URBAN AND ENVIRONMENTAL SERVICES PROJECT
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PRELIMINARY ASSESSMENT OF WASTE MANAGEMENT SYSTEMS IN OULAD TEIMA

Prepared For:

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The Office of Environment and Urban Programs

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General

The overall goal of this project is to evaluate the waste management systems in the cities of Meknes, Azrou, Sefrou and Oulad Teima. An initial assessment of waste management systems was performed in July, 1995 in Meknes, Azrou and Sefrou. A follow-up inspection and interview in these three municipalities was performed in May, 1997. The results of that follow-up evaluation are presented in a separate report.

This report specifically addresses the city of Oulad Teima, which is similar in size to Azrou and Sefrou with an estimated 1997 population of 54,000. Daily waste generation is estimated at 27 tons per day, increasing to 82 tons per day at the end of the 20 year planning period. Oulad Teima is the center of a large agricultural region and most of its residents work in the agricultural sector.

Landfills

The existing Oulad Teima disposal area is an uncontrolled dump located within the river bed of the river Sous. From an environmental view, this site is unacceptable and presents a significant threat of surface water pollution, should a heavy rain or flood cause the river Sous to flow beyond its present channel. Fortunately, the existing site does not appear to be a groundwater threat due to current operation which includes animal feeding, frequent burning and the low annual rainfall. Several previous attempts at locating a new site failed when local residents complained. When a new site is located and operating, the existing dumping area should be closed by removing all waste from the river bed.

Four new sites were presented to the project team for evaluation. Each site was inspected and evaluated for use as a controlled landfill. Conceptual site plans were prepared based on a 20-year life. Major differences between the sites were distance from the city center, access and long term potential impacts to the existing O.N.E.P. water wells. Two sites are recommended for elimination due to potential water supply impacts and two sites were technically acceptable as a controlled landfill.

Site 1 is 14 km from the city center and requires a new 1,500 meter access road. Site 2 is closer to the city (8km) and can be accessed by a shorter access road. Additional transportation costs to use Site 1 are estimated at 500,000 DH per year (1997) and the new Site 1 access road will cost an estimated 1,125,000 DH. Other issues to consider include litter and illegal dumping along route 32.

The project team recommends proceeding with the development of Site 2, based on lower development and operating costs and its lower potential for litter.

The new landfill should be designed and operated as a Level-1 controlled landfill in accordance with the new National Guidelines for Solid Waste Management. Additional controls including tree planting are recommended to reduce litter and other visual impacts.

Due to the relatively small size of the landfill, full time equipment is not justified. The project team recommends contracting with the private sector for the construction and operation of the landfill.

Collection

The collection system in Oulad Teima is similar to those found in Azrou and Sefrou during the original assessment study. Daily collection at the curbside is provided to approximately 60% of the city. The system appears well organized and efficiently operated. Existing truck capacity is more than adequate to service the city but many of the trucks are old and in need of replacement.

The National Guidelines have established goals for converting urban solid waste collection to container service and reducing collection frequency to 3 times per week. The guidelines conclude that this type of system is 20 to 30 % less expensive than daily collection from the curbside. The project team strongly agrees with this conclusion. As Oulad Teima replaces its aging collection trucks, they should purchase 14 or 16 m^3 rear loading compactors and 1,100 liter containers. An initial program of one new truck and 30 containers is recommended in the report.

Action Plan

Activity	By	Date
Final site selection	City/Governor	July 1997
Prepare design and operating plan for new landfill	USAID/TSS	August 1997
Secure equipment contracts for landfill operation	City	August 1997
Construct access road and initial excavation	City/Contractor	September 1997
Begin landfill operations	City/Contractor	September 1997
Close existing dumping area	City/Contractor	September 1997

1.0 INTRODUCTION

1.1 Background

In July, 1995, the United States Agency of International Development (USAID), through the Urban and Environmental Services Project (UESP), completed a preliminary assessment of solid waste systems in the cities of Meknes, Azrou and Sefrou. A similar assessment was provided to the City of Tetouan in 1994. In 1997, the USAID decided to expand the experience base of this program by adding the city of Oulad Teima.

The USAID technical assistance team consisted of a solid waste expert under contract with Technical Support Services (TSS), and a local engineering consultant. The field inspection was completed in Oulad Teima on June 3, 4 and 5, 1997.

1.2 Goals and Objectives

The overall objectives of the project are to evaluate the existing waste disposal and collection systems in the subject municipalities, assist them in making improvements and in planning for the future. Although the primary emphasis of the project is on waste disposal, through controlled landfilling, recycling and composting, waste collection systems and other related issues will be addressed.

By expanding the sample of municipalities to be assessed, USAID will identify common issues and prepare a list pilot best practices projects to be evaluated and implemented. These projects will be selected based on their ability to be replicated in other municipalities in Morocco. The pilot best practices projects will be presented in a separate report. This report will address only the assessment of solid waste management systems in the city of Oulad Teima.

1.3 National Solid Waste Strategy

In September, 1996 the Ministry of the Environment completed a comprehensive Study on National Guidelines for Solid Waste Management in Morocco. This 7-volume document presents technical as well as institutional and financial guidelines for the management of solid waste. In particular, volumes 4 and 6, Technical Guidelines and Infectious Waste, include documentation regarding waste collection and disposal which apply to this study. Several references are made in the following report to the National Guidelines.

1.4 Common Issues

Although the four municipalities assessed to date differed considerably in their waste management systems, there were several issues that were common to all four. These will be discussed in this section while issues specific to Oulad Teima will be include in Chapter 2.

