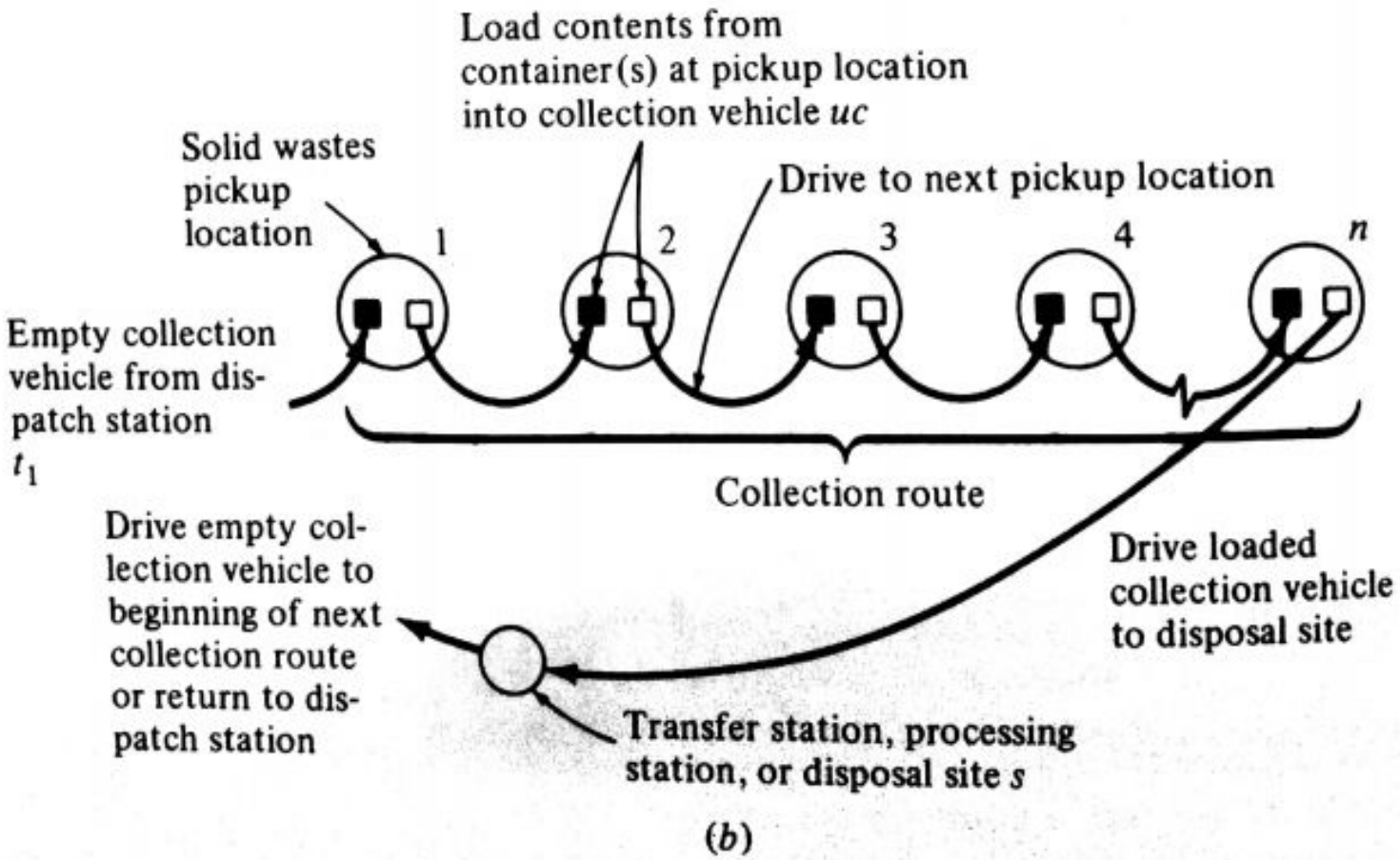

Figure: Schematic of operational sequence for stationary container system

DEFINITION OF THE TERMS INVOLVED IN THE COLLECTION OF SOLID WASTES

Term	Definition
Pickup (P)	
Hauled Container System, P_{hcs}	The time spent picking up the loaded container, the time required to redeposit the container after its contents have been emptied and the time spent driving to the next container location
Stationary Container System, P_{scs}	The time spent loading the collection vehicle, beginning with the stopping of the vehicle prior to loading the contents of the first container and ending when the contents of the last container to be emptied have been loaded

Term	Definition
Haul (H)	
Hauled Container System, h_{hcs}	The time required to reach the disposal site, starting after a container whose contents are to be emptied has been loaded on the truck, plus the time after leaving the disposal site until the truck arrives at the location where the empty container is to be re-deposited. Time spent at the disposal site is not included
Stationary Container System, h_{scs}	The time required to reach the disposal site, starting after the last container on the route has been emptied or the collection vehicle is filled, plus the time after leaving the disposal site until the truck arrives at the location of the first container to be emptied on the next collection route. Time spent at the disposal site is not included.

Term	Definition
At-site (s)	The time spent at the disposal site, including the time spent waiting to unload as well as the time spent unloading
Off-route (W)	All time spent on the activities that are nonproductive from the point of view of the overall collection operation. Necessary off-route time includes (1) time spent checking in and out in the morning and at the end of the day, (2) time lost due to unavoidable congestion and (3) time spent on equipment repair and maintenance. Unnecessary off-route time includes time spent for lunch in excess of the stated lunch period and time spent on taking unauthorized coffee breaks, talking to friends etc.,

Table: *Typical values for haul constant coefficient a and b*

Speed limit		a	b	
km/h	mi/h	h/trip	km/h	mi/h
88	55	0.016	0.011	0.018
72	45	0.022	0.014	0.022
56	35	0.034	0.018	0.029
40	25	0.050	0.025	0.040

Stationary container system (HCS) - Equation

For systems using mechanically self-loading compactors, the time per trip is:

$$T_{scs} = (P_{scs} + s + h) \quad \ldots\ldots\ldots \quad \textit{Eq. 1}$$

Where,

T_{hcs} = time per trip for SCS, h/trip

P_{hcs} = pick-up time per trip for SCS, h/trip

s = at-site time per trip, h/trip

h = haul time per trip, h/trip

$$h = a + bx \quad \ldots\ldots\ldots \quad \textit{Eq. 2}$$

a = empirical haul –time constant, h/trip

b = empirical haul –time constant, h/mi or h/km

x = average round trip haul distance, mi/trip or km/trip

The pickup time per trip, P_{scs} for the stationary container system is given by:

$$P_{scs} = C_t uc + (n_p - 1)(dbc) \ldots\ldots\ldots \quad Eq.\ 3$$

Where,

C_t = Number of containers emptied per trip, container /trip

uc = average unloading time per container for SCS, h/container

n_p = number of container pickup locations per trip, locations/trip

dbc = average time spent driving between container locations, h/location

The term $(n_p - 1)$ accounts for the fact that the number of times the collection vehicle will have to be driven between container locations is equal to the number of containers less 1.

