

URBAN AND ENVIRONMENTAL SERVICES PROJECT  
Contract No 608-C-00-96-00000

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**LANDFILL DEVELOPMENT AND OPERATIONS PLAN:  
MUNICIPALITIES OF OULAD TEIMA & GUERDANE**

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*Prepared For*

**United States Agency for  
International Development**  
Rabat, Morocco

**The Office of Environment and Urban Programs**

*By*

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# LANDFILL DEVELOPMENT AND OPERATION IN OULAD TEIMA

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## EXECUTIVE SUMMARY

**General-** The existing dumping sites in Oulad Teima and Guerdane are uncontrolled sites and the potential source of significant environmental damage. The Landfill Development and Operations Plan has been prepared to give these municipalities the opportunity to upgrade their waste disposal to a controlled landfill as defined by the new National Waste Management Guidelines.

**Waste generation -** The combined population of the two Municipalities is estimated at 63,500 in 1998. At assumed waste generation and collection levels, it is estimated that 20 tonnes per day will be collected and will require disposal. Population is expected to grow to approximately 182,000 at the end of the 20 year planning period, increasing waste collection and disposal to 73 tonnes per day.

**Existing dumping Areas -** Previous evaluations conducted in June 1998, identified a serious environmental threat to the lower Sous River valley due to uncontrolled waste dumping along the northern bank of the river. The January 1998 inspection found this situation to be significantly worse, with dumping occurring on the southern river bank, directly in the active river channel and the dumping of liquid milk waste in the river channel. During this past rainy season, the river flowed on two occasions, washing waste in to lower river valley. The continued dumping of liquid milk waste in the river channel could impact the water quality of the ONEP wells which are approximately 300 meters from the dumping site.

*The existing situation calls for emergency actions, which are outlined in the Implementation Plan. Measures should be taken to return dumping to the northern bank of the river, out of the active river channel and termination of the milk waste dumping.*

**New Landfill Site -** The previous report evaluated 4 sites selected by the Municipality. The selected site is approximately mid-way between the Municipalities of Oulad Teima and Guerdane. It is in an agricultural area on public land, approximately 1,000 meters south of Highway 32. Hydrogeological features of the site, including low rainfall, clay soils and a deep groundwater, favor the location of a landfill site. The first year of landfill activity will require only 25 ha, but as the region continues to grow, a 10.28 ha site will be needed for a 20-year landfill.

**Landfill Design and Construction -** Due to the flat topography and strong summer winds, the landfill design includes a low profile, including a 1.5 meter excavation depth and a maximum fill height of 4 meters. An earth perimeter berm will enclose the landfill and reduce the effects of the strong summer winds.

A new access road, through existing agricultural land, will be the largest component of the new landfill. Other components of the initial construction include a guard house and excavation for the first 3 years of operation. The soil from the excavation will be used to build approximately 50% of the perimeter berm. The remainder of the berm will be built gradually as new areas of the landfill are excavated and filled.

**Environmental Impacts** - The landfill site is located approximately 2 kilometers from three small villages, El Bied, Bou Assida and Ain Beida. The villages obtain their drinking water from very deep wells, 150 meters (492) feet below the surface. The soil between the surface and groundwater is clay. Leachate and landfill gas are the major pollutants released from landfill and are directly related to the amount of rainwater flowing through the landfilled waste. With an average annual rainfall of less than 200 mm and the large depth to groundwater, environmental impacts from leachate and landfill gas should be minimal to non-existent.

Due to limited resources, the operating plan will include only periodic compaction and covering of the waste. This may result in increased insect and odors at the landfill. Although these are expected to be significant at the landfill, the impacts to neighboring villages should be minimal due to the 2 kilometer buffer distance.

**Landfill Operation** - The operating plan has been prepared, following National Guidelines for a Level 1, Controlled Landfill A. This classification requires only periodic covering of the waste. Due to severe financial constraints, the plan recommends compaction and covering of the landfill once per month, using equipment contracts with private companies. The plan further recommends a full time staff of three with specific operating and reporting responsibilities. The full time staff would be supplemented with part time staff for periodic clean-up of wind-blown debris.

**Financing** - The Landfill Plan includes a cost estimate which is summarized as follows:

Emergency Actions	10,000 dh
Close Existing Dump Site	105,000 dh
Landfill Construction	842,000 dh
<b>TOTAL CAPITAL COSTS</b>	<b>957,000 dh</b>
<b>ANNUAL OPERATING COSTS</b>	<b>2,000 dh</b>

Oulad Teima has a current budget of 600,000 dh designated for construction of a wall surrounding the new landfill site. This wall is of little practical use to the landfill and the 600,000 dh should be used to construct the access road. Preliminary discussions with Guerdane indicate that they could contribute an additional 100,000 dh for the landfill for a total available funding of 700,000 which is approximately 247,000 short of the required estimated funds.

**Implementation Plan** - The Implementation Plan presented in Section 10 includes a strong emphasis to perform the Emergency Actions as soon as possible, followed by negotiations and agreements between the two municipalities and for the site. Once the financing is secured the landfill construction should begin.

## SECTION 1 - BACKGROUND

### 1 1 Intent of This Plan

This report has been prepared by the United States Agency for International Development (USAID) as part of its efforts to promote the effective development and operation of solid waste landfills throughout Morocco. This USAID solid waste management effort is part of the Urban and Environmental Services Project (U&ES). Through this program, solid waste management systems were evaluated in

- Meknes
- Sefrou
- Azrou
- Oulad Teima & Guerdane

This landfill development and operations plan has been prepared for the Municipalities of Oulad Teima and Guerdane (Municipality) by a project team consisting of a local engineer and a United States solid waste management consultant. It is intended to define the physical characteristics, development and operation of the new Oulad Teima landfill and closure of the existing landfill. Through the progressive implementation of the recommendations and procedures outlined in this report, the Municipality of Oulad Teima will continue the progress that has been made through the USAID project in achieving long term effective solid waste management.

In many countries, increasing population and urbanization has caused significant problems in most environmental sectors including 1) potable water supply, 2) wastewater disposal, 3) groundwater pollution, 4) deforestation and 5) solid waste management. Many countries, like Morocco, are just beginning to deal with environmental problems that have been years in the making. In Morocco, the ability to achieve effective environmental management is influenced by a number of factors, not the least of which is the lack of financial resources to pay for new facilities and equipment, and to operate at a new, higher environmental standard. Effective environmental management can be relatively costly when new systems and procedures are required. Typically, countries with limited resources have been faced with competing priorities that have often impeded their progress in environmental management. With a recognition of this fundamental fact, the landfill plan defined in this report has been developed to achieve **reasonable practical results** in the development and operation of the Oulad Teima landfill while using a minimum of resources.

**1 1 1 Problem Statement** - The basic problem to be addressed through this landfill plan can be defined by the following facts:

- Oulad Teima must now take full control of the landfill, but, in general, there are limited financial resources to do so.
- Previous solid waste disposal methods (random dumping, etc.) continue to exist providing unhealthy but low cost disposal alternatives to controlled landfilling. Currently, solid waste is being dumped at an uncontrolled site within the river banks of

the River Sous This is obviously a significant threat to surface water resources in the lower river valley

Currently, not all solid waste in Oulad Teima and Guerdane is collected Some disposal is accomplished through random dumping or burning near the locations where the waste is generated or stored for collection In addition, some of the waste that is collected may not reach the landfill but may be disposed of in other locations Typically, the design basis for an effective solid waste management system separates the sources of pollution from the people and places waste materials in controlled facilities such as landfills If this general goal is maintained, more waste should reach the landfill in the future so long as the financial resources exist to do this The project team's projections of landfill capacity requirements in Oulad Teima are based on the assumption that more waste material will be collected in the future and that most of the collected waste will be brought to the landfill This, in addition to other factors such as increasing population, etc , forms the basis for landfill capacity projections and design recommendations contained in this report

**1 1 2 Objectives** - This intent of this report is to define procedures for landfill development and operations for the Municipality of Oulad Teima The objectives of the plan are as follows

- Sustain the progress that has been made by USAID and the Municipality in developing the Municipality's new landfill and eliminate the environmental threat of the existing landfill
- Establish procedures for effective operation of the landfill at a reasonable environmental standard that can be achieved with minimum financial resources

## **1 2 National Guidelines**

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 guidelines for the management of solid waste In particular, Volume 6, Part 2, Technical Guidelines, include documentation and technical data regarding waste disposal Pertinent sections of these guidelines will be used in this document and the entire portion of the guidelines dealing with landfill construction and operation are presented in Appendix B of this plan for reference

## **1 3 Previous Reports**

Several previous reports on solid waste management have been prepared under the U&ES program including a Preliminary Assessment of Waste Management Systems in Oulad Teima, June 1997 This report identified significant problems with the waste disposal facilities in Oulad Teima and performed an evaluation of several landfill sites proposed by Municipal officials During the review process of previous reports and their recommendations, a final site was selected by local and provincial government officials that will serve Oulad Teima as well as the neighboring municipality of Guerdane Oulad Teima will have the primary responsibility of developing and operating the new landfill, with Guerdane contributing to the construction and operating costs This Landfill Development and Operation Plan is a recommendation of the previous report and will incorporate many portions of previous reports for reference

## SECTION 2 - PLANNING ISSUES

### 2 1 General

Oulad Teima is approximately midway between the coastal resort area of Agadir and the provincial capital of Taroudant along national primary highway 32. The region is noted for its agriculture, where most of the region's vegetables and citrus are grown. The municipality is nearly totally dependent on agriculture including planting, harvesting, processing and shipping. Over the past 10 years, Oulad Teima has eliminated most of its informal housing (shanty towns) replacing them with multi-story housing units.

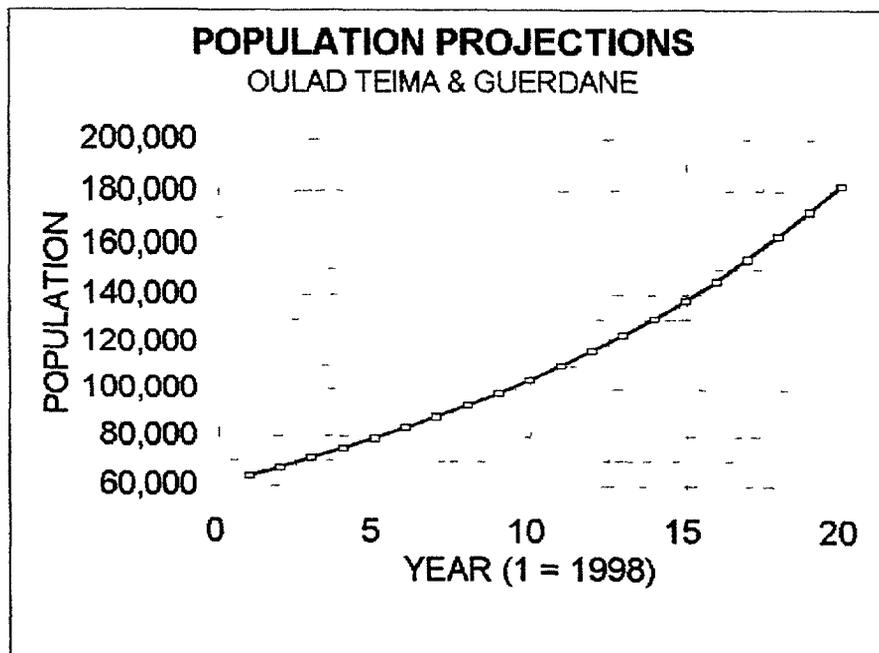
Guerdane is a smaller municipality located approximately 20 kilometers east of Oulad Teima along Highway 32. Like Oulad Teima, its economy is totally dependent on agriculture.

