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CHIANG MAI SOLID WASTE DISPOSAL ANALYSIS

Final Report

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The opinions expressed in this final report are of the contractor, Price Waterhouse, Administrator of the Energy Project Development Fund, and not of the Agency for International Development.

TABLE OF CONTENTS

Executive Summary				1
I.	Understanding of the Situation			2
	A.	Recent History		2
	B.	Current Situation		2
II.	Solid Waste Management: Options			4
	A.	The McGill Proposal		4
		1.	Disposal Location	4
		2.	Landfill Requirement	5
	B.	Incineration		5
	C.	Solid Waste Management Options Summary		7
III.	Recommendations and Conclusions			8
IV.	Appendix:	Financial Analysis, Tables and Assumptions		11

Executive Summary

Chiang Mai is currently facing a solid waste disposal crisis. Developing a complete waste disposal system has taken on increased urgency due to the fact that the city will host the South East Asian Games in December of 1995. Currently, Chiang Mai is developing and utilizing interim disposal sites, leased on a short-term basis to satisfy its disposal requirements. In addition to the collection and disposal of the refuse collected from the current city of Chiang Mai, the city is faced with planning for an expansion to about 200 square kilometers and a potential doubling of its population in the foreseeable future. In addition to being faced with a near term disposal problem which is expected to compound with growth, the city is not recovering any significant portion of their operating cost through fee collection. Current revenues average Baht 20 per unit per month and can only be collected from approximately 30% of the serviced population.

The city has taken various steps to deal with this situation. It recently privatized half of the city's waste collection services. In addition, the city is currently considering the implementation of a materials recovery facility, as well as various other options, in an effort to increase efficiency and reduce costs.

As a result, Price Waterhouse has been contracted by the U.S. Agency for International Development to analyze the current situation, and make recommendations for solid waste management in the future. Our analysis was constrained due to the unavailability of detailed budgetary information and other exact technical information. As a result, we have relied on the information and estimates as provided by the officials of the Municipality of Chiang Mai, as well as the Department of Environment al Engineering at Chiang Mai University. The unavailability of detailed information regarding the actual incineration units to be used and their final implementation methodology has severely hampered our cost estimates for the incineration portion of this study. In addition, we did not attempt to perform a quantitative analysis of the potential economic and health benefits resulting from the different solid waste management options.

The brief nature of our visit to Chiang Mai provided us with an understanding of the situation and a general framework for analyzing various options for the city. Our study should be used by the city of Chiang Mai as one of many pieces of information to consider while developing its own short and long-term solid waste management policy.

I. Understanding of the Situation

A. Recent History

The city's landfill has been closed after approximately 20 years of operation due to poor disposal practices, increased population surrounding the site, public opposition to the operation and an increase in land value. Studies indicate that the site was primarily operated as an open dump which generated large amounts of landfill leachate. Migration of the leachate offsite was tied to public opposition to continued operation of the facility. As in many landfills worldwide, the site initially operated outside the metropolitan area of Chiang Mai. Population growth and municipal expansion moved the "dump" into the public eye and created sufficient public opposition to close the facility.

Prior to closure of the original dump site, the Government of Thailand provided money for the construction of a 20 to 24 tonne per day incinerator as a pilot project to remedy some of the conditions at the original site. The incinerator never operated properly and has since been abandoned.

In addition to the incinerator, a pilot composting project was also established at the original landfill site. This project was intended to reduce the quantity of material going into the landfill, and as a result, extend its life. The poor quality of the resulting compost combined with a lack of readily available markets for the composted material doomed this project to early failure.

In terms of solid waste collection, such services for one-half of the city were privatized within the last year. A Baht 73,000,000 contract spanning five years was awarded. In addition to the Baht 73,000,000, the contractor was awarded 50% of the monthly collection fees in their sector, estimated to be worth an additional Baht 1,200,000 per year.

B. Current Situation

Chiang Mai currently faces a situation in which it is developing and utilizing interim disposal sites, leased on a short-term basis from private individuals or companies, to satisfy its disposal requirements for the approximately 200 to 240 tonnes per day of refuse it generates. The facility we visited appears to be a gravel operation which the owner is allowing the city to backfill. The current mine will be completely filled within the next few weeks and operations will move to a second open pit mining operation across the road. Despite the transient nature of this disposal methodology the actual operation itself is quite well organized with very little litter or smell and

cover material being applied promptly to the in place refuse.