The number of containers that can be emptied per collection trips is related directly to the volume of the collection vehicle and the compaction ratio that can be achieved. This number is given by:

$$C_t = vr/cf \ldots\ldots \quad \textit{Eq. 4}$$

C_t = number of containers emptied per trip, container /trip

v = volume of collection vehicle, cum/trip

r = compaction ratio

c = container volume, cum/container

f = weighted container utilization factor

The number of trips required per day is given by:

$$N_d = V_d/vr \ldots\ldots \quad \textit{Eq. 5}$$

V_d = daily waste generation rate, cum/day

N_d = no. of collection trips required per day, trips/d

The time required per day, taking into account the off route factor W, can be expressed as follows:

$$H = [(t_1 + t_2) + N_d\,(T_{scs})]/\,(1\text{-}W) \ \ldots\ldots\ \textit{Eq. 6}$$

t_1 = time to drive from dispatch station (garage) to the location of the first container to be emptied on the first route of the day, h

t_2 = time to drive from disposal site at the end of the day after completing the collection work to the dispatch station or garage, h

Primary & Secondary Collection

- Primary collection (from door to door) is carried out using a small non-motorized vehicle (handcart or animal cart)
- When full, the primary collection container is emptied directly into a large motor vehicle that is utilized solely for the high-speed transport of full loads
- The performance of this system can be evaluated by assuming that trailers has huge capacity and that they are exchanged when full by an agricultural tractor
- The tractor then takes the trailers to the disposal site. A tractor can travel at an average speed of 15 km/hr.

COLLECTION VEHICLES

- The collection of refuse involves all of the steps necessary for transferring the solid wastes from the storage point to the place of treatment or disposal
- The process involves emptying the storage container into a vehicle in which the wastes are transported
- The collection service may be designed in different ways and can use several transport methods
- Transportation methods range from handcarts to 30-Mg vehicles
- Solid waste collection is a very costly service and traditionally has been the most expensive phase of waste management
- Every jurisdiction should carefully evaluate types of vehicles and collection methods in order to select the system that is most appropriate to local conditions in terms of quality and efficiency of service and cost of operation

1. Handcarts

- Handcarts are almost universally used in developing countries for street sweeping because they cause minimum obstruction to traffic and their capacity is sufficient to keep a sweeper busy for up to two hours.
- Collection along very narrow streets that are inaccessible to motor vehicles & typically, the handcarts have open boxes that are attached to the frame

2. Pedal tricycles

- Pedal tricycles equipped with a box carrier in front/rear, commonly used in Latin America and in Asia, can be adapted to carry wastes
- Pedal tricycles reduce travelling time and can, therefore, operate over a larger radius than a handcart
- Refuse collectors can serve about 200 dwellings/day using tricycles

3. Animal Cart

- Horses were widely used in North America and in Europe for door-to-door refuse collection up until World War II
- The capacity of draught animal carts generally ranges between 2 and 4 m3. In some cases, the carts are equipped with bodies that can be tipped, by either pivoting the body or by using a manually-operated worm and nut mechanism
- Animal carts have the following advantages: no consumption of fossil fuels, very low capital and operational cost compared with motor vehicles, and very quiet operation
- The low speed of animal carts limits their effective radius of operation to about 3 km

4. Motorized Tricycles

- The two-stroke, three-wheel motorcycle is a very common means of transportation in several developing countries and is a viable alternative for waste collection
- The tricycle can be fitted with a high-level tipping body of about 2 m3 capacity
- Its relatively high speed gives this system an operating radius of about 10 km
- If the road system to the disposal site is inadequate, tricycles should discharge at either transfer facilities or processing plants.

5. Tractor and trailer systems

- The agricultural tractor is one of the most utilized motor vehicles for collecting waste in economically developing countries
- Advantages over other types of motorized vehicles like relatively low capital cost, capacity to transport a large load relative to energy use, readily available maintenance facilities, maneuverability on a landfill due to large tires and high torque, and ability to use the power takeoff to operate hydraulic tipping gear on a trailer.
- Despite its relatively low road speed (about 20 km/hr), tractors offer one of the least expensive methods of motor transport of solid wastes, up to a trailer capacity of about 6 m3


JOHN DEERE
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6. Light commercial trucks

- This type of vehicle is available almost worldwide and is primarily designed for the transport of bulk materials /construction materials. However, it is also widely used for the collection of wastes from communal sites. The body of the truck is usually made of steel, with a flat platform equipped with hinged sides and tail-boards about 40 to 60 cm high (5 to 6 m3)
- The advantages of this type of truck are the following: it is relatively inexpensive, it is sturdy and easily obtainable, it has good ground clearance, and it performs well on rough roads.

7. Compactor trucks

- These trucks have an opening at the rear that a waste collector can throw waste bags or empty the contents of bins into it
- Often in many areas they have a lifting mechanism to automatically empty large carts without the operator having to lift the waste by hand
- The modern rear loader usually compacts the waste using a hydraulically powered mechanism
- Can handle more quantity of waste compared to other collection vehicles
- Usually used to transport waste from transfer station to disposal site

8. Container-hoist

- This unit utilizes a standard commercial chassis equipped with two hydraulically-operated lifting arms which helps to lift metallic containers on or off the floor of the vehicle
- The containers have a capacity of 3 m3 or more. The containers can be tipped to discharge their contents while in position on the vehicle.
- The container-hoist is a viable alternative to tractor-trailer units; it is cheaper, faster but the cost of a container vehicle is about twice that of an agricultural tractor

COLLECTION ROUTES

- Once the equipment and labor requirements have been determined, the collection routes must be laid out so that both collectors and equipment are used effectively
- Layout of collection route is a trail and error process
- No universal set of rules / Common sense process

1. Existing policies and regulations related to such items as the point of collection and frequency of collection must be identified
2. Existing system characteristics such as crew size and vehicle types must be coordinated
3. Wherever possible, routes should be laid out so that they begin and end near arterial street, using topographical and physical barriers as route boundaries

4. In hilly area, routes should start at the top of the grade and proceed downhill as the vehicle becomes loaded

5. Routes should be laid out so that the last container to be collected on the route is located nearest to the disposal site