1.4.1 Collection Procedures

All four municipalities provide collection services using curbside collection of domestic refuse or communal bins of 3 to 5 m^3 capacity serviced by a specialized bin hoist vehicle (multi-benne). The majority of service is provided through curbside collection using a variety of manually loaded vehicles. Waste which is left at the curbside by individual residents or commercial establishments, is gathered in baskets by collection workers and then loaded onto collection vehicles. Most of these collection vehicles are standard flat bed dump trucks of 6 m^3 capacities. These are multipurpose vehicles and waste must be lifted approximately 1.5 meters to the bed of the truck. Only Meknes uses specialized rear loading waste compaction vehicles of 6 and 8 m^3 capacity but they are not equipped to load containers.

The curbside placement of waste without containers is creating problems in most of the urban locations, especially when waste is not placed in containers or plastic bags. Non-containerized waste attracts insects, animals, promotes odors and makes collection more difficult.

Since all four municipalities mentioned increasing collection efficiency as a goal, the expanded use of communal containers and larger rear loading compaction trucks are appropriate options for all four municipalities. Typical containers used with compaction trucks are manufactured in several sizes but the most common size is 80, 600, 750 and 1,100 liters, which are currently being used in Rabat and other larger cities in Morocco. The 1,100 liter containers will hold approximately 495 kg of waste at a density of 450 kg/m^3. At a generation rate of .5 kg per person per day, each container can hold the daily waste generated by 990 persons or 194 families at the national average of 5.1 persons per family.

The increased collection efficiency using containers is obtained through decreased collection time, smaller collection crews and fewer vehicles. Standard 1.1 m^3 containers can be serviced in 1 to 3 minutes each, including driving to the next container. This is compared to the curbside collection of the equivalent of 194 individual households, which may take as long as 30 to 60 minutes, depending on many variables. The increased efficiencies are obvious and will more than offset the increased cost of the containers and compactor trucks distributed over the life of the equipment.

The use of communal containers is especially appropriate in the newer areas of the three cities, where new multi-unit housing is being constructed along with infrastructure improvements, and wide streets. Ideally, the containers should be located in enclosures and visually screened, which should be designed into new road and housing infrastructures. Spacing of containers should consider convenience as well as capacity. In general, residents should not be required to walk further than 75 meters to access a waste container. The use of containers in residential areas may also permit less frequent collections, if containers are kept clean and free of odors. Collection frequencies of three times per week, rather than daily, are possible with communal containers.

The wider streets of the new areas will also accommodate larger capacity collection trucks. If containers are considered in these areas, new compaction trucks should be at least 14 or 16 m^3 capacity, equipped with hydraulic lifting devices for the containers. The larger compaction trucks will also improve transportation efficiencies as new landfills are located farther away from the urban population centers.

The use of large containers will not be appropriate for all areas of the city and many of the older areas will still require manual curbside pickup due to narrow streets or lack of adequate locations to place the containers. Several cities, including Rabat, are using 80 liter plastic containers in the high density areas. Specific recommendations for Oulad Teima regarding the use of containers will be presented in chapter X.

1.4.2 Medical Waste

In general, medical waste from hospitals, clinics, doctors, dentists and laboratories in all four communities is disposed of with mixed domestic waste, without any special handling or packaging. This presents a significant hazard to waste collectors, landfill operators and persons who recycle materials from the waste. A long term goal should be adopted to require all medical waste to be disinfected at the source, prior to disposal, using an autoclave, controlled incineration, or chemical treatment.

In the short term, all infectious medical waste should be placed in specifically marked containers, to alert collection workers and recyclers that the contents may be dangerous. The international standard includes the use of heavy "red" plastic bags for infectious medical waste which has not been disinfected and "yellow" bags for medical waste which has been autoclaved or chemically treated. Ashes from medical waste incinerators should be placed in ridged containers with special markings.

Solutions for the proper handling and disposal of medical waste are addressed in the National Waste Strategy, Volume X. Reports, workshops national committees have sought solutions to this problem since 1982, without significant results.

1.5 Technical Issues

Based on information obtained during the municipality site inspections and data gathering, there is a need to present some of the general technical issues regarding waste generation, collection and disposal and how these issues are applied to the specific conditions found in the four municipalities and in Morocco in general. This is especially important since most of the reference material on waste management is based on western waste, typically found in European countries and the United States. Differing waste composition, weather and geologic features found in Morocco will significantly impact the application of waste disposal systems in Morocco.

1.5.1 Waste Composition

Waste composition will vary greatly from area to area based on physical and economic conditions. Most reference material lists the various components of waste as they are generated and not as disposed. Waste characteristics, especially in poorer economic conditions will change significantly between generation and final disposal due to sorting and recycling. The following list of typical components in Moroccan waste is presented as a general guide only and must be reviewed in more detail for each municipality.

Paper	15% to 25%
Glass	3% to 5%
Tin Cans	1% to 3%
Textiles	1% to 3%
Bones	1% to 3%
Wood	2% to 3%
Plastic	3% to 5%
Organic food waste	50% to 70%
Inert Fines	5% to 7%

The most important aspect of waste composition in Morocco is that it is changing. As economies develop, more and more packaging and throw-away items are entering the waste stream. In particular, the increased use of plastics and metal beverage cans has had a dramatic effect on waste management in Morocco. Plastic bags are a major source of litter and plastic containers for soft drinks, juice and water.

