A GENERALIZED ECONOMIC MODEL FOR EVALUATING DISPOSAL COSTS AT A LOW LEVEL WASTE DISPOSAL FACILITY

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ABSTRACT

An economic model is developed which can be used to evaluate cash flows associated with the development, operations, closure, and long-term maintenance of a proposed Low-Level Radioactive Waste disposal facility and to determine the unit disposal charges and unit surcharges which might result. The model includes the effects of nominal interest rate (rate of return on investment, or cost of capital), inflation rate, waste volume growth rate, site capacity, duration of various phases of the facility history, and the cash flows associated with each phase. The model uses standard discounted cash flow techniques on an after-tax basis to determine that unit disposal charge which is necessary to cover all costs and expenses and to generate and adequate rate of return on investment. It separately considers cash flows associated with post-operational activities to determine the required unit surcharge. The model is applied to three reference facilities to determine the respective unit disposal charges and unit surcharges, with various values of parameters. The sensitivity of the model results are evaluated for the unit disposal charge.

INTRODUCTION

Because Congress has made it the responsibility of each State to arrange for the disposal of Low-Level Radioactive Waste (LLW) generated within its boundaries,[1] there is heightened interest in the question of economic viability. This increased interest results from concerns that the smaller facilities that are anticipated to be developed by interstate compacts of States may not generate sufficient revenues to recover development costs, pay operating expenses, provide for site closure and long-term maintenance, and produce an adequate rate of return on investment to the developers. Thus, there is concern that LLW generators in States and interstate compacts where little LLW is generated may be penalized economically to receive the same service rendered less expensively in areas where LLW is generated in abundance.

In this paper, a generalized economic model is presented which allows the evaluation of cash flows associated with proposed LLW disposal facilities. The model is applied to three reference facilities, the results presented, and generalizations made about the economic behavior of the facility relative to variations in independent parameters.

ECONOMIC MODEL

In general, a proposed financial commitment can be justified if the present value of the expected revenue cash flows equals or exceeds the present value of all costs and expenses associated with the proposal, including an adequate rate of return on the required investment. The present values noted above depend upon the required rate of return for the investment and upon the magnitude, nature, and timing of each component of the cash flows. For an investment in the private sector, the cash flows must be those which result after taxes are paid.

In order to properly determine the effect that each cash flow has on the economics of the proposed facility, it is necessary to consider the time value of money using conventional discounted cash flow techniques.[2] This technique is based upon the well-known relation:

$$F = P(1 + i)^n$$

where

- P = the present amount
- F = the future amount
- i = the periodic interest or discount rate
- n = the number of periods in the future over which the present amount is allowed to grow

When this relation is solved for the present value, $P = F/(1 + i)^n$, the discounting nature of the interest rate is apparent--that is, the future amount is reduced by the interest or discount rate.

The magnitude and timing of each cash flow, together with their tax treatments, determine the importance of each cash flow. An expense in the early stages of a project will be more important than an equal expense later in the project. A cash flow which is not reduced by tax effects will be more important than one which is.

With these facts in mind, a thorough development of the present values of the cash flows associated with a given facility will facilitate the economic evaluation of the proposed facility.

Cash Flows

The generalized cash flows for the development, operation, closure, and long-term maintenance of a dedicated SLF are depicted schematically in Fig. 1. The cash flows shown in the figure are:

E_j - Pre-Operating Expenses: Cash flows in the j^{th} year of the initial phases of the project which are tax-deductible as business expenses but not depreciable. The index, j, is referenced to the start of the development phase.

