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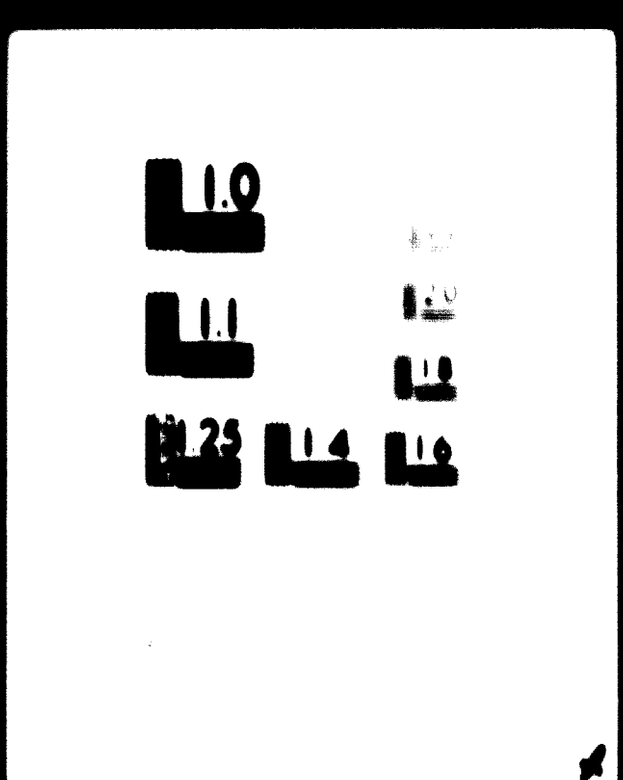

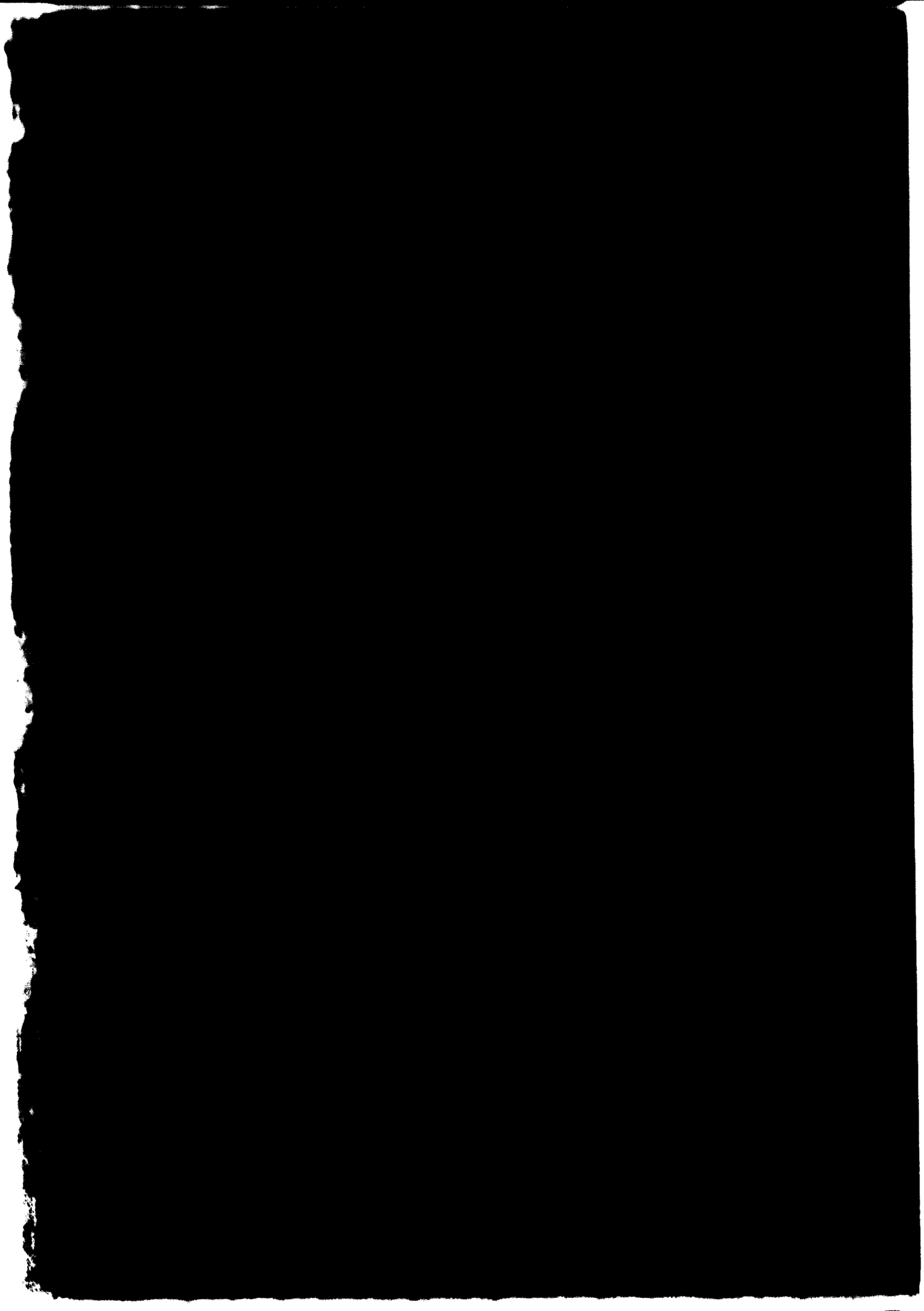

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Morocco. STUDY ON THE REORGANIZATION OF HOUSEHOLD REFUSE COLLECTION BY THE APPLICATION OF COMPUTER TECHNIQUES

CASABLANCA / MOROCCO

AGRAR- UND HYDROTECHNIK GMBH
Consulting Engineers

in Cooperation with

MESSERSCHMITT-BÖLKOW-BLOHM GMBH

ESSEN, FEDERAL REPUBLIC OF GERMANY

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SOME FIGURES
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AND WILL NOT
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1. Introduction

The following study was carried out by AGRAR- UND HYDROTECHNIK GMBH (AHT), Consulting Engineers in Essen, Federal Republic of Germany, at the request of the UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION (UNIDO), Vienna, for the KINGDOM OF MOROCCO and on behalf of the Prefecture of the City of Casablanca.

The main objective of the study was to determine the most rational and economic system for refuse collection in the city of Casablanca, with the help of computer technology in order to ensure a regular and efficient supply of household refuse for the city's compost plant.

Two experts, one on refuse treatment and the other on electronic data processing (EDP), travelled to Casablanca for five and four weeks respectively to collect the existing basic data and elaborate it for their own investigations.

However, when the team leader arrived in Rabat, the capital of Morocco, he was informed by UNDP and the government that the Casablanca compost plant had been closed down in April this year because of intolerable environmental hazards due to bad odours from anaerobic fermentation in the compost plant.

At present the municipality of Casablanca carries out more or less sanitary landfilling near the boundary of Casablanca. However, because of the expansion of the human settlements this dumping site will also have to be closed soon.

The Prefecture of Casablanca found a new site for dumping the household refuse. Unfortunately this dumping site will be full within less than two years of sanitary landfilling and for subsequent years there are no plans for refuse disposal at all.

With regard to the present situation a new objective was formulated in agreement with the local authorities. Now the expert mission had a threefold task:

a. Analyse the possibilities of optimizing the collection routes for household refuse by electronic data processing (EDP)
b. Recommend suitable organisation and equipment for refuse collection
c. Recommend new locations, refuse transfer stations, refuse treatment facilities and refuse dumping sites.

For the optimisation of the routes for travel, a pilot area was chosen just to make an EDP test run and the present study will show how the EDP can be applied to parts or the whole of the city of Casablanca.

The recommendations concerning organisation and refuse collecting equipment will consider dust-bins and containers as well as the normal collection vehicles and special equipment.

For the further treatment of the household refuse of Casablanca, some comments will be made on transfer stations, compost plants and sanitary landfilling as well as on the location of these various items.

Finally, the experts would like to thank all the people

engaged with the problems of this study. We would like to extend our special thanks to the Prefecture of Casablanca with its Department of Public Works and its subdivisions of Public Parks and Public Cleaning, who were not only concerned in the study itself but also provided as much personal assistance and useful information as possible.

2. Survey of the present situation

2.1. General aspects of the city of Casablanca and its household refuse

Casablanca, with a population of about 1.8 million inhabitants, is not only the biggest town in Morocco but also the most important centre of trade, commerce and industry. Nearly half of the industrial capacity of the country is concentrated there.

Due to its favourable position on the Atlantic Ocean and its trade with overseas countries, the port of Casablanca has become the greatest port in Morocco and the second greatest on the African continent. 65 per cent of the country's imports and 75 per cent of its exports pass through Casablanca.

Casablanca is connected to all the important places in the country by well equipped railway lines and a good road network.

As Casablanca has developed to its present importance only during the course of this century - in 1907 the population was only 25,000 - it is for the greater part a modern and generously planned metropolis with commercial skyscrapers, wide avenues and a lot of green areas and public parks. On the other hand there is the Ancienne Médina with its narrow streets and - since 1923 - a new Médina also erected in the traditional architectural style of Morocco. Along with the town's rapid development in trade, commerce and prosperity, the formation of a number of slums, the so-called 'bidon-villes', on the outskirts was inevitable.

The climate of Casablanca is characterised by a dry summer and a rainy winter season. The average annual rainfall in the years from 1943 to 1972 was only 377.3 mm. The average number of rainy days with over 1 mm was only 75 per year. More climatic details of Casablanca are shown in Table 1. In spite of the small amount of precipitation and the few or no rainy days, the relative humidity in summertime is also high because of the humid air currents blowing in from the Atlantic.

The geographical position of Casablanca is 8° west and 34° north. At present Casablanca extends over an area of 150 sq.km. and has a road network of about 1,300 km. The extension of the area along the Atlantic coast in the east-west direction is 21 km and in the north-south direction about 7 km (see Fig. 1). However, a comparison of older maps with the anticipated development clearly shows that the further expansion of the urban area is directed towards the hinterland in the south. On account of this expansion, the kidney-shaped form of the urban area will soon change into a more or less square form.

The expansion of the urban area is accompanied by an increase in population. From 1907 until 1960 the population grew from 25,000 to 962,000 inhabitants. That means that the population was doubling every 11 years. Between 1960 and today the annual growth rate was above 5 per cent and for the period until 1992 the growth rate is estimated to be about 6 per cent.

However, this development will not be uniform over the whole urban area. To illustrate the difference in population increase rates, the town and its surrounding area has been subdivided into 30 zones (see Fig. 1, Table 2).

At the moment zones 24 to 30 are still outside the perimeter of the town, but further expansion is expected in the near future. The detailed population development is shown in Table 2. From this table it becomes evident that until 1992 the annual rate of population increase within the present boundary of the town will amount to 2.7 per cent whereas it will reach an average of 20 per cent on the outskirts.

In general, the production of household refuse depends on the standard of living, which can be determined by different parameters. Some socio-economic characteristics (stated in 1975) of the different areas of Casablanca are given in Table 3. For the number and position of these sectors see Fig. 1.

Table 3 shows that sector I has the highest standard of living. It has the highest rate of working population, private cars and revenues and the lowest rate of bicycles and of persons per habitation.

Additional and more detailed basic material can be found in the 'Etude de circulation urbaine, Casablanca et Rabat', volume 3, prepared by Transroute, Rabat, in October 1975, and the original data collection for this study which is stored on magnetic tapes in the record office of Transroute. These sources would be a helpful data basis if EDP was to be introduced for forecasting household refuse production and long-term plant location.

At present the household refuse produced in Casablanca per day is estimated by the local authorities to be 800 tons, incl. refuse collected by the street sweepers. Refuse is collected every day throughout the year and the quantity collected per annum amounts to approximately 292,000 tons. This figure and the actual number of inhabitants yield a

per capita refuse production of 161.5 kg per year. The latter figure combined with the standard of living is an important index for further household refuse production forecasts.