Plastic recycling and remanufacture are on the increase throughout Morocco. The National Solid Waste Strategy identifies plastics in the waste stream as both a growing problem and a growing resource which must be addressed. There are several basic types of plastics used in Morocco and a general understanding of them will assist waste managers in handling the problems of plastic wastes disposal and recycling.

Polyethylene Terapthalate (PET). Most soda and soft drink containers holding liquid under pressure (gas) are made of PET. It has a relatively high recycle value and is used to make synthetic textiles.

High Density Polyethylene (HDPE). HDPE has many applications and is used primarily for its chemical resistance and elastic strength. It is commonly used for oil, bleach, laundry detergents and milk containers. It is also one of the materials commonly used to make thin film plastic bags, and has a high recycle value.

Polyvinyl Chloride (PVC). This plastic is used in many structural applications, including pipe and furniture. It is also the material used most for non-gasified bottled water and other food containers. It has a good recycle value. Several companies in Morocco manufacture PVC plastic pipe and use large quantities of recycled material.

Polystyrene. This plastic also has wide applications, including plastic utensils, dishes and toys. It is also used in most plastic foam packaging. It has a relatively low recycle value.

Plastics are inert materials and although they create many aesthetic disposal problems they do not create an environmental problem in the landfill. However, they will create toxic gases when burned, and are a significant source of air contamination in populated areas. PVC, in particular will produce hydrochloric acid when burned.

The recycling of plastics is developing world-wide into a major industry. Environmental concerns and conservation of petroleum resources has encouraged many manufacturers to utilized recycled plastic whenever possible. This will be discussed in more detail in later sections of this report.

1.5.2 Leachate Production

Leachate is a mixture of liquid contaminants produced from waste and can be a significant problem in both waste collection and disposal. Leachate liquids are either the result of the decomposition of organic matter within the waste or liquid wastes, such as synthetic solvents, waste oil or cleaning fluids that have been disposed of along with the solid waste. This latter category of leachate is normally only associated with industrial or commercial activities. If a municipality contains only residential development, they are not likely to have a significant problem with solvents or industrial contaminants which are a major concern in western waste landfills.

As organic waste decomposes, it produces strong organic acids which dissolve other chemicals in the waste, including heavy metals which are a major contaminant in landfill leachate. While discussing heavy metals, it is important to note the sources of these heavy metals in the waste, which primarily include colored inks in magazines and newspapers and batteries of all kinds. Lead from car batteries and mercury from small watch and hearing aid batteries are common sources of heavy metal contamination in western waste leachate. Although these sources are very common in western waste they are much less common in less developed economies such as Morocco, and therefore heavy metals should be less of a problem in leachate produced from Moroccan waste.

Waste requires water to decompose and produce leachate, and therefore water control is an important aspect of landfill management. The ideal water content for organic waste decomposition is between 40% and 100% and decomposition essentially stops at moisture levels below 20%. Therefore, typical Moroccan waste at 60 to 70 percent moisture will certainly begin to decompose in the landfill, but if additional water is restricted, or the waste dries, decomposition and leachate generation will stop. Since Morocco is in a semi-arid climate, with defined wet and dry seasons, leachate generation will not be as significant a problem as it is in western areas with higher rainfall. In addition to lower rainfall, a high evaporation index will reduce moisture in the waste as it is placed in the landfill.

The National Solid Waste Guidelines recognize the role of rainfall in leachate production. Four categories of landfills have been proposed, based in part on the location of the landfill and its annual rainfall. Landfills in areas with less than 200 millimeters per year are not required to have leachate collection and control systems.

1.5.3 Methane Gas Production

Methane gas is another product of the decomposition of organic matter in the landfill. It is subject to the same variables as leachate generation and will increase at higher moisture contents and decrease as moisture is reduced. Methane gas is explosive at concentrations above 5%. It is lighter than air and will normally escape to the atmosphere above the landfill while the landfill is in active operation. When the landfill is closed and a layer of low permeability soil is placed on the upper surface, the escape of methane gas will be blocked, which could cause it to accumulate under the soil cover and possibly migrate off-site through porous layers of soil. If houses are located nearby, the methane gas could enter the houses and possibly cause an explosion. If this potential exists, then the final cover soil should be applied along with methane gas vents, to prevent a build-up of gas and to allow the gas to escape to the atmosphere.

1.5.4 Geologic Issues

Several geologic characteristics will impact the environmental effects of the landfill. Both the physical and chemical content of the soil under a landfill will determine its ability to filter or chemically remove many, if not all of the harmful contents of landfill leachate.

In general, a fine grained sandy silt, with a permeability in the 1×10^{-5} to 1×10^{-7} cm/sec range is the ideal landfill base soil. The fine nature of the soil will filter solid components of the leachate and promote biological growth which will remove organic by-products of leachate decomposition. Heavy metals in the leachate will also be chemical immobilized through ion exchange by fine grained soil containing adequate calcium ions. If the leachate is mainly organic in nature, a 5 to 10 meter layer of unsaturated fine grained soil, as described above, should provide adequate treatment for landfill leachate. Unfortunately, most synthetic industrial solvents will pass through the soil unchanged.

Due to the semi-arid climate of Morocco, groundwater levels are generally very deep. At one of the municipal landfill sites, groundwater was reported to be in the range of 200 meters below the surface. This large separation between the bottom of the landfill and any groundwater that may become contaminated, is also a very positive characteristic of the local geology for landfill siting. Morocco has many areas with excellent soils for landfill siting, with the combination of limited leachate production due to low rainfall, fine grained soils and deep groundwater.