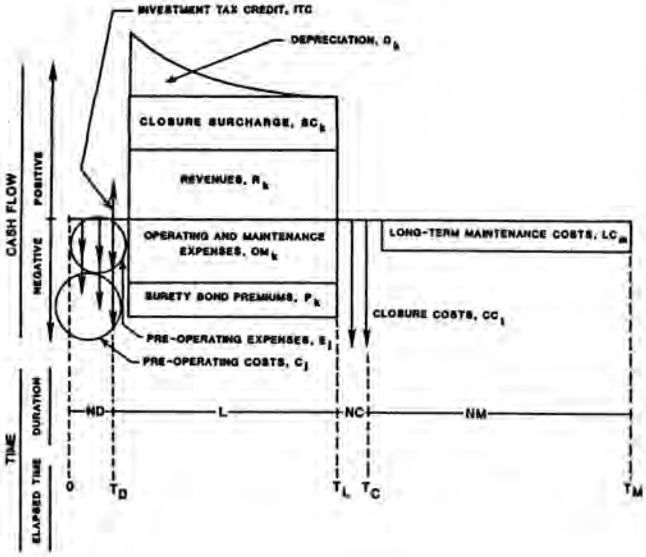

Fig. 1. Schematic representation of cash flows for typical LLW disposal facility.

C_j - Pre-Operating Costs: Cash flows in the j^{th} year of the initial phases of the project which are capitalized and thus depreciable but not tax deductible.

ITC - Investment Tax Credit: Credits which result from capital investment in the initial phases of the project. The ITC is assumed to be available in the year the facility is commissioned.

R_k - Operating Revenues: Taxable revenues generated by waste disposal operations. Assumed to be proportional to the annual volume of waste disposed. The index, k, is referenced to the beginning of operations.

OM_k - Operating and Maintenance Expenses: Tax-deductible expenses incurred during waste disposal operations. Assumed to be proportional to the annual volume of waste disposed.

D_k - Depreciation Expenses: Tax-deductible allowance for depreciation of capital investment. Governed by Internal Revenue Service regulations.

P_k - Surety Bond Premiums: Non-deductible costs incurred during operations for maintaining surety bonding sufficient to assure closure and long-term maintenance. Assumed to be constant over the life of the facility.

SC_k - Closure and Long-Term Maintenance Surcharge: Tax-exempt revenues placed in escrow to cover expected site closure and long-term maintenance costs. Assumed to be proportional to revenues from disposal operations.

CC_l - Closure Costs: Non-deductible costs associated with closing the site at the conclusion of disposal operations. The index, l, is referenced to the end of disposal operations.

MC_m - Long-Term Maintenance Costs: Non-deductible costs associated with long-term maintenance after site closure. The index, m, is referenced to the end of site closure activities.

The operating revenues in any year, k, can be expressed as the product of the annual volume disposed in that year, Q_k, (m^3/yr) and the unit disposal charge, r_k (\$/m^3). The annual volume disposed, Q_k, is assumed to grow at a constant annual rate, g, over the operating life of the facility.

In Fig. 1, the durations of the various project phases are denoted as:

ND - Years required for site and facility development (typically 3 years for LLW disposed facilities)

L - Operating life of the facility (typically 20 years)

NC - Years required for site closure (typically 3 years)

NM - Years required for site maintenance (typically 100 years)

There are two major aspects of the cash flows associated with a disposal facility. The first includes those cash flows which are influenced by tax effects. These cash flows are discounted at a rate of return required by the organization undertaking the facility development. The second includes those cash flows which are tax-exempt, namely all revenues and costs associated with site closure. These cash flows are discounted at a rate which reflects a very secure investment, typical of government securities.

In the model development that follows, it is assumed that the developing organization is sufficiently large that it can immediately utilize all tax benefits as they are generated. If the developing organization is a public body, the marginal tax rate will be zero and its cost of capital or discount rate will be lower than that for a private company. Costs, expenses and revenues, as well as the unit disposal charge and the unit closure surcharge, are expressed in current dollars.

In some cases where cash flows are constant over certain periods of time, it is possible to reduce some of the summations that follow to explicit and relatively simple algebraic expressions. However, in order to preserve the general nature of the model developed in the following sections, these simplifications have not been shown.

The unit disposal fees also vary according to the characteristics of the waste. This variability is readily accommodated in the generalized model, but for brevity, the unit disposal fee is represented in the following development as the average fee, weighted with respect to the waste volumes in each surcharge category. Thus, the effects of annual variations in the fraction of waste allocated to each surcharge category are not considered in the examples presented herein.