Besides the quantity for the proposed refuse treatment density is an important parameter. In the course of an investigation in this respect the average density of the household refuse was determined as follows:

- in dust-bins prepared for collection 130 kg/m^3
- in collection containers and collection vehicles without compressing devices 465 kg/m^3
- in collection vehicles with compressing devices 581 kg/m^3

These data differ considerably from European figures where the density is much lower.

This difference in density is due to the composition of the refuse. At Casablanca the content of bulky refuse such as tins, packing materials, etc. is very small. The refuse mainly consists of wastes from the preparation and serving of food, vegetable and fruit materials. Analyses of the composition of household refuse at the compost plant of Casablanca showed that the bulky refuse only amounts to 1 - 4 weight per cent and the ferric metals do not exceed 1 - 2 per cent. The moisture content, however, ranges between 61 and 68 per cent and is twice as high as the European ratio.

2.2. Present situation of waste handling

2.2.1 Legal aspects

The responsibility for keeping the town clean was delegated to the Prefecture of Casablanca by the municipal edict of 31st March 1930, dealing with public health, and the municipal edict of 2nd January 1952, regulating the question of responsibility for waste handling. The residents are bound by the municipal edicts no. 171 of 23rd February 1946 and no. 4/65 of 16th September 1965 to

keep their property clean
sweep the pavements
collect the household refuse in dust-bins
transport their rubbish to public dumping sites
not to dispose of waste in public or private roads, squares or other public places
not to scavenge in dust-bins prepared for collection or in refuse dumps.

However, the last point is often neglected. Scavenging in dust-bins and dumps is quite usual, despite the sanitary and hygienic risks.

2.2.2 Institutional aspects

The Prefecture of Casablanca is well organized to fulfil all its obligations and responsibilities. The administration is subdivided into the following 6 sections:

1. General administration
2. Finance
3. Planning and construction
4. Public works
5. Economic services
6. Judicial, social and cultural services

The Department of Public Works, which is also in charge of waste handling, is subdivided into the following subsections:

1. Public street lighting
2. Sewage network
3. Public roads, traffic and traffic regulations
4. Superstructure work
5. Municipal garages and public parks
6. Maintenance of public buildings, general depot
7. Public cleaning services

Waste handling is carried out by two subsections: all collection vehicles and bulldozers at the dumping site including the drivers and the maintenance services are provided by the municipal garages, whereas the public cleaning services are engaged with street sweeping, household refuse collection and the running of the dumping sites.

The compost plant, which is not in operation at the moment, is under the management of a separate firm, the 'Société d'Exploitation et de Traitement des Résidus Urbains', SETRU, which is also responsible for the marketing of the compost. For each ton of household refuse delivered to the plant the Prefecture had to pay 6 DH.

The division of waste handling in the above-mentioned way seems to be optimal and should not be altered. Otherwise the public cleaning services would have to install additional service stations for the maintenance of the vehicle park and to build up a new commercial subdepartment for compost marketing.

2.2.3 Financial aspects

The expenses for the public cleaning services are covered by a general tax levied by the Prefecture from every household for all public services, in particular street lighting, waste water treatment, road construction, maintenance of public buildings, parks, solid waste handling, etc. Every year a new budget is set up for each subsection of public works according to the real needs of the different subsections. Consequently the expenses for public cleaning are split up between the municipal garages and public cleaning services. When the compost plant was in operation a third amount had to be paid to the SETRU. The actual cost of public cleaning is given in Table 4. This table shows the cost of household refuse collection, including treatment at the dump, and of street sweeping.

In general the largest amount of the budget, i. e. 80 %, is spent on salaries and wages. This may be accepted with regard to the official programme to reduce unemployment. However, as far as the municipal garages are concerned, the relation between personnel costs and equipment is vice versa. Here only about 40 per cent of the budget is spent on personnel and the rest on machinery and equipment. A more effective and economical use of the refuse collection vehicles might lead to a considerable reduction of costs.

2.2.4. Organizational aspects

The city of Casablanca is divided into 11 sectors (Fig. 2) which are again subdivided into a total of 64 circuits. One (sometimes two) collecting vehicle and its crew is responsible for each circuit. The choice of the collecting route is left to the crew.

There are three types of collection:

- Collection of dust-bins by usual collecting vehicles (with or without compressing mechanism and with a capacity of 1.5 to 12 m^3)
- Collecting of bins by little vehicles with three wheels, so-called triporteurs, capacity about 0.5 m^3, which carry waste to containers located at specific points for this purpose. This type of additional collecting is usual in districts where the streets are too narrow for other vehicles.
- In the slums the streets are also too small for the usual collection vehicles, and in rainy periods vehicles cannot pass at all. Therefore, containers where the people can drop their waste are located at specific points.

All these containers are used also for the rubbish gathered by the street sweepers.

The borders of circuits as shown in Fig. 5 are no longer valid. Changes of vehicles in the past have caused changes in the circuits with the result that the circuits now overlap (an example is shown later). Besides this, some circuits consist of several disjointed parts, which obviously means extra travel. The collecting vehicles make 1 or 2 trips a day in most cases. There is no doubt that the utilization of capacity can be improved, since at present the vehicles are by no means full on the second trip.

As a result of a trial and error procedure worked out by the drivers, the collection routes themselves are certainly quite good. An example is shown in chapter 3.2.

However, a reorganisation of the circuits and allocation of vehicles to circuits on the basis of optimised collection routes would result in an essential reduction in collecting costs.

The location of containers and their respective capacities should also be analysed with regard to efficiency. The present situation can be improved in a way suited to the improvisatory character of the system, without using sophisticated methods.

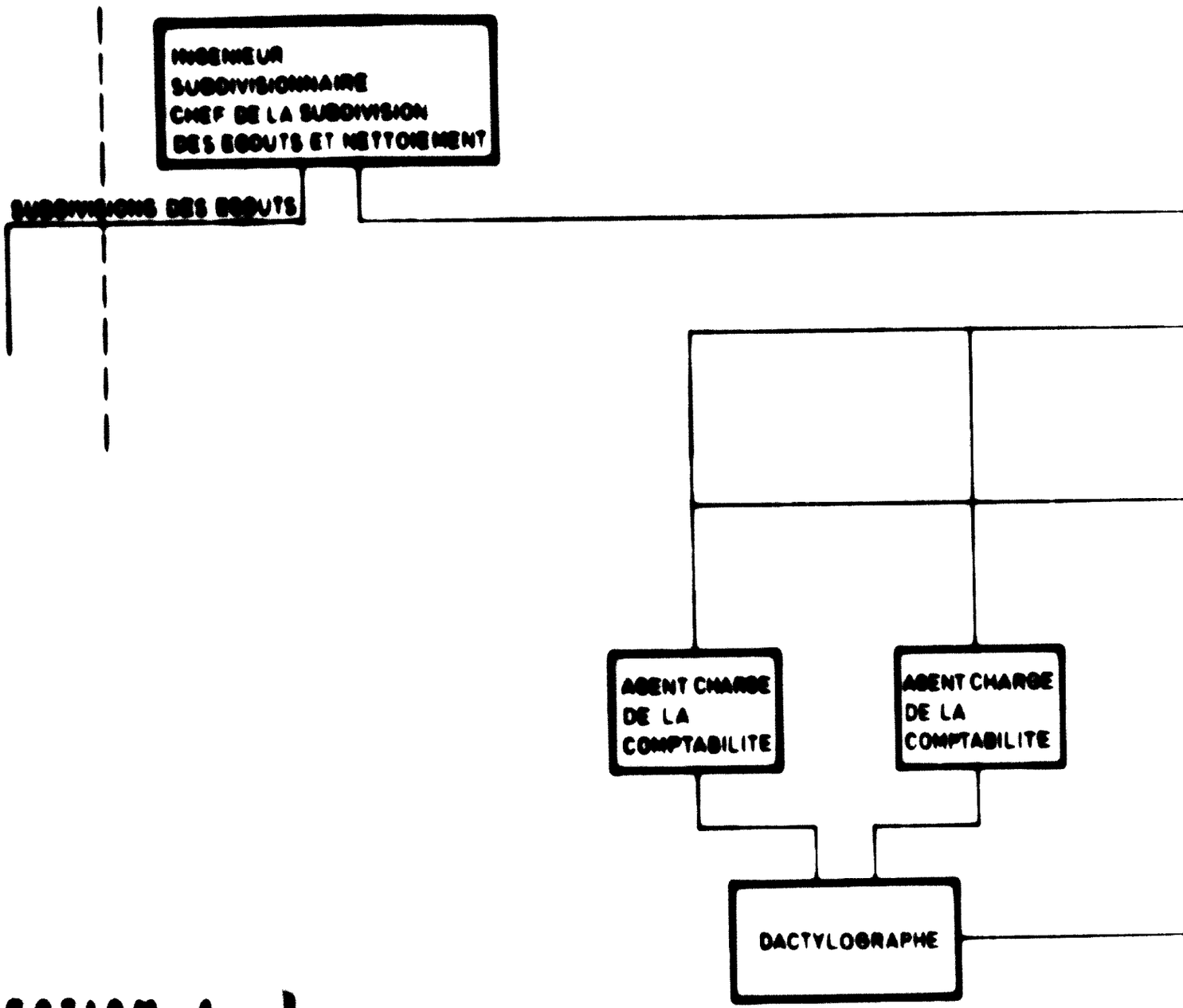
2.2.5 Personnel aspects

The section of public cleaning services in charge of street sweeping, household refuse collection and dumping sites employs 1700 people, not including drivers of collection vehicles. A synopsis of the different positions of these personnel is given in the organigram below.

The management is constituted by the engineer of public works, the chief of public cleaning services and his deputy, 5 bookkeepers and 11 inspectors.

The inspectors are the chiefs of the collection sectors (see Fig. 2) and are responsible for cleanliness within their sectors. They are assisted by supervisors and by foremen who are in charge of either street sweeping, refuse collection or landfilling. Some supervisors are responsible for emergency cases.

Organigramme du Service de Nettoie



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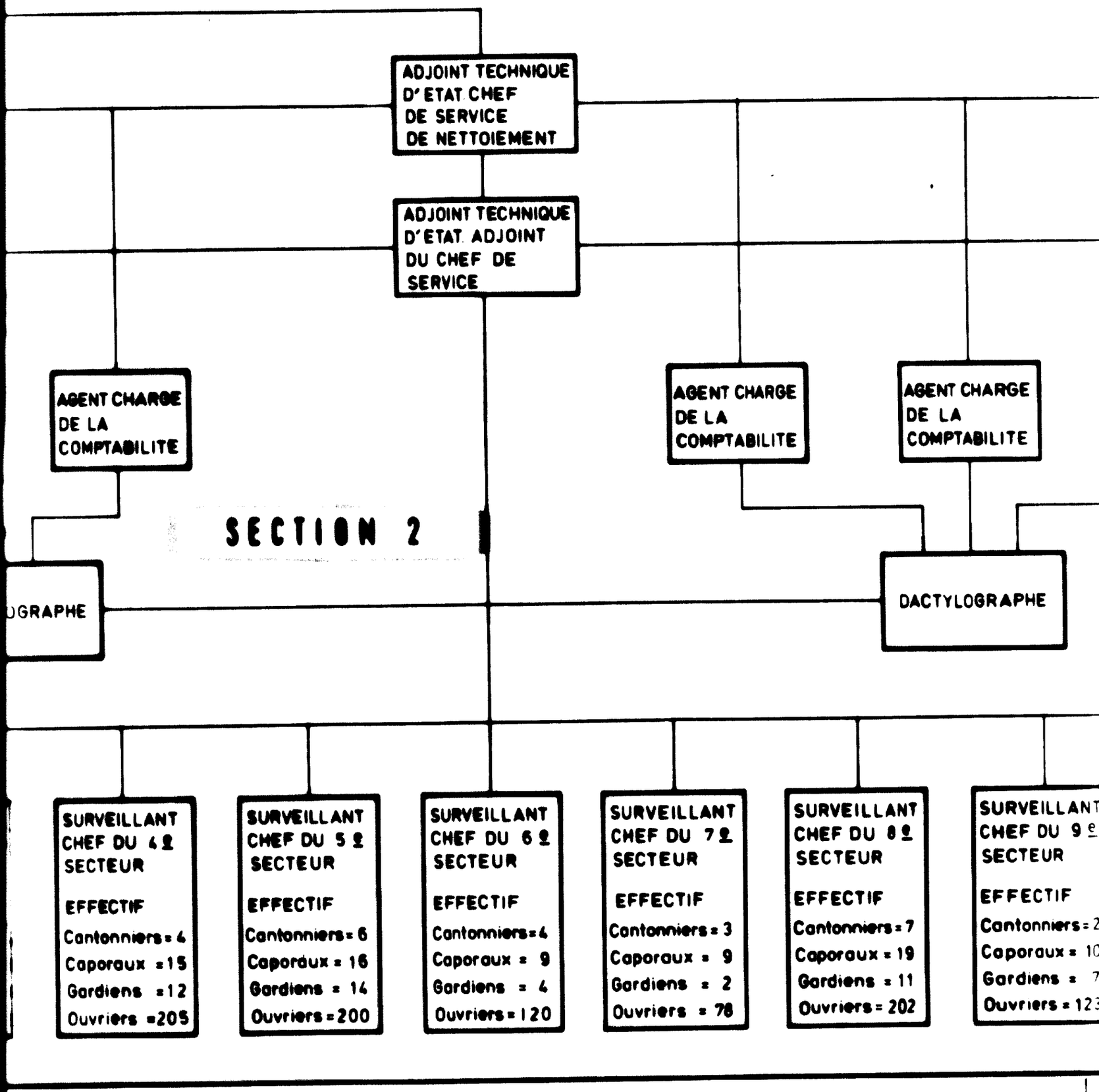