On the negative side, Morocco also contains many rocky areas. If the bedrock is fractured, leachate will pass through it relatively unaffected and may contaminate underlying groundwater, even at large depths. Landfills should not be located on bedrock formations.

1.5.5 Landfill Siting

From the above discussion of geology, it is obvious that landfill base soil is one of the most important landfill siting parameters. With proper location in natural clay or silty soils and deep groundwater, in excess of 5 to 10 meters, contamination of groundwater by landfill leachate should not be a problem. The combination of soil permeability and depth to groundwater is the

crucial parameter. A slightly more permeable soil may still be adequate if the depth to ground water is greater. In general, sandy base soils, with permeabilities greater than 1×10^{-4} cm/sec should not be used as a landfill base, regardless of groundwater depth.

The exception to the natural soil base is a landfill that accepts significant quantities of industrial wastes which may contain synthetic solvents or petroleum products. In this case, the landfill must be located in impermeable clay soils with permeabilities less than 1×10^{-8} cm/sec or constructed with a plastic liner and leachate collection systems. Since the evaporation index exceeds rainfall by a wide margin, the collected leachate should be treated through evaporation in open storage ponds.

In addition to the geologic characteristics, the following siting parameters should also be considered. These are meant to be a general guide and not a rigid set of criteria. Since a solid waste landfill is a negative landuse, a successful siting process will usually consist of compromises between environmental and economic issues which will differ for each municipality.

Distance to surface waters: In general, the landfill should be located at least 100 meters from a flowing or seasonal stream or river. This distance should provide an adequate buffer area to prevent waste or leachate from entering the river or stream. A hydrogeology study should confirm that there are no underground hydraulic connections between the landfill site and the surface water.

Distance from a well or potable water intake: The landfill should not be located in a recharge area for a public water well or within the drainage area of a public surface water intake.

Wind: The landfill should not be located in areas susceptible to sustained high winds which may result in a chronic windblown debris problem. Prevailing wind direction should also be considered to prevent odors or smoke from blowing toward urban areas.

Distance to residences: This is a difficult parameter to establish and is usually left to the local municipality to determine. Distances of 300 to 1000 meters have been used in the past. Some communities consider the density of residential development as well as the distance. Relocation of individual residences can be used to obtain adequate isolation distances.

Distance to public facilities, sensitive environments or archeological/historical sites: Landfills should not be located near public facilities, where blowing debris, smoke, odors or increased traffic will negatively impact the operation or public enjoyment of the facility. Since this will include visual as well as physical impacts, this criteria will require a site specific evaluation of each site.

Distance from the urban center: The distance that collection trucks must travel to access the landfill is also an important criteria. Although the landfill should be far enough away to minimize impacts, it should not be an economic burden to transport waste to the site. A

distance of 5 to 10 kilometers would satisfy this criteria. Modern collection trucks are designed for stop and go collection routes and are not very efficient at traveling long distances to the landfill. If the landfill must be located more than 20 kilometers from the urban center, the municipality should consider the use of a transfer station to access the site. The final decision should be based on an economic evaluation.

1.5.6 Landfill Controls

In many developing countries, landfilling in towns and small cities occurs in an informal and uncontrolled manner. The term informal disposal refers to diverse disposal, on-site, along roadways, in vacant lots, ravines or other non-centralized locations. An uncontrolled landfill applies to informal disposal, as well as disposal at a centralized location where there are no specific management methods used to control the generation or release of contaminants to the environment, or aesthetic impacts. Uncontrolled landfills are often burned on a regular basis to reduce the volume of waste and expose additional materials for recycling.

The fact that a landfill is uncontrolled does not necessarily mean that it is polluting the environment. That finding can only result from an evaluation of the waste composition, site conditions and the variables that cause waste to produce contaminants. One of the first issues to be addressed by decision makers, is when is a controlled landfill necessary to protect human health and the environment. The answer is actually quite complex and requires a basic knowledge of waste composition and the factors which cause waste to generate pollutants, which have been presented above.

In the United States the term "sanitary landfill" is used to define the environmentally correct landfill, but in developing countries the term "controlled landfill" is more common, which I feel is a more appropriate term. For the purposes of this report, I have grouped various landfill procedures and functions into three categories in an attempt to clarify the definition of a controlled landfill: Design Controls, Primary Operating Controls, and Secondary Operating Controls.

Design Controls

If the landfill is a new landfill, the control aspect begins in the design phase with proper site location. The location should be convenient to the waste generators but with adequate isolation from residential development. Buffer distances from surface water, and groundwater aquifers will minimize potential impacts to water resources.

Base soils are perhaps the most important aspect of locating a landfill. If good silty clays or silty fine sands can be located with sufficient separation distance to groundwater, then landfill liners and leachate management systems can be avoided. If proper base soils cannot be located, and the government the groundwater quality warrants protection then a lined landfill becomes necessary.

Primary Operating Controls

Primary operating controls are intended to control the short term impacts of landfilling, such as blowing litter, odors, flies and fires, while also reducing the factors leading to the generation of pollutants. These are the minimum controls that should be employed to convert an uncontrolled landfill to a controlled landfill.

Access Control: The vehicle access to the landfill should be limited to a single entrance which can be secured during the hours when the landfill is not open or supervised. The single access insures that all waste can be recorded and monitored.