In addition to the collection and disposal of the 200 to 240 tonnes of refuse collected from the existing population of approximately 163,000 people in the 40 square kilometer city, staff is faced with planning for an expansion to about 200 square kilometers and a potential doubling of its population in the foreseeable future.

Chiang Mai staff, in addition to being faced with a near term disposal problem which is expected to compound with growth, is not recovering any significant portion of their operating cost through fee collection. Current revenues average Baht 20 per unit per month and can only be collected from approximately 30% of the serviced population.

Coverage of operating costs is a serious near and long-term concern. Presently, staff is concerned with collecting fees from a higher percentage of the serviced population. The inability to collect fees for solid waste management programs is not an unusual problem in nations that are developing a high-quality, environmentally-sound, integrated solid waste management program. Residents are used to receiving public services and generally have the impression that the service is free or costs very little to perform. The "public perception" of the value of the solid waste management program speaks to the root of the majority of the problems identified in our visit to Chiang Mai. Although the staff is very knowledgeable regarding issues, alternatives and solutions, there has been little or no real effort made to educate the public on the importance of solid waste management strategies and their impact on the environment.

People are generally not willing to pay for something that they feel has little or no value to them. Past disposal practices have given the public little reason to trust staff recommendations regarding solid waste management disposal options. And, regardless of a resident's willingness to pay or not, their refuse continues to be collected. Clearly, an important task facing the municipality is the education of its population regarding solid waste management issues.

The municipality has not capitalized on the potential savings to be realized from privatizing its collection services. It is relatively clear that no firm numbers exist which readily substantiate the various costs of operating the solid waste collection portion of the Sanitary Engineering Department. As a result of privatizing half of the city, 42 collection laborers went to the private sector with a commensurate salary savings. However, no trucks have been eliminated from the system and our best information indicates that no collection drivers have gone to the private sector. There appears to be little in the way of audit procedures in place to allow the municipality to determine whether they will in fact save the estimated $2,000,000 anticipated over the five year contract life.

II. Solid Waste Management: Options

A. The McGill Proposal

Chiang Mai is seriously considering recycling and composting as strategies for managing present and future disposal tonnages. In an effort to reduce the current 200 to 240 tonnes per day going to the landfill, a contract Material Recovery Facility (MRF) has been proposed by McGill Environmental Systems. McGill has proposed a build, own and operate combination MRF and transfer station. Conceptually, all material collected would be transported to the McGill facility where it would be separated into recyclables, compostables and residual material. The residual material would be baled and landfilled, or incinerated, depending on the implementation of a new Thai national government incinerator project. The current proposal will pay McGill approximately Baht 190 per tonne for a minimum of 200 tonnes per day. McGill Environmental will also have the rights to market all compostable material and recyclable material recovered from the waste stream. It is our understanding that McGill has also agreed to deliver the baled residual material to the disposal site for this Baht 190 per tonne price (note: the final disposal site has not yet been identified). Chiang Mai is considering this proposal since it would offer the city the opportunity to avert the cost of building a long-term sanitary landfill and continue to utilize whatever site will ultimately be developed as a landfill site for the near-term. Additionally, the city hopes to save money on truck fleet operations by having such a transfer facility.

At this time, we cannot confidently determine whether there would be any future cost savings to the city from implementing this proposal until the following two issues are more fully developed:

1. Disposal Location

A vital issue to be considered before a determination can be made regarding potential savings from delivering solid waste to a transfer station/MRF versus direct haul to a landfill, relates to the final location of the disposal facility in relation to the transfer station. It is our understanding that there is still some question regarding the actual availability of the military base as a temporary disposal facility. In any event, this location is less than 34 kilometers from the transfer station/MRF. As a general rule, it has been determined that it is not economical to utilize a transfer station if haul distance is less than 34 kilometers one way. There are no documentable savings in terms of the cost of transfer over the cost of direct haul unless there are serious travel restrictions related to traffic or transportation infrastructure. To determine if there would be any actual savings in terms of transfer over direct haul, an exact location for a landfill should be determined and the cost of direct haul versus transfer could be compared based on actual capital

and operational scenarios.

