Chapter A-3
Tricycle primary collection and small transfer stations

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A-3.1 INTRODUCTION

A study of existing refuse collection, transfer and disposal systems in Mumbai identified many inefficiencies with the existing methods and equipment. Proposals are put forward for an alternative system based on primary collection by means of tricycles bringing the wastes to small transfer stations where the refuse is transferred to large enclosed containers for transport to the disposal site. Outline designs are provided for a typical small transfer station (STS), based on a concept which has proved successful in China. The transfer station will be completely hygienic and odour free and have a capacity of up to 105 tonnes of solid wastes per day, within an overall site area of less than 180 m^2. Thus it is possible for this type of transfer station to be constructed in areas with high population densities.

Costings are included which show that such a system will have operating costs as low as Rs 207 per tonne and capital costs of only Rs 38 per tonne. This is just two-thirds of the cost of existing collection and transfer procedures and this system is also very hygienic and provides a much higher level of service.

Proposals are also put forward for the design of the primary collection tricycles and the container transfer vehicles. Recommendations are made for the setting up of a pilot project based on this system to be used as a demonstration of the small transfer station concept and to remove any fears from the public concerning the location of transfer stations in their localities.

It is considered that this project could have applications in many other cities of India as a hygienic and cost effective system of solid waste management.

Land costs have not been included in the study in line with the policy adopted in a study carried out by NEERI in 1994. In some situations land costs may be a significant factor in choosing sites for the small transfer stations.

A-3.2 BACKGROUND INFORMATION

With the passage of time Mumbai no longer consists of the original seven islands of Colaba, Fort, Byculla, Parel, Worli, Matunga and Mahim, but it has grown into a megapolis with a population of 9.9 million (1991 census) and with a continuing high growth rate. The total area of 438 km^2 is divided into 23 wards according to the density of population and utilisation statistics. The islands are in the form of a peninsula, with the "central" business district at the southern extremity.

At present the MCGM handles and disposes of about four thousand tonnes of solid waste every day at the four existing dumping grounds. For primary collection, transportation and disposal, MCGM deploys 141 refuse vehicles for the city region and 120 for the suburbs and, to keep these vehicles running, 13 garages are provided at different locations within the Greater Mumbai area. The total conservancy staff comprises approximately 33 000 workers, staff and officers. It has been observed that whilst most of the refuse collection vehicles carry the wastes directly from the collection points to the disposal site, a number of vehicles discharge their loads at transfer stations where the wastes are loaded onto larger vehicles for transporting to the disposal sites. There are at present two such transfer stations, situated at Mahalaxmi and Kurla. (see Figure A-3.1 for the locations of existing disposal sites and transfer facilities).

Mahalaxmi Transfer Station This transfer station is located near the Mahalaxmi railway station and serves South Mumbai. Previously the wastes were taken from here to the disposal site by railway, but the facility has since been transformed into a road vehicle transfer station to cater for the wastes of southern Mumbai. The land area taken up by this site is approximately 240 m by 57 m (13,700 m^2.) The transfer facility is of the split-level type, with a central split-level raised platform from which the containers can be directly discharged into bulk refuse carriers standing below and adjacent to the platform at either side. In general, dumper placer trucks bring the wastes in 4.5 m^3 containers and empty them into bulk refuse carriers which, when full, carry the wastes to the disposal site at Deonar. (Operations at this site are described in more detail in section B - 1.) Occasionally loads of sewer silt and offal wastes are also transferred at this site. This transfer station is well maintained but it has been observed that the access to this site through a congested market area causes problems for the movement of the refuse vehicles. The Mahalaxmi transfer station is presently transferring around 300 tons of wastes per day although it is capable of a much greater throughput if fully utilised.