Pre-Operating Expenses, Costs, Depreciation Benefits, and Investment Tax Credits

The "costs" and "expenses" associated with the development of the facility are negative, or are leaving the developing organization. Expenses are immediately tax deductible and therefore reduce the tax burden in the year they are incurred. The tax burden is reduced by the product of the marginal tax rate, t, and the magnitude of the expense, E_j, where the index, j, is referenced to the beginning of the development phase. Thus, the after-tax cost of an expense E_j in year j to the organization is $(1-t)*E_j$. The effects of inflation can be included by stating the expenses in terms of current dollars and allowing them to be escalated by the factor $(1+f)^j$, where f is the (constant) annual inflation rate. The present value of this expense is expressed by the relation:

$$PV(E) = (1-t)*\sum_{j=1}^{ND}(E_j*((1+f)/(1+i))^j)$$

where ND is the duration of the development phase. The tax treatment of the costs incurred during the development phase is somewhat more involved. Costs, C_j, are not deductible in the year they are incurred, as are expenses. Instead they must be capitalized. The present values of these costs, allowing for inflation is stated by the expression:

$$PV(C) = \sum_{j=1}^{ND}(C_j*((1+f)/(1+i))^j)$$

Some of the costs (D_0) are depreciable and thus produce tax benefits to the organization in subsequent years. In these cases, the tax benefit to the organization in a given year, k, after operations begin, is the product of the marginal tax rate, the depreciable basis (D_0), and the amount of the depreciation allowance (d_k, specified by regulations of the Internal Revenue Service), or $t*D_0*d_k$. The present value of this positive cash flow is given as:

$$PV(D) = t*D_0/(1+i)^{ND}*\sum_{k=1}^{15}(d_k/(1+i)^k)$$

The investment tax credit is allowed on the aquisition of certain new equipment and is available at the commencement of operations. This credit is assumed to be 10 percent of the purchase price of the equipment (CI_j). In this model, the purchases are escalated by the inflation rate during the development phase, and the sum of the escalated components discounted over the entire development period. The reduction in tax obligation, a positive cash flow, is expressed as:

$$PV(ITC) = 0.1/(1+i)^{ND}*\sum_{j=1}^{ND}(CI_j/(1+f)^j)$$

Operating Revenues and Operating and Maintenance Expenses

The annual operating revenues (R_k) received by the organization are assumed to be proportional to the annual volume of waste disposed (Q_k), with k referenced to the beginning of operations. It is further assumed that the annual volume disposed grows from its initial value (Q_0) at a constant annual rate, g, and that the unit disposal charge, r_k, escalates with inflation, from its initial value of r_0. Thus, operating revenues received in any year, k, after operations begin, are expressed as:

$$R_k = r_0*Q_0*((1+g)*(1+f))^k$$

Growth scenarios other than a constant annual growth rate could be proposed and may very well be reasonable, depending on the characteristics of the region being served by the disposal facility. Such changes are not explored in this paper.

Because of corporate income tax obligations, the cash flow to the organization is $(1-t)*R_k$. Discounting these cash flows over the lifetime of the facility and over the development phase, the present value of operating revenues is given by:

$$PV(R) = r_0*Q_0*(1-t)*(((1+f)/(1+i))^{ND})*\sum_{k=1}^{L}(((1+g)*(1+f)/(1+i))^k)$$

where L is the operating life of the facility.

Operating and maintenance expenses during operations (OM_k) are assumed to be proportional to the annual volume disposed and to escalate with inflation from its initial value of OM_0. The tax obligation of the organization is reduced by the factor of $t*OM_k$, so that the present value of the cash flow from the organization is stated mathematically as:

$$PV(OM) = (1-t)*(((1+f)/(1+i))^{ND})*\sum_{k=1}^{L}(OM_0*(((1+g)*(1+f)/(1+i))^k))$$

Cash Flows Associated With Facility Closure and Long-Term Maintenance

All cash flows associated with facility closure and long-term maintenance are taken to be tax exempt because the revenues (in the form of closure and maintenance surcharges on disposed waste) do not benefit the organization as normal income and because the revenues are assumed to be placed in an independently-administered escrow account. Since the revenues are not taxable, the associated costs (surety bond premiums, closure costs, and maintenance costs) are not deductible. Further differences are that these cash flows are discounted at a rate, e, which is much lower than required rates of return on investment, i, of private corporations, and which is characteristic of very secure financial instruments, such as government securities. Still, the development of the model is unaffected insofar as the discount rate is concerned.