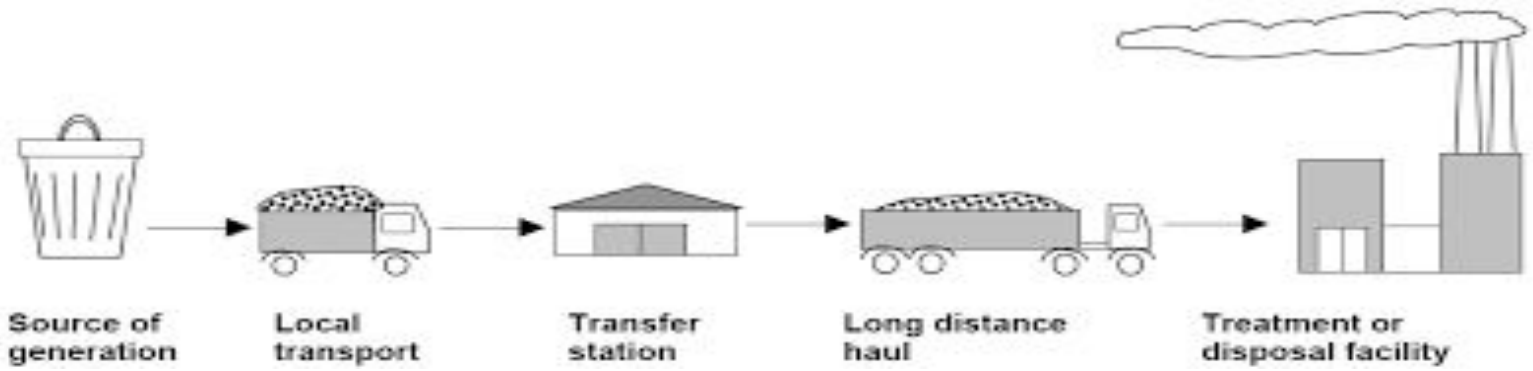
6. Wastes generated at traffic –congested locations should be collected as early in the day as possible

7. Sources at which extremely large quantities of wastes are generated should be serviced during the first part of the day

8. Scattered pickup points (where small quantities of SW are generated) that receive the same collection frequency should, if possible, be serviced during one trip or on the same day

TRANSFER AND TRANSPORT

- Refers to the means, facilities and appurtenances used for the transfer of waste from one location to another location (usually long distance)
- Typically, the contents of relatively small collection vehicles are transferred to large vehicles that are used to transport the waste over extended distances (MRF's or disposal site)
- Transfer & Transport operations are also used in conjunction with MRF's to transport recovered materials to markets or waste to-energy plants and to transport residual materials to landfills



Factors that tend to make use of Transfer stations

- Processing centers or disposal sites are sited in remote locations and cannot be reached directly by highway
- Illegal dumping due to excessive haul distance
- The location of sites relatively far from collection routes where direct hauling is not economical
- Existence of low density residential service areas
- Use of small capacity collection vehicles (generally 10 to 20 cubic yard)
- Use of hauled container system with relatively small containers for the collection of wastes from commercial sources
- The use of hydraulic or pneumatic collection systems

TRANSFER STATIONS

Transfer stations is building or site for the temporary deposition of waste. This often used as a place where local waste collection vehicles will deposit their waste into large transport vehicles.

Depending on the method used to load the transport vehicles

1. Direct – load
2. Storage – load
3. Combined direct- load and discharge –load

Depending on capacity of waste transferred and hauled

1. Small (less than 100 ton/day)
2. Medium (100 to 500 ton/day)
3. Large (more than 500 ton/day)

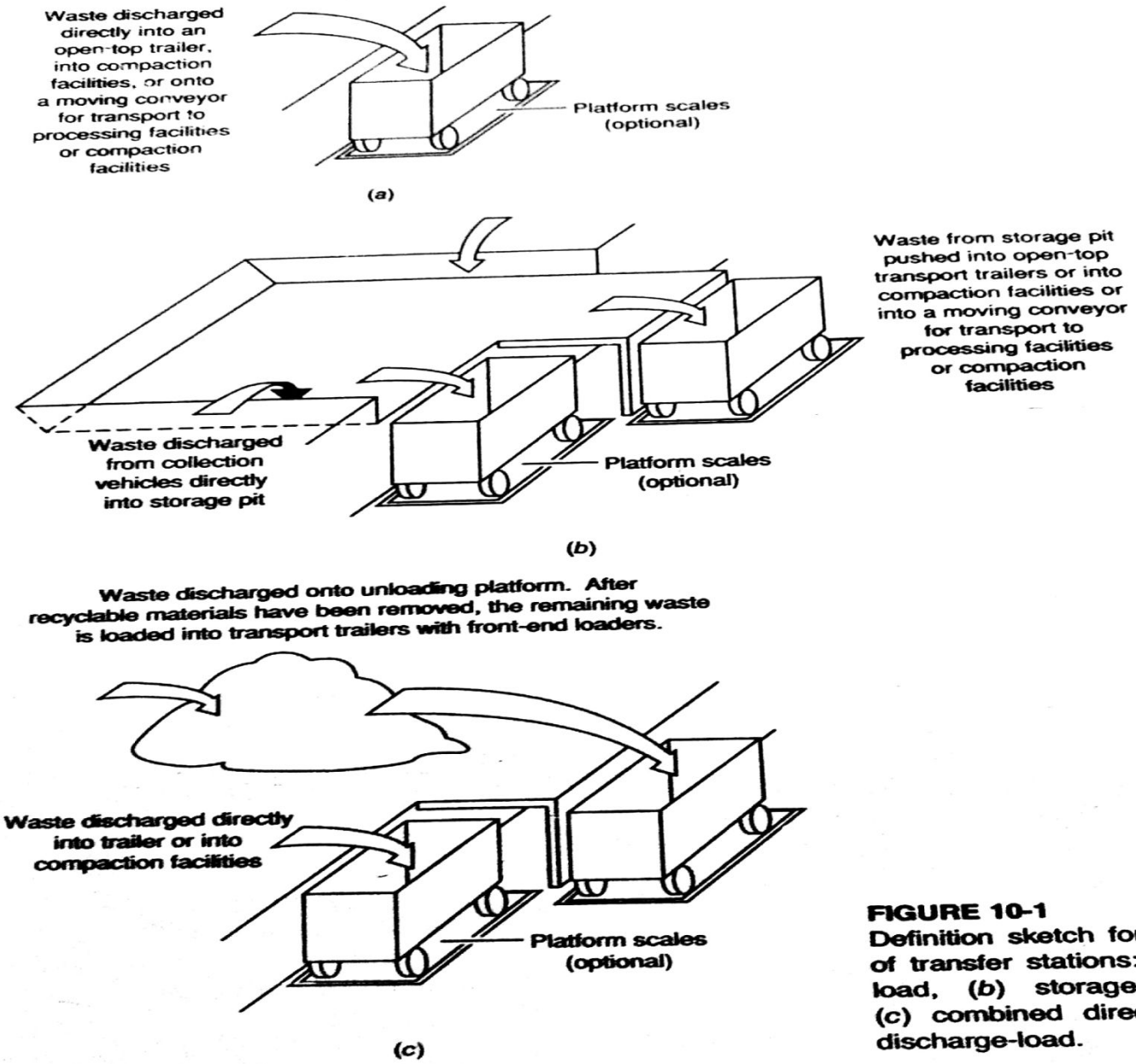


FIGURE 10-1
Definition sketch for the types of transfer stations: (*a*) direct-load, (*b*) storage-load, and (*c*) combined direct-load and discharge-load.