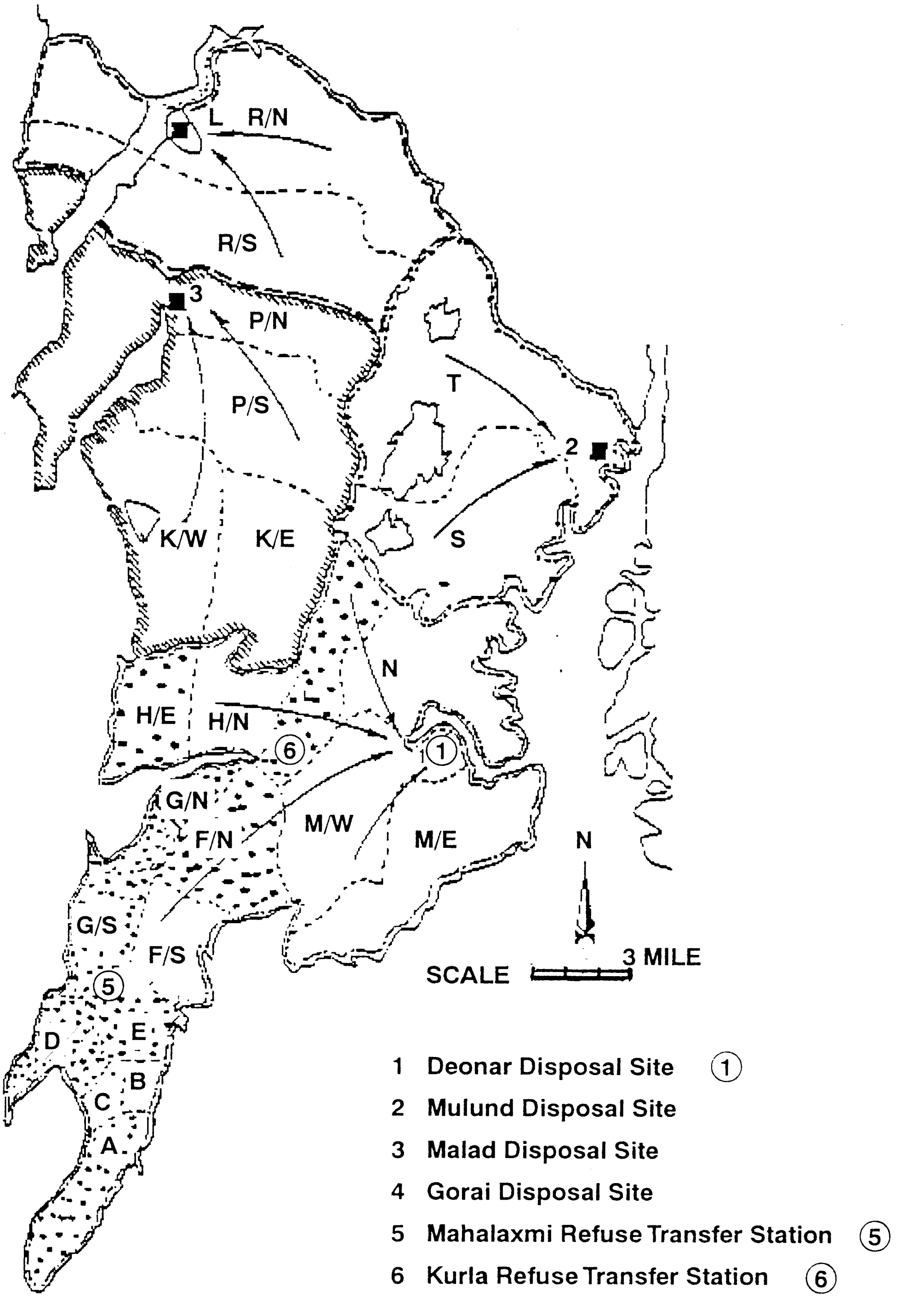


Figure A-3.1 Transfer and disposal sites in Greater Mumbai

Kurla Transfer Station This transfer station is situated in the Central Mumbai area (see figure A-3.1). It has a concrete ramp but it is not usable because of a failure in its foundations, perhaps because it is built on deposited refuse. Municipal vehicles unload the collected refuse from the nearby wards onto the ground from where it is loaded by front-end loaders into contractors' vehicles for transporting to the disposal site. The area of this transfer station is 70 m by 80 m (5,600 m^2).

A-3.3 ASSESSMENT OF EXISTING TRANSFER STATION (MAHALAXMI)

Advantages:

- ◊ Centrally located with an average haul distance of 5 km from the collection points to the transfer station.
- ◊ Because of the split level operation, transferring of the wastes avoids secondary handling, resulting in fast turn-around times for the collection vehicles. This means that the collection vehicles are very efficient in clearing wastes from the primary collection points situated in the congested city area.
- ◊ The gravitational transfer system from the containers on the platform to the bulk refuse carriers standing underneath the platform is a cost-effective and reliable method of transfer.
- ◊ Operational and maintenance costs (O & M) are low.
- ◊ The site is clean and easily operated.
- ◊ The workforce involved directly with the transfer station is small.
- ◊ This type of transfer station is environmentally acceptable and is suitable for its purpose.
- ◊ The check post, ramp, split level platform and the bulk refuse bay have enough space to receive, transfer and dispatch the existing total of 23 transfer vehicles during the three shifts. This indicates a daily capacity of 530 tonnes/day based on one load/truck/shift, a body volume of 24 m^3 and a waste density of 400 kg/m^3.
- ◊ The site has a well-defined area enclosed by a boundary wall with proper recording arrangements and security postings.
- ◊ All wastes are brought into the site in closed containers and discharged directly into the transfer vehicles. As a result no rag picking is carried out at this site.

Disadvantages

- ◊ The access road - through a congested market area - causes delays for the incoming and outgoing collection and transfer vehicles.
- ◊ The total potential of the transfer facility is under-utilised and space requirements are large in an area of scarce and costly land resources. It is estimated that this transfer facility could handle up to four times its present throughput although this might create unacceptable traffic congestion in the adjoining market area and would increase the collection area and the primary collection haul distances correspondingly.
- ◊ The containers that bring the waste and the bulk refuse carriers that take them out are undersized for the vehicle chassis used. This hampers the cost effectiveness of the transfer station and increases traffic problems.
- ◊ The space under the platform (if not filled up) could have been utilised for garaging, repairing, storing and other purposes.
- ◊ The dumper placer containers should be redesigned so that they can be discharged into the bulk transfer vehicles more easily as well as carrying larger loads.

A-3.4 DESCRIPTION OF PROPOSED SMALL TRANSFER STATION (STS).

The remainder of this section describes a more cost-effective transfer system using a number of smaller transfer stations in place of the two large existing facilities.