### 2 2 Waste Generation

**2 2 1 Population** - Due to the changing economic conditions, it is very difficult to determine actual population in many areas of Morocco with a high degree of accuracy. Previous estimates have placed the 1997 population of Oulad Teima at 54,000. Due to its regional nature, Oulad Teima is expected to grow at the rate of 6% per year for the foreseeable future, based on government planning projections. This relatively high estimated growth rate is based on the continued urbanization of rural populations that has been experienced during the last decade. The existing (1998) population of Guerdane was estimated by public officials to be approximately 6,500 and future growth is expected to be a relatively low 2% due to the lack of a central sewer collection system and other public infrastructure systems.

For the purposes of this report, we have assumed a 1998 population of 57,000 and a growth rate of 6% for Oulad Teima and 6,500 for Guerdane with growth rate of 2%.

FIGURE 2.1



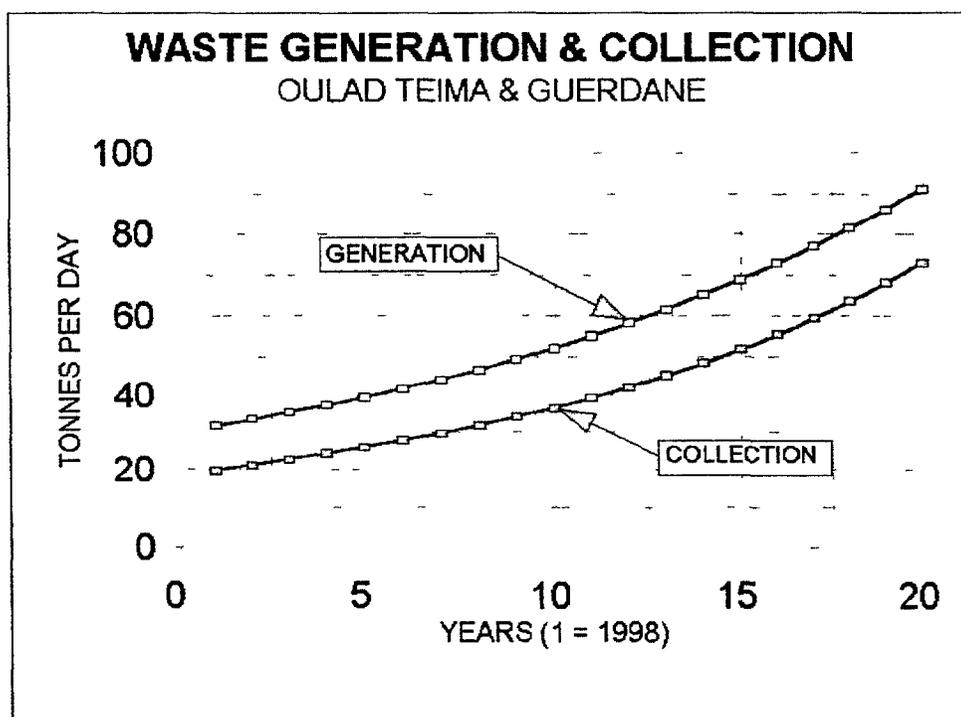
throughout the 20 year planning period. The combined population of the two municipalities is shown graphically on Figure 2.1 - Population Estimates. As you can see, this projection estimates a population of approximately 182,000 at the end of the 20 year planning period.

**2.2.2 Waste Generation** - Previous studies have estimated that the average daily waste generation in Oulad Teima is 0.5 kg per person per day. Actual waste generation will vary throughout the region, based on socio-economic conditions, and housing densities. On a per capita basis, waste generated in market areas and urban centers will exceed the 0.5 kg per capita estimate, while generation in the poorer areas will be significantly less. For the planning purposes of this report we will use the 0.5 kg per capita per day waste generation factor as an average, applied to the entire population.

The estimated waste generation is shown graphically in Figure 2.2 - Waste Generation and Collection. Waste generation in 1998 for Oulad Teima and Guerdane is estimated at 32 tonnes per day which increases to 91 tonnes per day at the end of the 20 year planning period.

Based on interviews with municipal officials and observations of the collection system, it is estimated that only 60% of the generated waste is actually collected in Oulad Teima and taken to the disposal site. This is the result of inefficient collection procedures, informal disposal, animal feeding and recycling. In Guerdane the collection percentage is higher because of the smaller population and lack of any recycling. Both collection percentages are estimated to increase by 1 percent per year through the planning period.

**FIGURE 2.2**



The estimated amount of waste collected and placed in the disposal site is shown on the lower half of Figure 2.2. This disposal estimate assumes an average 60% collection percentage in 1997, increasing through the planning period to 80% after 20 years. This assumes that informal disposal in the fringe areas of the municipality and animal feeding will continue in the future. It is also anticipated that increased recycling will occur once the new landfill begins operation.

**2.2.3 Waste Generation Database** - Prior to evaluating specific aspects of the landfill, a waste generation database was prepared. This database includes population estimates, waste generation, collection efficiency and landfill size estimates. The database calculates these variables throughout a twenty-year planning period. This database is intended to be a planning tool for the municipality as it proceeds to upgrade solid waste management practices. It should be revised periodically to adjust for actual conditions encountered that differ from the assumed values. This database forms the basis for Figures 2.1 and 2.2, and many of the numerical values mentioned in this report. The data base is included as Appendix A.

## 2.3 Waste Collection

**2.3.1 Oulad Teima** - Waste is collected in Oulad Teima using 6 and 8 m<sup>3</sup> dump trucks and a multi-benne hoist truck serving 5 m<sup>3</sup> containers. The previous evaluation judged these vehicles to be adequate for existing conditions but recommended a planned conversion to compactor trucks serving 750 liter containers in the future.

**2.3.2 Guerdane** - One dump truck of 3 m<sup>3</sup> capacity collects waste in the municipality. It makes two to three trips per day to a dump site in an abandoned quarry located about 6 kilometers west of the municipality.

## 2.4 Medical Waste

The generation and disposal of infectious medical waste is a significant problem in all regions of Morocco. At the present time, all hospital waste, including potentially infectious medical waste, is not separated and is collected and disposed of with all other waste. Considering the amount of recycling and animal feeding that occurs at the disposal site, this practice is potentially harmful.

Several programs have been proposed for a national program of medical waste identification and disposal but none have been implemented nor are they likely to be implemented in the near future. This operating plan will include interim measures for disposing medical waste until a more appropriate system is implemented.

## SECTION 3 - DESIGN AND CONSTRUCTION

### 3 1 General

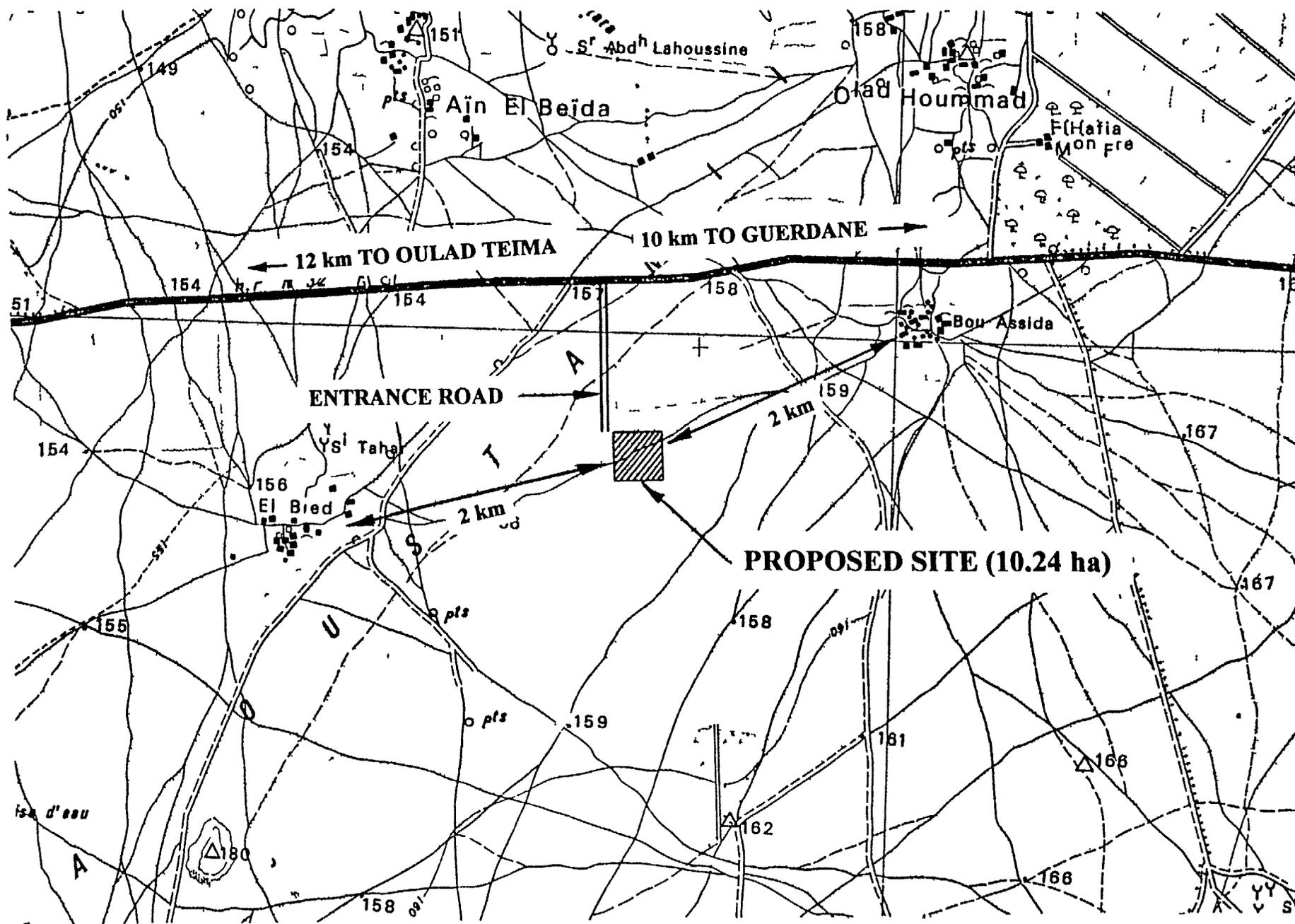
**3 1 1 Previous Studies, Site Selection** - The previous evaluation of waste management systems in Oulad Teima performed a conceptual design of the landfill for sizing purposes only. This was used in the evaluation of four landfill sites provided by the municipality. During the government review of that report and final selection of the site, it was decided to combine Oulad Teima with Guerdane and to construct one landfill for use by both municipalities. The following landfill design includes both municipalities.

The site selected by the government review of the siting report is shown on Figure 3 1, Location Map. It is located approximately 12 kilometers east of Oulad Teima along Primary Highway 32. The travel distance to the center of Guerdane is 10 kilometers. The site is about 1 kilometer from the highway and located in an agricultural area. The general area is publicly owned but leased to private farmers for growing vegetables. The actual site selected for the landfill is a rocky portion of this area which is not in current agricultural use.

Three small villages, El Bied, Bou Assida and Ain El Beida are located approximately 2 kilometers from the landfill site. These Villages and their water supplies will be discussed in a later section of this report.

**3 1 2 Landfill Sizing** - The waste generation database, presented in Section 2 2 4, includes estimates landfill sizes based on several variables. These include population, growth, per capita waste generation, collection efficiency and landfill operation. The most difficult variable to estimate was collection efficiency which will have a direct impact on landfill size and capacity.