1. Direct – Load Transfer Stations

- Wastes in the collection vehicles are emptied directly into the vehicle to be used to transport them to a place of final deposition
- In some cases like trailers are filled or are being hauled to the disposal site the wastes may be emptied onto an unloading platform and then pushed into the transfer vehicles
- Large capacity direct load transfer station without compaction – waste dumped into the vehicles without any compaction
- Large capacity direct load transfer station with compaction – Compaction facilities are used to compact waste directly into the trailers or to produce bales

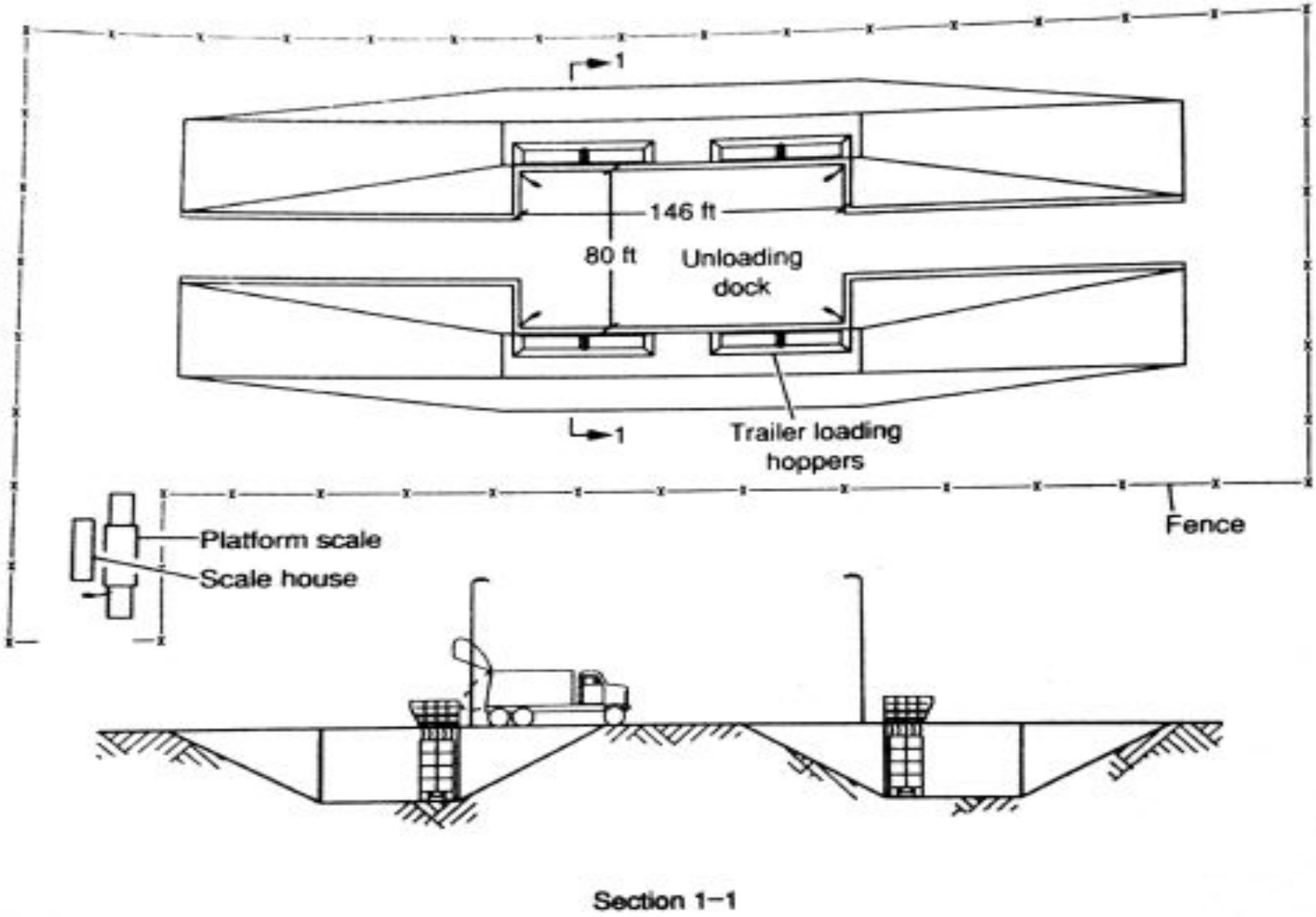


Figure: Typical direct load transfer station with transport trailer located in depressed ramps