2. Landfill Requirement

Under any scenario, a landfill must be included in Chiang Mai's overall solid waste management strategy. Reducing the tonnage from 240 tonnes per day to 60 tonnes per day because of the MRF will not significantly decrease the operating requirements in terms of personnel costs and equipment and supply costs. As a result, landfill costs on a per tonne basis will be much higher in the near term, with the only savings being the avoided cost of future landfill space. Even if the material being landfilled is just the residual from an incineration process, the operational requirements and capital investment will still see little reduction. The toxins from the incinerator ash will leach readily into the city's groundwater unless a proper containment process is designed into the disposal site. This type of containment may be more costly than managing regular refuse.

B. Incineration

In discussing the above MRF proposal, it is important to discuss incineration in detail as Chiang Mai municipal staff are faced with incineration as part of a national strategy. McGill's proposal to design, construct and operate an MRF facility could divert as much as 70% of all waste delivered to it. The diversion is expected to come from varying degrees of recycling and composting. At the average daily tonnages of approximately 200 tonnes per day, the City of Chiang Mai would expect approximately 60 tons per day of solid waste to be delivered to a site for either incineration and/or landfilling.

Any incineration scenario would be tied directly to the composition and moisture content of the waste, being delivered as residue, from the recycling-composting facility. Any organic waste holding moisture quantities above 30% would not be conducive to incineration without a costly preparation step added (i.e. drying/shredding). Readily combustible material such as wood products, plastics and contaminated recyclables could be directed for incineration. It is understood from interviews with Chiang Mai Solid Waste Management personnel that the 200 tonne per day average of solid waste generation may increase dramatically during the tourist season between October and March. Special attention should be paid to evaluating tonnages from month to month in order to generate an annual operating plan. It is also noted that dramatic increases in the amount of waste generated in Chiang Mai have occurred since 1986 according to the *Thailand Innovative Administration Consulting Institute-August 1990 Seminar*.

Additionally, consideration of potential annexation in areas contiguous to the City limits will also increase current estimates of tonnage. These increases will impact long term plans and evaluation

criteria based on transportation costs to facilities that will, to some degree, process solid waste, (i.e., incinerators, energy-from-waste facilities, composting facilities, recycling processing facilities, and landfills).

Tender documents bid this year by the Public Works Department at the Ministry of the Interior to design, construct and operate and maintain a 60 tonne per day incinerator within or near the City of Chiang Mai including ash/slag and fly-ash landfills on a site of approximately 27 rai, have produced a bid of 360 million baht. Limited interviews have indicated that fourteen companies bid this project, of which four were shortlisted as finalists. All finalists were Japanese companies. Subsequent to this bid phase, the Thai Government decided that the site would have to be at the slaughterhouse located within Chiang Mai. The slaughterhouse is smaller than the original area, which caused the four companies to re-bid the project. This has been described as a turnkey project which includes training of personnel and operation of the incinerator for two years. The program coincides with the national government mandate to incorporate incineration into solid waste disposal activities. As of this report there is no written policy for disposal. However, the Ministry of Science and Technology is generating a national code.

The following observations are made with reference to the outlook of incineration playing a significant role for Chiang Mai in the near future:

- Above average moisture content of the solid waste that would be handled by an incinerator system will be problematic and will need front-end modifications to treat the refuse and dry it to allow for adequate combust

- Highly skilled technicians will be needed to operate the incinerator(s) to maintain proper combustion levels and acceptable air quality standards. Improper operation of units will lead to premature failure of incinerators, above average residue to handle and dispose of, and air pollution, all which will cause significantly higher costs and community resentment

- Of all scenarios reviewed, incineration is most likely the most expensive and creates special problems with reference to ash landfilling

- Incineration is only a partial solution to Chiang Mai's solid waste situation since it does not deal with the fact that this waste stream has usable resources for energy production.

C. Solid Waste Management Options Summary

Even if the Thai Government were to cover all capital costs for the incinerator, it would still most likely be the most costly way for Chiang Mai to manage the residue from McGill's MRF facility. This is due to the high operating and maintenance expenses of the incinerator (Baht 21.9 million for the first two years based on 60 tonnes per day at Baht 500 per tonne). Additionally, when looking at the near term with the advent of the SEA Games in late 1995, the incinerator solution to processing residue does not provide any relief since it would require approximately 900 days for design, construction and testing.