Figures A-3.2 to 7 show a typical small transfer station which consists of a fully-enclosed transfer room (17 m x 8 m) and toilet and other facilities alongside.

- ◊ There are two pits in the floor of the station into which the 8 tonne capacity refuse transfer containers can be lowered so that the tops of the containers are at floor level. The containers are moved around within the building by means of an overhead gantry (rail-mounted) crane. Rubber flaps are used to prevent wastes falling down between the sides of the pit and the container.
- ◊ There is enough space (6.0 m) between the pits to allow the transfer trucks to pick up one of the full containers without interrupting the filling of the container at the other side of the building by the tricycle collection vehicles.
- ◊ There is sufficient space behind each of the pits to allow two full or empty containers to be stacked for storing waste between transfer collection. In this way there is a total storage capacity of 6 x 8 = 48 tonnes of containerised wastes in the transfer station at any time. This enables the collection and transfer operation to be carried out at different times with all wastes fully containerised at all times.
- ◊ The pits are fitted with simple load cells so that each container can be loaded to its full 8 tonne capacity, thus avoiding overloading of the trucks while maximising the vehicle capacity and minimising the number of loads transferred.
- ◊ The building is tiled throughout and provided with a high pressure wash-down pump for hosing down the containers and the building at the end of each shift. Roller shutter doors prevent rats or dogs entering the building when it is not operating and an electric mosquito/fly killer prevents any insect nuisance (with occasional spraying if required).
- ◊ The overall appearance of the STS may be similar to that of a modern fire station or a 'Mother Dairy' milk booth type building with tiling on the outside for easy hosing down. (The high pressure wash down pump can be used for this purpose).
- ◊ The wastes arrive at the STS on tricycles in plastic containers or in a fully enclosed tipping body. The wastes are transported away in fully enclosed containers, so that at no time should there be any loose waste about or inside the building.
- ◊ The fully enclosed transfer room is provided with air vents at high and low levels for good ventilation and sodium vapour lamps enable operation at any time of the day or night as required.
- ◊ The layout as shown includes an office, canteen for tricycle and STS operators, toilets, repair facilities and parking space for all tricycles serving the station. Quarters are provided for three families above the transfer station. This transfer station covers a total site area of 20.6 m x 15.9 m (328 m^2) and the building as shown has a height of 10.5 m including the overhead staff quarters. In areas where high rise buildings are permitted, further floors with additional staff quarters or rental apartments may be provided.
- ◊ The proposed layout can be modified and adapted to suit any particular site. If the collection service is contracted out or privatised, parking space for the tricycles may not be required. In this case the complete facility can be accommodated within an area of only 17.6 m x 8.6 m (152 m^2).
- ◊ The double pit transfer station illustrated has a daily capacity of 105 tonnes of wastes, if there is two shift working.
- ◊ It will also be possible to provide a single pit transfer station with a capacity of around 50 tonnes/day and storage capacity for 24 tonnes of wastes within an overall site area as small as 9.0 m x 6.0 m (54 m^2).
- ◊ A 15 kW stand-by generator will provide power for the gantry and lights in the event of power failures.