Waste Monitoring: At the entrance, all waste deliveries should be inspected to insure that they do not include large quantities of hazardous or liquid wastes that the landfill was not designed for. Many landfills have separate areas for special wastes such as tires, metals, or sludges. The initial monitoring of the incoming waste should identify these materials and direct them to the appropriate disposal location. If resources permit, a second inspection should be performed as the waste is unloaded and compacted. Depending on the administration of the landfill, a written record of all waste deliveries should be maintained.

Fire Control: The burning of mixed solid waste is one of the most polluting aspects of an uncontrolled landfill and should not be permitted in a controlled site. This is especially true as waste composition changes to include more plastics which can produce highly toxic fumes when burned. Fire control begins with the initial waste inspection, since fires can start from hot coals or ashes brought into the landfill with the waste. Fires started by scavengers is another frequent source of landfill fires and must be controlled. If a fire does start, it should be extinguished as soon as possible with water or cover soil.

Waste Compaction: Compaction of the waste and the building of cells is a basic requirement of controlled landfills and has many purposes. Compaction reduces waste volume and extends landfill life. Compacted waste will also be less permeable and will impede the flow of rainwater into the waste, and loose uncompacted waste will burn easier than compacted waste. Ideally, compaction should be performed by a specifically designed landfill compactor but can also be done with a tracked bulldozer or similar earth moving equipment. Compaction should be performed in a manner which forms daily cells of waste, which, ideally should be covered with soil at the end of each working day.

Cover Soil: Like compaction, cover soil is a required landfill control which has many purposes. In addition to controlling blowing litter, insect infestation and rodents, soil cover can be used to control the infiltration of rainwater by directing it away from the landfilled waste, thereby reducing leachate formation. Covering of daily waste cells is also another method for controlling landfill fires. The frequency of soil cover is usually determined by its availability. Ideally, waste should be covered at the end of each day but this is sometimes not possible due to limited availability or cost. Covering with soil should be performed at least on a weekly basis.

Scavenging: Scavenging of the landfill for food and recyclable materials is a common problem in all developing countries. Although the scavengers are exposed to many health and safety problems, they actually perform a positive function by removing materials and reducing the volume of waste requiring landfilling. Scavenging at a controlled landfill often conflicts with compaction and covering of waste, and should be restricted or eliminated. The objective should be to promote recycling within the collection system or through source separation programs rather than at the landfill.

Closure Plan: The last primary operational control is the preparation of a closure plan to be implemented when the landfill reaches its capacity. As a minimum, the closure plan should include final impermeable cover soil and a gas venting system. The cover soil should be planted with a mixture of grasses.

Secondary Operating Controls

Secondary operating controls are defined as those control procedures that deal with managing pollutants that have been produced by the landfilled waste. Some of them may not be applicable, depending on the landfill base design and others are highly dependent on site conditions.

Landfill Gas Control: The amount gaseous emissions from a landfill will be dependent on the amount of organic decomposition that occurs in the landfill. Although methane is the component of landfill gas that is of most concern, it is only about 50 percent of the actual gas volume. The remainder is made up primarily of carbon dioxide with traces of many hydrocarbons and other gases. The gas mixture is lighter than air and will escape through the landfill during its active life but will require specific venting systems after closure.

Leachate Management: If the landfill has been constructed with a liner, all leachate generated in the landfill will be collected, requiring treatment. Although treatment can be delayed by recirculating leachate back into the landfill, some form of treatment and discharge will ultimately be required. In semi-arid countries, the most economical treatment is storage and evaporation in lined evaporation ponds.

Environmental Monitoring: All controlled landfills should perform environmental monitoring to assess the potential release of contaminants to the environment. Monitoring will be dependent on site conditions and what type of landfill base has been implemented. If the landfill utilizes a natural soil base then the emphasis should be on monitoring groundwater to insure that natural filtering mechanisms are being effective. If a liner and leachate management system has been implemented, then the monitoring shifts to leachate quality and surface water sampling of the receiving river or stream. Air quality monitoring may also be required for large landfills located near residential development. All ground water and surface water monitoring programs should include the determination of background conditions prior to the landfill operation to adequately identify operational impacts from the landfill.

1.6 Waste Generation Data Base

Prior to evaluating specific aspects of solid waste management in Oulad Teima, a waste generation data base was prepared from population information and reference characteristics of solid waste management components. The data base includes population, waste generation, estimated waste collection volumes and landfill requirements throughout a 20 year planning period. Although the primary intent of the data base is to estimate future required landfill resources, it will also assist in the recommendations for waste collection systems. Two graphs have been generated from each data base.

The first graph shows estimated waste generation and collection based on estimated 1997 population and future growth, and reference per capita waste generation factors. The estimated waste collected takes into account the percentage of the city which is provided with collection services and the degree of waste recycling and informal disposal observed during the site inspection. In Oulad Teima, the present waste collected was estimated to be 60% of total generation.

The second graph makes several assumptions in calculating landfill requirements at five year intervals. In-place waste density was estimated at 800 Kg/M^3 , cover soil at 10% of waste volume and a landfill depth of 4 meters. The graph estimates actual landfill area in hectares, without buffer areas, which must be added to obtain the total area required for the facility. The waste generation data base is found in Appendix One.

2.0 OULAD TEIMA

2.1 General

Oulad Teima is similar in population to Azrou and Sefrou, two other small cities in the study group. It is located approximately midway between the coastal resort city of Agadir and the provincial capital of Taroudannt along national primary highway No. 32. Oulad Teima is also located along the River Sous.

