DRAFT
ANALYSIS OF ALTERNATIVE LANDFILL TECHNOLOGIES

“SITE 21” REGIONAL LANDFILL

WILLISTON, VERMONT

Prepared for

Chittenden Solid Waste District

January 21, 2005

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1 INTRODUCTION

EMCON/OWT, Inc. (EMCON) is pleased to provide the Chittenden Solid Waste District (CSWD) with this report on our analysis of alternative landfill technologies for the proposed "Site 21" regional landfill in Williston, Vermont. This work was completed in accordance with our October 21, 2004 proposal. This report presents the results of our review of landfill technologies as they may be applied to the site, the conceptual development models selected for cost model preparation, and the cost models prepared.

Section 2 of this report presents our evaluation of different landfill technologies for incorporation into the Site 21 landfill's development. The relative costs and benefits of the different landfill technologies were presented to CSWD and collectively CSWD and EMCON selected certain technologies for incorporation into 2 alternative conceptual development models. Section 3 provides a summary of the conceptual development models selected for further evaluation. The conceptual development models (Base Model, Model 1 and Model 2) were then evaluated for their relative financial merits by modeling each development model's costs and revenues. Section 4 presents the cost model that was developed and a summary of the modeling results.

2 ALTERNATIVE TECHNOLOGY REVIEW (TASK 1)

In the process of developing the conceptual plans, EMCON considered the impact of design and operational alternatives that could optimize the landfill disposal capacity and minimize the unit of capacity cost for the facility. The individual alternative technologies were each compared to the conceptual Base Model plan provided to us by CSWD, in order to determine the relative increase to site volume for each alternative. The alternatives were not assembled into conceptual development models until the relative benefits and costs of each were discussed with CSWD. Collectively, CSWD and EMCON assembled selected alternative technologies into conceptual development models as discussed in Section 3. The results of our evaluation of the alternative technologies are included in Appendix A. Each alternative is also discussed briefly in this section of the report. Table 2-1 summarizes the cost evaluation for each alternative.

The existing Current Base Model is based on the following criteria:

- Top of base liner grades were taken from O'Leary-Burke Civil Associates, PLC drawings.
- O'Leary-Burke base grades were based on base grades from Weston, which includes a plan to depress the natural water table at the north end of the site.
- Final grades were also taken from O'Leary-Burke drawings.
- Current base model volume was calculated using contours taken from O'Leary-Burke drawings for base and final grades and landfill footprint using Autodesk Land Development Desktop for AutoCAD.
- Air space volume for the current base model was calculated by subtracting the final cover volume from the landfill volume. The volume of the final cover was calculated by multiplying the three foot depth of final cover by the surface area of the final cover for the current base model, which includes slopes.
- Waste capacity volume for the current base model was calculated by subtracting 20% of the air space volume to allow for daily and intermediate cover.
- No volume adjustment was made for access and drainage.

2.1 Perimeter Walls

Perimeter walls create air-space by raising the height of the landfill at the perimeter and subsequently allowing for a height increase over a larger portion of the landfill. Perimeter walls provide increased air-space where footprint expansions are not possible because of the proximity of property lines or other exclusionary zones. Perimeters walls can either be in the form of near vertical, reinforced earth walls on the exterior side of the landfill, or sloping berms extending 20 to 30 feet above existing grade. Reinforced earth or mechanically stabilized earth walls are proven and accepted technology by the civil engineering, construction, and landfill industry. Based upon our discussion with the Vermont Agency for Natural Resources (ANR) perimeter walls are approveable with the appropriate stability and design documentation.