For comparison purposes, mass burn-modular units designed, constructed and operated in the United States have capital costs between $70-120 per ton below 100 ton per day design capacity, with an average operational and maintenance costs above that proposed for Thailand at US$30-50 per ton (Baht 750-1,250). These units produce from 25-40% residue by weight and do, however, include cogenerating equipment that would offset some of the operations and capital costs (probably less than 50% of total costs). Designing and constructing an incinerator without cogeneration capability will eliminate any future consideration for producing steam for processing or electrical generation and will keep per ton costs over any other practical alternative. Also, as specified in the tender documents, the 60 tonne per day sizing of the incinerator will only be available to intake a maximum of 30% of Chiang Mai's present day average waste generation. For long term analysis of this incineration option, a complete review of bid recommendation documents would be needed. This should produce break out costs that will allow for better comparisons between incineration and direct landfilling.

In lieu of the immediate concerns for handling solid waste for the City of Chiang Mai, a concentrated effort should be made to analyze other efforts in solid waste reduction-disposal.

III. Recommendations and Conclusions

- Open Pit Mine

It is our recommendation that the open pit mine, which is less than 1/4 mile from the existing site, be properly prepared and used as a near term landfill. This pit is estimated to have sufficient air space to accommodate over 200,000 tonnes of refuse if it is filled to ground level (possibly a minimal crown above ground level for proper runoff of ground water), and if compaction levels meet expected operational requirements. A detailed survey of the open pit mine should be accomplished to get specific dimensions and a better estimate of life expectancy. This could serve as a benchmark in which to develop longer term solutions to handling solid waste properly. Immediate engineering design and construction of a lining and leachate collection system should begin for the new interim landfill.

- Compaction

All studies and discussion to this point have looked at the possibility of reducing the amount of material going to the landfill as a way to save airspace (defined as the volume, in cubic yards, of land used to dispose of a certain amount of refuse). The method used to decrease the amount of airspace required for a given amount of refuse involves increasing the in-place compaction of the refuse (the number of pounds per cubic yard of airspace). This approach can significantly increase the life of a given facility at a lower cost than the implementation of recycling, composting and incineration programs which will reduce the incoming volume. In-place compaction can be facilitated by compacting the refuse in a compacting collection vehicle or by compacting it when it has been off loaded at the fill site or both. The City should procure a landfill compactor sized for the open pit mine and develop operational criteria to achieve a compaction ratio of 1600 lbs per cubic yard.

Consideration should be given to converting to rear-loading compaction trucks. Five of these vehicles, collecting two loads a day, could collect 100 tons a day or the equivalent of the amount in the city controlled zones. Consideration should be given to purchasing spares at a rate consistent with current fleet management practices. Rear-loading compactors would reduce fleet requirements, personnel requirements and the number of trips required to landfill waste collected. It would also increase the compaction of the waste to approximately 750 lbs./cubic yard in the truck.

- McGill MRF

If the city decides to move forward with this proposal, Chiang Mai should negotiate to create operational standards that mandate a minimum of the proposed 70% reduction of the waste stream with monetary incentives for greater reduction (consequent penalties if 70% reduction is not reached). Because of the crisis situation that exists with landfill options, these negotiations should commence immediately.

- Incineration

Refuse in Chiang Mai may be too wet to incinerate without additional treatment. The possible environmental problems combined with the high cost make incineration a less attractive option.

- Increasing Profits

Fee collection can be tied to a municipal services bill which bills for all municipal services such as water, sewer, sanitation and electric on one bill. Non-payment of this bill allows for services to be terminated which will readily affect the household or business and cause the bill to be paid. It would also appear that hotels do not pay their fair share based on their waste production. A careful look at the fee structure in relation to hotel generation rates versus fees charged seems in order. The team was informed that municipal service is not extended to businesses. Businesses would be a good source of revenue, which could offset residential costs, and should be explored both as a business opportunity and as a control on their environmental impact.