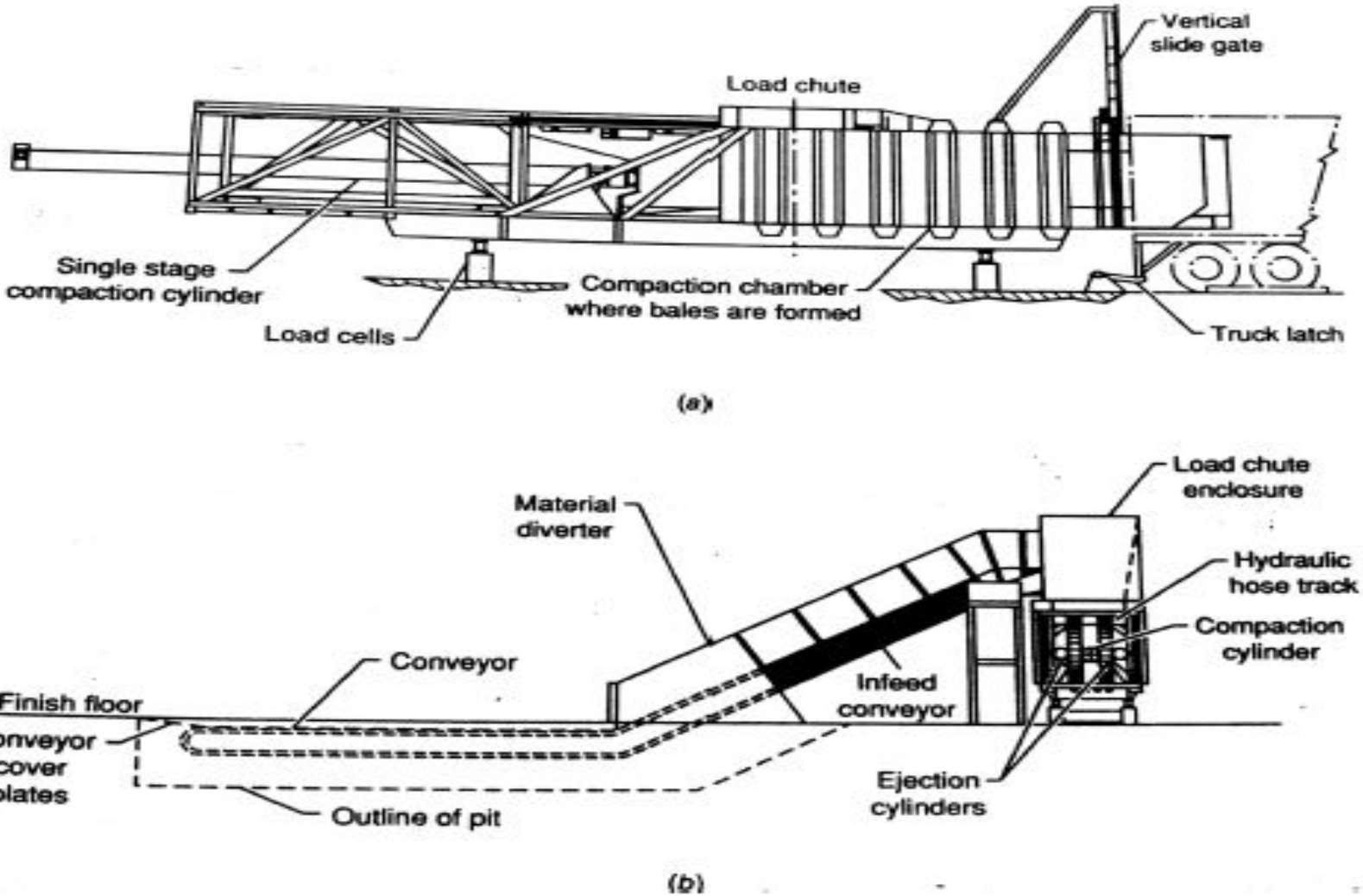
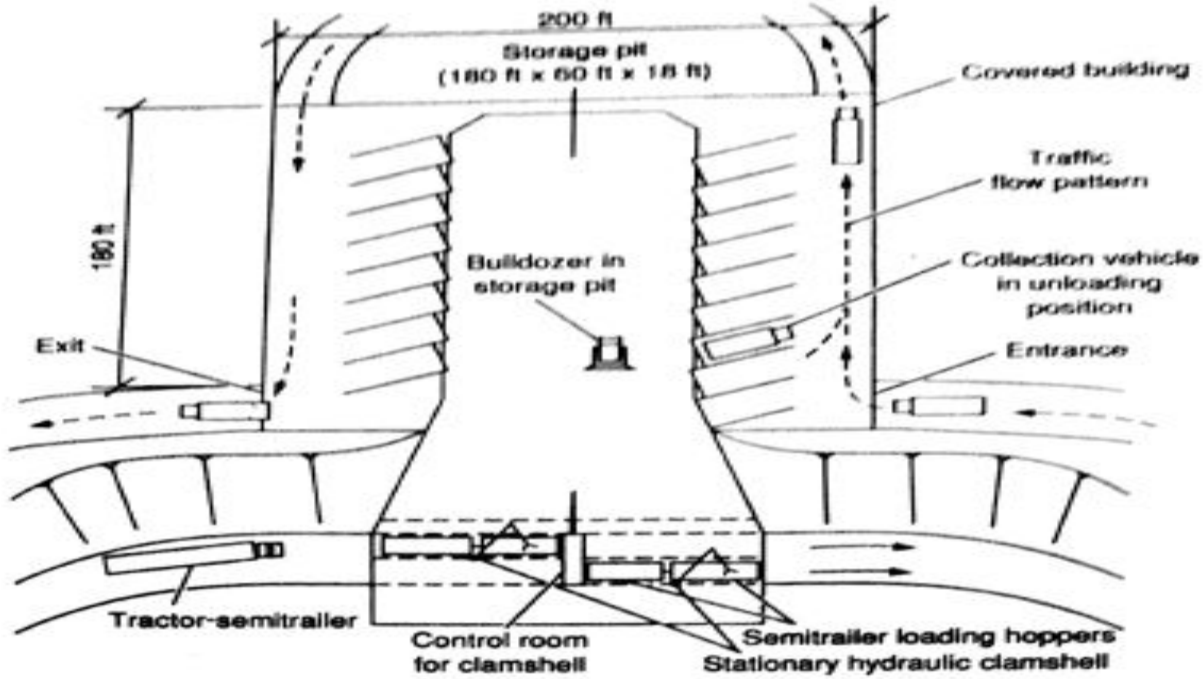


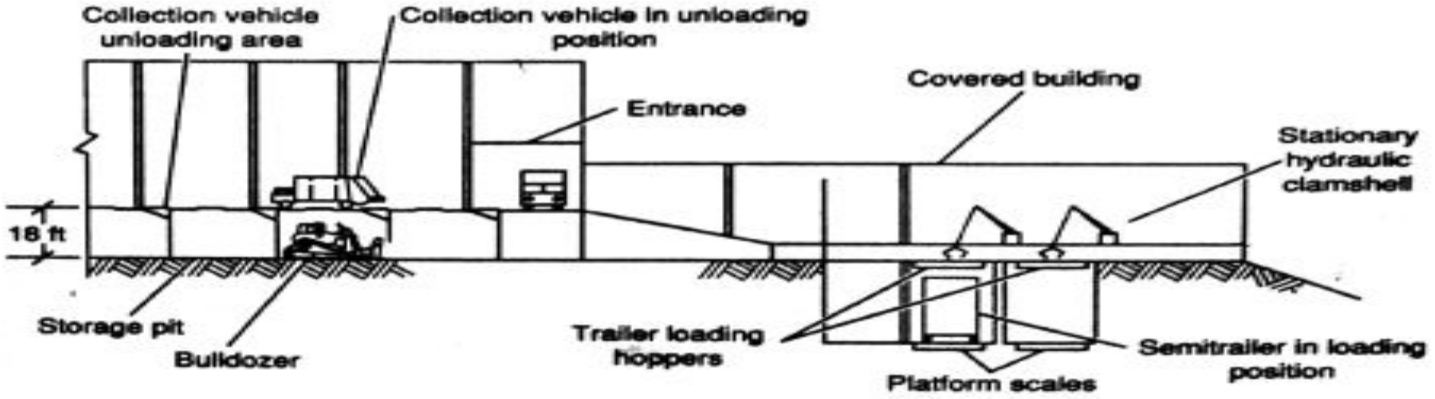
Figure: Direct load transfer station having compaction facility