The "Site 21" Base Model has a typical ten foot berm. The alternative conceptual development models provided for a 10 and 20-foot perimeter wall to increase available air-space. The detailed design for this site may yield a variable wall height, especially along the north perimeter where the toe of slope is actually excavated into the existing ground surface. The following criteria were used in developing the perimeter wall volumes:

- Final grades for a 10 or 20 foot perimeter walls are similar to the grades for the current base model, except contours are 10 and 20 feet higher, respectively.
- Perimeter Wall alternative additional volumes were calculated by multiplying the area of the current base model footprint by the height of each wall, and subtracting the volume of a 3:1 interior slope from the product. This additional volume was then added the calculated volume for the current base model.
- Air space volumes for the perimeter wall alternatives were calculated by subtracting the volume of final cover from the landfill volume calculated. The final cover volume was calculated in the same manner for each alternative as the final cover volume in the current base model.
- Waste capacity volume for the perimeter wall alternatives were calculated by subtracting 20% of the air space volume to allow for daily and intermediate cover for both alternatives.
- Perimeter walls design is based upon stability, which has not been performed yet. Outsides of the wall are vertical. The interior wall is sloped at 3:1. The price of the wall is estimated (preliminarily) at $20.00 per cubic yard. Wall dimensions were estimated as 50 feet wide by the height of the wall by the perimeter of the landfill footprint.

2.2 Slope Optimization

Maximizing the slope of finished landfill grades further optimizes landfill disposal capacity. Regulatory maximums are typically on the order of 3H:1V (33 percent). However, from a technical perspective, steeper slopes can be supported. Slope optimization also considers minimizing slope interruption for terraces or drainage channels again in order to maximize landfill volume. Even the plateau created at the top of the landfill can be optimized through the creation of steeper slopes draining to multiple discrete storm water channels. Modifying plateau grading in this way can add tens of thousands of cubic yards of air-space capacity without increasing the overall landfill height while at the same time minimizing the potential for long-term settlement maintenance at the landfill.

In discussions with the ANR, they provided a general position that the final landfill side slope should be at 3H:1V or less. However during operations, the outside slope could be steeper to accommodate settlement, as long as a significant amount of waste cutting was not required to achieve the allowable final grades. For this reason, the maximum final slopes were kept at 3H:1V final grade. The addition of drainage swales to the outside of the final slope was acceptable to ANR.

The "Site 21" Base Model's top area was relatively flat and could be extended upwards to a higher elevation, while maintaining a 3H:1V side slope. The maximum height with a 3H:1V slope was 100 feet higher at the center of the landfill as compared with the Base Model. One of the alternative conceptual development models included additional airspace from extending the sideslopes, but none included maximum extension of the sideslopes due to concerns over the potential visual impacts associated with such an increase in height.

The criteria used for evaluating Slope Optimization to enhance landfill volume are as follows:

- Landfill base grades for the slope optimized alternative were taken from O'Leary-Burke and are the same as the grades used for the current base model.
- Landfill final grades for the slope optimized alternative are the same as the current base model, which has a maximum elevation of 590, but are extended up from elevation 580 at a 3H:1V slope until an elevation 690 was achieved. Corners in the contours were rounded off at a radius of no less than 50 feet.
- The slope optimization volume was calculated using Autodesk Land Development Desktop for AutoCAD.
- Air space volume for the slope optimized alternative was calculated by subtracting the volume of final cover from the landfill volume. The final cover volume was calculated by multiplying the three foot depth of final cover by the surface area of the final cover for the slope optimized alternative.
- Waste capacity volume for the slope optimized alternative was calculated by subtracting 20% of the air space volume to allow for daily and intermediate cover.
- Addition to the surface area associated with increase of the final cover for the top areas of the landfill were reflected as an additional cost of 5% of the base model's final closure cost.

2.3 Geosynthetics

For the past 20 years, geosynthetics have demonstrated the ability to reduce the cost of landfill development, replacing the need for natural materials in areas where natural materials are not readily available. Further, judicious application of geosynthetics will not only replace natural materials, but in many cases can result in a reduction in the thickness of baseliner and cover systems. Often, an increase in air-space can be obtained equivalent to the reduction in liner thickness.

EMCON examined several geosynthetic options for both the base liner and the final cover systems. As a result of this alternatives analysis and the meeting with ANR, geosynthetics will be used as part of the base liner design and the final cover design.