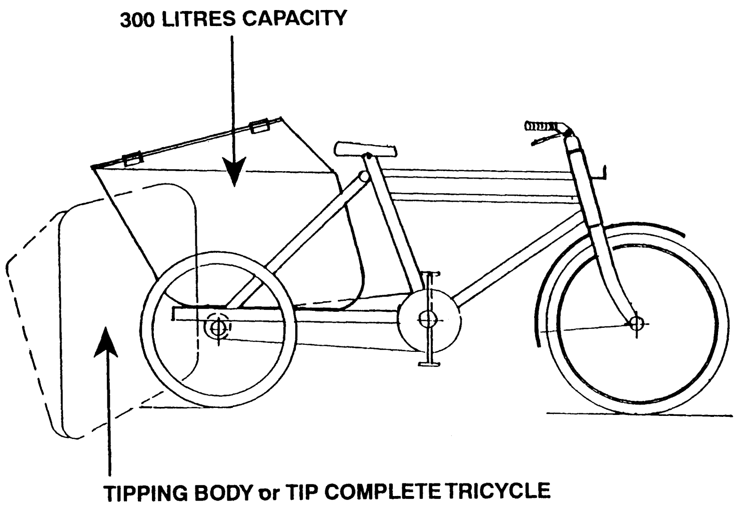


Figure A-3.2 Tricycle for primary collection

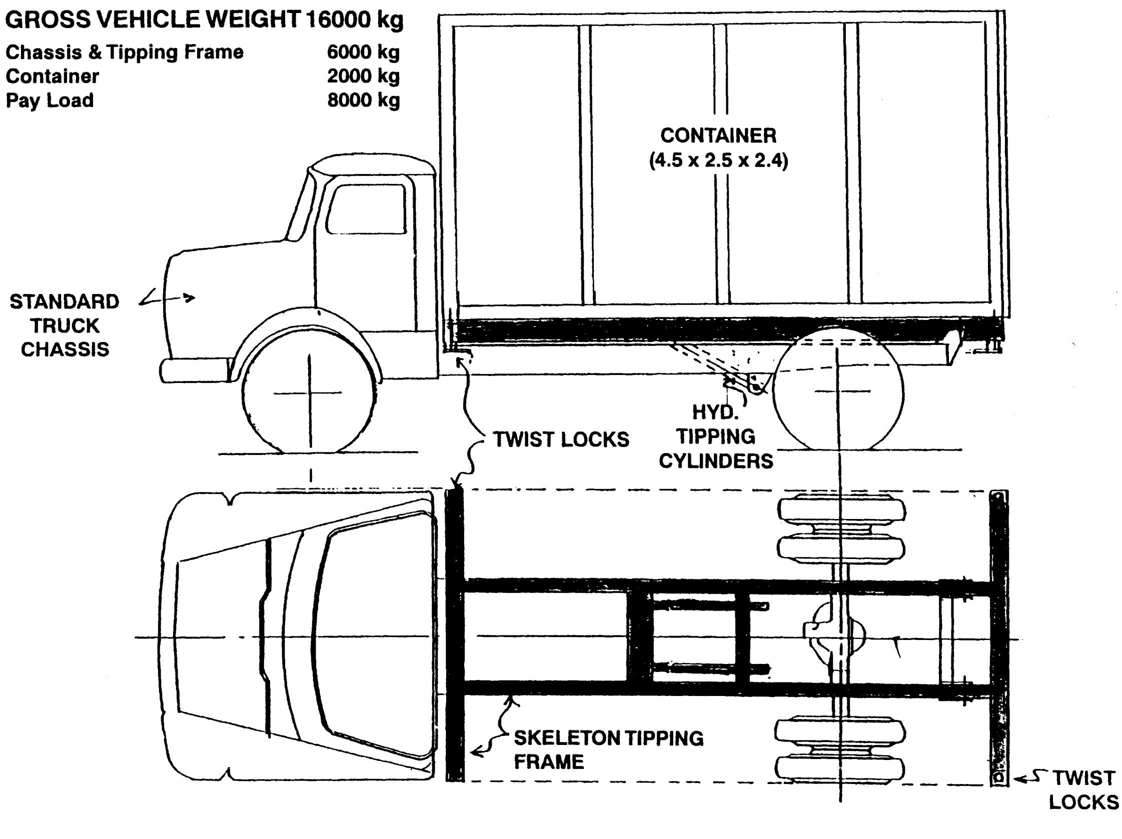
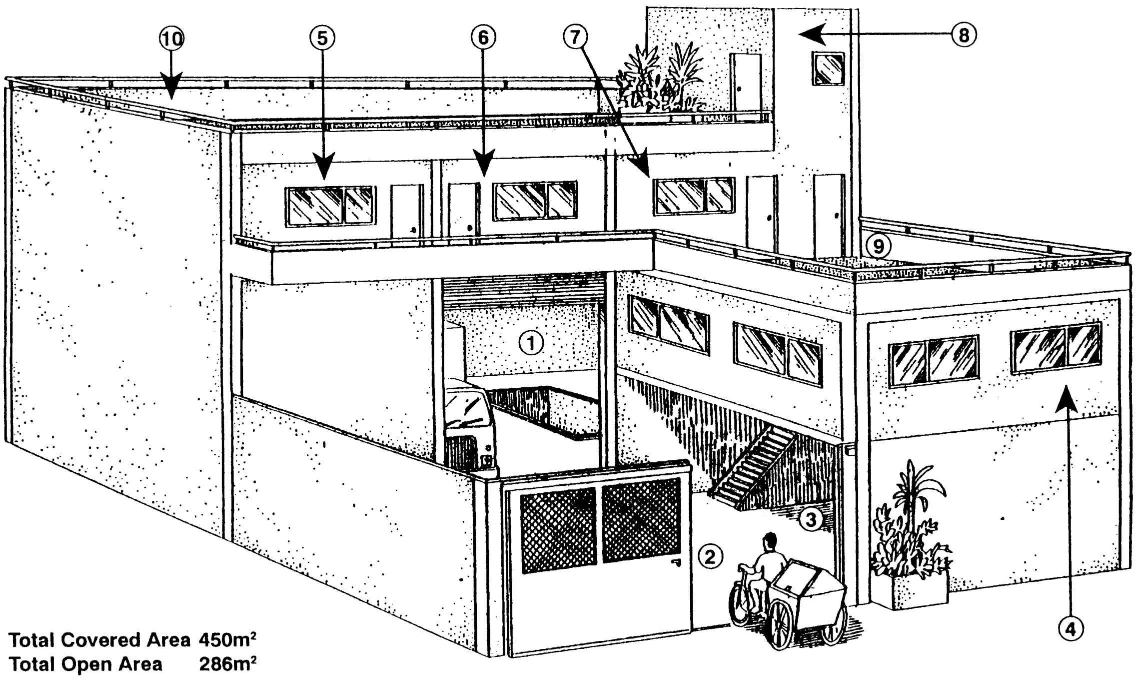


Figure A-3.3 Transfer vehicle



Total Covered Area 450m²
Total Open Area 286m²

1	Transfer Room	136m²	6	Apartment	48m²
2	Open Tricycle Storage & Access	80m²	7	Apartment	50m²
3	Tricycle Repair & Covered Storage	60m²	8	Stairs/Toilets	60m²
4	Canteen & Office	56m²	9	Terrace/Passage	70m²
5	Apartment	40m²	10	Roof Play Area	136m²