Oulad Teima has grown very rapidly, from 12,520 in 1982 to the present estimated population of 54,000. The region is noted for its agriculture, where most of the region's vegetables and citrus are grown. The city's economy is almost totally dependent on agriculture including, planting, harvesting, processing and shipping. Although unemployment is low, the average family income is also low relative to the other cities in the study group. Over the past 10 years, Oulad Teima has eliminated most of its informal housing (shanty towns) replacing them with multi-story flats. Based on the field inspection, there appears to be a surplus of multi-story housing units. This well planned conversion of housing has resulted in a good street pattern with wide, straight streets.

2.2 Waste Generation & Composition

Due to its low relative income, a per capita waste generation factor of .5 kg was used to estimate total waste generated in Oulad Teima. At an estimated 1997 population of 54,000 the total waste generated is estimated at 27 tons per day. Based on our interviews with city officials, waste collection services exist for approximately 60% of the City. It was also estimated that approximately 10% of the generated waste is disposed of in informal areas, fed to domestic animals, burned or is recycled prior to collection and disposal. The waste generation and collection estimates are shown for a 20 year planning period in Figure 1. A population growth of 6% per year was used for this estimate. This is a relatively high growth rate and may not be sustained over the planning period. If a lower growth rate is realized in the future, these projections should be revised. For more exact figures on waste generation, the reader is referred to the waste generation data base found in Appendix One.

Because of its regional agricultural nature, there is a large wholesale and retail market in Oulad Teima. This market produces a significant amount of organic waste (spoiled vegetables and citrus). Due to limited time during this project we were not able to quantify this market waste or determine how it is disposed. We observed one farmer, removing organic waste from the market to be used for livestock feed.

(Figure 1)

3.0 Waste Collection Systems

3.1 General

The city maintains a depot where all city vehicles are stored and maintained. The collection fleet includes a mixture of vehicles including 6 and 8 m^3 dump trucks, a multi-benne bin hoist truck serving 5 m^3 bins, and a small pick-up truck to service older neighborhoods with narrow streets. Assuming two trips per day and 6 containers per day for the multi-benne, the daily capacity of all collection vehicles is 92 m^3. Although this appears to be more than adequate compared to the estimated collection volume of only 36 m^3, several of the trucks are old and are frequently broken. Additional collection trucks will be necessary in the near future. The city has requested an 8 m^3 compaction truck as a future capital improvement to the collection fleet.

Daily waste collection is performed only in the morning, between 7:00 am and 11:00 am, 6 days per week, with all trucks returned to the depot in the afternoon. Collection is not performed on Sunday. Some of the collection trucks are reassigned to other activities in the afternoon. During our field inspection, we observed several areas in the afternoon that were not collected. This was due to road construction and special clean-up projects being performed by the city prior to the elections.

Except for the 5m^3 bins, all collection is performed daily at the curbside. Waste is placed at convenient locations by the residents, sometimes in small plastic bags or bins but often just dumped loose on the ground without any container. These piles of waste are often scattered by animals, or scavengers looking for recyclable materials. Waste collectors gather the uncontained waste into baskets which they then dump into the collection vehicle.

Informal dumping areas were observed in some of the fringe residential areas. In general these were minor in nature and are not a significant problem in Oulad Teima. Domestic animals, goats and sheep, eat any organic matter that is left in these areas.

3.2 Collection Problems

Waste storage, prior to collection is a continuing problem in Oulad Teima. Although curb-side collection is very convenient for the residents, the variety of containers and storage areas has made collection difficult. In some areas, _ barrels are used which are very heavy when full. These must be lifted to a height of 1.5 meters to be loaded onto the collection trucks. If collection is not performed every day, waste is often spread by animals searching for food. These problems would be eliminated by converting the collection system to using covered communal containers.

4.0 Existing Dumping Area

4.1 General

The current dumping area is located within the river bed of the River Sous, approximately 5 km north of the city center along secondary highway No.XX. The location of the existing dump is shown on Figure 2. Although waste is not being placed directly in the river, a major rainfall or flood could cause the river flow to rise and wash away a portion or all of the waste. The existing site is totally uncontrolled and not supervised by the city. Waste is simply dumped on the ground along several access roads. A large herd of 50 to 75 goats feed on the organic rich waste. There were no fires on the day of our inspection but there was evidence of many previous fires at the site. The site and the surrounding fields were littered with plastic bags.

During rainy weather the roads on the site become impassable. Collection trucks which cannot enter the site dump their waste along the embankment of the highway, just beyond the bridge over the River Sous.

4.2 Environmental and Health Issues

As discussed in Chapter 1, environmental contamination from waste dumps is dependent on waste composition and rainfall. Although the waste, as collected has a high organic content, most of this organic matter is eaten by the goats at the landfill. What is not eaten by the goats quickly dries in the hot sun and is eventually burned. Due to the limited amount of organic waste in the site and low annual rainfall, this site is not a significant source of groundwater pollution.
A more significant environmental threat exists to surface water. Being located within the banks of the River Sous, the waste could be washed into the lower river basin or out to the sea during heavy rains and flooding, causing major environmental damage.

In general, medical waste is not separated and is disposed at the dump site along with other waste. This presents a significant health risk to collection workers and scavengers at the dump.

4.3 Visual Pollution

Oulad Teima is located in a valley between two mountain ranges and is subject to high winds, almost every afternoon. Since the present site is uncontrolled, it has never been covered with soil. As a result, there is a large amount of paper and plastic debris which blows from the landfill during the daily high winds. These plastic bags can be seen for several hundred meters around the landfill in all directions. The road to the dumping site is also littered with plastic bags. Although each collection vehicle is equipped with netting to cover the waste during transport, they are not always used.