It would seem that the municipality has not gained the maximum advantage from it's privatization initiative. Although sanitation workers went to the private sector as a result of the contracting of 1/2 the city no trucks or drivers appear to have left the system. Given the physical size of the city and even allowing for three to four collections per week there is room to reduce resources and as a result costs. A general rule should be that refuse should be out by a certain time in the morning and collection vehicles pass that point only once on any given day. At present collection vehicles continue to rerun their area until the close of their business day. This is costly and nonproductive.

- Public Education

A citizens advisory committee should be established to help educate the public regarding solid waste issues. The value of employing a public relations firm to provide a conduit to educate the public regarding solid waste issues, programs and facilities cannot be underestimated. Proper public relations are even more effective when they are coupled with the employment of a citizens

committee, empowered by the mayor, to work with staff in the development of solid waste policy. This committee should adequately represent all sectors of the population if it is to be effective. A citizens committee should be appointed to work with staff on solid waste issues relating to Chiang Mai.

IV. Appendix: Financial Analysis

A. Approach

It is apparent that several near-term options exist to increase Chiang Mai's existing landfill life. In addition, there are several long-term solutions to deal with the city's solid waste problem for the future. As a means to differentiate between the various options, we have performed a cost analysis of various combinations of collection and disposal scenarios. The cost analysis can be used by the city as one of many deciding factors to consider in their process of deciding which method or combination of methods should be used in solving the city's solid waste problem. Issues such as environmental benefits were not factored into our cost analysis.

We have developed six scenarios for Chiang Mai to consider in the development of their solid waste plans for the future. These six scenarios do not represent the only options available to the city. The results of our financial analysis can only be applied to the scenarios which we have explored herein.

B. Cost-Analysis Methodology and Results

Our approach to analyzing the costs were based on the following information: We projected operating costs based on historical operating figures as given to us by the city. We built capital cost projections based on prices and assumptions concerning capital goods as described in proposals to the city, as well as from comparable figures of such goods in the United States. Our results in terms of cost per tonne were based on projected amounts of garbage to be generated as given to us by the city.

The cost analysis is divided into two areas, collection and disposal costs. The collection costs are assumed to be the same for all of the proposed scenarios, and will be described below. The disposal costs are different for each scenario, and will be described below after each scenario is listed. For disposal costs, the costs include the landfill, and any other garbage reduction machinery. At the end of the disposal costs analysis, there are reductions to the disposal cost. These reductions come from the ability of any garbage reduction machinery employed to extend the life of the current landfill. This ability to extend landfill life allows the city to push off into the future its need to purchase a permanent landfill area. This 'avoided cost' is the benefit associated with buying the garbage reduction machinery, and is represented in our analysis by the cost savings portrayed by a present value of analysis of buying the permanent landfill at a later date, whenever the current landfill is full.

Collection Cost Methodology:

The average collection cost per tonne of US$20.89 equals the average of the public sector and the private sector collection costs. This is because of the fact that one-half of the city's garbage collection was recently privatized. The city pays the private contractor approximately US$17.32 per tonne of garbage collected. This figure represents the annual cost of the privatization contract, made up of a five-year, Baht 73 million agreement, as well as 50% of collection fees (approximately Baht 1.2 million annually). The other 50% of the garbage collection is done by the city itself, at a cost of approximately US$24.46. This calculation was based on the budget figures given to us by the city, in terms of employees, energy, trucks, equipment and supplies, and divided by the estimates given to us concerning garbage to be collected.

Disposal Cost Methodology:

Scenario 1: Disposal Cost: US$4.75/tonne.

Collect refuse and direct haul to a landfill. A new landfill will be required after 1 year. In place compaction assumed to be 800 lbs. per cubic yard.

This scenario represents the current state of operations in Chiang Mai today. The disposal costs involve the operation of the landfill, which include land rental costs. We have calculated the disposal costs of the current site to be US$4.75 from the data given to us by city officials. After this site is filled up, it is possible that the military demo site will be used as the next landfill. We have calculated this site to have a slightly higher disposal cost, US$6.85 per tonne, because of higher projected land purchase costs. We have chosen to use the current site to represent today's unit disposal costs for this scenario. This scenario predicts that the current landfill site will fill up with garbage by 1996, which would require the purchase of the permanent site at that time. Since this serves as the base case scenario, and employs no garbage reduction machinery, there is no avoided cost.