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DACTYLOGRAPHE

SECTION 3

ILLANT
DU 6 ♀
FUR

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nniers = 4
aux = 9
ens = 4
ers = 120

SURVEILLANT CHEF DU 7 ♀ SECTEUR

EFFECTIF
Cantonniers = 3
Caporaux = 9
Gardiens = 2
Ouvriers = 78

SURVEILLANT CHEF DU 8 ♀ SECTEUR

EFFECTIF
Cantonniers = 7
Caporaux = 19
Gardiens = 11
Ouvriers = 202

SURVEILLANT CHEF DU 9 ♀ SECTEUR

EFFECTIF
Cantonniers = 2
Caporaux = 10
Gardiens = 7
Ouvriers = 123

SURVEILLANT CHEF DU 10 ♀ SECTEUR

EFFECTIF
Cantonniers = 1
Caporaux = 2
Gardiens = 3
Ouvriers = 34

SURVEILLANT CHEF DU 11 ♀ SECTEUR

EFFECTIF
Cantonniers = 2
Caporaux = 6
Gardiens = 5
Ouvriers = 75

This subdivision and subdivision of labour is shown in Table 5. In sector III, which corresponds to sector IX (see Fig. 2) refuse collection is carried out partly by the street sweepers.

To support the official staff in its duties about 750 labourers are employed and paid by the government within the official programme to reduce unemployment.

2.2.6 Technical aspects

Preparation of refuse collection

As there is a daily collection of refuse in Casablanca, the amount of refuse to be collected per person or per household is relatively small and so is the overall capacity of the bins used.

In areas where the population density is relatively low, people have their household bins in the street or bring their bins to the collecting vehicle when it announces its arrival by blowing a horn.

Where the population density is high enough, several households have one larger bin which is put in the street at collection times or carried to the next corner by the inhabitants or the dustmen, in order to reduce the distance driven by the collection vehicle.

In both cases the bins are of all types and sizes and most of them are not special dust-bins but any available type of containers.

In the slums there are containers of 1 m^3 capacity located at some central points, where the inhabitants drop their refuse.

The bins are in general unaesthetic and unhygienic. The larger ones are very cumbersome and thus reduce collection efficiency. The provision of special dust-bins suited to the character of the respective refuse producing units will greatly improve the situation. An analysis should be made of the possibility of extending the habit of saving vehicle travel by carrying smaller bins short distances to collection points by hand.

Collection

According to the different types of collection as mentioned in chapter 2.2.4, there are four different types of vehicles:

- collection vehicles with compressing mechanisms (8-12 m^3)
- collection vehicles without compressing mechanisms (1.5-8 m^3)
- little vehicles on three wheels ('triporteurs', 0.5 m^3)
- container transport vehicles.

Many of the vehicles are rather old and are to be replaced by new ones. The tendency is to use more and more compressing vehicles (in 1976 21 new vehicles will be bought by the municipality). However, as household refuse in Casablanca is very humid, there remains the technical problem of how to cope with the waste water which comes out of the compressing vehicles and even to a certain extent out of the other vehicles and the containers.

Transfer

Up to now 'transfer stations', that is to say containers located at certain points, have been used only by the little triporteurs. The loading of the containers, at present done by shovel, could be improved by building a ramp for the vehicles or a special hole for the container.

In addition, three transfer stations with compressing mechanisms have been ordered this year. It is intended to use one of them for the triporteurs of the Ancienne Médina district and the others for the slum regions of sectors V and VI to avoid inefficient long travel distances for the 3 m^3 containers used there. The use of additional transfer stations might be a further improvement. A comprehensive analysis should be started to find out the optimum transfer stations and their optimum locations.

Refuse treatment

Until April this year the household refuse collected was transferred to the compost plant at Oukkacha, in the eastern part of Casablanca, directly on the shore of the Atlantic Ocean (see Fig. 2). This plant is designed to operate in three lines according to the 'Biotank System' developed by the French company SGEA. The plant can handle about 700 tons of refuse per day. If it were extended by a fourth line the capacity would be increased to up to 900 tons.

Four processes are involved at the plant:
Preparation of refuse for composting
Prefermentation in biotanks
Final fermentation in high piles
Preparation of compost for sale

The collection vehicles dump their contents into a bunker. A gantry-type crane brings the waste material to a sifting station where the bulky refuse, such as plastic foil, packing material, bottles, rags, crates, etc., is separated for dumping. The scrap iron is separated by an electromagnetic device and subsequently

transferred to a scrap press which forms it into compact blocks. After having passed the screen the raw material goes through a double-rotor hammer-mill, where it is reduced to small pieces. A conveyor system transfers the ground material into the biotank where it stays for about 3 weeks for fermentation. After this procedure the raw compost is piled up in high layers for further and final fermentation. About 3 to 4 months later a second sifting is introduced in order to separate the non-compostable parts and prepare the compost for sale.

The experience of the last two years has shown that neither the system of composting nor the location of the plant suit the particular conditions in Casablanca. Recommendations will be made under point 3.3.2.

At present the household refuse collected is dumped in a more or less sanitary way in the south-eastern part of the urban area (see Fig. 2).

The collection vehicles (with and without compressing mechanisms and the containers of different sizes) discharge their loads near the slope of the dump. A great number of private scavengers try to sort out anything suitable for private use or sale (paper, plastics, metals, fodder, etc.). Then two bulldozers shovel the load over the slope, between 3 and 4 m high, and consolidate the surface of the dump by moving forwards and backwards. A private firm is commissioned to provide inert material for covering the refuse layers and a third bulldozer is engaged in distributing this material. Unfortunately, the quantity of covering material does not cover the daily demand, nor are bulldozers always available

when required because of the shortage of spare parts. Thus the uncovered refuse is an ideal breeding place for flies and other contaminating insects.

The unhygienic and dangerous private scavenging should be prevented and it should be ensured that the refuse is covered every day.

The distance from the present dump to the center of the city is about 10 km. The problem is that the vehicles collecting refuse in the western part of Casablanca not only have to travel a distance of 15 km and more but that they also have to go through the center of town with its heavy traffic. So a lot of time is wasted driving. Moreover, in the near future, the present dump will have to be closed and the location of the new dump (see Fig. 2) will add another 2 km to the distance to be travelled.

As the new dump will also be full after 2 years, long-term considerations should be made concerning the location of dumping sites and compost plants. The optimum number, type, location and capacity of treatment facilities will have to be determined with reference to the areas to be served and taking transfer stations into consideration.

3. [illegible]

3.1. Refuse presentation for collection

Except for in the slums household refuse is collected every day in Casablanca by house to house collections. In the households small dust-bins of about 10 - 20 l are usual and are considered sufficient. In some areas, especially where the population density is low, these bins are deposited in the streets at collecting time or else people bring them out when the dustmen arrive and blow their horn.

Where the population density is high enough, larger bins of up to about 100 l are used communally by several families or even by several houses. These bins are not of a special type: most of them are halves or thirds of oil barrels, olive barrels or similar casks. Only very few special dust-bins are currently in use.

In most cases the bins have no cover, so there is no protection from bad odours. Generally, they have no handles and therefore the bulkier and heavier ones are difficult and uncomfortable for the dustmen to handle.

At collection times the bins are stood along the streets and some small streets even have their collection points at the next corner, the dust-bins being carried there by the collection crew or the street inhabitants. Consequently the collection vehicle is not forced to go through every street, and thus here is a reduction of route length and collecting time.

The area covered by circuit no. 512 was analysed in detail to give an idea of the present situation. The collection vehicle was accompanied on its route on Tuesday 20th July, and on Wednesday 28th July, and besides other data (cf. 3.2.) the number of bins was registered together with the total estimated capacity of all bins in each refuse producing unit (defined as a 'street section between two crossings').These sections are shown in Fig. 3, while the number and capacity of bins and the amount of waste produced per day by each section is given in Table 6. The percentage distribution of different sizes of dust-bins is given below.

capacity l	20/7/76 %	28/7/76 %
20	8.7	12.4
30	12.6	11.2
40	19.7	22.7
60	47.8	40.9
80	9.9	11.6
100	1.3	1.2

In the slums, e.g. in sector VI (cf. Fig. 2), house to house collection is not possible because the streets are too narrow and in rainy periods not passable for cars at all. Therefore containers of 3 m^3 capacity are located at a number of central points (see Fig. 4). The inhabitants empty their household bins into these containers and the containers are transported to the dump as soon as they are filled up. Chapter 3.2. indicates the technical equipment used, including containers and transport vehicles.

There are three vehicles in sector VI, each of which can make 7 or 8 trips a day (in other sectors only 5 or 6)

because sector VI is very near the presently used dump. As 30 containers are in operation they can be replaced and emptied nearly every day.

The present situation is by no means satisfactory. The bins in use are

- unhygienic, unaesthetic

  Household refuse in Casablanca is very humid (about 68 per cent humidity). Many of the bins used have holes so that dirty water leaks out. The use of cardboard boxes increases the problem. In addition there are no covers which would help to retain bad odours.

  The open bins and boxes, many of them overloaded so that refuse even drops on the pavement, are unsightly.

- uncomfortable, hard to carry

  Generally the heavy bins have no handles. Thus it is very hard for the dustmen to carry them to the collecting vehicle, especially when they must be brought out of the small street to the next corner (as is usual in some streets). Because of the fact that the bins are not uniform the use of automatic or semi-automatic pouring mechanisms to facilitate the emptying of the sometimes quite heavy bins is not possible.

It is recommended that uniform dust-bins of only a few different sizes should be introduced in the near future. A thorough investigation is proposed to find the most suitable bins for the different refuse producing units, depending on the population density, population composition etc. An expansion of the practice of carrying bins by hand to save collecting vehicle travel should be seriously considered (cf. 3.2.).

The necessary investment in new bins can either be made at the direct expense of the inhabitants or financed by the municipality of Casablanca. To allow better control by the local authorities the latter would be preferable. A reasonable form of organization has to be found for the communal use of bins by several households.

The provision of new bins should be undertaken parallel to the renewal of collecting vehicles in connection with the use of automatic or semi-automatic pouring mechanisms.

It should be pointed out that in the long run the procurement of uniform bins is inevitable. An investigation as to the most suitable bins will cost about DH 68,500.-- corresponding to approximately 3 per cent of the necessary investment.*) A non-optimum choice of bins would certainly lead to misinvestment of a higher magnitude. In addition, appropriate bins will without any doubt reduce collecting costs (cf. 3.2.).