2. Storage/Discharge – Load Transfer station

- In this type wastes are emptied into a storage pit from which they are loaded into transport vehicles by various types of auxiliary equipment's
- This kind of transfer station designed with a capacity to store waste (typically 1 to 2 days)
- All the vehicles are weighed and sent inside the station for unloading
- Articulated bucket type hoists are located on the other side of the hoppers to remove any waste that could damage the transport vehicles
- When allowable weight limit reaches, the hoist operator signals the truck driver

- Loaded trailers are then driven out covering with wire screens to prevent blowing of waste
- Medium capacity storage load transfer station with processing and compaction facilities – waste are discharged into a storage pit (surge pit)
- Pushed onto a conveyor system and transported to the shredder
- Then ferrous metals are removed and wastes are compacted into transfer trailers


200 ft
Storage pit
(180 ft x 60 ft x 18 ft)
Covered building
Traffic
flow pattern
180 ft
Bulldozer in
storage pit
Collection vehicle
in unloading
position
Exit
Entrance
Tractor-semitrailer
Control room
for clamshell
Semitrailer loading hoppers
Stationary hydraulic clamshell


Collection vehicle
unloading area
Collection vehicle in unloading
position
Entrance
Covered building
Stationary
hydraulic
clamshell
18 ft
Storage pit
Bulldozer
Trailer loading
hoppers
Platform scales
Semitrailer in loading
position

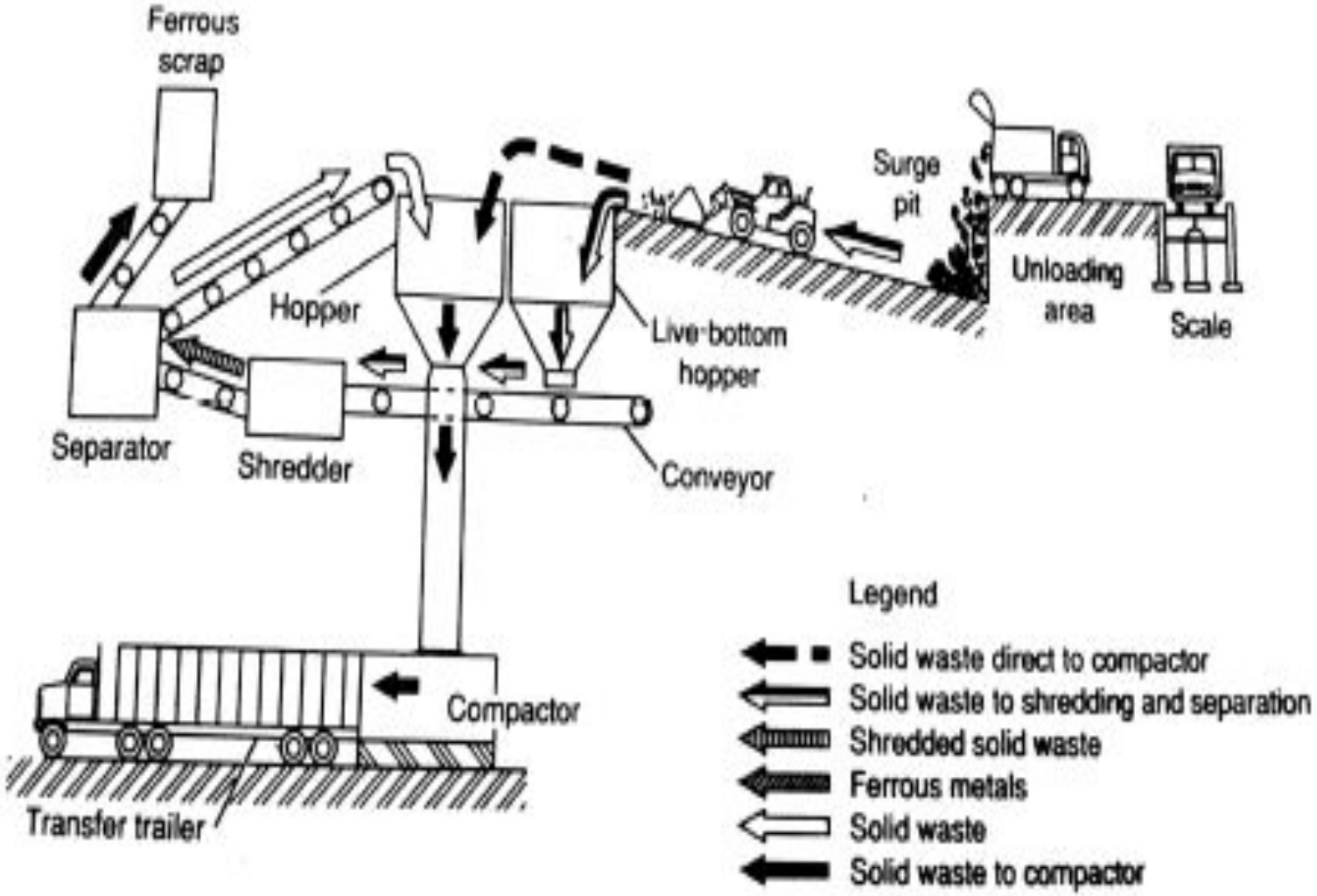


Figure: Storage load transfer station with processing and compaction facilities

3. Combined Direct load and Discharge load

- Both direct load and discharge load methods are used in this type of transfer stations
- These are multipurpose facilities that service a broader range of users than a single purpose facility
- General public and various waste collection agencies
- Separate place to unload recyclable materials
- Left out waste will be dumped on the platform and this area is separated from the direct load area
- Waste that accumulate in the unloading area are pushed periodically into the transfer trailers