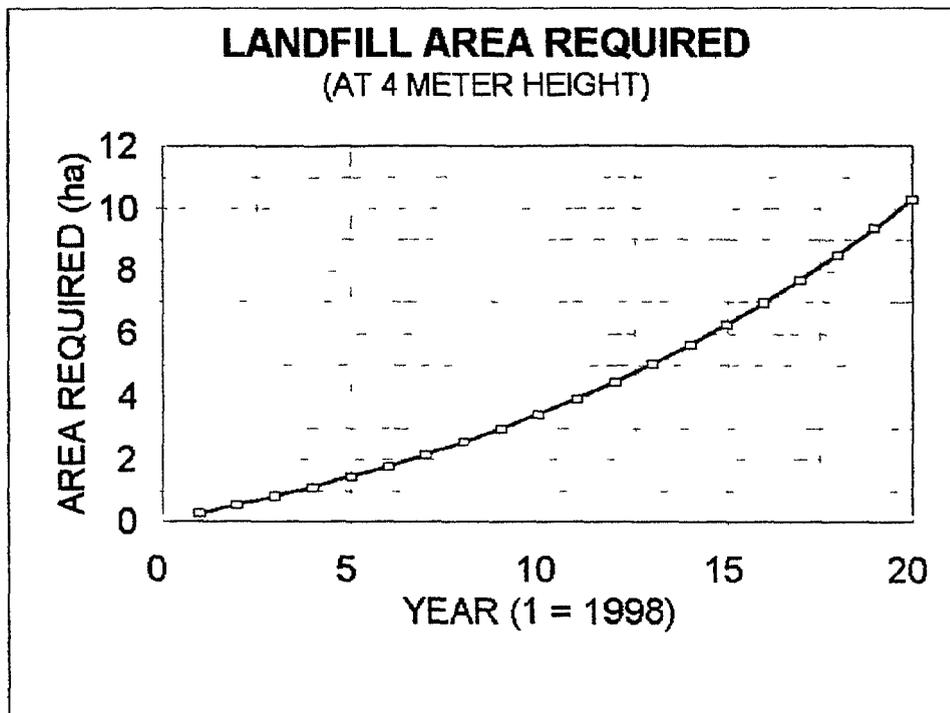
One of the objectives of the database was to estimate the amount of land needed for a landfill over a 20 year planning period. The results of the database indicate that a 5-year landfill will require a land area of 1 43 hectares depending on how efficient the collection system becomes. A 10-year landfill will require 3 44 hectares. At the assumed variables, the 20-year landfill would require a 10 28 hectare site. The landfill size estimates are shown graphically in Figure 3 2.



**LOCATION MAP**

**FIGURE 3.1**

FIGURE 3 2



**3 1 3 Existing Dumping Site** - The dumping site is within the northern banks of the River Sous and previous reports have judged it to be a serious environmental threat to surface water resources down stream. During the latest site inspection conducted in January 1998, the previous entrance to the site had been blocked by reconstruction of the main road from Oulad Teima. This has forced waste collection trucks to use an alternate route located on the south side of the river, closer to the ONEP wells. During this inspection, waste was observed being dumped directly into the active river channel. Waste recyclers at the site stated that standard practice was to leave the waste for three days, for sheep and goats to eat any food waste and to permit recyclers to remove materials. After three days the piles are burned. Two rainy periods in December produced flow in the river which has washed away waste that had been dumped in the active river channel. The municipal engineer stated that dumping waste in a river channel is a common practice in the region, including the provincial capital Taroudant.

The latest inspection in January, 1998 observed another new practice at the river bed site. Waste milk containers, containing out-of-date, spoiled milk are being dumped at the site. This liquid waste is seeping into the sandy soil and may lead to groundwater contamination. *This practice should be terminated immediately.*

When the new landfill is completed, all waste in the river bed should be excavated, loaded onto trucks and taken to the new landfill. It is estimated that the site contains approximately 5,000 m<sup>3</sup> of waste which must be removed.

*Immediate emergency action should include pushing all waste out of the active river channel and prepare a new access road and dumping area along the north bank of the river until the new landfill has been prepared. The dumping of liquid milk waste should be terminated.*

### **3 2 Site Access**

Figure 3 1, Location Map, and Figure 3 3, Site Plan, show the proposed access road to the new landfill site. The road passes through several leased agricultural fields which are irrigated. Final alignment of the access road should accommodate irrigation pipelines and channels and provide a minimum of interruption of the existing agricultural land use. The access road design should be sufficient for two-way heavy truck traffic.

### **3 3 Site Topography**

The selected site is basically flat, without significant change in topography. Normally, this would create some design problems for surface drainage but due to the low annual rainfall this should not be an issue. The flat topography will require consideration of visibility from Highway 32 and the neighboring municipalities of El Bied and Bou Assida. Figure 3 3, Site Plan and Figure 3 4, Construction Details, show an earth perimeter berm around the entire landfill site. The berm is designed with a height of 2 5 meters. Combined with an excavation depth of 1 5 meters, normal landfill activity should be screened from view from the highway and neighboring municipalities. Additional tree plantings in front of the perimeter berm will further screen the landfill from view.

On a regional basis, the River Sous valley is located between two mountain ranges, which are approximately perpendicular to the sea. These mountain ranges channel normal winds into the valley floor through Oulad Teima. These winds are strong and consistent, especially during summer days, May through November. These winds are a significant problem for landfill operation due to wind blown debris. The landfill design includes a relatively low profile (4 meters) and a perimeter berm to reduce the wind effects on daily landfill operations.

### **3 4 Hydrogeology**

The site is located in a dry plain in heavy silt and silty clay soils. Potable water for Oulad Teima and other municipalities and villages in the region comes from deep wells. The O N E P wells serving Oulad Teima are located adjacent to the River Sous, and the existing dumping site, and were discussed in previous reports. Potential contamination of the O N E P wells was an issue in the final selection of the landfill site.

Water supplies of El Bied, Bou Assida and Ain El Beida were discussed with local municipal officials, the provincial representative and a local well driller. All three villages obtain water from deep drilled wells, with steel casings. The water table is located at a depth of 100 to 120 meters (330 to 396 feet) below the surface, but the quality and yield of the water at that depth is poor for potable use. Good, higher quality water comes from a lower aquifer located approximately 150 meters (495 feet) below the surface. The general soil type between the surface and nearest groundwater level is clay. It is assumed that the recharge sources of the deep 150 meter aquifer are in the mountain ranges which form the Sous river valley.

According to the National Rainfall Map included in the National Solid Waste Guidelines (see Appendix B), average annual rainfall in Oulad Teima is less than 200 mm per year.

This is compared to an estimated evapotranspiration potential of over 1,000 mm per year. Under these conditions, it is not likely that the landfill will produce any significant leachate or methane gas, and potential impacts to groundwater are minimal to non-existent. Based on the National Guidelines, the proposed Oulad Teima landfill would be classified as Level 1 Controlled Landfill A. This landfill classification does not require a liner for leachate collection or gas venting due to the low annual rainfall and minimal leachate/gas generation potential.

Although the hydrogeological conditions appear ideal for the location of a landfill, conditions at the site, including depth to groundwater, should be verified with an on-site test well. During installation of the test well, a log of subsurface soils should be prepared, noting the type of each soil encountered, its depth and thickness. Samples of each soil should be collected for future evaluation.

### 3.5 Environmental Issues

**3.5.1 General** - The Oulad Teima landfill site is very well located to limit any environmental impacts that may result from landfilling activity. The site meets or exceeds all environmental siting criteria included in Chapter 2, Volume 6, Part B of the National Guidelines. It is well isolated from residential development and the very dry climate virtually eliminates any potential leachate impacts to water resources or air quality due to methane generation. Minimal impacts from insects, odors and fires are potential impacts but, due to the site's remote location, these impacts will be minimal and within a manageable range.

**3.5.2 Leachate Generation** - Leachate generation is a result of the organic decomposition of organic waste and will be a function of many variables. The quality of the leachate will be determined by the nature of the waste placed in the landfill. Oulad Teima is predominantly a residential/agricultural area with minimal commercial and industrial waste. This will result in a waste composition which is high in organic material and low in industrial/commercial waste which can contain organic pollutants and heavy metals. Industrial solvents and other such wastes can create pollutants that will travel further in the soils under the landfill. Previous studies have estimated an organic waste content from 60 to 70 percent. Leachate produced by the Oulad Teima landfill will have a relatively high organic content (BOD) and low heavy metals as compared to typical leachate in more developed countries.

The quantity of leachate generated in a landfill will be a factor of the initial moisture content of the waste (estimated at approximately 50%), rainfall and evapotranspiration. Evapotranspiration is the loss of water through evaporation and uptake by plants, and is a factor of sunshine, relative humidity and temperature. The analysis of rainfall and evapotranspiration is called a water balance. In addition to rainfall and evapotranspiration, waste in a landfill has a water storage capacity, which can be compared to a sponge. The waste storage capacity is called the field water capacity. The landfilled waste will not produce significant leachate, until its water storage capacity is nearly full. This storage potential also allows uncovered waste to absorb water during periods of rainfall and then release that water during non-rain periods through evapotranspiration. The relationship between cover material, rainfall, evapotranspiration and leachate generation will be discussed in more detail in the operations section of this report.

On an average annual basis, leachate generation at the Oulad Teima landfill will be minimal due to the low annual rainfall, below 200 mm. However, during the rainy season, heavy

rains of short duration are common which may produce significant amounts of leachate for short periods of time

**3 5 3 Leachate Management** - The landfill is located in excellent soils for natural leachate attenuation. Attenuation is a technical term used to describe the many physical and chemical treatment processes that occur as leachate flows through natural soil. These attenuation processes are very effective in removing most, if not all of the pollutants typically found in leachate. Therefore, the primary leachate management objective will be to direct leachate into the soil. Since permeability tests have not been performed on the base soils, we cannot accurately predict the amount of leachate that the base soil can accept. However, with the negative water balance, it is not likely that this landfill will produce any significant long term leachate problem.

**3 5.4 Landfill Gas Generation** - The same factors which control leachate generation also control landfill gas generation. Landfill gas contains methane, which can be explosive if it is permitted to accumulate in a confined space. Both leachate and gas are products of the biological decomposition of organic waste. Without water this decomposition is very slow and with less than 200 mm of rainfall per year, landfill gas will not be a significant issue for the Oulad Teima landfill.