Figure A-3.4 Architectural features of small transfer station

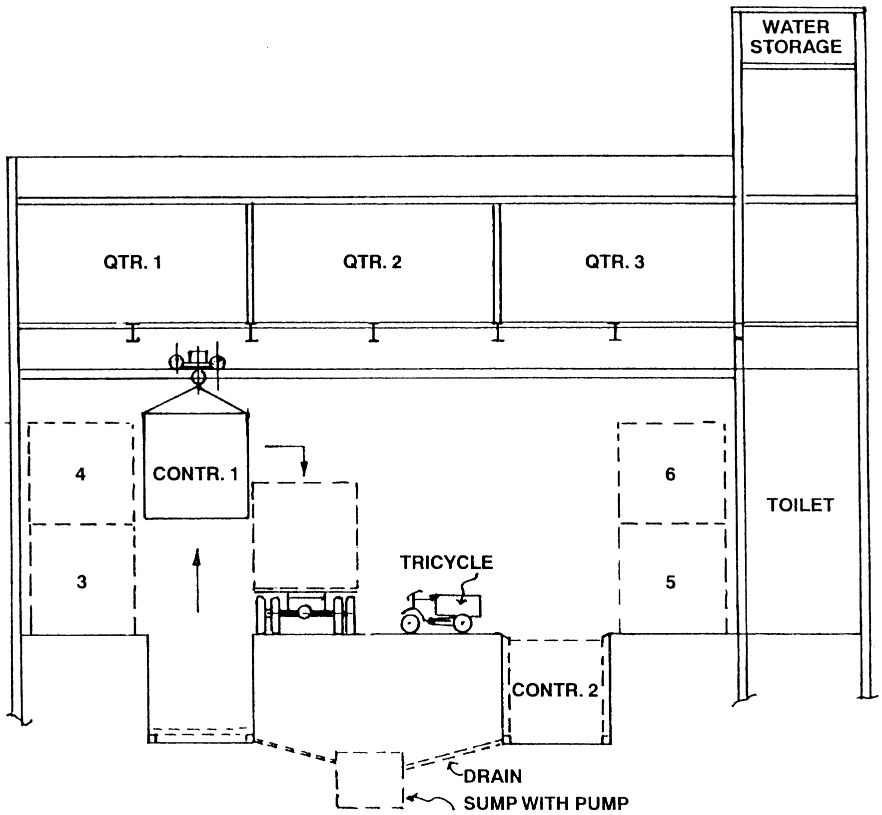


Figure A-3.5 Sectional view of small transfer station

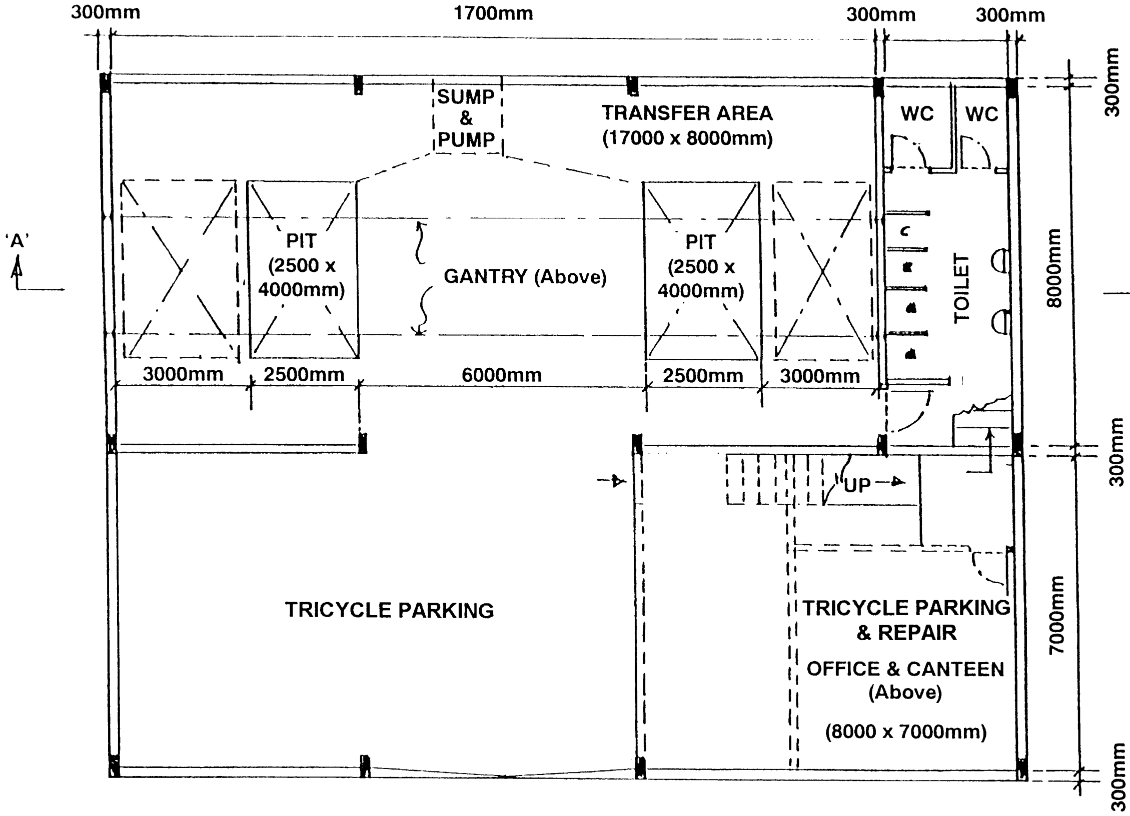


Figure A-3.6 Plan of ground floor of small transfer station

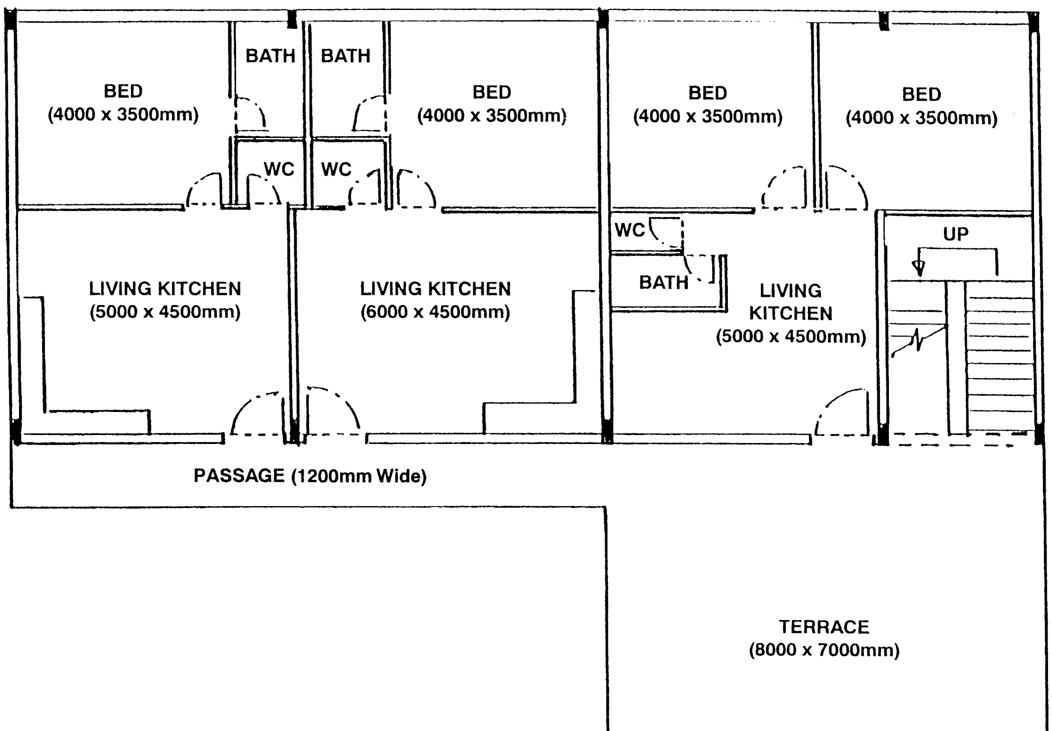


Figure A-3.7 Plan of first floor of small transfer station

A- 3.5 ADVANTAGES AND DISADVANTAGES OF PROPOSED SMALL TRANSFER STATIONS

Advantages

◊ A high level of service is provided by the door-to-door primary collection from individual houses.

◊ Hygiene - all the wastes are covered/containerised from the point of collection to the landfill. Loading heights are low. No one has to lift refuse over his head as is frequently necessary with many existing systems.

◊ No secondary handling - transfer does not require any manual reloading.

◊ Low capital cost and small space requirement for the STS allow them to be located at strategic points thus reducing primary haul distances.

◊ Storage capacity at the STS enables the primary collection and the transfer to take place at different times of the day to suit local traffic conditions. (Primary collection with tricycles may be done during the day, and bulk transfer at night when traffic congestion is less.)

◊ Primary collection by tricycle can work in congested areas and narrow streets.

◊ Traffic congestion will be reduced with the larger haul capacity of the transfer truck resulting in fewer trips.

◊ Optimum loads are carried by the transfer trucks at all times by the use of load cells at the STS to maximise loads without overloading.