The criteria for the geosynthetics alternatives are a follows:

- Base grades for the geosynthetics alternative were calculated as 4.5 feet lower than the grades for the current base model.
- Final grades are exactly the same as the current base model; however the thickness of the landfill cap was reduced by 1 foot.
- The geosynthetics alternative volume was calculated by multiplying the area of the footprint of the landfill by 4.5 feet and adding the product to the calculated volume of the current base model. In addition the final cover volume removed to calculate the air space was 1 foot less in thickness than the final cover volumes of the other alternatives.
- Air spaced volume for the geosynthetics alternative was calculated by subtracting the volume of final cover from the landfill volume calculated by Land Development Desktop.
- Waste capacity volume for the geosynthetics alternative was calculated by subtracting 20% of the air space volume to allow for daily and intermediate cover.
- The geosynthetics option was considered to have no significant change in the cost due to offsetting of the material costs.

The details of these alternatives are shown in Figures 2-1 and 2-2.

Based upon the alternatives evaluation, CSWD selected the following base liner profile (top to bottom):

- 6-inch gravel protective layer
- 12-inch sand drainage layer
- A geocomposite drain for scenarios with leachate recirculation
- A 60 mil textured HDPE primary geomembrane liner
- 12-inch sand drainage layer
- A 60 mil textured HDPE secondary geomembrane liner
- 24-inch low permeability clay liner with a minimum permeability of 1×10^{-7} cm/sec.

Based upon the alternatives evaluation, CSWD selected the following final cover profile (top to bottom):

- 6-inch topsoil layer
- 12-inch low permeability soil layer
- a high capacity geocomposite drain consisting of two non-woven geotextiles fuse bonded to an HDPE geonet,
- a 40 mil texture polyethylene geomembrane
- a geosynthetic clay liner(GCL) meeting the design shear strength specifications
- 6-inch gas venting layer

These landfill liner and final cover configurations are detailed in Figure 2-3.

2.4 Alternative Materials

Alternative construction materials can, if available at no additional cost, represent significant cost savings during landfill construction. Materials such as recycled glass and tire chips can be used effectively within the landfill cell construction to offset the need for natural soils in applications such as the leachate collection system blanket drain.

For the “Site 21” conceptual development models, the utilization of alternative construction materials was not selected. The use of alternative materials may be considered again during final facility design.

2.5 Lower Base Grades

Depending upon groundwater and bedrock considerations, lowering the base grades by digging deeper may be an option to create additional air-space. Although this often represents an additional “up front” cost, the cost to excavate soil is typically less than the construction of new baseliner. If excavation can be staged throughout the life of the landfill facility, then the excavation can satisfy the on-going soil needs of the facility. At “Site 21”, the soil availability may be further impacted by the requirement to provide the Redmond sands to HS&G.

The Site 21 hydrogeology is characterized by two groundwater zones. The upper zone is found within the glacial till layer and the overlying sand layer and has an unconfined groundwater table. The lower zone is found in the bedrock below the glacial till and glaciolacustrine clay and would be considered a confined bedrock groundwater aquifer.

The water pressure level of the confined aquifer is called the piezometric surface. This is typically measured as the water level in a groundwater well screened in the bedrock.

Based on our evaluation of the this alternative, the "Site 21" alternative conceptual development models assume the base grades will be made as deep as possible while keeping the top of the base liner system at least 25 feet above the bedrock piezometric surface. This includes a constructed groundwater control system to maintain the upper (glacial till) water table at least 6 feet lower than the bottom of the base liner. ANR indicated that groundwater controls for the upper water table were acceptable if the 6 foot separation criterion was met between the controlled groundwater table and the bottom of the base liner.

ANR indicated that a groundwater control system for the bedrock aquifer would not likely be approved; however, there is no technical limitation that prevents excavation below the bedrock piezometric surface. For instance, at RW-2 there is 100 feet of soil above the bedrock that fits into this category. This may be further explored at a later date.