Scenario 2: Disposal Cost: US$11.97/tonne.

Collect refuse and implement the McGill MRF. A new landfill will be required after 3 years. In place compaction is assumed to be 800 lbs. per cubic yard.

The McGill Materials Recovery Facility proposes to separate the garbage at an interim facility, and to recycle and compost a portion of it, so as to reduce the resulting waste going to the landfill by 70%. The cost proposed by McGill to accomplish this is US$7.50/tonne. This would extend the life of the current landfill to 1998. This translates to an avoided cost of US$0.28/tonne on the $4.75/tonne current landfill.

Scenario 3: Disposal Cost: US$93.17/tonne.

Collect refuse and implement the McGill MRF. Utilize incinerator for the balance of the material not volume-reduced at the MRF. Landfill will be required after 5 years. In place compaction assumed to be 800 lbs. per cubic yard.

The Incinerator would be used to burn the 30% of garbage not treated by the McGill Materials Recovery Facility. There would be some ash created by the incinerator, which would need to be landfilled. The total cost provided to us of such an incinerator divided by garbage estimates comes to US$81.45/tonne. This would extend the life of the current landfill to 2000. This translates to an avoided cost of US$0.53/tonne on the $4.75/tonne current landfill.

Scenario 4: Disposal Cost: US$5.06/tonne.

Collect refuse and direct haul to landfill. Utilize a compactor to increase in-place compaction to 1600 lbs per cubic yard. New landfill required after approximately two years.

This scenario represents the current state of operations in Chiang Mai today, with the addition of implementing a compactor at the landfill site. To the current landfill disposal costs of US$4.75, we add the unit cost of the compactor of US $0.45. This compaction allows more garbage to be dumped into the landfill, extending its life an extra year to 1997. This translates to an avoided cost of US $0.15/tonne on the $4.75/tonne current landfill.

Scenario 5:

Same as scenario 2 except increase compaction to 1600 lbs per cubic yard. Landfill life approximately 6 years.

This scenario is the same as the incorporation of the McGill MRF, except that here we also assume the use of the US$0.45/tonne compactor at the landfill site. The combination of the MRF and the compactor would potentially extend the life of the current landfill to 2001, representing an avoided cost of US$0.64/tonne on the $4.75/tonne current landfill.

Scenario 6:

Same as scenario 3 except increase compaction to 1600 lbs per cubic yard. Landfill life is extended to approximately 10 years.

This scenario is the same as the incorporation of the McGill MRF plus incinerator, except that here we also assume the use of the US$0.45/tonne compactor at the landfill site. The combination of the MRF, incinerator and the compactor would potentially extend the life of the

current landfill to 2005, representing an avoided cost of US$1.00/tonne on the $4.75/tonne current landfill.

C. Assumptions and Data Used:

The following assumptions were made as a basis for our analysis:

- This will be a ten-year present value analysis, in real terms
- No interest expense is assumed, Exchange rate utilized is Baht 25 = US$1
- Current amount of refuse equals 200 tonnes per day (tpd) in 1994 increasing to 300 tpd by the end of 1995. A growth rate of 15% per year is assumed thereafter.
- If the 200 tpd is divided into categories we would assume the following distribution of tonnage by scenario:
  - scenario 1 and 4: 100% to a landfill
  - scenario 2 and 5: 30% to a landfill, 16% recycled, 54% would be composted.
  - scenario 3 and 6: 30% incinerated (10% residual ash taken to landfill), 16% recycled and 54% composted.

The following data was used as a guideline in developing our net cost numbers:

One of the most important factors in developing projections for landfill life is the level of compaction that should be attained by proper operational equipment and procedures. The table that follows develops landfill life based on consistent landfill size and refuse composition with variable compaction ratio. (source: Caterpiller Performance Handbook #24)

COMPACTION		LANDFILL LIFE	GAIN
590 KG/M3	1000 LB/YD3	9.6 YRS	0
710 KG/M3	1200 LB/YD3	11.5 YRS	1.9 YRS
830 KG/M3	1400 LB/YD3	13.4 YRS	3.8 YRS
950 KG/M3	1600 LB/YD3	15.3 YRS	5.7 YRS