◊ The STS uses appropriate technology at low capital cost, using only locally manufactured equipment.

◊ It is a labour-intensive collection system providing local employment.

◊ Both primary collection and transfer are suitable for privatisation where applicable due to the low cost and non-specialised equipment used.

◊ The STS interior specification allows for easy washing and cleaning facilities on a daily basis thus eliminating odours, rodent and insect problems.

◊ Visual impact will be pleasing and very acceptable to the local householders.

◊ No rag-picking will take place at transfer or collection points thus avoiding scattering of waste and fire hazards.

◊ The cost per ton of waste collected and transferred will be a small fraction of that of existing systems of direct haul or large transfer stations.

◊ Space above the STS is used for accommodation and offices.

◊ Due to the de-centralisation concept each supervisor will have a better control over the cleanliness of his locality and his sub-zone.

Disadvantages

◊ To procure land at strategic points may be difficult (although space requirements are small).

◊ The amount of supervision required for primary collectors will be high.

◊ The loading and unloading of containers at the STS is dependent on electricity. (A standby generator must be included to provide power in emergencies).

◊ Truck noise may create disturbance if night haulage is used. (Day haulage only is practical due to the storage capacity of the STS and the small number of truck hauls, but this will require a larger numbers of trucks since each truck will do fewer trips).