### **3 5 5 Environmental Impact Assessment (EIA)**

The National Guidelines include a format for preparation of Environmental Impact Assessments for waste disposal facilities. Key elements of the EIA process include

- Pollution Control
- Conservation of Natural Resources
- Conservation of Social Resources

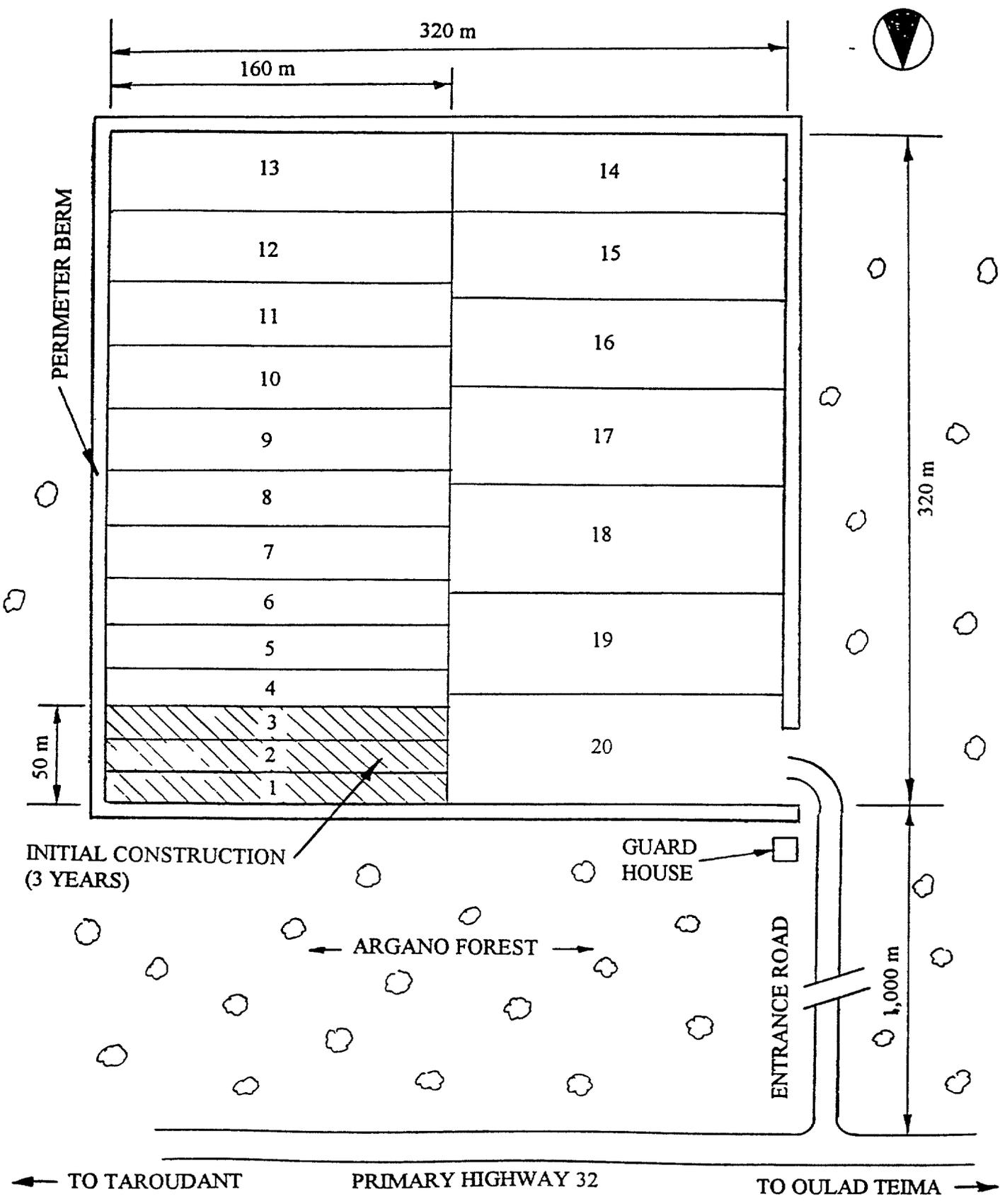
Although the Oulad Teima landfill appears well suited for a landfill in respect to environmental impacts, an EIA is recommended to insure compliance with National Guidelines. Specific elements of the EIA should concentrate on

- **Construction Impacts**
- **Agricultural Impacts**
- **Specific impacts to Argana forest and number of trees removed**
- **Traffic**
- **Post Closure**

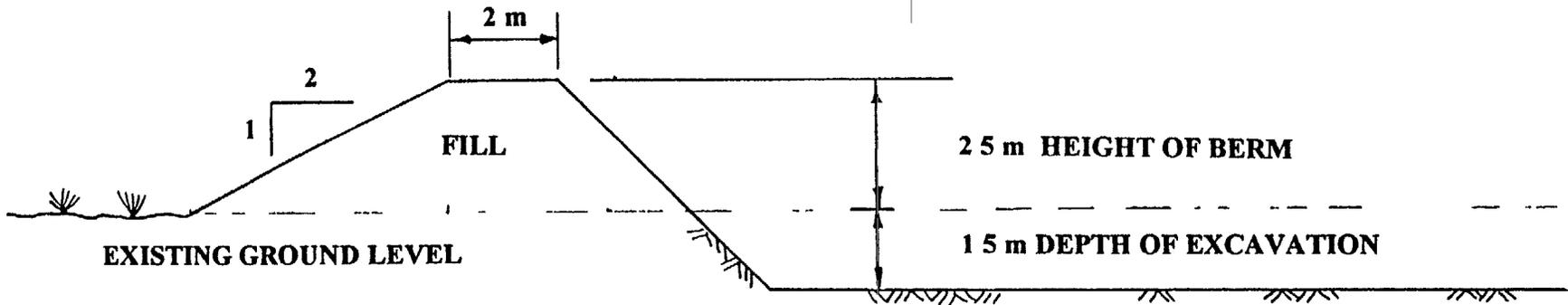
### **3 6 Landfill Construction**

**3 6 1 Configuration** - Due to the flat topography, the proposed 20-year landfill configuration, shown in Figure 3 3, is a square. At the assumed 4 meter depth, used in the waste generation data base, the approximate area of each year is shown on the plan. The size of each successive annual landfill cell increases due to the estimated 6% population increase in Oulad Teima.

As shown on the site plan, the landfill includes a perimeter berm to contain the landfill and reduce the effects of wind. The construction of the berm will require approximately 20,000 m<sup>3</sup> of soil. It is proposed to construct the north and east portions of the perimeter berm during the initial phase of construction.

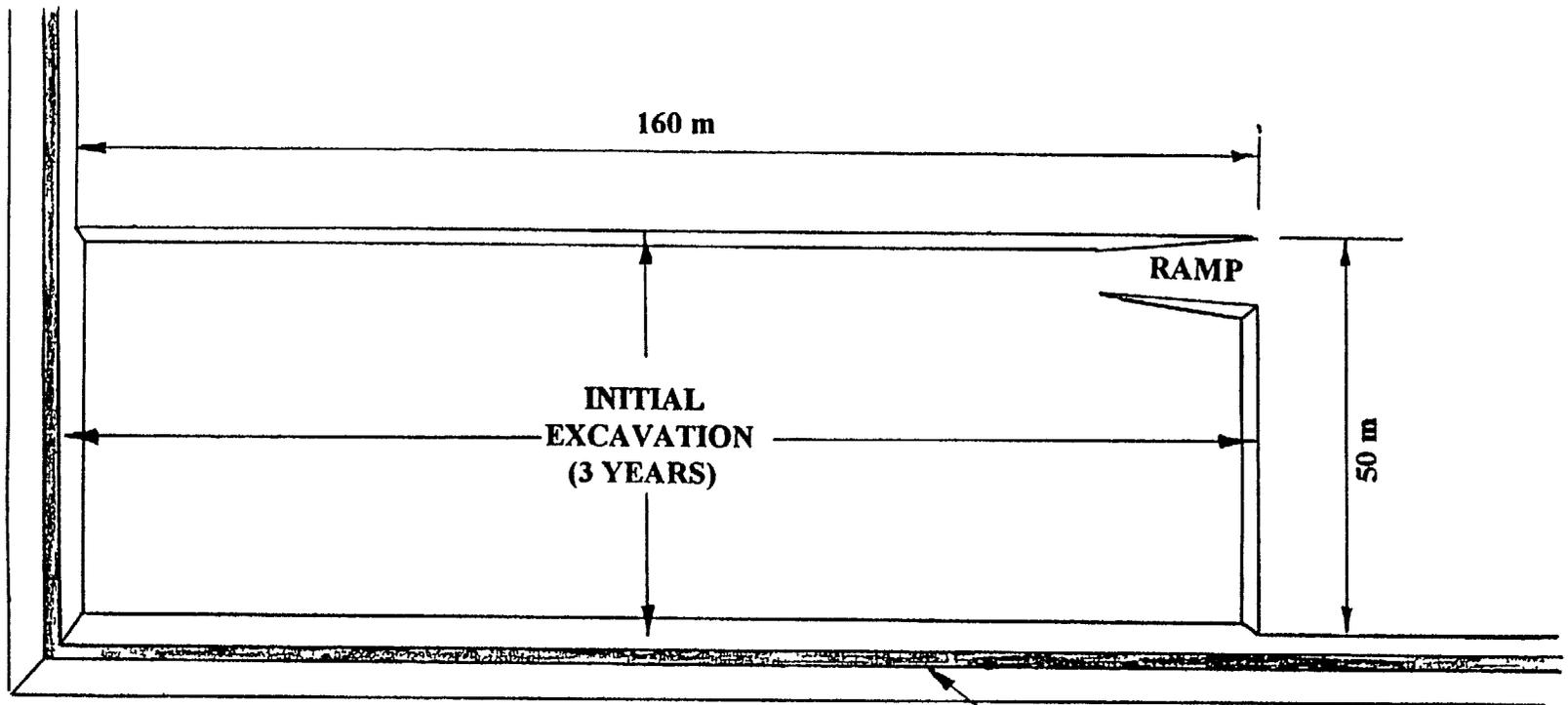


**FIGURE 3.3**  
**SITE PLAN**



**SECTION A-A**

SCALE 1 125



**PLAN**

SCALE 1:1,000

CONSTRUCTION DETAILS

FIGURE 3.4

The proposed initial construction, shown in Figure 3 4 includes the 1,000 meter access road from highway 32, a permanent guard house, internal access road from the guard house to the active landfill area and initial excavation for the first three years of operation. The soil excavated from the 160 m x 50 m excavation will be approximately 12,000 m<sup>3</sup> which will be used to construct the north and east portions of the perimeter berm.

**3 6 2 Lift and Cell Construction** - Each phase of the landfill will be constructed with multiple layers of waste and cover material called lifts. A cell is defined as a volume of waste to be landfilled within a period of time. The dimensions of each cell and lift are a function of how the landfill is operated and the equipment available for spreading and compacting the waste. This will be discussed in more detail in a later section of this report.

**3 6.3 Surface Water Control** - Due to the flat topography and low annual rainfall, control of surface water should not be a significant problem. During the rainy season, December to April, the operator should dig drainage ditches to prohibit surface water from flowing into the active landfill cell. Temporary internal infiltration basins may be required in excavated pits to control ponding of rainwater.

### **3 7 Design and Construction Summary**

- The existing site is an environmental threat requiring emergency action
- The proposed site is the best of 4 sites which were evaluated
- 10 28 hectares are required for 20-year life
- Site has excellent hydrogeological features
- Leachate and gas will be minimal due to low annual rainfall

#### **Initial Construction**

- Construct 1,000 meter access road
- Construct permanent guard house
- Internal access roads
- 50 m x 160 m initial excavation
- Construct north and east portions of perimeter berm

## SECTION 4 - MANAGEMENT, STAFFING AND EQUIPMENT

### 4 1 General

Any work associated with the landfill requires that there be effective management and staff to operate the facility in the correct and cost efficient way. The basic role of management is to provide direction for individuals who will be directly responsible for performance of all day to day tasks at the landfill. The project team believes that a clear line of responsibility must exist to assure that all operation of the landfill is done in the manner recommended in this report and adopted by the Municipality.

### 4 2 Management Structure

Management of the landfill will be provided by the Municipality of Oulad Teima. We recommend that the same individual responsible for solid waste collection be given responsibility for the landfill since this will help to coordinate activities in both solid waste management processes.