As regards the slums it has to be checked whether the introduction of closed containers is possible (for hygienic reasons); further, whether the number, location and capacities of the containers are the optimum with respect to collecting points, amount of refuse produced and location of the disposal sites (also considering traffic conditions). This optimization problem is of the type dealt with in chapter 3.3.2. as 'plant location problem' and could be solved most easily by an existing EDP programme provided detailed data on refuse production in the slums were available. But as the collection of these various data, as well as the estimation of future refuse production, is rather difficult, only short-term planning is possible and it is likely that the cost reduction which could be achieved

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*) 1 DH = 0.23 US $

would not be great. Therefore sophisticated methods are unsuitable and intuitive ad hoc decisions of personnel accustomed to these problems should be preferred.

Apart from simple changes in the locations of containers, improvements cannot be brought about immediately but only in connection with the renewal of the old vehicles and/or containers.

3.2 Refuse collection

Organisation

Casablanca is at present divided into 11 sectors for street cleaning and refuse collection. Most of the available data refer to 1979 or earlier, when the city was divided into 9 sectors. Parts of sectors II and VIII later became sectors XI and X respectively (cf. Table 7). Sectors III and IX indicate the same area which is called sector III for street sweeping and sector IX for waste collection. The sectors are organisational units as mentioned in chapter 2.2.4.

There are three different modes of collection:

- house to house collection with collecting vehicles of between 1.5 m^3 and 12 m^3 capacity (see also 3.1) with or without compressing mechanisms. The collection vehicles transport the refuse to the dump;
- house to house collection with small collecting vehicles (about 0.5 m^3) without compressing mechanisms which carry refuse to strategically located containers (used for transfer stations);
- container service, especially in the slums, where people bring their waste to containers located at central points whenever they like.

Every sector has several circuits, which are the areas served by one (in a few cases two) vehicle and its crew. All circuits of the city are shown in Fig. 5. In addition every sector has a number of containers distributed in its area which are used by the street sweepers for dropping their sweepings, by the little collection vehicles (as described later) as transfer stations and by the inhabitants of the

slums for disposing of their household refuse. The container transport vehicles can make 5 to 8 trips per day depending on the distance to the dump.

To give an idea of the collection situation as it was in May 1975 (9 sectors) the amount of refuse collected daily, the vehicles used and the size of the crews are listed in Table 7. The data are taken from weight cards at the compost factory. For some circuits no weight cards existed; therefore, the list is not complete. In addition the approximate amount of waste transported in containers is given in Table 7.

Equipment

There are four different types of collection vehicles presently in use. These are

- compressing vehicles (bennes tasseuses) with capacities of 10 and 12 m^3
- vehicles without compressing mechanisms like ordinary covered lorries with capacities of 8 m^3, 6 m^3, 4 m^3, and 1.5 m^3 (bennes basculantes)
- little vehicles on three wheels with a capacity of about 0.5 m^3 (triporteurs) especially for very narrow streets
- vehicles for the transport of containers of 8 m^3 and 3 m^3 (porte - coffres)

For further details refer to Table 8.

Furthermore, there is a reserve of 4 'bennes tasseuses', 10 'bennes basculantes' and 11 'porte - coffres' to replace any vehicles out of services due to repairs.

In 1976 the following vehicles were to be bought:

16 'bennes tasseuses' (7 of 8 m^3 capacity, 6 of 12 m^3, and 3 of 16 m^3)
5 'bennes basculantes' of 6 m^3 capacity
3 compactor stations of 17 m^3 capacity each

If necessary, up to 20 private vehicles assist the municipal fleet. They collect approximately 200 tons per day.

The present tendency is to increase the number of vehicles and to replace old vehicles by new ones with compressing mechanisms and capacities as large as possible bearing in mind the traffic situation (e.g. narrow streets in several districts).

Problems

Figure 5 shows that the circuits, the areas served by individual vehicles, are sometimes disconnected (e.g. circuit nos. 285, 135, 222). Certainly this situation can be improved by a reorganization. Since 1975, when the circuits were fixed as shown, some new vehicles have been taken into use and therefore most of the circuits underwent certain changes. So numerous obviously non-optimum situations arose where circuits even overlap. A situation like this is shown in Fig. 3 for the example of circuit 512 (vehicle 512).

The refuse in the refuse producing units which are not numbered is collected by vehicle 398 (of circuit 398). But these units could also be served practically without additional travel (cf. routes in Fig. 6) by vehicle 512 This would reduce the collection route of vehicle 398 by about 3 km or 25 per cent. The total length of the collection route of vehicle 512 is about 12 km, excluding the distance from the depot to the circuit and

from the circuit to the dump.

There is no doubt that the collection vehicles could make better use of their capacity. To give just one example, in circuit 512 on four days per week - Tuesday, Thursday, Saturday, and Sunday - only one trip is necessary. On the other days of the week a second trip has to be made for collecting about 1.6 tons only.

The trips on two observed days which characterize the situation are described below.

	20/7		28/7			
			1st Trip		2nd Trip	
	time	km (speedometer)	time	km	time	km
Departure Depot	6.55	28 975				
Pick up the workers	7.00	28 977				
Begin collection	7.05	28 979	7.32	694	9.41	720
End collection	9.12	28 991	9.05	704	10.06	722
Arrival dump	9.30	28 999	9.17	712	10.25	730
Departure "			9.27	712		
Length of collection route		12 km	10 km		2 km	
			total 12 km			
Collection time	2 h 7 min.		1 h 33 min.		25 min.	
			total 1 h 58 min.			
Refuse collected	7 200 kg		6 800 kg		1 600 kg	
			Total 8 400 kg			

The collection times given above, i.e. the efficiency of the collecting crew, should be regarded with some reservation, because the dustmen being observed were working as hard as they possibly could, which they would be unlikely to do normally. Therefore the normal efficiency may be somewhat lower. But even then, the circuits could be enlarged to achieve better utilization of the capacity of the collecting vehicle without overburdening the crews.

Circuit size depends on the efficiency of the vehicle used; this again depends on the type of area being served and the collecting routes to be followed. That means that decisions on circuit dimensioning, vehicles, crews, and collection routes have to be made simultaneously because the basic parameters are very closely interlinked. Therefore, a reorganization of the circuits and collection routes with reference to all these factors is highly recommended.

A technical problem arises from the composition of the refuse. Because it is extremely humid, dirty water comes out of containers and vehicles, especially of those with compressing mechanisms. A technical solution should be looked for to avoid this leakage.

Optimization

The consultant has already developed a computer programme for optimizing refuse collection, presenting solutions to the problems of

- how the circuits should be chosen,
- which type of vehicle should be used, together with what crew size,
- which collection routes should the vehicle follow within its allocated circuit.

The programme input is based on refuse production units defined as street 'sections' (as indicated by numbers in Fig. 3). For each section the type and number of bins have to be registered (cf. Table 6) and the distances to the neighbouring sections have to be measured considering traffic conditions like one-way streets etc. There is some further information to be collected, but it is not necessary to go into details within this report.

There is a data collection procedure developed according to the EDP programme. Explaining this procedure will be part of the training section.

The routes now used by the vehicles are those reached by the drivers after a long 'trial and error' process. The routes developed in this way are, of course, at least very nearly optimum.

For circuit 512 the applicability of the programme was tested without taking into consideration the possibility of changing circuits or vehicles. The routes calculated with the aid of the computer are shown in Fig. 7. The superimposition of the relsvant parts of Fig. 3 and Fig. 7 is shown in Fig. 9.

As was supposed only small changes were suggested and only a marginal reduction in the length of the collection route was achieved. But it was proved that the programme supplies good routes and that it is suitable for the conditions in Casablanca.

It should be emphasized that the programme cannot significantly improve the routes taken at present, as they are almost optimum. But it can - and is required to - reorganize refuse collection, that is to say define circuits and allocate vehicles and crews on the basis of optimum routes. Of course, the routes themselves are computer output too.

As already mentioned before the reorganisation of refuse collection has to be carried out step by step. As shown in chapter 2, Casablanca is in the process of a rather dynamic development, so that the refuse situation will change rapidly as time goes on.

Therefore, it would not aid the municipality sufficiently if the proposed calculations were only done once. Rather the programme has to be run at least for parts of the city whenever significant changes occur in refuse production or in equipment for refuse collection or in traffic conditions. With regard to small changes it can be assumed that the drivers will react appropriately themselves.

Therefore, it is intended to implement the programme on a computer in Casablanca and to train a Moroccan staff for collecting and updating the data and handling the programme.

According to a conversation with the Chef Department Centre Ordinateurs, Mr. Mohamed Bennani, it will be no problem to implement the programme on the local IBM computer. On the other hand, the RAD (Regie Autonome de Distribution d'Eau et d'Electricité) is going to acquire a new Honeywell-Bull computer. As confirmed by experts only slight changes of the programme will be necessary in order to use it on this computer, which would be less expensive for the municipality.

To implement the programme and to train the necessary Moroccan staff it is intended

- to have the data for the first sector of the city collected by the Moroccan staff under the supervision of consultants

- to have the first computer evaluations in Germany, while the Moroccan staff is beginning to collect data for a second sector,
- to check the data collected for the second sector and to implement and run the programme in Morocco at the same time familiarising the Moroccan staff with the handling of the programme,
- to advise the Moroccan staff on request during further data collection and computer runs.

There are no special requirements concerning the qualification of the staff. For data collection in Germany students were successfully employed. The employment of students for similar work is usual in Morocco too.

Special problems

In some districts (e.g. Nouvelle Médina) the streets are very narrow so that the greatest problem is to find the most suitable vehicles. They must be small enough to pass through the streets, but as large as possible in order to have a high overall efficiency bearing in mind the long way to the treatment plant. In these areas a very thorough investigation of the street network will be necessary. Strongly linked to the search for suitable vehicles are questions about the utility of transfer stations (cf. 3.3.1) and suitable locations for bins (see below). This, of course, applies for other districts as well, but the solution of the problems considered is most urgent for districts like Nouvelle Medina and will result in particularly pronounced improvements there.

As to the location (and type) of bins it has already been mentioned that it is usual for inhabitants or dustmen to carry bins out of some streets to the next corner or, if the bins are only small, to the vehicle itself. Even in districts with a good street network, where every type of collection vehicle can pass through all the streets, clever planning and organisation to expand this habi. might shorten the collection routes considerably, especially in areas of one-way streets.

In districts with a weak street network (like Nouvelle Médina) it would in addition allow the use of larger vehicles if it were not necessary to drive through narrow streets.

In both cases, the efficiency of vehicles would increase; their capacity would be better utilised and the number of vehicles required would be reduced. The personnel of the then superfluous vehicles should be employed as an advance crew for carrying the bins. This, however, will be extremely difficult with the bins used at present. Here again, the matter of providing suitable bins should be pursued.

Investigations of this kind will be supported by iterative use of the collection optimisation programme. The proposed training programme will include instruction on these aspects.

Parts of the district Ancienne Médina have such narrow streets that collection is possible only with very small vehicles (triporteurs).

The collection routes must be chosen every day according to the current situation. An improvement as regards the preparation of refuse for collection may be possible, as in Nouvelle Médina. But for the moment the application of the optimisation programme does not seem very useful.

In the slums, where containers are used by the inhabitants, no problem of optimising collection routes arises. Instead the number, locations, and capacities of the containers (cf. 3.1) should be studied.

The reorganisation of refuse collection as described above will lead to an estimated reduction of about DM 685,000.-- in annual collecting costs, by reducing the number of vehicles in operation. A reduction of personnel is also possible through the measures proposed but, at least in the near future, this is not desirable, because it would by no means contribute to the national objective of maintaining or increasing employment rates.

It is estimated that the training of the Moroccan staff and the supplying of suitable EDP support will together cost approximately DM 600,000.-- including programme licence fees.

3.3. Refuse treatment

3.3.1. Transfer stations

At present most sectors have some 'triporteurs', little collecting vehicles with a capacity of about 0.5 m^3 (see chapter 3.2.). These vehicles are used in addition to the larger collection vehicles (one for each circuit) and are independent of circuit borders. They carry the collected refuse to containers which are also used by street sweepers and the inhabitants themselves.