◊ It is essential to operate these STS with a very high standard of cleanliness. Failure to keep the stations clean will make them a nuisance to the local residents.

A-3.6 DESIGN CALCULATIONS

Area to be covered by each small transfer station and haul distances for primary collection tricycles. A study was carried out into the wastes generated and the population densities in different wards in Mumbai to determine the area which can be served by each small transfer station based on a throughput of 105 tonnes of wastes per station per day (assuming two shift operation). From this data the average haul distance for the primary collection tricycles can be estimated as well as the number of stations which would be required to serve the total population of each ward. These estimates are set out in table A-3.1.

It can be seen that the maximum straight line haul distance (collection radius) varies between 0.48 km and 1.36 km and the average straight line distance to be travelled by the tricyclist will be between 0.34 km for Ward A and 0.96 km for Ward G/N. Allowing for some deviation from a straight line the average distances travelled by the tricyclists will vary between 0.5 km and 1.4 km.

Table A-3.1 Area to be covered and haul distances for STS

Ward No.	Area (km^2)	Waste generated per km^2 (t/day)	Area to be served by 105 t/day STS (km^2)	Average collection radius (km)	No. of STS needed
A	1.4	145	0.72	0.48	3
D	6.63	32	3.28	1.02	7
E	7.4	31.5	3.33	1.03	7
G/s	10.00	19	5.53	1.33	8
G/n (part)	3.02	18	5.83	1.36	2
				Total No. of STS	27

Daily capacity of each tricycle and number required per STS

For calculating the daily capacity of each tricycle the following assumptions can be made:

- ⇒ Each tricycle will carry a maximum of 125 kg.
- ⇒ Each tricycle can make 8 trips per shift (one hour per trip).
- ⇒ An overall efficiency of 80% is assumed to allow for inefficiencies in the loads carried and the number of trips made.

On this basis each tricycle will collect an average of :

$$\frac{8 \times 125 \times 80}{100} = 800 \text{ kg / shift.}$$

To collect 105 tonnes / day with double shift work will require:

$$\frac{105{,}000}{2 \times 800} = 66 \text{ tricycles.}$$

Assume 75 tricycles per STS to allow 14% for breakdowns and repairs.

Based on the above figures each STS will take in a total of 1050 tricycle loads per day or 525 loads per eight hour shift. During twelve hours each day up to four tricycles can unload at the same time and during the remaining four hours, when the transfer truck is loading or unloading or the containers are being moved, only two tricycles can unload at the same time. On the above basis each tricycle has an average unloading time of 3.2 minutes. This is considered to be more than adequate and the extra time available will help to offset the problem caused by large numbers of tricycles arriving at the transfer station simultaneously at certain times of the day.

Daily capacity of each transfer vehicle

Each transfer container will be sized to hold a minimum of 8,000 kg of wastes and, as load cells are provided at the STS, each container load will be filled to this capacity. (This only applies to high density wastes such as those found in Indian cities - where wastes have low densities it may be difficult to provide containers of sufficient volume to hold 8,000 kg of uncompacted waste.)

The following assumptions can be made to arrive at the daily capacity of each transfer vehicle:

⇒ Average haul distance from transfer station to disposal site 17.5 km. (Based on the distance from the city centre area to Deonar disposal site).
⇒ Average speed of haul vehicle 25 km/hr. (Assuming that most transfers are undertaken during off - peak traffic times.)
⇒ Loading time at the transfer station: 10 minutes
⇒ Unloading time at the disposal site: 10 minutes. (including weighing).

Number of loads to be transferred = $\frac{105,000}{8,000} = 13.125$

Theoretical round trip time:

$$\frac{17.5 \times 2 \times 60}{25} + 10 + 10 = 104 \text{ minutes}$$

If two trucks are allocated to each STS, working two shifts, there will be a theoretical transfer capacity of:

$$\frac{2 \times 2 \times 8 \times 60}{104} = 18.5 \text{ loads per day.}$$

Thus these two trucks will have a surplus capacity of 40% to allow for breakdowns, servicing, tea breaks, etc.

Capital costs for small transfer stations

Construction costs (Based on the designs shown in Figs A-3.4 to 7)

Ground floor covered area.

Transfer area	17.0 m x 8.0 m	136 m^2
Toilet/wash room	2.7 m x 8.0 m	22 m^2
Tricycle repair	7.0 m x 8.0 m	56 m^2
Total covered ground floor area		214 m^2

Second floor area.

3 staff quarters	158 m^2
Office & canteen area	56 m^2
	214 m^2

Building costs

Ground floor 214 m^2	2,306 ft^2 @ Rs 600	Rs 1,383,600
First floor 214 m^2	2,306 ft^2 @ Rs 350.	Rs 807,100
Total building cost		Rs 21,90,700 or Rs 22 lakh

Depreciation on building @ 4% 0.8 lakh

Note: This does not include the value of the land which must depend upon location and availability. Some of the land value can be offset against the rental value of the three staff quarters included in the above costings.

Equipment at transfer station

	cost: Lakh Rupees
Gantry crane	3.0
High pressure wash down pump	1.5
Gates, roller shutter door, fencing	2.0
Electrical installations	1.5
Stand by generator	1.5
Load cells	2.0
	11.5

Depreciation on plant @ 10% 1.2 lakh

Transport costs

Two 16 tonne GVW trucks with skeleton tipping bodies.