Revenues resulting from surcharges to the waste disposed are assumed to be a fraction, s, of the revenues from operations. Thus, the present value of the revenues from surcharges is expressed as:

$$PV(SC) = s*r_0*Q_0*(((1+f)/(1+e))^{ND})*\sum_{k=1}^{L}(((1+g)*(1+f)/(1+e))^k)$$

The present value of the cost of surety bond premiums, P, is assumed to be constant over the life of the facility and is represented by:

$$PV(P) = P*(1/(1+e)^{ND})*\sum_{k=1}^{L}(1/(1+e)^k)$$

Closure costs, CC, are assumed to be constant for the duration of the closure phase, NC years. Their present value is given as:

$$PV(CC) = CC*(1/(1+e)^{(ND+L)})*\sum_{l=1}^{NC}(1/(1+e)^l)$$

where L is the operating life of the facility, the index, l, is referenced to the conclusion of operations, and NC is the duration of closure activities.

Finally, maintenance costs, MC, are assumed to be constant for the duration of the long-term maintenance phase. Their present value is given as:

$$PV(MC) = MC*(1/(1+e)^{(ND+L+NC)})*\sum_{m=1}^{NM}(1/(1+e)^{m})$$

where m is referenced to the end of closure activities and NM is the duration of the maintenance period.

Unit Disposal Charge

Frequently in an economic analysis, all cash flows are evaluated to determine the rate of return the project will generate. In this case, however, the magnitude of the revenues is unknown, since the unit disposal charge has not been determined. It is a simple change of emphasis to specify the required rate of return on investment and to determine the resulting unit disposal charge necessary to produce that rate. Thus, the expression for revenues is expanded as derived above and the resulting equation solved for r_o, the unit disposal charge.

As noted earlier, the test of economic viability is whether the present value of cash flows received by an organization equals or exceeds the present value of cash flows leaving the organization. On the basis of the expressions described above, an equation for this condition can be derived and solved for the unit disposal charge, r_o. By including the expression for PV(R), which contains the desired unit disposal charge, we obtain:

$$r_o = (PV(E)+PV(C)+PV(OM)-PV(D)-PV(ITC))/$$

$$(Q_o*(1-t)*(((1+f)/(1+i))^{ND})*\sum_{k=1}^{L}(((1+g)*(1+f)/(1+i))^{k}))$$

This relation defines the unit disposal charge which will produce sufficient revenues to the organization to satisfy all claims, meet all operating expenses and costs, pay corporate income taxes on the income from the operations, and generate a satisfactory rate of return on the investment. Upon inspection, this relation behaves as one intuitively expects it to do, i.e., as pre-operational costs and expenses and operating and maintenance costs increase, the unit disposal charge increases. Also, as the depreciation allowances and investment tax credit increase, the unit disposal charge is reduced. The effects of the parameters of rate of return, inflation, and growth rate of the volume disposed are not clear but are investigated later in the paper.

Unit Closure Surcharge

The total disposal cost to a waste generator consists of the sum of the unit disposal charge and the unit closure surcharge to cover the cost of site closure and post-closure maintenance. The present value of surcharges must equal the present value of costs for which the surcharges are imposed. This yields:

$$s*r_o*Q_o*(((1+f)/(1+e))^{ND})*\sum_{k=1}^{L}(((1+g)*(1+f)/(1+e))^{k})$$

$$= PV(P) + PV(CC) + PV(MC)$$

The expression PV(P), which contains the desired unit closure surcharge, s, has been utilized in obtaining this expression.

Having solved for the unit surcharge, s, and multiplied by the unit closure disposal charge, r_o, the initial unit surcharge, SC_o, is described by the relation:

$$SC_o = r_o*s = (PV(P) + PV(CC) + PV(MC))/$$

$$(Q_o*(((1+f)/(1+e))^{ND})*\sum_{k=1}^{L}(((1+g)*(1+f)/(1+e))^{k}))$$

This expression is useful in determining the necessary magnitude of the unit surcharge in order to cover all costs associated with disposal site closure and maintenance. It behaves as expected in that the magnitude of the surcharge increases as the costs associated with closure and maintenance increase. Again, the effects of the discount rate, inflation, and waste volume growth rate are not clear.