### 4 3 Staffing Levels

An adequate number of people is required to perform the tasks outlined in this report. As will be described in greater detail later in this report, we recommend a modified area method of landfill operation. This is compatible with National Guidelines and with the fact that financial resources available to operate the landfill are limited. Through this approach, some operating tasks will only have to be done periodically and full time staff or equipment will not be necessary to perform them. All of the work tasks required to effectively operate the landfill may be accomplished using a combination of full time and temporary staff and municipal equipment or equipment from outside contractors.

**4.3.1 Permanent Staff** - The project team recommends that three full time people be employed at the landfill in initial operations. Once the collection system becomes more effective and more waste reaches the landfill, additional staffing may be required. The permanent landfill staff will be responsible for the following activities at the landfill:

- Controlling traffic at the landfill and directing trucks to the correct location for dumping
- Recording all solid waste deliveries
- Inspection of waste loads
- Limited site clean-up
- Regular communication with the Municipality's solid waste manager concerning conditions at the landfill and coordination with the collection staff

**4.3.2 Part Time/Temporary Staff** - The project team is also recommending that temporary staff be periodically used for tasks that do not have to be performed every day. Generally, temporary staffing will be used to accomplish labor intensive tasks such as periodic site clean-up.

**4.3.3 Staff Training** - Fundamental training should be provided to all staff involved in the operation of the landfill. This training will be important in assuring the health and safety of landfill staff and to establish the importance of effective operations. During initial operations where only three full time staff will work at the landfill, training should be

provided on the following subjects

- General waste characterization
- Estimating of solid waste quantities delivered
- Health and safety
- Waste placement
- Waste load inspection
- Waste receipt recording

Given the limited scope of temporary staff activities at the landfill, we recommend that only basic health and safety instruction be given to those individuals who will have any direct contact with solid waste materials

#### **4 4 Mechanized Equipment**

Periodically, mechanized equipment will be required for operation, maintenance and expansion tasks at the landfill. Common mechanized equipment work tasks include the following

- Access road maintenance and improvement
- Storm water diversion maintenance and improvement
- Landfill area preparation
- Waste distribution and compaction
- Periodic cover excavation, transport and application

At a minimum, the mechanized equipment to be required will include

- 1 Bulldozer (Caterpillar D-4 or equivalent)
- 1 Dump Truck (minimum 8 cm<sup>3</sup> capacity)
- 1 Front-end Loader

Through the procedures outlined in this operations plan, the mechanized equipment will only be required periodically. The frequency at which mechanized equipment tasks are performed will be based on the amount of waste collected and transported to the landfill. Initially, the project teams recommends that the mechanized equipment tasks be performed at 1-month intervals. However, this should be reviewed at the end of six months to determine if the time between mechanized equipment tasks should be increased or decreased. The factors that should be evaluated in looking at the tasks frequency includes

- The amount of waste collected and delivered to the landfill,
- The extent of vectors (flies, etc ) at the site,
- The difficulty in controlling waste dumping locations at the site,
- The extent of fires, and
- Recycling activity

The actual amount of waste received will also determine the frequency at which new landfill cells must be constructed

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In the future, some dedicated mechanized equipment may be required for the landfill as the amount of waste brought to the landfill increases. However, in the immediate future, we are recommending that mechanized equipment from the municipality and/or a private contractor be utilized for mechanized work tasks.

It is our understanding that the municipality has its own dump trucks and a front end loader which could be made available for periodic use at the landfill, subject to other responsibilities.

Given the periodic nature of the tasks requiring mechanized equipment, privately contracted equipment should be considered. Through contracted services, mechanized equipment would only be hired at the time that it is required to complete mechanized equipment tasks.

## SECTION 5 - OPERATIONS

### 5 1 General

Effective landfill operations require a sufficient level of definition and detail to meet acceptable operation guidelines. The procedures also need to be defined sufficiently so that those responsible for the overall function of the landfill can monitor the tasks assigned to other individuals or private contractors.

According to the National Guidelines, the Oulad Teima landfill should be operated as a Level 1, Controlled Landfill A, or a Level 2, Controlled Landfill B. The basic differences between the two classifications are the Level 2, Controlled Landfill B includes a truck scale and daily landfill cover. Based on the relative small size of the Oulad Teima landfill, and limited financial resources, a scale and daily cover are beyond current resources. Therefore, the following operational procedures follow Level 1, Controlled Landfill A requirements of the National Guidelines. As future resources permit, the landfill should be converted to a Level 2, Controlled landfill B classification, with application of daily cover.

### 5 2 Operations Procedures

The following are recommended procedures for the initial operation of the Oulad Teima landfill. These are based on an attempt to achieve reasonable operating and environmental standards through the application of a minimum of financial resources.

**5 2 1 Landfill Area Preparation** - Periodically, mechanized equipment will be used to prepare new landfill areas as designated in Figure 3 3 and 3 4 for waste receipt. Preparation work will consist of removing surface vegetation, soil excavation and general grading for truck access.

**5 2 2 Site Access Control** - Site access should be controlled to prevent unauthorized dumping, scavenging and animal feeding. However, as is the case in many landfills in developing countries, the ability to control access may be limited unless structures such as fencing or natural barriers exist to prevent access. Building fences or other manmade barriers to control access is costly and is not recommended or required by the National Guidelines at this time. If constructed as designed, the perimeter berm should be an effective control for truck access.

Truck access will be controlled by providing a full time landfill staff at all times that trucks are expected at the landfill. All trucks must use the designated access road. All other access points to the landfill must be blocked. Trucks should only unload waste at locations designated by the landfill staff. Uncontrolled truck access often leads to dumping in improper locations that may impede effective operations, requiring considerable clean-up effort or causing environmental damage. The hours of operation of the landfill (defined as the hours that the full time staff works at the landfill) should be coordinated with the anticipated time (hours per day, days per week) of collection and delivery of solid waste to the landfill.

**5 2 3 Commencing Operations in New Landfill Areas** - Waste placement in new landfill areas should begin with a back to front configuration. Care must be taken to assure that the first material placed in the new area is along and against the back boundary of the area furthest away from the access point so as to make effective use of the entire area.

Once an area has been prepared and operations are to begin, trucks will enter from the internal access road and proceed to the discharge point where they are directed to dump. Waste loads will be dumped in a row along the back boundary as close to the area perimeter as possible. As more loads are delivered, progressive rows will be accumulated along the previously placed rows. As a result, the rows will progress toward the internal access road. After sufficient material has been accumulated, mechanized equipment will be used to spread the waste piles, compact the material and cover the waste. The initial operations of the landfill are shown graphically and summarized in Figure 5.1, Lift 1 Construction.

**5.2.4 Waste Receipt and Placement** - Waste will be placed only in locations designated by the landfill staff. Collection truck drivers will be directed to place each load as close as possible to allow for the maximum number of loads to be placed in each area. This will help to decrease the frequency of periodic compacting and covering of the waste. Once the entire surface area of each area has been covered and all material has been compacted into a cell and covered, the next area will commence by repeating the same steps used in waste placement for the initial area.

Waste will be placed into each area of the landfill in two 2-meter lifts that will accomplish the design grade for each area. As shown in Figures 5.1 and 5.2, waste placement in each area will consist of two lifts.

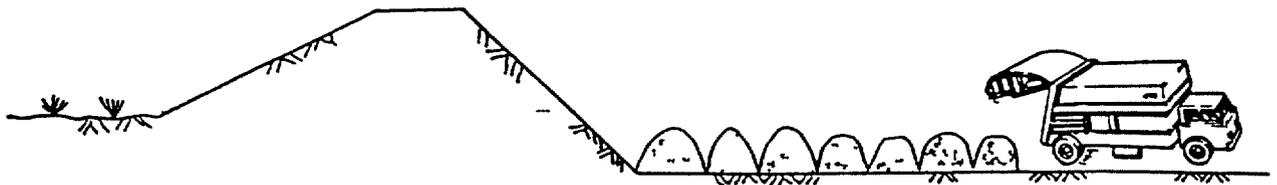
**5.2.5 Load Tracking and Inspection** - All trucks delivering waste to the landfill should be recorded by the landfill attendant to keep basic records of waste delivery. At a minimum, the waste receipt record should include the following information:

- If public, truck number (license plate, etc.)
- Municipality or sector of waste origin
- If private, hauler name and truck number
- Time waste received
- An estimate of the amount of waste delivered in m<sup>3</sup>
- Type of waste delivered
- Any unusual characteristics or circumstance associated with that particular load

The information collected through the record will be important in overall landfill monitoring and planning and may also assist the Municipality in determining the efficiency and cost effectiveness of its collection system. In the future, more accurate information concerning waste delivery may be required. While truck scales are often used in landfills to determine the exact quantity of waste delivered, this is not recommended for initial operations at the Oulad Teima landfill because of the small size of the landfill and the costs associated with installation and operation of a truck scale.

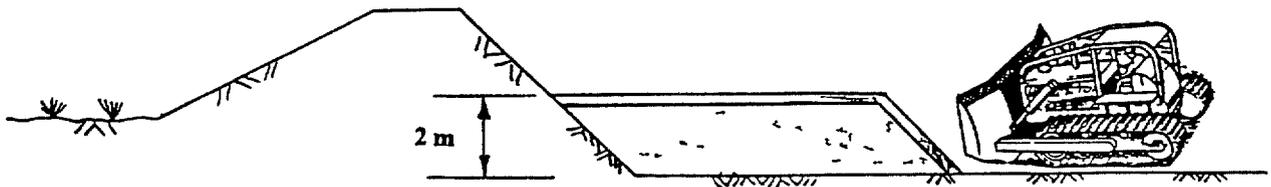
In addition to recording all trucks, a landfill attendant should also inspect all loads as the trucks are being emptied to verify that only materials designated for landfilling are received. In particular, a landfill attendant should watch for large containers that may contain liquids that could cause significant groundwater or surface water pollution.

**5.2.6 Mechanized Equipment Procedures** - Periodically, mechanized equipment will be used to spread, compact and cover the waste that has been accumulated. The mechanized equipment procedures are illustrated in Figures 5.1 and 5.2 which presents the general



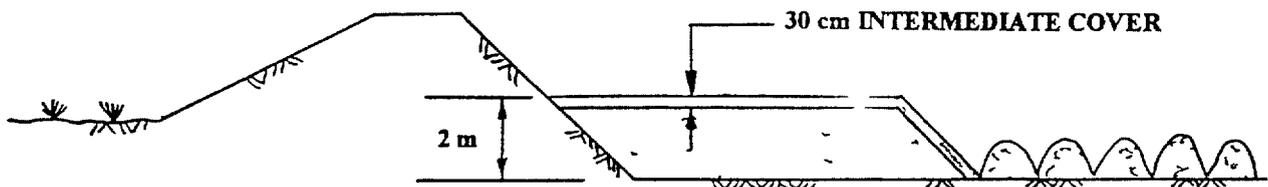
### **STAGE 1**

- a. DUMP WASTE IN CLOSE PILES AT REAR OF ACTIVE LANDFILL AREA
- b. PERMIT CONTROLLED RECYCLING OF MATERIALS.
- c. PROHIBIT ANIMAL FEEDING
- d. EXTINGUISH ALL FIRES.