Open Pit (Interim Landfill) Waste Capacity Calculations

Dimensions:	150 yds. X 150 yds. X 20 yds.
Capacity:	337,500 cubic yards (450,000 cubic yds. * .75 - compensation for side slopes)
Compaction:	1600 lbs. per cubic yard - proper Compactor needed to achieve this level.
Cover Material:	25% maximum volume for proper daily cover
Total Tons Capacity:	202,500 tons - (337,500 X 1600 X .75/2000)
Operational Life:	@ 65,000 tons per year - 3.11 years * @ 20,000 tons per year - 10.13 years

* 20,000 tons per year reflects an approximate 70% reduction in the waste stream if McGill proposal is accepted and produces as promised. It is important to note that certain specifications should be considered in designing the interim landfill. A clay or polyethylene liner for the bottom and slopes should be considered for leachate containment. A leachate collection system should also be considered for proper protection of the groundwater resource.

TABLE 1	**Scenario 1** (landfill)	**Scenario 2** (W/McGill)	**Scenario 3** (+ incinerator)
Collection Costs:			
Private Sector	$17.32	$17.32	$17.32
Public Sector	$24.46	$24.46	$24.46
Avg. Cost Per Ton	$20.89	$20.89	$20.89
Disposal Costs:			
MRF Costs (McGill):			
*Today's Cost Per Ton:	$00.00	$7.50	$7.50
Incinerator Costs:			
Annual Cap. Amort.\Tonne	$00.00	$00.00	$61.45
Operating Costs Per Tonne	$00.00	$00.00	$21.00
*Total\Tonne	$00.00	$00.00	$81.45
Landfill Disp. Costs:			
Current Cost\Tonne	$4.75	$4.75	$4.75
Military Demo Site:			
Cost Per Tonne:	$6.85	$6.85	$6.85
Date When Current Land-fill and Demo Landfill Will Be Full: (est.)	1996	1998	2000
Total PV (@8%) Land Cost For a 50 Rai Perm. Site 10 Year Annual Life:	$1,455,026	$1,247,451	$1,069,488
Annual PV Land Cost For 50 Rai Perm. Site Per Tonne:	$1.99	$1.77	$1.47
Avoided PV Unit Land Cost Compared to Scenario 1:	$0.00	($0.28)	($0.53)
Today's Effective Landfill *Disposal Unit Cost Per Ton:	$4.75	$4.47	$4.22
SOLID WASTE DISPOSAL UNIT COST PER TON:(*1,*2,*3)	$4.75	$11.97	$93.17

TABLE 2	**Scenario 4** (landfill)	**Scenario 5** (W/McGill)	**Scenario 6** (+ incinerator)
Collection Costs:			
Private Sector	$17.32	$17.32	$17.32
Public Sector	$24.46	$24.46	$24.46
Avg. Cost Per Tonne	$20.89	$20.89	$20.89
Disposal Costs:			
MRF Costs (McGill):			
*Today's Cost Per Tonne:	$00.00	$7.50	$7.50
Incinerator Costs:			
Annual Cap. Amort.\Tonne	$00.00	$00.00	$61.45
Operating Costs Per Tonne	$00.00	$00.00	$21.00
*Total\Tonne	$00.00	$00.00	$81.45
Landfill Disp. Costs:			
Current Cost\Tonne	$4.75	$4.75	$4.75
Compactor Cost Per Tonne:	$0.45	$0.45	$0.45
Total Cost Per Tonne:	$5.21	$5.21	$5.21
Military Demo Site Cost Per Tonne:	$6.85	$6.85	$6.85
Date When Current Landfill and Demo Landfill Will Be Full: (est.)	1997	2001	2005
Total PV (@8%) Land Cost For a 50 Rai Perm. Site 10 Year Annual Life:	$1,347,247	$990,267	$727,875
Annual PV Land Cost For 50 Rai Perm. Site Per Tonne:	$1.85	$1.36	$1.00
Avoided PV Unit Land Cost Compared to Scenario 1:	($0.15)	($0.64)	($1.00)
Today's Effective Landfill *Disposal Unit Cost Per Tonne:	$5.06	$4.57	$4.21
SOLID WASTE DISPOSAL UNIT COST PER TON:(*1,*2,*3)	$5.06	$12.07	$93.16