APPLICATION OF THE MODEL TO REFERENCE LLW FACILITIES

Because of the many degrees of freedom in the model resulting from the numerous parameters that must be defined, the application of the model for the purposes of this presentation has been constrained to three base cases and a particular set of parameter values. We examined LLW disposal sites of capacities 100,000, 300,000, and 1,000,000 m^3. The costs and expenses associated with these facilities are presented in Table I[3]. The values of other parameters that are independent of site capacity are as follows. The rate of return was allowed to be 15, 20, 25, or 30 percent per year. The inflation rate was allowed to be 0, 5, 10, or 15 percent per year and the waste volume growth rate took on values of 0, 5, or 10 percent per year.

In cases where the growth rate is other than the value specified in the base case (Table I), it is necessary to modify both the initial operating and maintenance expenses and the initial waste disposal rate in order to retain the same total site capacity. The changes necessary are detailed in Table II.

The results of analyses using the economic model developed in the previous section are portrayed graphically in Figs. 2 through 5. In Fig. 2 the unit disposal charge is presented as a function of the nominal interest rate or the rate of return on investment, with the site capacity as a parameter and for inflation and the waste growth rates equal to 5 percent per year. From this figure it is apparent that the smaller the capacity of the site, the greater the unit disposal charge. The disposal charge for the base case nominal interest rate of 20 percent per year ranges from about \$7.20 to about \$36.80 per cubic foot as site capacity varies from 1,000,000 to 100,000 m^3. This result is consistent with findings of other studies.[2,3,4]

TABLE I

Base Case Costs and Parameters used in Evaluating Reference Facilities

Cost Component	Site Capacity (m^3) 100,000	300,000	1,000,000
Development Phase ($000)			
Tax Deductible Costs			
Year 1	2,100	2,300	3,200
Year 2	2,000	2,300	3,100
Year 3	1,200	1,400	1,900
Non Deductible Costs			
Year 1	500	600	1,000
Year 2	400	500	800
Year 3	2,000	2,400	4,000
Depreciable Basis	2,000	2,300	3,600
Operating Phase ($000/yr)			
Tax Deductible Costs	2,280	2,700	4,940
Operating & Maintenance Expenses			
Non Deductible Costs			
Surety Premiums	400	600	1,200
Post Operating Phase ($000/yr)			
Closure Costs (over 3 years)	700	800	900
Maintenance Costs (over 100 years)	100*	170*	390*
Rate of Return (% per year)	20	20	20
Escrow Account Interest Rate (% per year)	2	2	2
Volume Growth Rate (% per year)	5	5	5
Inflation Rate (% per year)	5	5	5
Marginal Tax Rate (%)	46	46	46
Development Phase (years)	3	3	3
Operating Phase (years)	20	20	20
Post-Operating Phase			
Closure (years)	3	3	3
Long Term Maintenance (years)	100	100	100

* Levelized using discount rate of 2% per year.

It is also interesting to note from Fig. 2 that the smaller the capacity of the site is, the more sensitive the unit disposal charge is to variations in the nominal interest rate. Whereas the unit disposal charge ranges from $6.40 to $9.30 per cubic foot at the 1,000,000 m^3 site, it varies from $31.90 to $49.70 per cubic foot at the 100,000 m^3 site as the nominal interest rate ranges from 15 to 30 percent per year.

In Fig. 3 the unit disposal charge is displayed as a function of the inflation rate with site capacity as a parameter for the cases where the nominal interest rate equals 20 percent per year and the waste volume growth rate is 5 percent per year. Here, the unit disposal charge declines as the inflation rate increases. This is according to intuition and experience, since the model assumes that the revenues grow at the same rate. Hence, the initial costs and expenses are recovered from a progressively greater margin between operating costs and operating revenues. At the small site, the unit disposal charge ranges between $43.90 and $28.10 per cubic foot as the inflation rate varies between 0 and 15 percent per year. At the intermediate site this variation is between $17.00 and $11.00 per cubic foot, while at the large site, $8.30 to $5.80 per cubic foot. As seen in Fig. 2 and the values presented above, the unit disposal charge is higher for sites of smaller capacity.