The alternative conceptual development model base grades also assume a groundwater control system that can freely drain the upper water table by gravity. The distance from the bedrock piezometric surface to the top of the base liner will be 25 feet. This includes:

- Base grades for this alternative were made as deep as possible while keeping the top of the base liner system at least 25 feet above the bedrock aquifer piezometric surface.
- Final grades for this alternative are exactly the same as the current base model.
- The site' additional volume was calculated using Autodesk Land Development Desktop for AutoCAD to determine the net difference between the current base model base grades and the lower base grades. The net difference was then added to the current base model's volume
- Air space volume for this alternative was calculated by subtracting the volume of final cover from the landfill volume. The final cover volume was calculated by multiplying the three foot depth of final cover by the surface area of the final cover.
- a minimum of 10 feet above the bedrock aquifer piezometric surface to the groundwater drain, which may be reduced at a later date,
- a one foot groundwater drain,
- a 6 foot separation distance between the drain and the bottom of the liner,
- a 4.5 foot of liner thickness,
- 3.5 feet was added to account for possible changes to the bedrock piezometric surface since the 1991 data.
- Additional cost for this alternative was calculated by multiplying the net volume difference between the current base model's base grades and the lower base

grades by an estimate of $4.00 per cubic yard. The $4.00 per cubic yard estimate was taken from a construction costs guide.

The base liner grade was brought up rapidly in the middle of the site due to boring refusal at RFW – 44. This may not be bedrock and deeper excavation would then be possible towards the south end of the site. We recommend that the geology around RFW - 44 be more thoroughly evaluated as part of the final facility design. Conceptually, an up-gradient groundwater cutoff drain is proposed. This drain may not be needed depending upon the permeability of site soils. The cost for an up-gradient cutoff drain is generally included in the estimate with the entire sub drain system. The actual design will be determined as part of the final site design.

2.6 Site Geometry

With the layout of potential landfill areas, site geometry plays a critical role in the optimization of waste disposal capacity. Clearly, the more regular the landfill space, the more air-space that is created. Therefore we look to avoid irregularly shaped areas and acute angles. Although these are often viable landfill areas, the air-space comes at a premium with a higher than average unit of capacity cost. These irregularly shaped areas of the site, therefore, are better used for ancillary facilities such as storm water basins, and other structures necessary to support landfill operations.

The criteria used in developing the Site Geometry alternative are as follows:

- The site geometry plan was made by extending the eastern side of the landfill footprint as far to the east as possible while still keeping appropriate landfill shape and separation from the eastern property line.
- Base and final grades were made by extending the current base model grades to the east.
- The site geometry alternative volume was calculated using Autodesk Land Development Desktop for AutoCAD.
- Air space volume for the site geometry alternative was calculated by subtracting the volume of final cover from the landfill volume. The final cover volume was calculated by multiplying the three foot depth of final cover by the surface area of the final cover for the site geometry alternative.
- Waste capacity volume for the site geometry alternative was calculated by subtracting 20% of the air space volume to allow for daily and intermediate cover.
- Additional cost for the site geometry alternative was determined by calculating the cost per square foot for site development, base liner surface area, and final cover surface area of the current base model to the alternative model. Total additional cost was calculated by summing the products from multiplying the cost per square foot of site development, base liner surface area, and final cover surface area, by the change from the current base model in landfill footprint area, base liner surface area, and final cover surface area respectively.

In evaluating the site geometry alternative, the “Site 21” landfill limits were extended to the eastern side of the landfill footprint as far to the east as possible while still keeping appropriate landfill shape and separation from the eastern property line. CSWD has decided to reserve this area for future landfill facilities, such as a storm water sedimentation pond and scale house, therefore site geometry will not be optimized as one of the site alternatives.

2.7 Biostabilization

Implementation of biostabilization in operational landfills (Bioreactor or “Moisture Optimized" landfills) has been demonstrated to increase landfill waste density and as a result maximize the quantity of waste that can be disposed in a given landfill cell. As waste decomposes, its volume diminishes allowing the landfill to settle and create additional air space. By increasing the rate of organic waste decomposition, the settlement volume is gained during the operational life of the landfill rather than after the landfill is full, closed, and inactive; thereby extending the active life of the landfill. Also, landfill gas generation is enhanced during anaerobic biostabilization. Biostabilization involves recirculation of leachate (and/or addition of other liquids) to the waste to optimize bio-degradation. Although not specifically a design element, biostabilization should be considered at the outset of any landfill planning activity to assure landfill stability and proper baseliner drainage requirements are provided.