4.4 Interim Landfills

During the past two years, the city has attempted to begin a new dumping area. Unfortunately these areas were operated the same as the present dumping area and local residents objected and the sites were discontinued. Dumping has returned to the river bed site.

4.5 Recycling

There is very little recycling in Oulad Teima. Piles of sorted materials, plastic and glass bottles, were observed at the dumping site but there were no signs of recent activity. The waste observed at the landfill contained a lot of plastic bottles which are being recycled elsewhere in Morocco. Although markets exist for these materials in Agadir the informal collection and transportation systems have not developed in Oulad Teima as we have seen in other cities in the study group.

5.0 New Landfill Site

5.1 General

As stated above, the city has tried unsuccessfully to open a new dump at two other locations. The city is continuing to assess sites for a new dumping site. Four potential sites were inspected and evaluated during this project. These four sites are shown on Figure 3, General Location Map. All four sites are located on State land, outside of the Oulad Teima municipal boundaries.

Prior to evaluating these sites, a conceptual design was performed to determine the landfill area required. The waste generation data base calculates landfill volume including a 10% factor to account for cover soil. Landfill area in hectares has been calculated for 5, 10, 15 and 20 year increments as shown on the landfill graph in Figure 4. Due to the regional high winds, the landfill design height has been assumed at only 4 meters. A higher landfill may be difficult to operate in the high wind. Based on the data base information, a 20-year landfill will require a site of approximately 8.9 hectares. Adding additional area for access roads and other related facilities, a 12.25 hectare area (20 years) was used in the assessment of landfill sites.

(Figure 4)

5.2 Site Descriptions

Site 1: The first site is located in an agricultural area, approximately 14 km from the city center, and about 1.5 km east of the small village of El Bied The site is accessed by approximately 11 km of highway 32, but the last 3 km are over un-improved dirt farm roads. These roads pass through prime agricultural land, assumed to be in private ownership. The site itself is not in the agricultural zone but in an area of rocky fine sand and clay soil. This site would not be accessible during wet weather due to the poor quality roads and requires a new access road.

Site 2: The second site is also accessed by highway 32 for about 6.5 km. At this point a new good quality, gravel road turns right towards El Koudia, through a forest area of organum trees. Although the area is referred to locally as a forest, the trees are spaced 10 or 20 meters apart. The area is not agricultural and there are no homes or villages near the site.

Site 3: Site 3 is near one of the previous areas used as a dumping area by Oulad Teima. Like site 2, this site is located in an area shown as forest on topographic maps of the area. However, the density of trees is much lower than site 2, being 20 to 30 meters apart. This site is approximately 3.5 km from the city center along the road to the existing dumping area. It is also within 1 km of the River Sous and within 2 km of the two main O.N.E.P. wells, which provide drinking water to Oulad Teima.

Site 4: The last site is the furthest from the city center at 18 km, 15 km along highway 32 and approximately 2.5 km along an agricultural road. The predominant feature of the agricultural road is an elevated irrigation pipe channel running down the middle of the road. The irrigation pipe was not operational on the day of our inspection. Portions of this road were in poor condition and it was obvious that water leaking from the irrigation pipe at many locations, caused the poor road conditions. The land on either side of the road is

prime agricultural land, with an extensive irrigation network. The actual site is in a dry clay area lying between the River Sous to the north and hills to the south and east rising to 135 meters above the level of the site. The hills may offer some relief from the region's high winds.

5.3 Site Evaluation

After inspecting each site, a conceptual site plan was prepared for each site at a scale of 1:10,000. These site plans are included as Figures 5, 6, 7 and 8. Based on the site maps and the inspections there are several criteria on which to compare the four sites.

Distance to Landfill: The four sites vary from 3.5 km to 18 km from the city center. The distance to the landfill will have two significant impacts to the City.

The first impact is litter along highway 32. As we have seen along the road to the present dumping area, litter will blow or drop from the collection trucks, littering the roadway. This can be minimized by requiring all trucks to cover their waste with netting or conversion to enclosed compaction trucks. In addition to litter falling from the trucks, illegal dumping along highway 32 may also become a problem. On the way to sites 1, 2 and 4 the road passes through a forest area. There are many informal roads into the forest and many places for collection trucks to dump waste rather than make the long trip to sites 1 and 4.

The second distance impact is cost of transporting the waste. This issue was addressed in detail by the National Solid Waste Guidelines, Volume 7, Section 6.4. Major transport costs include increased fuel and labor. Figure 9 compares waste transport cost versus distance. The data used in Figure 9 was obtained from the national guidelines, assuming future transport in mid-sized compactor trucks.

The cost chart compares the cost of transport in DH per ton. As an example, the transport cost chart allows us to compare transport costs between Sites 2 and 4. For Site 2, at 8 km from the city center, the transport cost is estimated at 230 DH/ton. For Site 4, at 18 km the transport is 315 DH/ton or an increase of 85 DH/ton. On an annual basis (5,900 tpy) Site 4 would cost 501,500 DH more per year to operate than Site 2.