The results presented in Fig. 4 illustrate the strong sensitivity in the unit disposal charge to

TABLE II

Initial Disposal Volume and Operating and Maintenance Expenses for Various Growth Rates

Initial Annual Waste Disposal Rate (000 m^3)	Annual Waste Volume Growth Rate (% per year) 0	5	10
Site Capacity			
100,000 m^3	5	2.88	1.59
300,000 m^3	15	8.64	4.76
1,000,000 m^3	50	28.8	15.9
Initial Operating and Maintenance Expense ($000)			
Site Capacity			
100,000 m^3	3,950	2,280	1,250
300,000 m^3	4,680	2,700	1,490
1,000,000 m^3	8,580	4,940	2,720

variations in the nominal interest rate for the intermediate capacity (300,000 m^3) site with the waste growth rate equal 5 percent per year. In the figure, the inflation rate is shown as a parameter. Without inflation, the disposal charge ranges from $14.50 to $23.00 per cubic foot as the nominal interest rate varies from 15 to 30 percent per year, while the same variation is $10.10 to $13.90 for an inflation rate of 15 percent per year. Thus, for a given site, the sensitivity to nominal interest rate is greater with lower inflation rates.

In Fig. 5 the unit disposal charge is presented as a function of nominal interest rate with the waste growth rate as a parameter for the intermediate

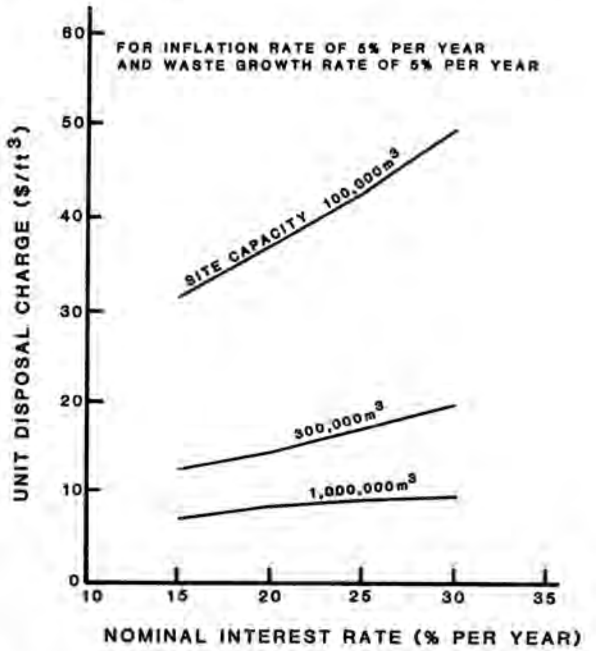

Fig. 2. Unit disposal charge as a function of nominal interest rate with site capacity as a parameter.

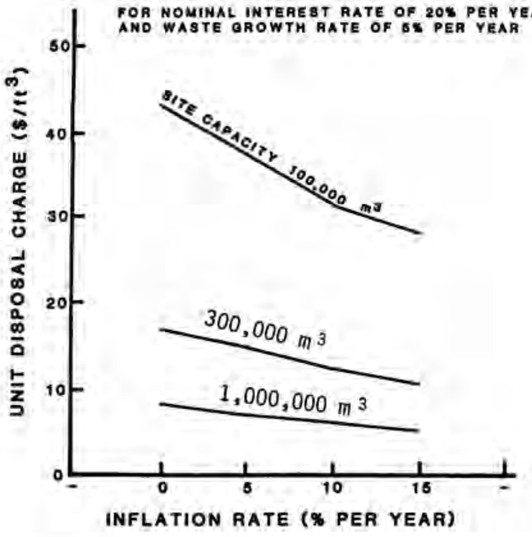

Fig. 3. Unit disposal charge as a function of inflation rate with site capacity as a parameter.