Table A-3.2 Capital and annual depreciation for vehicles and containers

	Capital cost: Lakh Rupees per truck		Capital cost: Lakh Rupees for whole system	Economic life (years)	Depreciation cost (Capital cost/life), Lakh Rupees per year
Chassis	7.0				
Hydraulic system	2.0				
Tipping frame	0.5				
Total, (x 2 since two trucks)	9.5	x 2 =	19.0	8.0	19.0/8.0 = 2.38
Ten containers @ Rs 60,000			6.0	3.5	6.0 / 3.5 = 1.71
75 tricycles @ Rs 6,000			4.5	5.0	4.5 / 5.0 = 0.90
Small tools etc.			0.5		
		Total	**30.0**		**4.99**

Annual costs

Table A-3.3 Calculation of annual costs

Item	Explanation or calculation	See note	Costs, Lakh Rupees	Total costs, Lakh Rupees
Fixed costs				
Depreciation	Buildings (calculated above)		0.80	
	Plant (calculated above)		1.20	
	Vehicles (Table A-3.2 above)		4.99	
Interest on capital	Buildings 22.0 x 12%	1	2.64	
	Plant 12.0 x 12%	1	1.44	
	Vehicles 30.0 x 12%	1	3.60	
	TOTAL FIXED COSTS			14.67
Maintenance costs				
Trucks:	assuming 10% of cost		1.9	
Containers:	assuming 5% of cost		0.3	
Tricycles:	assuming 15% of cost		0.7	
Buildings	assuming 2.5% of cost		0.55	
Plant	assuming 5% of cost		0.6	
	TOTAL ANNUAL MAINTENANCE			4.05
Energy and water				
Fuel	13.125 loads x 35 km x 365 days @ 4 km/litre @ Rs 4 per litre			3.4
Electricity & water	Guesstimate			1.0
Overheads	Guesstimate			3.0
Labour costs				
Tricycle operators	193 operators @ Rs 2,500 per month	2	57.9	
Truck crew	9 drivers @ Rs 4,000 per month	3	4.3	
	9 helpers @ Rs 2,500 per month	3	2.7	
STS staff	3 attendants @ Rs 2,500 per month	4	0.9	
	3 mechanics @ Rs 3,000 per month	4	1.1	
	3 cleaners @ Rs 2,000 per month	4	0.7	
	TOTAL LABOUR COSTS			67.6
	TOTAL ANNUAL COSTS			**93.72**

Notes for table A-3.3

1. A NEERI study used a 12 % rate for this purpose.
2. [66 tricycles x 2 shifts x 365 collection days per year] / [250 working days per man per year] = 193
3. [3 trucks x 2 shifts x 365 collection days per year] / [250 working days per man per year] = 9 drivers and 9 helpers
4. One of each category (attendant, mechanic and cleaner); STS works two shifts but three of each category are needed to allow for holiday periods etc.

Cost per tonne of waste collected and transported

One small transfer station, working two shifts, can handle 105 tonnes of waste per day.
Therefore, waste handled per year = 105 x 365 tonnes, and cost per tonne is

$$\frac{93,72,000 \text{ Rs per year}}{105 \times 365 \text{ tonnes per year}} = \textbf{Rs 245 per tonne}$$

Note: This figure can be compared with the estimate provided in the NEERI report at Rs 378 per tonne for the existing system of collecting wastes from community containers and transporting them to the disposal site. It can be seen that the proposed STS system will provide a much higher level of service in a hygienic manner at less than two-thirds of the cost of the existing system.

A-3.7 CONCLUSIONS AND RECOMMENDATIONS

The economics and hygiene advantages of this proposal suggest that this method of waste collection and transport merits serious consideration. It is recommended that a potential site in an urban area be identified and that a research and development grant be awarded for the construction and operation of such a system. It is unlikely that the initial design will be perfect, so time and money must be allocated to allow improvements to be made to the prototype before a decision is made as to the viability of this system. Operational data will need to be verified before a definitive costing of the system can be obtained. A similar approach in China has been successful, so it is worth investing money and skill into the introduction of this system in India.

If the waste is collected directly from houses, and is kept containerised all the way to the disposal site, there is very little opportunity for rag pickers or recyclers to separate materials that can be reused or reprocessed. Such a system could be operated in conjunction with household separation - each tricycle having two compartments for two types of waste (such as wet and dry) - or the waste could be sorted by the collector at each house, so that the value of the recyclable materials and the opportunities for employment (which are provided by resource recovery) are not lost.

A-3.8 EXERCISES

A sensitivity analysis could be conducted on the calculated cost per tonne. For example, it may be that the average speed used for the transfer vehicles in the analysis above is too optimistic, and that a lower speed should be used if two-shift operation is specified. The effect of a lower average speed on the number of vehicles and the collection cost per tonne would show how sensitive the results are to traffic conditions. Another variable that could be considered is the time allowed for each tricycle to collect its load. By using different times, the sensitivity of the final results to the number of tricycle trips undertaken in a day could be investigated. Such sensitivity analyses can be used to indicate which items of data are most influential on the final result, so that extra effort can be concentrated on obtaining accurate values for these key items.