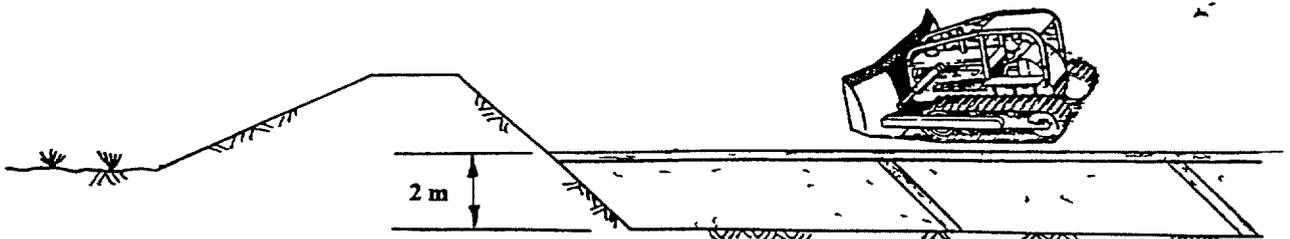
### **STAGE 2**

- a. AT PERIODIC INTERVALS PUSH AND COMPACT WASTE INTO A CELL
- b. EXCAVATE COVER SOIL FROM ADJACENT AREA
- c. APPLY 30 cm OF INTERMEDIATE COVER TO ALL WASTE SURFACES



### **STAGE 3**

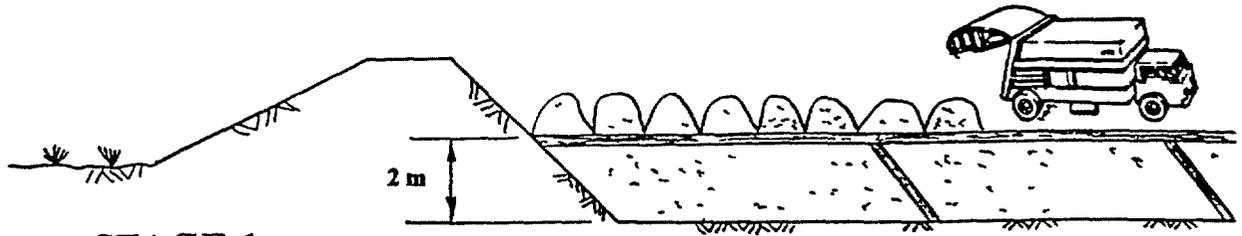
- a. REPEAT STAGE 1, DUMP WASTE IN CLOSE PILES



### **COMPLETE LIFT 1**

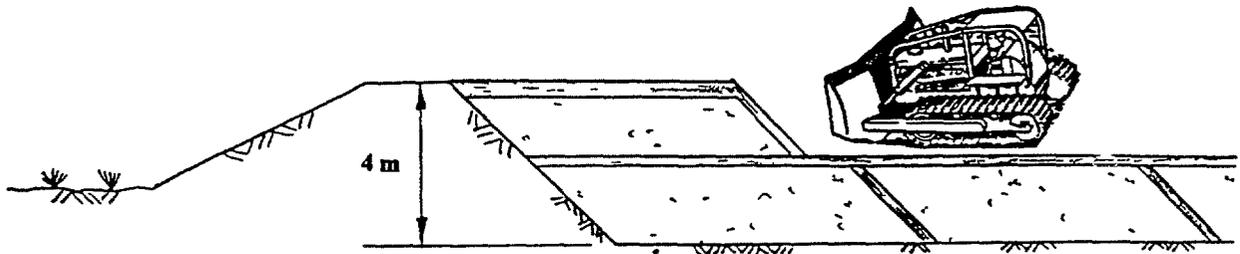
- a. ADD ADDITIONAL SOIL AND COMPACT AS NECESSARY
- b. CONSTRUCT ACCESS ROAD TO SUPPORT PLACEMENT OF LIFT 2

FIGURE 5.1  
**LIFT 1 CONSTRUCTION**



**STAGE 1**

- a. DUMP WASTE IN CLOSE PILES AT REAR OF ACTIVE LANDFILL AREA.
- b. PERMIT CONTROLLED RECYCLING OF MATERIALS
- c. PROHIBIT ANIMAL FEEDING
- d. EXTINGUISH ALL FIRES



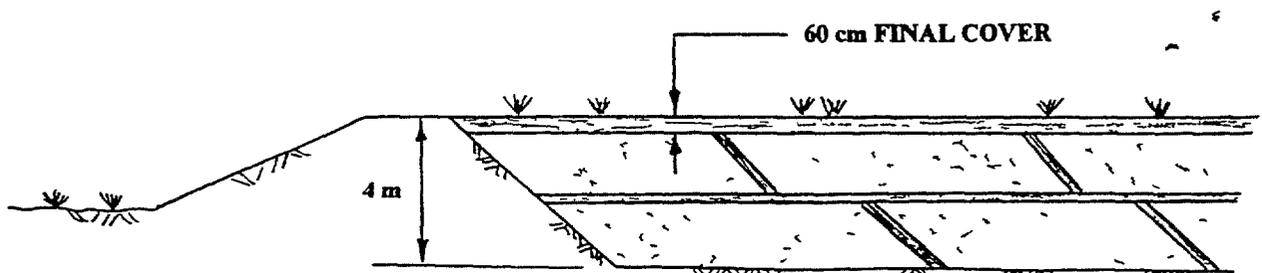
**STAGE 2**

- a. AT PERIODIC INTERVALS PUSH AND COMPACT WASTE INTO A CELL.
- b. EXCAVATE COVER SOIL FROM ADJACENT AREA.
- c. APPLY 60 cm OF FINAL COVER SOIL TO ALL WASTE SURFACES



**STAGE 3**

- a. REPEAT STAGE 1, DUMP WASTE IN CLOSE PILES



**COMPLETE LIFT 2**

- a. ADD ADDITIONAL FINAL COVER SOIL AND COMPACT AS NECESSARY
- b. PLANT SHALL ROOT PLANTS

**FIGURE 5.2**  
**LIFT 2 CONSTRUCTION**

sequence of accomplishing the mechanized operations in each lift in a landfill cell. During the mechanized equipment work at the landfill, the following procedures are recommended:

- Mechanized equipment work at the landfill will be coordinated with municipal equipment and/or contracted with a private contractor
- A bulldozer will be used to push the accumulated piles of solid waste into a uniform cell of waste
- The bulldozer will compact the solid waste with a minimum of 3 passes over the material after it has been spread
- Once the waste has been compacted, an intermediate cover layer of 30 cm of soil cover will be applied. All cover soil will be excavated on-site in future landfill areas adjacent to the active area

**5.2.7 Cover Application** - Due to the lack of resources and equipment, the project team is not recommending the application of daily cover during the initial operation of the landfill. The standard practice, as defined in the National Guidelines, is to provide three forms of waste cover, including daily, intermediate and final cover. Generally, the application of daily cover to solid wastes can:

- Reduce litter, odors, vectors and other nuisances
- Reduce infiltration of water and potential leachate generation
- Minimize fire danger
- Improve the aesthetics of the landfill, thereby improving public perception of the operation

Intermediate cover is normally applied as landfill lifts are completed, to provide improved storm water runoff, thereby reducing the amount of leachate produced. It is also intended to provide a working area for trucks to bring waste in the next lift of the landfill.

Final cover is used once a landfill has been filled to capacity. Generally, soils are used for final cover that will allow the growth of vegetation that will stabilize the final landfill surface. Final cover should be installed once individual areas within the landfill have reached capacity.

Due to a lack of resources and equipment, daily cover may not be feasible in the initial operation of the Oulad Teima landfill. It is recommended that intermediate cover be placed on an accumulated lift of material after there are sufficient waste piles from delivery vehicles to justify the use of mechanized equipment to spread and compact the waste. The initial period is recommended to be monthly. After spreading the waste piles, and forming a waste cell, 30 cm of intermediate soil cover will be placed over the waste and compacted.

This intermediate cover will serve the functions of both daily and intermediate cover as defined above.

Since only periodic cover will be applied, the landfill will experience some conditions that would otherwise be eliminated by daily cover. For example, increased vectors and litter may result from the waste material that remains exposed between cover placement. Procedures aimed at controlling vectors and other nuisances are presented in Section 5.2.10. An increased number of vectors, such as flies, should only be a problem at the

landfill site itself. Increased litter, however, may require a greater effort to keep the landfill site clean. The lack of daily cover may increase the potential for periodic fires. To the degree possible, fires should be put out as they occur because of the dangerous effects of exposure to smoke from solid waste fires.

As discussed in Section 3.7.2 - Leachate Generation, the Oulad Teima landfill site will generally experience more evapotranspiration than rainfall. This will help to keep the amount of leachate generated to a minimum. The periodic covering will allow more time for moisture in the waste to evaporate, further reducing the potential for leachate generation. However, irrespective of the amount of leachate generated, its effect should be minimal since the site is underlain with relatively impermeable silt and clay soils which should provide good attenuation treatment to any leachate that is produced.

Soil cover material may originate from a number of sources including

- Soil excavated from an adjacent area of the landfill
- Waste soil, demolition or construction waste which is brought to the landfill for disposal

During the first year of operation, it is estimated that the landfill will receive 750 m<sup>3</sup> of waste per month. At an assumed lift depth of 2 meters, 375 m<sup>2</sup> of waste surface will require covering. At a cover depth of 30 mm, the monthly volume of cover soil to be excavated and applied is approximately 110 m<sup>3</sup>.

**5.2.8 Compaction** - In initial operations, the project team is recommending limited compaction only at the time that accumulated waste piles are spread for cover application. In large landfills, specialized equipment is often used solely for the purpose of compaction. However, the project team does not believe that this is feasible for the Oulad Teima landfill. A basic level of compaction will be provided during periodic mechanized equipment operations through a minimum of 3 passes by a D4 bulldozer at the time waste piles are spread and formed into cells.

**5.2.9 Scavenging/Recycling** - Scavenging for recycle materials is common practice at most Moroccan waste sites. The removal of recycle materials, including paper, plastic, metal, glass, wood or reusable items is beneficial to landfill operation by reducing the amount of waste to be landfilled. Unfortunately, the removal of these items from the landfill exposes the scavengers to injury and disease. Long term programs should be initiated to encourage removal of these materials at the source of generation or during collection and eventually eliminate all scavenging at the landfill. Assuming that scavenging at the landfill will continue in the foreseeable future, landfill attendants will take all precautions to prevent harm to scavengers from haul vehicles, mechanized equipment operations and exposure to dangerous materials such as medical waste. The scavengers must cooperate with the landfill attendants so they will not interfere with necessary landfill operations.