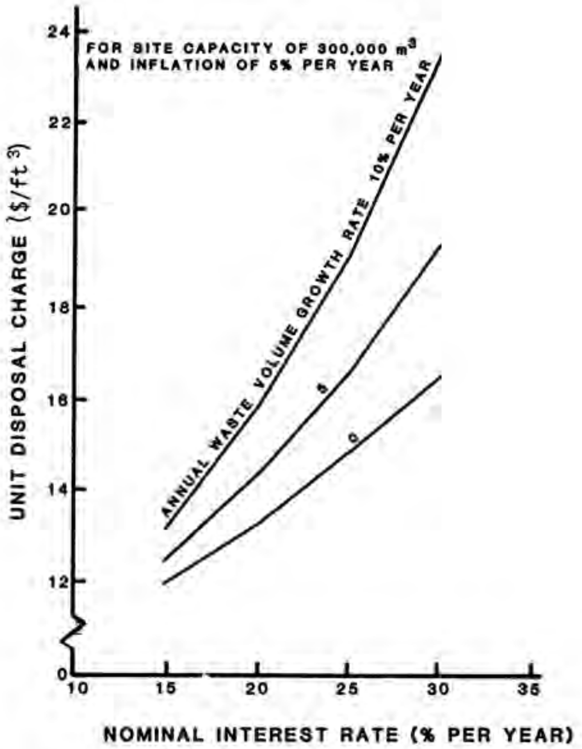

Fig. 5. Unit disposal charge as a function of nominal interest rate with waste volume growth rate as a parameter.

capacity site and an inflation rate of 5 percent per year. With a zero waste growth rate, the unit disposal charge ranges from $12.00 to $16.60 per cubic foot as the nominal interest rate varies from 15 to 30 percent per year. However, with a waste growth rate of 10 percent per year, the same variation is from $13.20 to $23.30 per cubic foot. Thus, for a given site, the sensitivity to changes in the nominal interest rate is greater for higher waste growth rates.

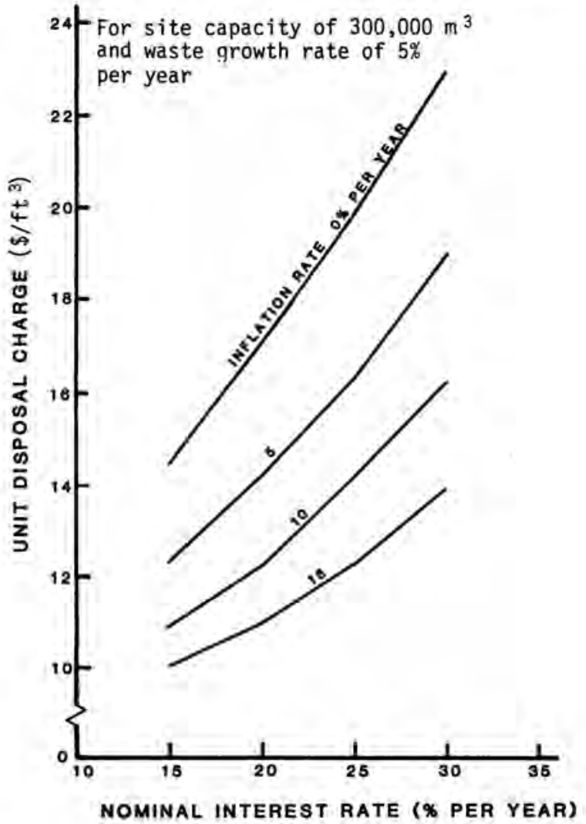

Fig. 4. Unit disposal charge as a function of nominal interest rate with inflation rate as a parameter.

The results of these investigations are shown in the perspective of results from other studies[3,5,6,7] in Fig. 6. In most cases, there are a variety of conditions which make direct and thorough comparison of results impossible. Nevertheless, it is instructive to observe that the results are comparable. While most of these results are produced by economic models similar to that described in this paper, there is ample room for discussion of what the magnitudes of the cash flows should be for a particular facility. This discussion is, of course, beyond the scope of this paper.

The model presented herein is, however, fully capable to identify those cash flows which are of greatest significance in determining the unit disposal charge and the unit closure surcharge. In fact, previous work[3] with this model has shown that the operating and maintenance costs comprise about 70 percent of the unit disposal charge, when considered in present value terms on an after-tax basis. Pre-operational costs and expenses contribute about 30 percent of the unit disposal charge. Obviously, the effects of depreciation and the investment tax credit have *much smaller* influences.