(Figure 9)

Site Access: Sites 2 and 3 will require relatively short new access roads of approximately 250 meters to enter the site from primary paved highways. Site 1 will require a new access road approximately 1,500 meters in length. Site 4 will require a major upgrade of the agricultural road and repair of the irrigation pipe to stop. The cost of providing an adequate access road should be considered in selecting the appropriate site. At an estimated 750 DH/meter, the access road costs for each site are summarized s follows:

Site 1	1,500 meters	1,125,000 DH
Site 2	250 meters	187,000 DH
Site 3	250 meters	187,000 DH
Site 4	2,500 meters	1,875,000 DH

Water Quality Impacts: Under current conditions, the landfill should not be a source of groundwater pollution. This is due primarily to the domestic nature of the waste and the dry climate. However, the site is being considered for a 20-year landfill, and future conditions are unknown. As Oulad Teima continues its rapid growth, they may attract industries which may

change waste characteristics. At this point in the site selection process, it would be wise to be conservative and assume that the landfill may be a source of contamination in the future. Therefore sites that are near the existing O.N.E.P. wells or the water bearing aquifer under the river Sous should not be considered. This would eliminate Sites 3 and 4 from consideration.

5.4 Landfill Operation

In considering the site for a new landfill, the City must commit to operating a controlled landfill as presented in Chapter 1 of this report. As a minimum the new operation should include access control, waste monitoring, compaction and periodic covering with soil. Using the terms presented in the National Guidelines, the new landfill should be operated as a Level 1 landfill. This requires periodic compaction and covering of the waste. The reader is referred to Volume 6, Chapter 3 of the National Guidelines for a more detailed explanation of operating requirements for a Level 1 landfill.

When the final site is selected, the city should prepare a preliminary design which will guide the operation of the landfill. As stated above, we have made assumptions in this report regarding the operation of the landfill. We have assumed and recommended that the landfill begin with an excavation of 2 meters. This is a very important step because it creates the cover soil needed to cover the waste. After filling the initial excavation, the landfill should continue for another 2 meters, for a total waste depth of 4 meters. As the waste is landfilled, the excavation continues, providing addition landfill volume and cover soil.

5.5 Landfill Equipment

The City Has prepared a list of new equipment needs that includes a compactor and bulldozer for use at the landfill. The Oulad Teima landfill will be too small to justify full-time use of this equipment. There are many companies in Oulad Teima that have equipment that could be used to construct and operate the new landfill. These companies provide equipment for the extensive agricultural operations or process sand and gravel, excavated from the river Sous. Since the

proposed Level-1 landfill will only require periodic compaction and covering, it is recommended that this service be contracted to a private company.

6.0 Recommendations

6.1 General

The collection system in Oulad Teima is well organized and efficiently operated. The older trucks will need replacing in the near future and the City's continued rapid growth will require other improvements to the system. National Goals, presented in the National Solid Waste Guidelines should be considered in the future for upgrading the collection system.

The existing landfill is a major problem and should be terminated as soon as possible. The closure will require excavation and removal of the existing waste from the river bed site. A new site should be selected as soon as possible, and operated as a Level-1 controlled landfill.

6.2 Collection Recommendations

Containers: Oulad Teima is an ideal city for container collection, due to its multi-story housing and good street patterns. Containers will improve collection efficiency, and health conditions. The use of containers may also permit the frequency of collection to be reduced to three times per week rather than daily. The National Guidelines includes a goal to convert urban collection systems to containers systems and reduce collection frequency to 3 times per week. This will reduce overall collection costs by 20 to 30 percent.

New Collection Truck: New truck purchases should consider rear loading compactor trucks with capacities of 14 or 16m^3 which should be able to negotiate wider streets in the City. All new compactor trucks should be equipped with mechanical lifting devices or winches to be able to service containers.

It is recommended that Oulad Teima purchase one new 14 m^3 compactor and 30 communal containers. A new collection zone should be established, to be serviced by the 30 new containers. This new zone should be collected 3 times per week. If operated efficiently, making 2 to 3 trips to the landfill each day, the new truck should replace 3 or 4 of the existing trucks. As resources permit, the number of containers should be increased until the entire city is converted to container collection. This should occur over a 5-year period.

6.3 Existing Site Closure

As soon as a new site is located and becomes operational, the existing dumping area should be closed. Since the threat of flooding will continue, all waste in the existing site should be removed

from the river bed. This waste should be buried in an excavation made near the river bed or taken to the new landfill.

6.4 New Landfill Site

The proposed sites for the new landfill have been reviewed in Section 3.5. Site 3 is near the existing O.N.E.P. wells may be a source of future pollution. Site 3 should not be considered. Site 4 is very near the river Sous and can be assumed to be over the sand aquifer that feeds the O.N.E.P. wells. The potential for contamination from site 4 will depend on the soil characteristics below the landfill and the depth of the aquifer. Before this site is considered further, a hydro geology study should be performed to determine the soil characteristics.

From a technical evaluation, Sites 1 and 2 are good sites for a landfill. The deciding factor will depend on costs. Site 1 will be more expensive to operate because of the longer transportation

required. Site 1 also has no current access and a new 1,500 meter access road will be required, at an estimated cost of 1,125,000 DH.

Site 2 is closer to the City and is located on a good gravel secondary road. It requires only a 250 meter access road. By placing the landfill within the forested area, the effects of the wind will be reduced. The trees will block some of the wind and catch many of the blowing plastic bags.

6.5 Other Recommendations

Medical waste is a problem in Oulad Teima, as it is in all of the cities in the study group. The hospital should be encouraged to separate its infectious medical waste and provide proper treatment before disposal.

The regional market creates a large amount of organic waste. During our inspection, we observed a portion of this waste being used as animal feed. This practice should be evaluated and expanded in the future if possible. As an alternative to animal feed, the organic waste could be composted and sold to farmers as a soil additive. Further study should be performed to investigate this possibility.