So the containers serve as transfer stations for the triporteurs. The illustation in Fig. 8 shows the situation in the Ancienne Médina where there are three triporteurs which carry the refuse to three points where containers are located. The allocation of triporteurs to containers and the routes taken are up to the personnel.

The 'transfer stations' are simply places where the containers are deposited. The refuse is discharged on to the ground by the triporteurs and then shovelled into the container. By simple technical means, e.g. building a ramp or sinking the container into the earth, this transfer could be made much easier. But often the locations are only available for short periods, e.g. in areas where reconstruction is under way.

There are in addition many small collection vehicles, some with a capacity of as little as 1.5 m^3, and about 170 containers of 3 m^3 capacity. As the distance to the presently used dump is on average about 10 km, it is not very efficient to transport these small containers to the dump or to drive the little vehicles such a long distance.

For this reason the municipality of Casablanca intended to buy three compressing stations with a capacity of 17 m^3 each at the end of this year. With the compressing ratio given as 1:3 about 50 m^3 of collection vehicle loads could be transported to the dump in one trip. But it has to be mentioned that refuse in Casablanca is already very dense (in the bins about 330 kg/m^3, in containers up to 465 kg/m^3) so that the given compressing ratio might not be applicable in this case.

Furthermore, the problem of waste water should be kept in mind. There will be a considerable amount to cope with.

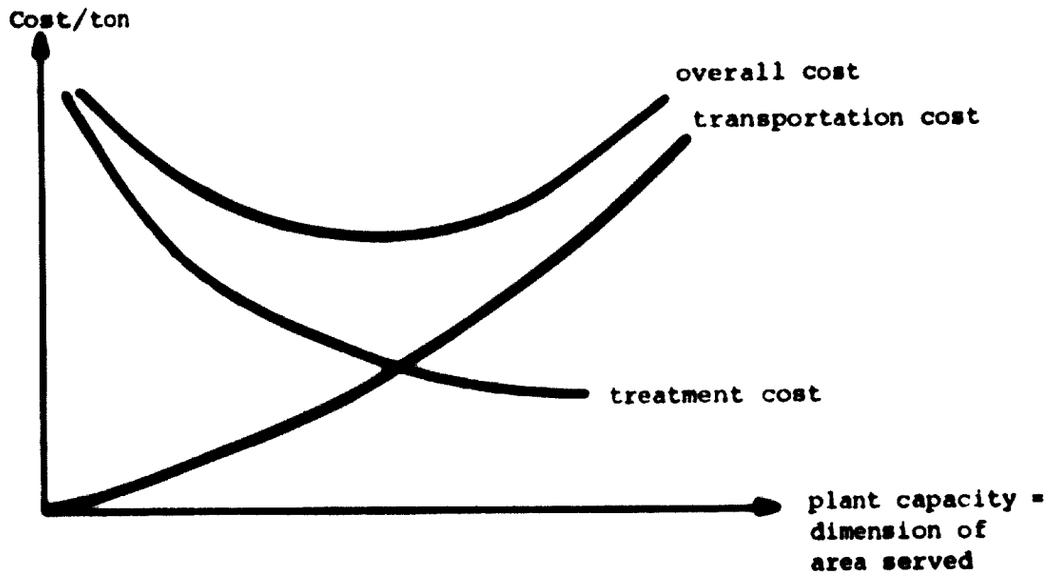
Of the three stations already ordered, one will be used in the Ancienne Médina (Rue Gounod), one in the slums of sector V and one in the slums of sector VI. An investigation should be started to find out if the use of further transfer stations would lead to further savings. An analysis must be carried out to determine the type of transfer stations to be installed at which locations and to serve which areas. This optimization problem is of the type 'plant location' as described in the next chapter for the optimization of compost factory and dump location. Of course, an analysis of the efficiency of the first three stations bought will be very instructive for the purposes of further planning.

The optimal use of transfer stations could reduce collection and transportation costs by up to 20 per cent, as has been done in other countries. The costs of the investigations recommended are included in the cost estimates for optimization of the treatment plant location given in the next chapter.

3.3.2. Treatment plants

As well as for the transfer plants (3.3.1) decisions have to be made on the number, locations, and capacities of treatment plants such as compost factories and/or controlled dumps and also on the definition of the area to be served by each plant.

Plant costs (per shipped unit) generally decrease with increasing plant capacity. Transport distances depend on the sizes of the areas served. As the sizes of these areas are proportional to the plant capacities, the decrease in plant costs runs parallel to an increase in transport costs. The minimum overall costs may be found as shown schematically in the figure below, by choosing the optimum number, locations etc. of plants.



Decisions on solid waste management system should be optimum not only according to the present situation but also for future needs. The solution to be proposed should therefore be

as dynamic as the environment concerned. That means that any solution envisaged should be a phased plan covering the next 20 or 30 years and adapted to the expected or planned development of the city.

This development will influence

- availability of locations for treatment plants
- plant costs
- amount and type of waste produced
- compost demand
- traffic situation
- collection and transportation costs

All these are parameters which will determine the optimum solution.

Locations for treatment plants

To find the best solution it is necessary to have a sufficient number of locations available for plants. The locations should be situated such that no danger (e.g. contamination of ground water) or inconvenience (e.g. dust, bad smells) for the inhabitants are to be expected. They should therefore be at a certain minimum distance from buildings, depending on wind velocities and directions, and should not be located in areas where the ground water is used. Besides that there are numerous further criteria regarding environmental protection, which have to be checked before a location can be said to be suitable for a plant. Systems of criteria for the selection of potential plant locations have been developed by the consultant and various authorities in Germany and are available. These systems or one of them may be applied to the situation in Casablanca, possibly after slight changes in some points due to particular circumstances.

Plant costs

It is necessary to know the costs for several different capacities for every possible type of plant at every potential location. As regards technical and personnel equipment there are general standards which should be checked as to their validity for Casablanca. Costs for installations and personnel can easily be estimated taking the expected evolution of costs into careful consideration. In addition the cost of the site itself and of developing the location (road, water, electricity) has to be estimated.

Amount and type of waste produced

In Table 7 the amount of waste in the circuits is shown for the year 1975. This gives an idea of the centers of waste production. Due to transportation cost the amounts of waste and the location of the different waste producing units (circuit, street or section) strongly influence the optimum locations, capacities, etc. of treatment plants. If the analyses proposed in chapters 3.1. and 3.2. are carried out a very good and sufficiently detailed data basis will be available for the status quo situation.

Otherwise vehicle weighing would give an updating of the figures shown in Table 7 as a fairly rough basis for the optimisation of plant locations.

However, the amount of waste produced by a city is always changing. It may be forecasted for the whole city by trend extrapolation or similar methods. Yet, as plant location demands locally detailed data, forecasting is necessary for the individual waste producing units. Trend extrapolation or similar methods could not be used even if there were time series from the past, because the expected or planned

socio-economic development of the units may be unsteady and quite different from development in the past.

On the other hand, the amount (and composition) of waste produced in a unit depends on the socio-economic structure of the unit. Correlations can be found by means of available programmes. For instance in the Munich area the consultant found a very strong dependence of the amount of waste on population density and employment in two different economic sectors.

The report of the study

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performed by TRANSROUTE gives an idea of the socio-economic data which are available. For the status quo sufficiently detailed data exist on

- number of inhabitants
- size of households
- age of inhabitants
- employment
- professions
- type of habitations
- size of habitations
- revenues
- mobility

Projections of the number of inhabitants have been made up to 1992. The other parameters have not yet been forecast.

With the status quo data a correlation function could be developed by means of available programmes. It will show which of the above-listed parameters have significant influence on the amount of waste. Only these parameters need then be forecast to allow the application of the correlation function for the calculation of future figures. The function

itself will be subject to slight changes as time goes on, with respect to changes in social habits.

In addition estimations of the development of waste composition will have to be made to ensure the applicability of the proposed techniques for the future.

Compost demand

In the same way as waste production influences the selection of the locations of plants in general, compost demand influences the location of compost factories according to the distribution costs for the compost. An analysis of the compost market including its development is therefore inevitable if compost plants are still taken into consideration.

Traffic situation

For optimizing refuse collection (3.2) the road network will be analysed in a very detailed manner. The possible locations for transfer and treatment plants have to be considered in connection with this network in order to give information about distance and travelling time from waste producing units to the potential plants.

Transportation costs

The cost per distance or time unit may be easily derived from the budget calculations. Transportation costs can be calculated with these unit costs and the travelling times or distances.

With all the necessary data mentioned above a software package (developed by the consultant) can be run to find out the optimum number, types, locations and capacities of future plants together with the optimum area they should serve.

According to the experience of the consultant, plans elaborated with EDP support as described above will lead to solutions with overall costs at least 10 per cent lower than those of 'handmade' plans. The elaboration of these plans is estimated to cost about DH 515,000.-- if the data is collected as described in chapter 3.2. The available software package should - in contrast to the optimization programme for refuse collection - preferably not be installed in Casablanca because updating of plans will be necessary only every 3 or 4 years and the installation of the package and training of counterpart staff would be comparatively expensive.

Updating services, however, could be guaranteed for a relatively small fee so long as input data are presented in a consistent form.

Recommendations

The Prefecture of Casablanca can dispose of the refuse only by

- controlled dumping or
- composting

Because of the specific composition of the refuse (high water content) incineration is not at all advisable. On account of the inevitable environmental pollution, the refuse can only be treated and disposed of properly outside densely populated areas.

For controlled dumping the site must make adequate allowance for expansion in order to cope with the amount of refuse collected. Composting only requires a certain area, but a well organized compost market is indispensable. Formerly Casablanca has employed both methods of refuse disposal.

The compost plant was in operation for a few years only. It had to be closed down for two reasons:

the location of the plant
the composting system

It was a considerable mistake to establish the compost plant directly on the coast even though the Oukkacha area is an industrial area. As the plant is right in the east almost every vehicle had to pass the center of town with its heavy traffic. Apart from this the distance and time that the collection vehicles had to travel were considerable, in addition to which the constant wind blowing in from the Atlantic polluted the entire urban area in the east with intolerable odours from the plant.

Furthermore the system chosen for composting with its high piles of refuse did not take into account the local refuse characteristics. The biotank system may be successfully used in France and other industrial countries where the refuse collected has a far lower water content than that of Casablanca. For Casablanca, however, the consultant would recommend only two composting systems:

Windrow composting with small windrows and frequent turning of the rows (as practised in Rabat);
The Brikollare System.

As far as the first alternative is concerned the consultant would recommend that refuse grinding before fermentation is abandoned.

In the absence of an approved composting system in Casablanca the consultant would recommend the erection of a pilot plant with a relatively low capacity initially, as this could easily be extended if positive results were achieved. However, it must be emphasised once more that any location for either composting or sanitary landfilling is acceptable only if situated outside the residential areas.

In accordance with this and bearing in mind that the urban area will develop as stated in chapter 2.1., the optimum location for refuse treatment will be somewhere in the south of the town.

From the point of view of compost marketing it would be best to have two plants, one in the south-eastern and one in the south-western part of the urban area.

In this case, with an optimum allocation of the refuse collection districts to one or other of the treatment plants the distances travelled by the collecting vehicles could also be optimized.

4. Review and proposals

The aim of the present study was to determine whether the application of EDP for the reorganization of household refuse handling in Casablanca is feasible or not.

From the legal, institutional and personnel point of view in general, the system of waste handling in Casablanca works well. However, from the point of view of hygiene, working conditions, organization, equipment, and economy some improvements are desirable.

The main field for the implementation of these improvements is that of refuse collection. An optimization of the use of collection vehicles would save a lot of money. An optimum reorganization of the service areas together with an optimum allocation of vehicles to these areas will enable vehicles to be used to their full loading capacity. In this way the number of collection vehicles can be reduced and the collection - or transportation - routes can be shortened as well.

For reasons of hygiene and better working conditions the dust bins should be standardised and have a cover attached to the bin to avoid unpleasant smells.

Strategically located transfer stations with compressing devices into which the 1 m^3 containers can be emptied will save transport vehicles and shorten transport routes.