**5.2.10 Nuisance Control** - The primary nuisance conditions associated with landfill operations are disease vectors, dust, blowing litter and odor. Procedures that will be used in controlling each are as follows:

**Disease Vectors** - Typical landfill vectors can include birds, rodents and insects. Through contact with waste materials placed in the landfill, these can all transmit disease. Vectors include birds, insects, and rodents, which are capable of carrying a pathogenic disease-causing bacteria, virus, fungus, or organism from one host to

another Experience has shown that daily soil cover (20 mm minimum) is the best means for achieving vector control (Typically, it is also the best means for controlling odor and blowing litter ) However, since daily cover will not be applied in the initial operation, the landfill attendant should monitor the general level of landfill vectors to determine if vector control techniques must be implemented As a result, vector control may become a factor in determining the frequency of mechanized equipment operations at the site or may ultimately lead to a conclusion that daily cover is required

- **Insects** - Based on our observations at the existing dumping area, we believe that insects will be the most problematic vector However, the location of the site should help to keep the vector problem isolated to the landfill Flies and mosquitoes are two types of insects that are of concern at landfills, because they both spread diseases and are nuisances Flies can spread many food-borne diseases by carrying bacteria from the waste materials to food Adult flies, eggs, and larvae, often arrive at a landfill in the solid waste There they continue to develop and/or reproduce since they are supplied with food, water, and shelter, as a result of the physical conditions of the solid waste

Mosquitoes breed in water or in very wet waste and can carry diseases from many sources to human beings Effective control includes eliminating areas where water is found and effective use of cover soil

- **Rodents** - Rodents can spread diseases such as rabies, rat bite fever, typhus and plague They can damage a landfill by burrowing through cover or even gnawing liner material, buildings, electrical wires and insulation Rodent populations can be introduced to a landfill by being brought to the site in waste loads or by migrating to the landfill from surrounding areas They will remain at the facility if there is available food, water and shelter Shelter areas for rodents can include structures, as well as salvage storage areas and the open spaces that can occur between bulky materials A rodent infestation can be identified by looking for droppings, evidence of gnawing, burrows, holes in buildings or berms, rodent runs, or by physically observing them in the landfill Normally, rodents are not visible during working hours as most of their activity takes place at night

**Dust** - Dust at landfill sites is normally caused by vehicular traffic At landfill sites where an appropriate source of water is present, water is often used to suppress dust along access roads and other areas where vehicular traffic is anticipated A truck or trailer mounted tank can be used to wet down roads to keep dust levels down

**Litter** - All windblown or dropped litter from waste delivery or waste piles in the landfill cells should be periodically collected and placed in the landfill cell Litter should be periodically collected by the permanent or temporary staff on a regular basis Since waste loads are to remain uncovered for extended periods, an effort should be made to collect litter at least weekly at the landfill and along the access road leading to it This is important for a number of reasons including

- The municipality is attempting to demonstrate that an effectively operated landfill is important in environmentally sound solid waste management

Uncontrolled litter defeats the purpose of this demonstration

- Staff attitudes concerning the environmental control aspects of the landfill will be enhanced by recognizing the importance of a clean site
- Uncontrolled litter can provide breeding areas for vectors away from the landfill cells

Depending on the number of trucks that go to the landfill and the time require to direct them, the landfill attendant should work toward controlling litter in the vicinity of the active dumping area. This will help to prevent the accumulation of material and reduce the amount that will have to be periodically collected by temporary staff

Litter control can be improved by planting trees or cactus around the landfill in the direction of the predominant wind

**6 2 11 Medical Waste** - At the present time medical waste is not separated from general waste. Staff at the landfill should receive training on recognizing medical waste and avoid any contact. Scavengers should be prohibited from recycling any medical waste item, including "IV" bottles which is now a common practice. The National Guidelines have devoted a separate volume to medical waste. This volume presents medical waste definitions, standards and an implementation strategy. If the strategy is implemented, the first component will be the separation of infectious medical waste into color coded or otherwise marked containers or bags, and separate collection systems. Depending on other disposal alternatives, the landfill should establish a separate disposal area for medical waste which should be covered daily. Future disposal options should include an incinerator at the hospital or landfill

**6 2 12 Animal Feeding** - Solid waste collected in Oulad Teima has a relatively high organic content consisting primarily of food waste and vegetable trimmings. Like most dumping areas in Morocco, the dumping site in Oulad Teima is used to feed a variety of animals including goats, sheep and cattle. Although this practice provides a free source of food for the animals, it also subjects them to harmful items in the waste including infectious diseases. These diseases can be passed onto the residents of the area through direct contact with the animals or through meat or milk from infected animals. Another common hazard with animal feeding is plastic bags which are often eaten by goats and sheep. In some instances, the plastic builds up in the animals stomach causing death

General animal feeding at the landfill should be prohibited. In addition to the above hazards, the animals will cause many problems in the general area which includes many unfenced vegetable farms

The ministry of agriculture collects food waste from the large wholesale market for use as animal feed. This food waste is not mixed with general domestic waste and potential feeding hazards are minimal. This practice is acceptable and should be expanded as an alternative to animal feeding at the new landfill

## SECTION 6 - MAINTENANCE

### 6.1 General

Effective operations can only be sustained if there is effective maintenance of the systems and structures required for operations. Maintenance procedures must include all equipment and structures whose function is important in the long term operation of the landfill. This will certainly include any mechanized equipment but will also include fixed landfill site structures such as the completed landfill areas, drainage ditches/berms and access roads.

There are two classifications of maintenance used in the care of the above structures and equipment. These include:

- **Repair Maintenance** - In this form of maintenance, equipment or structures are repaired when they breakdown or do not function as anticipated. In some cases, repair maintenance must occur immediately since an operating function cannot be accomplished without the completion of the repair. In some cases, the nature of the required repair can allow the repair to be deferred to a more convenient time. Some care, however, must be taken to assure that deferred maintenance does not lead to a more significant breakdowns that requires more time and money to fix.
- **Preventative Maintenance** - In this form of maintenance, work is done on the structures or equipment to try to keep breakdowns from occurring. In the case of mechanized equipment, preventative maintenance needs to be sufficient to assure that the equipment will be effective for the longest possible time.

Generally, manufacturers of mechanized equipment specify a minimum level of maintenance that, through their experience, will give the most effective use of the equipment over the longest time. At a minimum, such recommendations should be used as a basis for preventative maintenance work done on any specific item of mechanized equipment. Experience has shown that a lack of effective preventative maintenance often leads to an increased level of repairs and decrease life expectancy. This can have a major impact on the cost associated with operating mechanized equipment through increased repair costs and premature replacement of the equipment so as to maintain its function. It is important to note that effective preventative maintenance also includes the simple tasks of making inspections to verify that conditions exist for continued optimum performance. Effective daily operation of mechanized equipment, for example, normally begins with an inspection of the equipment and a check of operating fluids and other critical factors for the operation of the equipment. Regular preventative maintenance inspections can include mechanized equipment as well as fixed structures such as drainage diversion ditches and berms.

### 6.2 Maintenance Procedures

The project team recommends the following minimum maintenance requirements for the landfill:

**6.2.1 Access Road Maintenance** - The site access road must be maintained so that there is a minimum of disruption in getting waste to the landfill. If the landfill access road becomes difficult to use, waste will be deposited in other areas away from the landfill site that are perceived to be more convenient.

The level of maintenance required for the access road will be a function of the natural and man-made factors that can damage surface condition of the road. For example, traffic or wet weather may require periodic grading of the roadway using a bulldozer or grader. At a minimum, the project team recommends annual maintenance of any area where conditions could disrupt the travel of trucks to and from the landfill site. The landfill manager should review such locations to determine the actual frequency at which access road maintenance tasks must be performed. At a minimum, following tasks should be used in access road maintenance:

- Periodic grading using the bulldozer provided for the landfill cover operation. If required, this may be limited to those areas needing the greatest amount of work.
- Filling in any major holes that develop in the road. This may be done by mechanized equipment when on site, temporary staff when available or by the landfill attendant for those areas near the active landfill cell.
- Maintaining the function of storm water ditches and culverts to prevent excessive road flooding or deterioration. This may require periodically cleaning out the soil and solid waste materials that can accumulate.

The benefits that will be realized from effectively maintaining the landfill access road include:

- Easy access to the landfill will prevent waste deposit in other more convenient locations where there is greater potential for environmental and public harm.
- A well maintained access road will decrease the wear and tear on the vehicles that must travel to the landfill. As a result, vehicle maintenance cost will be decreased.

**6.2.2 Site Maintenance** - There are a number of maintenance tasks that should be regularly performed by landfill staff. At a minimum, these include the following:

- Monthly, inspect all drainage diversion ditches and berms to verify that water cannot flow into an active or completed waste cell.
- Weekly, collect all debris from areas outside of the landfill cells and place this material in the active disposal area. The landfill attendant should be instructed to keep the area near the landfill cells as clean as possible.
- Annually, clean out all drainage diversion ditches of any accumulated sediment to renew its drainage performance. The frequency of this work may increase if the accumulation of materials in the drainage diversion ditches warrants it.

**6.2.3 Site Clean-up** - At a minimum, general site cleanup should occur on a weekly basis. To the degree possible, the landfill's permanent staff should collect litter at the time that it occurs. This will diminish the amount of litter that will need to be collected weekly.

**6.2.4 Equipment Maintenance** - In latter phases of the landfill development and operation, dedicated equipment may become available. If landfill staff becomes responsible for that equipment, an effective maintenance program should be incorporated into the landfill's operating procedures. If new equipment becomes available, the maintenance procedures should, at a minimum, conform to the program recommended by the manufacturer of the equipment. Specific assignments should be made to assure that one individual is responsible for performing all daily and periodic tasks required in the preventative maintenance program.

The use of used equipment in the future does not diminish the need for effective maintenance. If anything, there is a greater need for effective maintenance in older equipment since parts are more apt to wear out faster. In some cases, used equipment is not accompanied with any documentation presenting the manufacturer's recommendation for maintenance procedures. However, information can usually be obtained from the manufacturer. At the very least, a program can be established based on similar equipment.

## SECTION 7 - HEALTH AND SAFETY

### 7.1 General

Landfill workers are exposed to many potentially dangerous materials and situations as they supervise and direct the disposal of waste. Landfill staff must be properly trained and equipped to safeguard themselves from the dangerous properties of the waste materials placed in the landfill. Universally, the most common basis for health and safety procedures is to minimize the contact between the waste and the people whose health could be affected by contact. This is particularly the case for dangerous materials such as medical or toxic wastes.

In Morocco, where environmental management is just evolving, all of the different forms of solid waste are apt to be received at the landfill. This reinforces the need for effective health and safety control at the landfill. Ultimately, laws and regulations may exist in Morocco, as in other countries, where particularly hazardous materials are separated from the normal waste stream and disposed of in a more appropriate manner than simply incorporating it into the waste going to the municipal landfill. However, in the near term future, the health and safety approach for the Oulad Teima landfill must assume that all forms of toxic solid waste are included in the solid waste received at the landfill. The landfill staff should be trained to identify the various types of solid waste that will be brought to the landfill so that they are cautious when working around particularly dangerous materials.

### 7.2 Health and Safety Plan

The health and safety of landfill staff and others (waste delivery vehicle drivers, equipment operators, scavengers) at the site can be affected by a number of factors, including

- Vehicular Operations
- Exposure to waste materials particularly dangerous materials such as medical and toxic waste, etc
- Exposure to air emissions from toxic wastes or fires at the landfill

The following are basic health and safety procedures that are recommended to be adopted at the landfill to control the risks associated with health and safety hazards

**7.2.1 Personnel Protective Clothing** - Personnel protective clothing should be provided to the landfill staff. At a minimum, this should include

- High visibility vests for working around mobile equipment,
- Leather work gloves,
- Rubber boots

Any temporary landfill staff who will come into contact with waste materials by collecting litter should be temporarily issued leather work gloves and rubber boots for the period of time that they work at the landfill.

The following work rules should apply to personal protective clothing

The landfill manager should be responsible for maintaining an inventory of personal protective clothing so that it is available for permanent and temporary landfill staff

Permanent or temporary staff required to handle any waste materials will be required to use leather work gloves and rubber boots when handling or working around waste materials. This will include landfill area operations as well as site litter clean-up.

The use of this personal protective clothing should be made a prerequisite for work at the landfill and all staff who are issued equipment should be responsible for its care while they have it. (Personal protective clothing will wear out in time. As a result, leather work gloves may have to be issued to the landfill full time staff every six months. Replacement rubber boots may need to be issued once a year. Temporary staff required to handle solid waste materials will be issued gloves and boots that will be collected and stored upon the completion of their work at the landfill.

All staff required to work around vehicles delivering waste to the landfill or around mechanized equipment involved in waste spreading, compaction and cover should be required to wear high visibility safety vests to aid in preventing vehicle/pedestrian accidents.