On the basis of the assumptions made regarding the constant surety bond premiums, these premiums are responsible for about 60 percent, the long-term maintenance costs for about 30 percent, and the closure costs for about 10 percent of the unit closure surcharge, in terms of present values, given the 2 percent per year discount rate. If a more refined model for the surety bond premiums were used, this distribution would change, but the impact on the total cost to generators will be small, as described below.

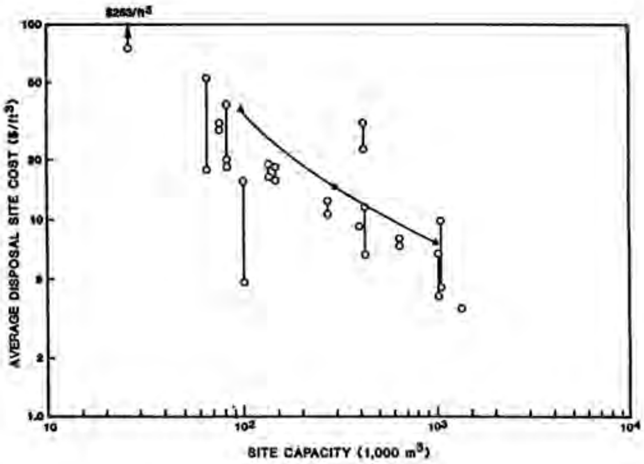

Fig. 6. Disposal site costs (1984 $) as a function of site capacity.

The variations of the unit closure surcharge are less interesting because their magnitudes are much smaller. For the one extreme of the small disposal site, the range of unit closure surcharge is from \$0.22 to \$2.53 per cubic foot, depending on the valuesof parameters used. These unit closure surcharges are but 0.8 and 6.2 percent of their respective unit disposal charges and in no case did the unit closure surcharge exceed 6.7 percent of the respective unit disposal charge for the small site.

However, as the site capacity increases, the relative significance of the unit closure surcharge increases. At the large site, the most significant unit surcharge was 14.4 percent of its respective unit disposal charge. In this case, the unit closure surcharge ranged from \$0.11 to \$1.25 per cubic foot. Thus, even though the relative magnitude of the unit closure surcharge appears to justify greater interest, its absolute magnitude leaves one wanting in motivation.

SUMMARY

In this paper, a generalized economic model was developed to assist in the economic evaluation of proposed LLW disposal facilities. The model was applied in evaluations of generic or reference facilities with the following observations:

- Unit disposal charges range from \$25.70 to \$75.10 per cubic foot for disposal at the small (100,000 m^3) facility, from \$10.30 to \$29.50 per cubic foot for disposal at the intermediate (300,000 m^3) facility, and from \$5.40 to \$13.40 per cubic foot for disposal at the large (1,000,000 m^3) facility, depending on the nominal interest rate, the inflation rate and the waste growth rate assumed.

- The smaller the capacity of the site, the greater the unit disposal charge.

- The smaller the capacity of the site is, the more sensitive the unit disposal charge is to variations in the nominal interest rate.

- The unit disposal charge declines as the inflation rate increases.

- The sensitivity to nominal interest rate is greater with lower inflation rates.

- The sensitivity to changes in the nominal interest rate is greater for higher waste growth rates.

- Operating and maintenance costs comprise about 70 percent of the unit disposal charge, when considered in present value terms on an after-tax basis.

- Variations of the unit closure surcharge are less interesting because their magnitudes are much smaller.

- Unit closure surcharges ranged from \$0.22 to \$2.53 per cubic foot for disposal at the small (100,000 m^3) facility, from \$0.18 to \$2.09 per cubic foot for disposal at the intermediate (300,000 m^3) facility, and from \$0.22 to \$1.25 per cubic foot for disposal at the large (1,000,000 m^3) facility, depending on the inflation rate and the waste growth rate assumed.

- Surety bond premiums are responsible for about 60 percent, the long-term maintenance costs about 30 percent, and the closure costs about 10 percent of the unit closure surcharge, in terms of present values.

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