The application of EDP for the above-mentioned improvements is considered to be feasible and is to be recommended.

In the following a summary of proposed investigations is given together with approximate costs and approximate benefits. For all the work certain support from the Moroccan authorities would be necessary. Therefore only specialised personnel requirements are mentioned. Within the first work package the main data basis is to be produced. These data are necessary before the second and third work packages, referred to as 'additional' can be undertaken.

Reorganization of refuse collection:

Implementation of computer programme, training of staff for data collection and handling of programme, supervising data collection and running the programme for two sectors.

Cost: DM 600,000.--
+ 30 man-months Moroccan personnel

Benefit: Reduction of collection costs by about DM 685,000.-- per year

Additional:

Investigations on suitable bins in accordance with the reorganization

Cost: DM 68,500.-- (about 3 per cent of necessary investment)

Benefit: Avoidance of misinvestment, amelioration of hygiene and working conditions

Additional:

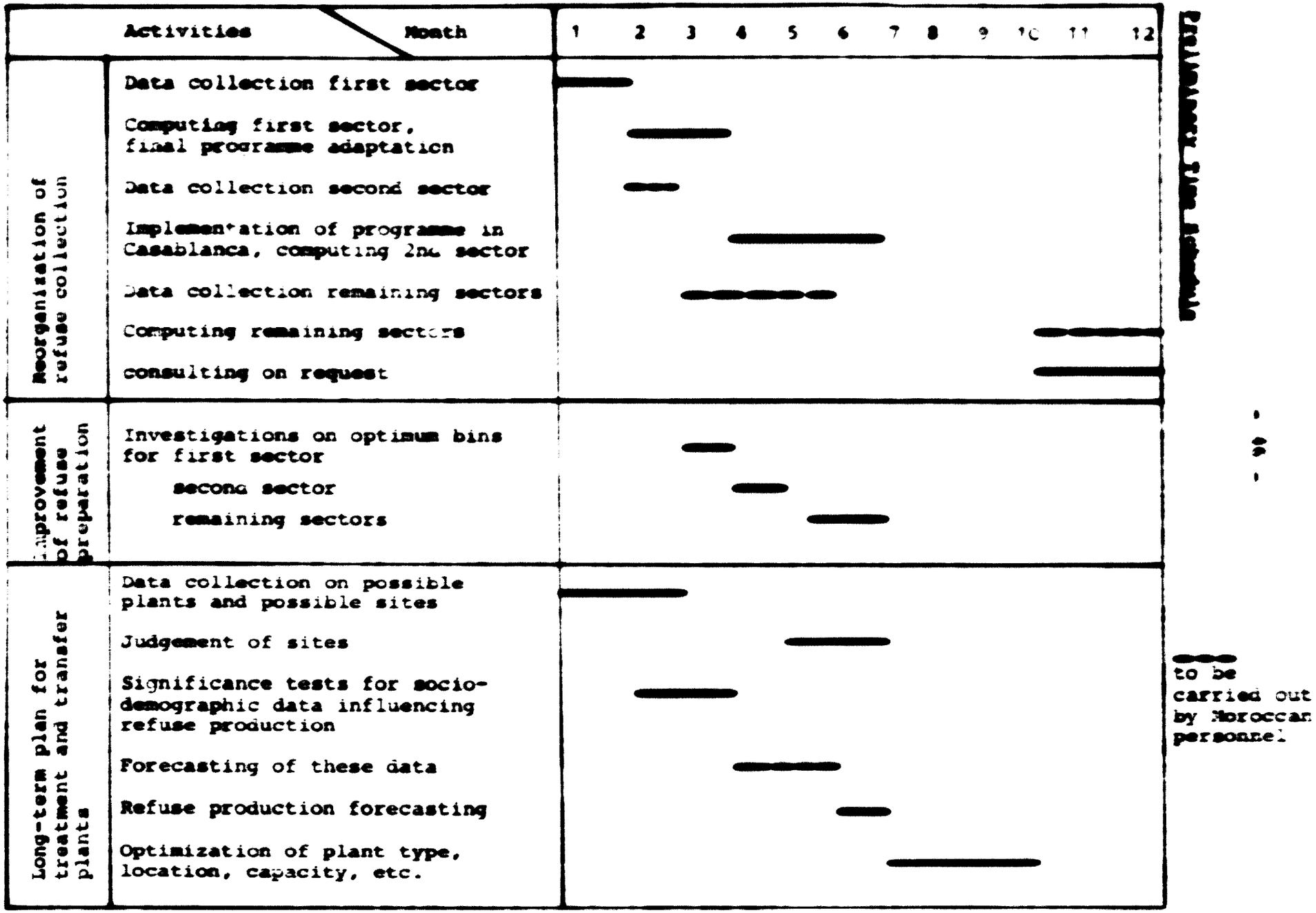
Long-term plan for treatment plants and transfer stations

Data preparation, refuse production, forecasts, optimisation of plant type, number, locations, capacity, and catchment areas of each.

Cost: DM 515,000.--

Benefit: Avoidance of misinvestment, guarantee of best solution which, according to experience, leads to at least 10 per cent lower costs than plans made without LDP support, i.e. in in this case economies of about DM 1,712,000.-- per year.

A preliminary time schedule for the execution of the necessary activities is given below.


Activities
Month
1
2
3
4
5
6
7
8
9
10
11
12
Reorganization of refuse collection
Data collection first sector
Computing first sector, final programme adaptation
Data collection second sector
Implementation of programme in Casablanca, computing 2nd sector
Data collection remaining sectors
Computing remaining sectors
consulting on request
Improvement of refuse preparation
Investigations on optimum bins for first sector
second sector
remaining sectors
Long-term plan for treatment and transfer plants
Data collection on possible plants and possible sites
Judgement of sites
Significance tests for socio-demographic data influencing refuse production
Forecasting of these data
Refuse production forecasting
Optimization of plant type, location, capacity, etc.
to be carried out by Moroccan personnel

The Chef des Traveaux Municipeaux and the Chef de Division de Nettoiement of Casablanca have declared their readiness to prepare the next step for the reorganisation by collecting data, information, and material and by starting work as far as possible.

There we give here a list of items which would be very helpful at the beginning of the reorganization. Detailed instructions concerning the individual items will be given directly to the municipality as soon as the intention of beginning the next phase is announced.

These items for action on the part of the municipality of Casablanca are:

1. Preparation of town plans (if possible on scale 1:1000) containing information on the present situation and the forseeable development of traffic conditions and settlement.
2. Estimation of the distances between every two neighbouring crossings (in accordance with specific instructions).
3. Preparation of detailed information about foreseeable or planned population development.
4. Preparation of plans concerning hydrogeology and land use, also for the area surrounding Casablanca.
5. Estimation of possible compost demand around Casablanca.
6. Identification of possible locations for transfer and for treatment plants.
7. Detailed description of the immediate neighbourhood of these places with respect to land use, type of settlement, type of buildings, population density, etc. with the aid of a questionnaire which will be supplied to the municipality.

TABLES

Table 1:

Climatic Data for Casablanca

Month	Temperatures °C			Precipitations in mm				Relative Humidity in %	
	monthly average	average max.	average min.	rainy days	monthly average	quantity max.	quantity min.	average	noon
January	12.0	21.5	2.0	6	32	110	0	84	73
April	15.0	26.0	5.5	8	38	125	2	80	70
July	22.5	32.5	14.0	0	0	10	0	77	68
October	19.5	30.5	9.5	7	75	170	2	78	65

Table 2: **Population Development in Casablanca**

Zone \ Year	1960	1971	Yearly increase 1960/71 %	1975	Yearly increase 1971/75 %	1982	Yearly increase 1975/82 %	1992	Yearly increase 1982/92 %
1	6,875	9,038	+ 2.86	10,900	+ 5.15	13,300	+ 3.14	19,200	+ 4.44
2	12,165	34,948	+ 17.02	51,200	+ 11.62	66,900	+ 4.38	104,000	+ 5.55
3	39,140	68,238	+ 6.76	87,700	+ 7.13	103,400	+ 2.56	145,300	+ 4.05
4	110,544	130,450	+ 1.64	142,000	+ 2.21	152,400	+ 1.05	173,600	+ 1.39
5	6,347	4,670	- 2.40	4,200	- 2.50	3,300	- 3.06	2,800	- 1.51
6	22,215	30,580	+ 3.42	40,100	+ 7.78	41,200	+ 0.39	52,700	+ 2.79
7	20,099	18,980	- 0.51	18,600	- 0.50	17,800	- 0.61	17,000	- 0.45
8	20,628	28,470	+ 3.47	34,000	+ 4.85	40,700	+ 2.81	58,600	+ 4.40
9	20,099	22,290	+ 0.99	23,800	+ 1.69	24,400	+ 0.36	26,300	+ 0.78
10	11,636	19,432	+ 6.09	23,000	+ 4.59	25,800	+ 1.74	30,400	+ 1.78
11	20,099	50,012	+ 4.44	62,500	+ 6.24	79,000	+ 3.77	111,600	+ 4.13
12	14,810	33,743	+ 11.62	63,100	+ 21.75	85,700	+ 5.12	128,500	+ 4.99
13	107,370	135,576	+ 2.39	140,300	+ 0.87	143,200	+ 0.30	148,200	+ 0.35
14	3,702	17,920	+ 34.96	29,800	+ 16.57	40,000	+ 4.89	54,900	+ 3.72
15	118,478	270,550	+ 11.67	287,000	+ 1.52	297,800	+ 0.54	320,300	+ 0.76
16	125,354	206,375	+ 5.88	258,200	+ 6.28	304,400	+ 2.55	422,700	+ 3.89
17	180,890	243,280	+ 3.14	282,000	+ 3.98	322,300	+ 2.04	406,800	+ 2.62
18	28,562	30,280	+ 0.55	40,100	+ 8.10	48,400	+ 2.96	68,400	+ 4.13
19	46,545	75,620	+ 5.68	103,600	+ 9.25	130,100	+ 3.65	183,900	+ 4.13
20	24,859	34,797	+ 3.63	49,000	+ 10.20	66,500	+ 5.10	89,600	+ 3.47
21	1,058	3,314	+ 19.38	4,900	+ 11.96	6,000	+ 3.21	14,500	+ 4.16
22	20,628	37,810	+ 7.57	52,000	+ 9.38	61,000	+ 2.47	78,700	+ 2.90
23	0	0		0		0		0	
Σ 1-23	962,103	1,506,373	+ 5.14	1,808,000	+ 5.00	2,074,000	+ 2.10	2,658.000	+ 2.82
24						196,000		460,000	+ 13.47
25						131,000		235,000	+ 7.94
26						197,000		400,000	+ 10.30
27						95,000		300,000	+ 21.58
28						0		105,000	
29						5,000		55,000	+110.00
30						0		95,000	
Σ 24-30				70,000		624,000	+113.34	1,650,000	+ 16.44
Σ 1-30				1,878,000		2,698,000	+ 6.24	4,308,000	+ 5.97

Table 3:

Selected Socio-Economic Data for Casablanca

Section	I	II	III	IV	V	VI	VII	Total
Population (in '000)	63	230	119	193	486	608	109	1,808
Active population (in %)	39	25	25	26	21	21	20	22.9
Population at school, college, etc. (in %)	28	34	35	38	36	33	38	34.4
Inactive population (in %) (1)	33	41	40	36	43	46	42	42.7
No. of habitations (in '00)	154	383	198	297	704	881	165	2,782
Persons per habitation	4.1	6.0	6.0	6.5	6.9	6.9	6.6	6.5
No. of private cars (in '00)	110	115	123	164	233	158	56	959
Private cars/100 persons	17.5	5.0	10.3	8.5	4.8	2.6	5.1	5.3
No. of bicycles (in '00)	27	145	123	164	301	486	65	1,311
Bicycles/100 persons	4.3	6.3	10.3	8.5	6.2	8.0	6.0	7.3
Monthly revenue (2)	high	non significant	medium	medium	low	low	low	

(1) including unemployed persons

(2) high = 1,200 - >2,000 DH
medium = 700 - 1,200 DH
low = 0 - 700 DH

Table 4:

Public Cleaning Budget 1976

Specification	Municipal garages		Public cleaning services				Total	
			refuse collection		street sweeping			
	DH	%	DH	%	DH	%	DH	%
Salaries and wages	1,740,000	38	5,362,000 (1)	92	6,762,000	97	13,864,000	80
Maintenance and repairs	742,000	16	35,000	1	10,000	0	787,000	5
Materials (fuel, brooms, baskets, etc.)	565,000	13	130,000 (2)	2	40,000	1	735,000	4
Replacements	1,500,000	33	300,000	5	100,000	2	1,900,000	11
Total	4,547,000	100	5,827,000	100	6,912,000	100	17,286,000	100

(1) Of this amount 1,660,000 DH is paid by the Government in order to help combat unemployment.