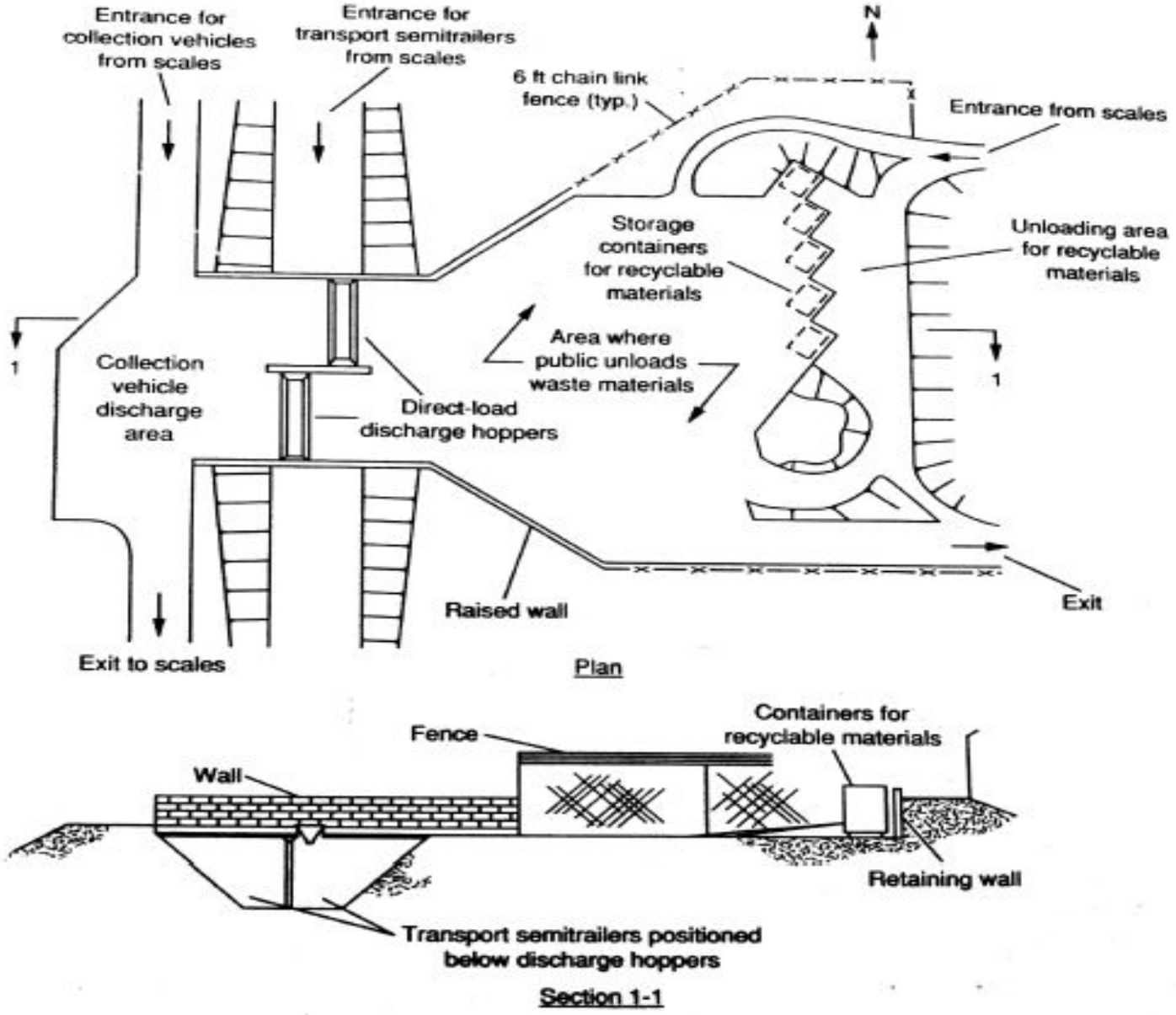


Figure: Combination of direct load and discharge load transfer station

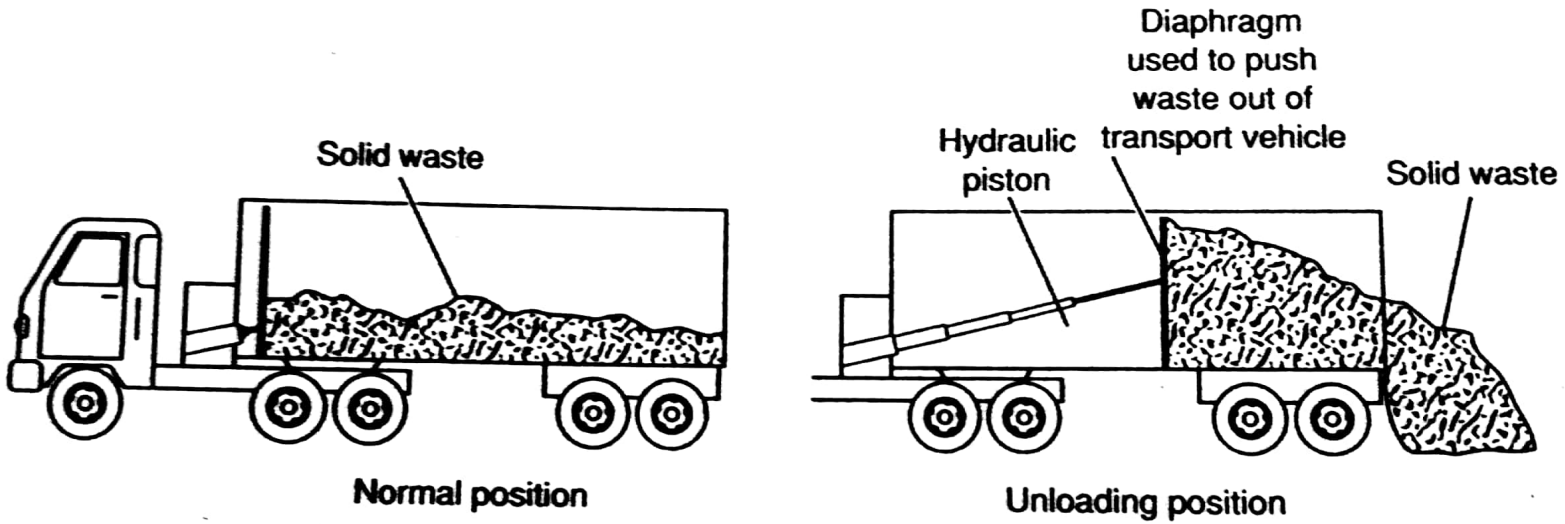

STOP
STOP
STOP
1
2
3

TRANSPORT MEANS AND METHODS

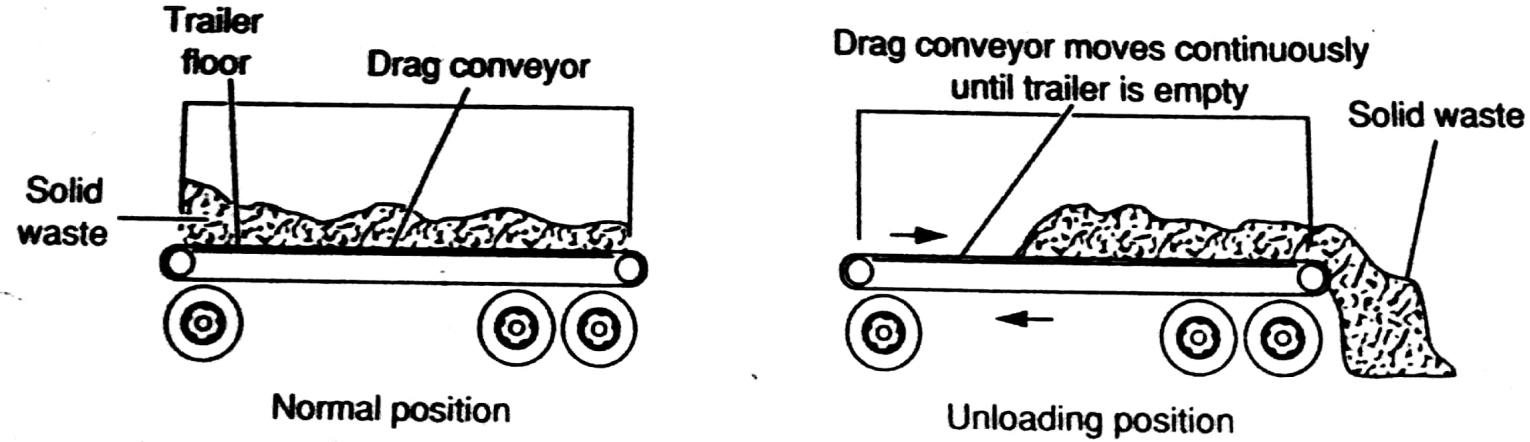
1. Motor vehicle transport
2. Railroad transport
3. Water transport
4. Pneumatic transport

1. Motor vehicle transport

- Common means of transportation for SW and used to transport through highways, only when they satisfy the following requirements
  - Vehicles must transport wastes at minimum cost
  - Waste must be covered during the haul operation
  - Vehicles must be designed for highway traffic
  - Vehicles capacity must be such that allowable weight limits are not exceeded
  - Methods used for unloading must be simple and dependable
- Maximum volume that can be hauled depends on the regulations in force in the state in which they are operated
- Open top trailers and semi trailers have found wide acceptance
- Sumps are equipped to collect accumulated liquid
- Self emptying – hydraulic dump, powered diaphragms or moving floor
- Auxiliary equipment – "pull off" type : movable bulkhead or wire –cable slings or hydraulically operated tipping ramps


Solid waste
Normal position
Diaphragm
used to push
waste out of
transport vehicle
Hydraulic
piston
Solid waste
Unloading position

(a)


Trailer
floor
Drag conveyor
Solid
waste
Normal position
Drag conveyor moves continuously
until trailer is empty
Solid waste
Unloading position

(b)

2. Railroad transport

- Old methods and now only few communities use this kind of transport
- Used especially to remote landfill areas where highway travel is difficult and railroad lines now exist

3. Water Transport

- Barges, scows and special boats used to transport solid waste to processing locations and to seaside ocean disposal sites
- Cost is more compared to other modes of transportation

4. Pneumatic, Hydraulic and other systems of transport

- Both low pressure air and vacuum conduit transport systems have been used to transport solid wastes
- Need to use blowers or high speed turbines further complicates the installations and maintenance
- Hydraulic transportation – Food waste

TRANSFER STATION DESIGN REQUIREMENTS

1. The type of transfer operation to be used
2. Storage and throughput capacity requirements
3. Equipment and accessory
4. Sanitation/Environmental requirements
5. Health and safety

LOCATION OF TRANSFER STATIONS

1. As near as possible to the weighted center of the individual solid waste production areas to be served
2. Within easy access of major arterial highway routes as well as near secondary or supplemental means of transportation
3. Where there will be a minimum of public and environmental objections to the transfer operations
4. Where construction and operation will be most economical

RECYCLING OF WASTE MATERIALS