**7 2 2 Health Exposure Control** - Long term exposure to certain elements of the waste can be harmful to the health of operating personnel. As a result, landfill operations should be organized so that there is a minimum of exposure and contact to waste materials. Personnel who must work in proximity to the waste material placed in the landfill should be trained as to the particular hazards of certain types of waste. At a minimum this should include

- Exposure to various forms of medical waste
- Containers with liquids
- Possibility of harm and infection from sharp objects
- Long term danger from exposure to smoke from burning waste

To the degree possible, fires should be prevented at the landfill. Exposure to smoke from landfill fires can have a damaging affect to the staff exposed to it and to other people away from the landfill who are exposed to it. If a fire does occur, an attempt should be made to put the fire out using soil cover or water, if it is available. However, this attempt should only be made where there is no direct danger to the personnel attempting to put out the fire.

The overall principle of operations should be to prevent exposure and contact with solid waste placed in the landfill. Where contact cannot be avoided (site clean-up, etc ) personal protective clothing should be used.

**7 2 3 Equipment Safety** - The landfill manager should work to make sure that all site staff (permanent and temporary) are aware of the dangers associated with working around the equipment. The landfill manager should also be responsible for making sure that all equipment operators operate their equipment in a manner that does not endanger other people (landfill staff, scavengers, etc ) at the site.

## SECTION 8 - MONITORING

### 8 1 General

One of the keys to sustainable effective operations is performance monitoring. The following minimum monitoring program is recommended for the landfill.

### 8 2 Environmental Control

The landfill is intended to perform an important environmental function in the Municipality of Oulad Teima. The simple fact of getting the waste to the landfill accomplishes an important part of that function. However, the design and operation of the landfill must attempt to control the environmental effects of the material after it is placed in the landfill. Often, landfill environmental monitoring includes the placement and sampling of groundwater monitoring wells to determine that the landfill is not damaging groundwater. In addition, surface water accumulations are also tested to verify that surface water is not being contaminated through contact with waste materials.

### 8 3 Vector Monitoring

The use of periodic intermediate cover rather than daily cover may permit vectors such as insects and rodents to increase above acceptable levels. These vectors should be monitored daily to determine if preventive action is required. More frequent covering, especially during the wet season, may be necessary to control these vectors.

### 8 4 Operations/Performance Monitoring

The time for developing cells and performing mechanized equipment tasks will be a function of how much waste is actually received at the landfill. While the overall goal of solid waste management in Oulad Teima should be the delivery of as much waste as possible to the landfill, there are issues (costs of collection, etc.) that may keep waste from reaching the landfill.

Close monitoring of the pace of receipt will determine the pace at which certain activities are undertaken. For example, the frequency at which deposited piles of material are spread, compacted and covered will, more than likely, be based on how much waste needs to be covered. This can be determined by summarizing waste deliveries by the day, week, month and year. A yearly plot of waste deliveries (TPD) will identify trends in waste deliveries that will effect future operations.

### 8 5 Site Operations

Performance monitoring for tasks at the landfill is simply a conscious effort by the person responsible for the landfill to regularly visit the landfill and make sure that tasks are being performed in the manner required. It has been the project team's experience that close monitoring in the form of a daily visit to the landfill by the person responsible for its operation is important in assuring that reasonable conditions and performance are maintained.

## SECTION 9 - COST ESTIMATES

It has been recognized that there are minimal resources available to build and operate the new landfill in Oulad Teima. The following cost estimates assume minimal levels of effort to attain a reasonable level of operation. In addition to minimal costs, optional costs are presented in the event that additional resources are obtained.

**Emergency Actions** **10,000 dh**

**Close Existing Dump Site.**

1	1 Loader/Bulldozer @ 3,000 dh/day =	3,000 dh/day
2	3 Dump trucks @ 2,000 ea per day =	6,000 dh/day
3	10 Laborers @ 150 dh/day =	1,500 dh/day
	Subtotal =	10,500 dh/day

**TOTAL ESTIMATE @ 10 days** **105,000 dh**

**Minimal Landfill Capital Costs**

1	Access Road 1,000 meters @ 750 dh/m =	750,000 dh
2	Guard House =	10,000
3	Initial Excavation and Berm Construction	
	10 days @ 8,000 per day =	80,000
4	Tools, protective clothing, supplies =	2,000

**Subtotal Minimal Capital Costs** **842,000 dh**

**Recommended Optional Capital Costs**

1	Utilities, (telephone & electricity) =	40,000 dh
2	Office and toilet facilities =	20,000

**TOTAL LANDFILL CAPITAL COSTS** **902,000 dh**

**Operating Costs**

1	Staff 1 Site Supervisor @ 36,000 dh/yr =	36,000 dh/yr
	2 Laborers @ 24,000 dh/yr =	48,000 dh/yr
	Subtotal Staff	84,000 dh/yr

2 Mechanized Equipment (Private Contract)

	1 Bulldozer @ 3,000 dh/day =	3,000 dh/day
	1 dump truck @ 2,000 dh/day =	2,000 dh/day
	4 Part time Staff @ 150 dh/day =	600 dh/day
	Subtotal =	5,600 dh/day

Subtotal Equipment @ 24 days/yr 134,400 dh/yr

**TOTAL OPERATING BUDGET** **218,400 dh/yr**

## SECTION 10 - IMPLEMENTATION PLAN

### 10 1 General

The existing waste dumping site in Oulad Teima must be closed as soon as possible to end the continued contamination of the lower Sous River valley. This will require the construction and implementation of a new controlled landfill as soon as possible. The following implementation plan is recommended.

### 10 2 Emergency Actions

Prior to considering the new landfill site, several emergency actions are necessary to reduce the serious environmental threat to the Sous River Valley. They include the following:

- Immediately terminate dumping of waste in the active river channel
- Improve the previous access road to the north bank dumping area of the river
- Prepare and supervise a dumping area on the north bank of the river away from the active river channel
- Prohibit dumping of milk waste at the existing dump site

### 10 3 New Controlled Landfill

The following steps are necessary to begin construction and operation of the new controlled landfill:

#### Construction

- Obtain all permits and authorizations from governmental officials to secure the site and begin construction
- Complete the Environmental Impact Assessment
- Negotiate and execute an agreement between Oulad Teima and Guerdane for sharing capital and operating costs
- Prepare tender documents for the construction of the access road, guard house and initial excavation/berm construction
- Construct the landfill

#### Operation

- Train the landfill attendant as to the procedures required to operate the landfill
- Instruct all collection staff that they are to follow the direction of the landfill attendant in waste placement
- Find and secure the source of mechanized equipment to be used for periodic tasks at the landfill
- Hire or assign temporary staff for performance of temporary staff tasks as outlined in this report

## 10 4 Financial

The municipality of Oulad Teima has an existing budget item for 600,000 dh to construct a closure, or wall around the new proposed landfill. Given the remote nature of the landfill site this wall is not necessary. The wall will be of no benefit if there is no access road to the new landfill. It is recommended that this amount be used to build the access road and initial excavation. In addition to the existing 600,000 dh budget, initial discussions with Guerdane indicate that they will contribute an additional 100,000 dh for landfill construction. This will bring the total existing available funds to 700,000 dh. Unfortunately the estimate for minimal construction costs and closure of the existing dump site is 957,000, leaving an estimate 257,000 dh which must be obtained from other sources.

# APPENDIX A

## Waste Generation Database

MUNICIPALITY	OULAD TEIMA	GUERDANE
POPULATION (1998)	57 000	6 500
WASTE GENERATION (KG/CAP/DAY)	0.5	0.5
ANNUAL POPULATION INCREASE (%)	6.0%	2%
WASTE DENSITY LOOSE (KG/M)	350	350
WASTE DENSITY IN COMPACTORS (KG/M)	500	500
LANDFILL DENSITY (KG/M)	800	800
COVER SOIL (%)	10%	10%

YEAR	OULAD POP	OULAD WASTE GEN (TPD)	OULAD PERCENT COLLECT (%)	OULAD WASTE COLLECT (TPD)	GUERD POP	GUERD WASTE GEN (TPD)	GUERD PERCENT COLLECT (%)	GUERD WASTE COLLECT (TPD)	TOTAL WASTE COLLECT (TPD)	WASTE COLLECT (T/YR)	DAILY LANDFILL VOLUME (M/DAY)	ANNUAL LANDFILL VOLUME (M/YR)	ANNUAL COVER VOLUME (M/YR)	TOTAL LANDFILL VOLUME (M/YR)	CUMULATIVE LANDFILL VOLUME (M/YR)	LF AREA @4 METER DEPTH (METERS)	LANDFILL AREA (ha)		
1	1998	57 000	29	60%	17	6 500	3.3	80%	2.6	20	7 191	25	8 988	899	9 887	9 887	2 472	0.25	1 YR
2	1999	60 420	30	61%	18	6 630	3.3	81%	2.7	21	7 706	26	9 633	963	10 596	20 483	5 121	0.51	
3	2000	64 045	32	62%	20	6 763	3.4	82%	2.8	23	8 259	28	10 323	1 032	11 356	31 839	7 960	0.80	
4	2001	67 888	34	63%	21	6 898	3.4	83%	2.9	24	8 850	30	11 063	1 106	12 169	44 008	11 002	1.10	
5	2002	71 961	36	64%	23	7 036	3.5	84%	3.0	26	9 484	32	11 855	1 185	13 040	57 048	14 262	1.43	5 YR
6	2003	76 279	38	65%	25	7 177	3.6	85%	3.1	28	10 162	35	12 702	1 270	13 973	71 021	17 755	1.78	
7	2004	80 856	40	66%	27	7 320	3.7	86%	3.1	30	10 888	37	13 610	1 361	14 971	85 991	21 488	2.15	
8	2005	85 707	43	67%	29	7 466	3.7	87%	3.2	32	11 665	40	14 582	1 458	16 040	102 031	25 508	2.55	
9	2006	90 849	45	68%	31	7 618	3.8	88%	3.4	34	12 487	43	15 622	1 562	17 184	119 215	28 804	2.88	
10	2007	96 300	48	69%	33	7 768	3.9	89%	3.5	37	13 388	46	16 735	1 674	18 409	137 624	34 406	3.44	10 YR
11	2008	102 078	51	70%	36	7 923	4.0	90%	3.6	39	14 342	49	17 927	1 793	19 720	157 344	39 336	3.93	
12	2009	108 203	54	71%	38	8 082	4.0	91%	3.7	42	15 363	53	19 203	1 920	21 124	178 468	44 617	4.46	
13	2010	114 695	57	72%	41	8 244	4.1	92%	3.8	45	16 455	56	20 569	2 057	22 626	201 094	50 273	5.03	
14	2011	121 577	61	73%	44	8 408	4.2	93%	3.9	48	17 624	60	22 030	2 203	24 233	225 327	56 332	5.63	
15	2012	128 872	64	74%	48	8 577	4.3	94%	4.0	52	18 875	65	23 594	2 359	25 954	251 281	62 820	6.28	15 YR
16	2013	136 604	68	75%	51	8 748	4.4	95%	4.2	55	20 214	69	25 268	2 527	27 795	279 075	69 769	6.98	
17	2014	144 800	72	76%	55	8 923	4.5	96%	4.3	59	21 647	74	27 059	2 706	29 765	308 840	77 210	7.72	
18	2015	153 488	77	77%	59	9 102	4.6	97%	4.4	64	23 180	79	28 975	2 898	31 873	340 713	85 178	8.52	
19	2016	162 697	81	78%	63	9 284	4.6	98%	4.5	68	24 820	85	31 025	3 103	34 128	374 841	93 710	9.37	
20	2017	172 459	86	79%	68	9 469	4.7	99%	4.7	73	26 575	91	33 219	3 322	36 541	411 382	102 845	10.28	20 YR

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## APPENDIX B

### National Guidelines