(2) Covering material for the dumping sites.

Table 5:

Personnel for Public Cleaning

Sector	Street sweeping				Refuse collection			Controlled tipping		Total
	Super-intendent	Fore-man	Street Sweeper	Guard of depot	Super-intendent	Fore-man	Dust-man	Fore-man	Labourer	
I	2	13	120	17	1	3	63			219
II	4	6	79	6	2	2	51			150
III	4	11	152	3	-	-	-			170
IV	3	13	155	12	1	2	50			236
V	4	12	125	14	2	4	75			236
VI	3	6	75	4	1	2	34	1	11	137
VII	2	6	53	2	1	3	25			92
VIII	6	15	127	11	1	4	75			239
IX	2	5	44	7	-	5	79			142
X	1	2	24	3	-	-	10			40
XI	2	5	50	5	-	1	25			88
Total	33	94	1,004	84	9	26	487	1	11	1,749

Table 6:

Number and Size of Bins and Total Amount of Daily Refuse in the Various Production Units

(referring to Fig. 3)

Observation 20/7/76

Section No.	20 l	30 l	40 l	60 l	80 l	100 l	Total amount (l)
2	1	1	3	6	1	-	610
3	2	-	-	1	2	4	660
4	-	1	1	6	4	1	850
5	1	2	-	3	-	-	260
6	-	1	1	3	1	-	330
7	-	-	3	2	2	-	400
8	2	4	1	4	-	-	440
9	-	-	-	1	-	-	60
10	-	1	3	-	-	-	150
11	-	-	3	2	-	-	240
12	-	-	-	2	4	1	440
13	-	-	-	2	4	1	540
14	1	-	2	-	2	1	260
15	-	-	1	3	2	-	380
16	-	2	-	3	-	-	240
17	1	1	-	2	-	-	170
18	1	1	2	3	-	-	310
19	-	-	8	3	-	-	500
20	1	-	-	-	1	-	100
21	1	-	1	2	2	-	340
22	-	-	1	2	-	-	160
23	-	4	3	-	1	-	320
24	-	-	-	2	1	-	200
25	1	-	2	3	2	-	420
26	-	-	2	6	-	-	440
27	-	-	2	2	3	-	440
28	-	-	1	1	4	-	420
29	1	1	-	5	-	-	350
30	-	-	-	1	-	-	60
31	2	5	2	4	-	-	510
32	-	-	-	7	-	-	420
33	-	-	-	4	1	-	320
34	1	-	-	1	-	-	80
35	-	-	-	4	-	-	240
36	1	4	2	12	-	-	940
37	-	1	1	2	-	-	190
38	2	2	1	3	-	-	320
39	-	2	-	7	-	-	480
40	-	-	-	6	-	-	360
41	2	1	1	-	1	-	190
42	-	-	1	1	-	-	100
43	-	-	2	2	1	-	280
	21	34	50	123	38	6	14,520

Table 6: (continued)

Observation 20/7/76

Section No.	20 l	30 l	40 l	60 l	80 l	100 l	Total amount (l)
Totals from previous page:	21	34	50	123	38	6	14,520
44	-	-	1	-	-	-	40
45	-	2	-	-	-	-	60
46	-	-	-	-	-	-	-
47	-	2	2	-	-	-	140
48	-	2	2	3	2	-	480
49	-	-	2	6	-	-	440
50	-	-	1	1	-	-	100
51	-	-	2	12	-	-	800
52	-	-	1	5	-	-	340
53	-	-	1	2	-	-	160
54	1	-	1	8	-	-	540
55	-	-	-	7	-	-	420
56	2	2	1	-	-	-	140
57	-	4	2	-	2	-	360
58	-	-	-	1	1	-	140
59	-	-	-	2	-	-	120
60	1	-	1	2	-	-	180
61	1	4	4	4	-	-	540
62	1	-	-	2	-	-	140
63	-	-	2	4	-	-	320
64	-	-	-	2	-	-	120
65	4	-	2	8	-	-	640
66	3	3	4	8	-	-	790
67	-	-	2	2	-	-	200
68	-	-	-	-	-	-	-
69	-	-	-	4	-	-	240
70	3	1	1	4	-	-	370
71	2	-	2	1	-	-	180
72	-	-	2	2	1	-	280
73	-	-	-	-	-	-	-
74	-	-	-	-	-	-	-
75	-	-	-	-	-	-	-
76	-	2	2	-	-	-	140
77	-	-	-	-	-	-	-
78	-	-	-	-	-	-	-
	39	56	88	213	44	6	22,940

Table 6: (continued)

Number and Size of Bins and Total Amount of Daily Refuse in the Various Production Units

(referring to Fig. 3)

Observation 28/7/76

Section No.	20 l	30 l	40 l	60 l	80 l	100 l	Total amount (l)
2	9	-	8	7	-	-	920
3	2	1	3	2	2	-	530
4	1	1	3	8	3	-	890
5	1	1	2	1	1	-	270
6	-	-	2	2	1	-	280
7	1	-	3	3	1	-	400
8	3	1	2	5	-	-	470
9	3	1	2	-	1	-	250
10	-	1	2	-	1	-	190
11	2	-	3	3	-	-	340
12	2	-	1	5	1	-	460
13	1	-	1	4	4	-	620
14	1	-	-	2	1	-	220
15	2	-	1	5	2	-	540
16	2	2	-	2	1	-	300
17	-	-	-	2	-	-	120
18	-	-	-	5	1	-	380
19	1	2	3	8	1	-	760
20	-	-	-	2	-	-	120
21	-	-	3	2	2	-	400
22	-	1	1	4	1	-	390
23	-	-	1	2	-	-	160
24	-	-	-	1	-	-	60
25	1	2	2	1	2	1	480
26	-	-	1	3	2	-	380
27	1	2	5	2	-	-	400
28	1	-	2	5	-	-	400
29	-	-	-	1	2	2	420
30	-	-	-	2	1	1	300
31	2	-	5	2	2	-	520
32	-	1	1	3	2	-	410
33	1	-	1	2	1	-	260
34	1	-	-	1	1	-	160
35	1	-	2	4	1	-	420
36	-	-	5	3	1	-	460
37	1	1	2	2	-	-	250
38	1	-	2	4	3	-	580
39	2	4	4	5	1	-	700
40	1	-	2	6	-	-	460
41	3	-	-	-	1	-	140
42	1	-	2	1	-	-	160
43	1	-	2	1	1	-	240
	49	21	79	123	45	4	16,210

Table 6: (continued)

Observation 28/7/76

Section No.	20 l	30 l	40 l	60 l	80 l	100 l	Total amount (l)
Totals from previous page:	49	21	79	123	45	4	16,210
44	-	-	1	1	-	-	100
45	2	-	-	-	-	-	40
46	-	-	-	-	-	-	-
47	2	1	1	-	-	-	110
48	4	2	1	2	-	-	300
49	1	1	1	5	2	-	550
50	1	1	-	-	1	-	130
51	-	1	4	6	2	-	710
52	-	1	-	1	2	-	330
53	-	-	-	1	-	-	60
54	-	2	2	2	-	-	260
55	-	-	2	3	1	-	320
56	4	-	2	-	-	-	160
57	2	-	2	-	1	-	200
58	-	-	1	-	-	-	40
59	-	-	-	1	1	-	140
60	1	1	2	4	-	-	370
61	4	2	1	2	1	-	380
62	4	-	2	1	-	-	220
63	1	-	1	1	2	-	280
64	-	1	-	3	-	-	210
65	-	3	4	7	-	-	610
66	1	2	6	6	2	-	710
67	1	2	-	1	-	-	130
68	-	-	-	-	-	-	-
69	-	1	1	-	1	1	250
70	-	1	4	-	1	-	260
71	1	3	4	-	-	-	270
72	-	-	1	1	1	-	180
73	-	-	1	-	-	-	40
74	-	1	1	2	-	-	180
75	-	1	-	1	1	-	170
76	1	2	2	-	-	-	150
77	-	-	1	1	2	-	260
78	-	-	1	-	-	-	30
	69	50	128	175	66	5	24,360

Table 7:

Refuse Collected Daily and Vehicles Used in the Circuits, May 1975

Sector I

Circuit No.	Type of vehicle	Crew workers + driver	Number of trips per day	Used capacity (tons)	Total amount
285	Tanoeuse	6 + 1	2	3.950	7.900
166	Basculante	2 + 1	1	550	550
168	Basculante	2 + 1	1	500	500
223	Basculante	2 + 1	1	550	550
167	Basculante	3 + 1	2	2.100	4.200
224	Basculante	3 + 1	2	1.700	2.400
411	Basculante	2 + 1	-	-	-
454	Basculante	4 + 1	1 - 2	2.100	4.200
					20.300
			+ refuse transported in containers approximately		60.000
					80.300

Table 7: (continued)

Refuse Collected Daily and Vehicles Used in the Circuits, May 1975

Sector II

Circuit No.	Type of vehicle	Crew workers + driver	Number of trips per day	Used capacity (tons)	Total amount
350	Tasseuse	6 + 1	1 - 2	6.500	10.000
255	Tasseuse	5 + 1	1	5.100	5.100
256	Tasseuse	5 + 1	2	5.000	10.000
206	Tasseuse	5 + 1	2	3.600	7.200
204 ↔)	Tasseuse	6 + 1	1	5.800	5.800
352	Tasseuse	6 + 1	2	3.500	7.000
462 →)	Tasseuse	6 + 1	1	4.500	4.500
463	Tasseuse	6 + 1	1	4.500	4.500
502	Tasseuse	6 + 1	1	5.500	5.500
515 ↔)	Basculante	5 + 1	2 - 3	2.100	5.200
					70.600
			+ refuse transported in containers approximately		8.000
					78.600

→) now sector 11

↔) now partially sector 11

Table 7: (continued)

Refuse Collected Daily and Vehicles Used in the Circuits, May 1975

Sector III - Sector IX

Circuit No.	Type of vehicle	Crew workers + driver	Number of trips per day	Used capacity (tons)	Total amount
397	Tasseuse	5 + 1	1	4.400	4.400
135	Tasseuse	5 + 1	2	4.000	8.000
398	Tasseuse	5 + 1	2	4.000	8.000
512	Tasseuse	5 + 1	2	3.500	7.000
133	Tasseuse	5 + 1	1	6.200	6.200
134	Tasseuse	6 + 1	1	4.000	4.000
169	Tasseuse	5 + 1	1	3.800	3.800
397	Basculante	5 + 1	2	1.500	3.000
441	Tasseuse	5 + 1	1	6.000	6.000
503	Tasseuse	5 + 1	2	4.000	8.000
133	Tasseuse	5 + 1	1	4.800	4.800
442	Tasseuse	5 + 1	1 - 2	5.200	5.500
136	Tasseuse	-	-	-	-
					67.700
			+ refuse transported in containers approximately		27.000
					94.700

Table 7: (continued)

Refuse Collected Daily and Vehicles Used in the Circuits, May 1975

Sector IV

Circuit No.	Type of vehicle	Crew workers + driver	Number of trips per day	Used capacity (tons)	Total amount
203	Basculante	6 + 1	2	2.800	5.400
309	Basculante	6 + 1	2	2.500	5.000
351	Tasseuse	6 + 1	2	5.000	10.000
323	Tasseuse	6 + 1	2	4.800	9.600
324	Tasseuse	6 + 1	2	4.000	8.000
440	Tasseuse	6 + 1	2	4.200	8.400
464	Tasseuse	6 + 1	1	6.200	6.200
					52.600
			+ refuse transported in containers approximately		27.000
					79.600