- MRF's are used to separate commingled MSW into usable materials and they recover paper, plastic, glass etc., for remanufacturing into new products
- Organic portion of solid waste can be recovered as a feedstock for composting or other biological processes
- Waste materials that have been source separated must be collected or gathered together before they can be recycled
- Drop-off centers and buy back centers are specially designed for the collection of these recovered materials

UNIT OPERATIONS USED FOR THE SEPARATION OF WASTE MATERIALS

1. Size reduction
2. Size separation
3. Density separation
4. Electric and magnetic field separation
5. Densification
6. Materials handling

TABLE 12-1
Methods used for the processing and the recovery of individual waste components from MSW

Processing options	Description
Size reduction	Unit operation used for the reduction of both commingled MSW and recovered materials. Typical applications include (1) hammermills for shredding commingled MSW; (2) shear shredders for use with commingled MSW and recycled materials such as aluminum, tires, and plastics; and (3) tub grinders used to process yard wastes.
Size separation	Unit operation in which materials are separated by size and shape characteristics, most commonly by the use of screens. Several types of screens are in common use, including (1) reciprocating screens for sizing shredded yard wastes; (2) trommel screens used for preparing commingled MSW prior to shredding; and (3) disc screens used for removing glass from shredded MSW.
Density separation	Unit operations in which materials are separated by density. Typical applications include (1) air classifiers for the preparation of RDF; (2) inertial separation for the processing of commingled MSW; and (3) flotation for the processing of construction debris.
Electric and magnetic field separation	Unit operations in which materials are separated by their electrostatic charge and magnetic permeability. Typical applications include (1) the separation of plastics from paper and (2) the separation of ferrous from nonferrous materials (e.g., "tin cans" from aluminum cans).
Densification (Compaction)	Densification and compaction are unit operations that are used to increase the density of recovered materials to reduce transportation costs and simplify storage. Typical applications include (1) the use of baling for cardboard, paper, plastics, and aluminum cans; and (2) the use of cubing and pelletizing for the production of densified RDF.
Materials handling	Unit operations used for the transport and storage of MSW and recovered materials. Typical applications include (1) conveyors for the transport of MSW and recovered materials; (2) storage bins for recovered materials; and (3) rolling stock such as forklifts, front-end loaders, and various types of trucks for the movement of MSW and recovered materials.