Table 7: (continued)

Refuse Collected Daily and Vehicles used in the Circuits, May 1975

Sector V

Circuit No.	Type of vehicle	Crew workers + driver	Number of trips per day	Used capacity (tons)	Total amount
182	Basculante	6 + 1	2 - 3	3.500	9.000
317	Basculante	6 + 1	2 - 3	1.500	4.000
313	Basculante	6 + 1	2 - 3	2.500	6.200
343	Basculante	6 + 1	2	3.000	6.000
137	Basculante	4 + 1	2	2.200	4.400
251	Basculante	6 + 1	2 - 3	3.200	8.300
253	Basculante	-	-	-	-
158	Basculante	-	-	-	-
additional vehicles	Tasseuse	6 + 1	1 - 2	4.900	7.400
	Basculante	6 + 1	2	3.000	6.000
	Basculante	6 + 1	2 - 3	3.000	7.500
	Basculante	6 + 1	3	2.800	8.500
	Basculante	6 + 1	1 - 3	3.200	4.800
	Basculante	6 + 1	2	3.700	6.000
	Tasseuse	6 + 1	1 - 2	4.400	4.800
	Basculante	6 + 1	3	3.200	8.200
					101.100
			+ refuse transported in containers approximately		45.000
					146.100

Table 7: (continued)

Refuse Collected Daily and Vehicles Used in the Circuits, May 1975

Sector VI

Circuit No.	Type of vehicle	Crew workers + driver	Number of trips per day	Used capacity (tons)	Total amount
384	Basculante	5 + 1	2 - 3	3.400	8.500
345	Basculante	5 + 1	3	3.100	9.300
315	Basculante	5 + 1	3 - 4	1.900	6.700
455	Basculante	5 + 1	2	2.200	4.400
					24.500
			+ refuse transported in containers approximately		26.000
					50.500

Table 7: (continued)

Refuse Collected Daily and Vehicles Used in the Circuits, May 1975

Sector VII

Circuit No.	Type of vehicle	Crew workers + driver	Number of trips per day	Used capacity (tons)	Total amount
408	Basculante	6 + 1	1 - 2	2.900	4.400
410	Basculante	6 + 1	2	1.700	3.400
513	Basculante	5 + 1	1	2.600	2.600
316	Basculante	5 + 1	2 - 3	1.900	4.800
					15.200
			+ refuse transported in containers approximately		7.000
					22.200

Table 7: (continued)

Refuse Collected Daily and Vehicles Used in the Circuits, May 1975

Sector VIII

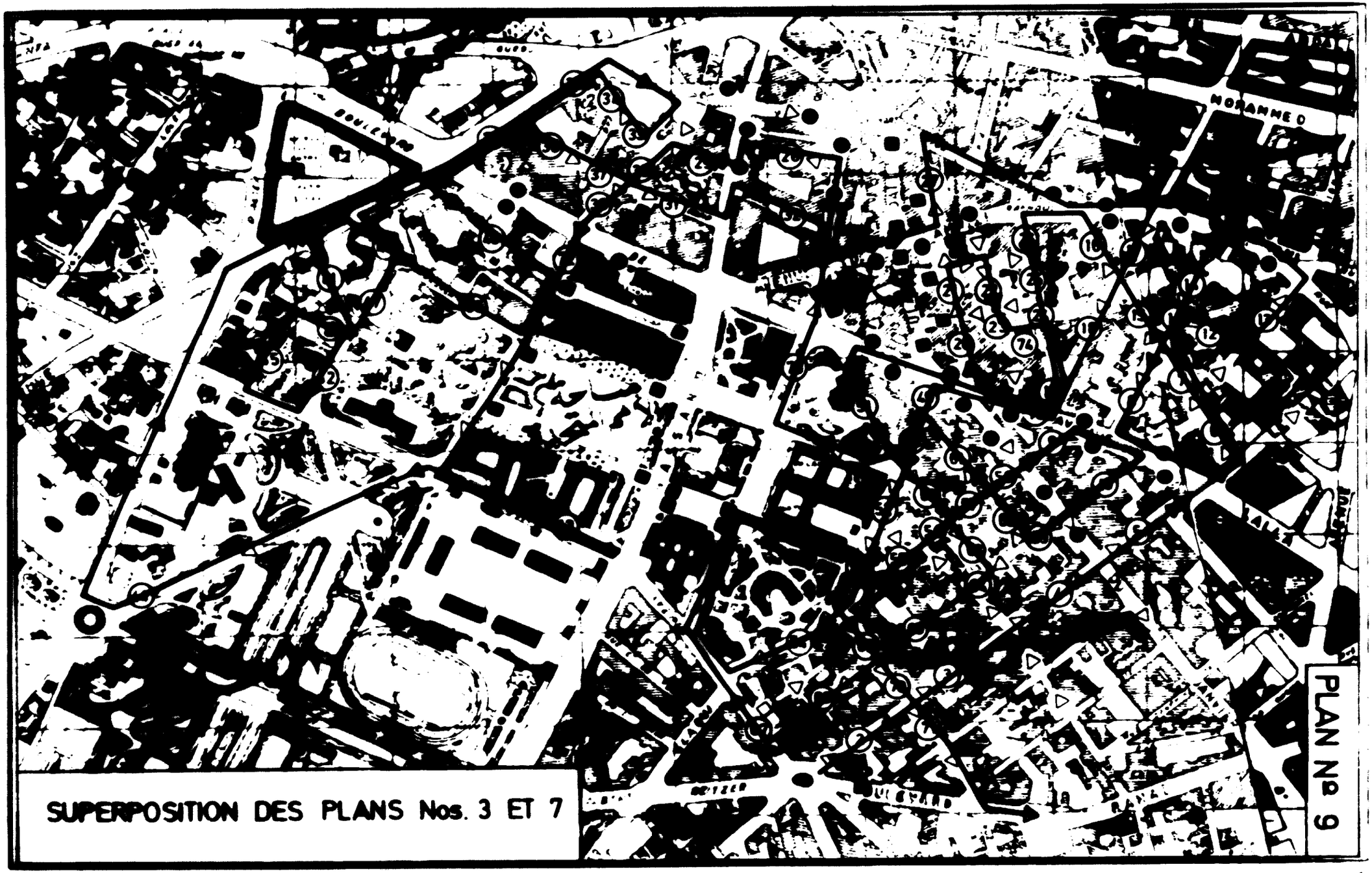
Circuit No.	Type of vehicle	Crew workers + driver	Number of trips per day	Used capacity (tons)	Total amount
222	Basculante	6 + 1	2	800	1.600
143	Basculante	6 + 1	2 - 3	3.000	4.500
142	Basculante	6 + 1	-	-	-
275 +)	Basculante	6 + 1	2	3.000	6.000
344	Basculante	6 + 1	2	3.400	6.800
385	Basculante	5 + 1	2	2.200	4.400
159 +)	Basculante	6 + 1	1 - 2	2.900	4.400
514	Basculante	5 + 1	3	3.100	9.300
144	Basculante	6 + 1	3	3.100	9.300
252	Basculante	6 + 1	3	3.300	9.900
250 +)	Basculante	5 + 1	2	3.300	6.600
145	Basculante	-	-	-	-
					67.300
			+ refuse transported in containers approximately		40.000
					107.300

Table 8:

Synopsis of Types of Collection Vehicles and their Allocation to the Different Sectors

Sector	Benn-s tasseuses	Bennes basculantes	Triporteurs	Porte - coffres 8 m^3	3 m^3	Containers 8 m^3	3 m^3
I	1	7	4	3	-	24	-
II	8	-	1	-	-	44	6
III-IX	12	2	3	1	1	22	18
IV	5	1	1	1	1	28	21
V	1	10	1	-	6	-	67
VI	-	4	1	-	3	-	30
VII	-	4	1	-	1	-	17
VIII	-	11	1	2	-	31	-
X	-	2	-	-	-	-	-
XI	3	-	2	1	1	-	11
Total	30	41	15	8	13	115	170

PLANS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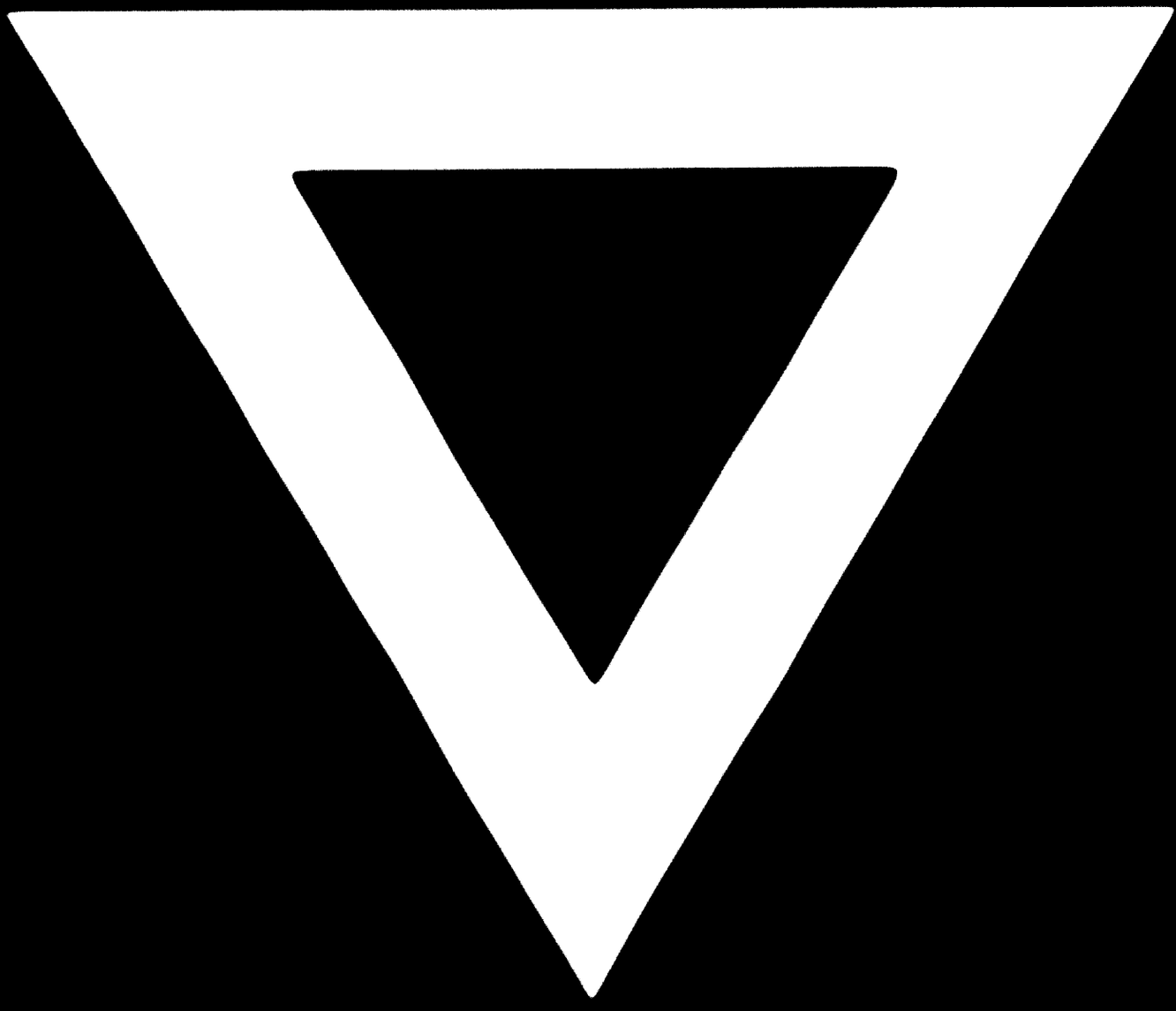
PLAN Nº 9

G-942



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