Bioreactor landfills and leachate recirculation have been demonstrated to be an effective landfill technology to increase the rate of waste decomposition (thereby accelerating waste settlement and landfill gas production) in recent years. Leachate recirculation has been effectively conducted in northern climates by Waste Management, Inc. landfills in Minnesota and Quebec and Onyx (Superior) landfills in Wisconsin. A significant amount of current and promising research is occurring in Canada. The Canadians are not only interested in the rapid stabilization of the waste material, but also the enhanced gas recovery and leachate treatment benefits. New York State Department of Environmental Conservation, one of the leading state agencies with respect to support of solid waste research, has published its favorable position for bioreactor technology.

Challenges exist with respect to leachate recirculation during winter months. Colder ambient temperatures, colder raw waste temperatures, and the cooling of leachate after collection all contribute to a lowering of operational temperatures and a slowing of waste decomposition. With respect to Site-21, operations in Canada and New York are similar to the cold conditions found in Vermont. As such, CSWD can benefit from the experience gained from observing biostabilization in these cold climate locations.

The need to manage leachate will always be present, and the methods to recirculate leachate back into the landfill may be no more difficult than connecting a pipe to a tank truck in cold weather. The bottom line is that the appropriate infrastructure for leachate recirculation must be in place for this type of operation to be effective. The typical cold weather leachate handling techniques required to prevent freezing include burial of leachate piping and the inclusion of heat trace for above ground piping. Further, to the extent possible, leachate should be handled in a way that minimizes the extent to which it is cooled between collection and recirculation.

Leachate recirculation will provide an opportunity to manage a significant portion of leachate generated at the site. However, even with this benefit, contingencies for the potential off-site disposal of leachate must also be in place.

For the Site 21 conceptual site biostabilization plan, the same base grade and final grade contours as the current base model were used, but it assumes an increase of 15% of the waste volume by settlement of the in place waste due to the accelerated decomposition of the putrescible waste. Waste capacity volume for the biostabilization alternative was calculated by subtracting 20% of the air space volume to allow for daily and intermediate cover. Additional cost from biostabilization will come from the piping required to recirculate leachate into the landfill and operations of the system.

2.8 Waste Processing

Processing incoming waste could help extend the landfill life. Most likely, this would take the simplest form of bypassing residential MSW directly to the landfill and processing construction and demolition (C&D) materials to separate wood and inert materials such as soil, concrete, wall board, and carpeting. The wood can be crushed and ground, or chipped and then either composted, used for mulch or erosion control cover, or even daily cover on the landfill. The inert material can be crushed and used for daily cover. This could reduce the 20% cover soil usage and add the equivalent saved capacity to the landfill volume.

The waste processing technology alternative uses the same base grade and final grade contours as the base model. However, due to the fact that waste processing provides waste materials as daily cover, it would not require that 20% of the landfill volume be used by daily and intermediate cover. The waste capacity volume for the waste processing alternative was calculated by subtracting 10% of the air space volume to allow for intermediate cover. Additional cost for the waste processing alternative was considered to be zero for landfill construction, as it is an operational alternative. The cost for processing demolition material was assumed to be offset by the daily cover soil purchase savings. Waste processing was not incorporated into the conceptual development models because of CSWD's other recycling efforts and because of potential odor impacts associated with utilizing C&D fines for cover.

2.9 Alternative Daily Covers (ADCs)

Use of these materials minimizes the fraction of landfill air-space that is occupied by soil and therefore maximizes the airspace available to waste disposal. As with biostabilization, this is not a design issue but does contribute to overall life expectancy considerations as well as potentially reducing operational costs.

The criteria for the Alternative Daily Cover alternatives are a follows:

- Alternative daily cover uses the same base grade and final grade contours as the current base model.
- Due to the fact that alternative daily cover uses other methods to cover waste, it does not require 20% of the landfill volume to be used by daily cover. The waste capacity volume for the alternative daily cover alternative was calculated by subtracting 10% of the air space volume to allow for intermediate cover.
- Additional cost for the alternative daily cover alternative was considered to be zero for landfill construction, as it is an operational alternative.
- The cost for purchasing alternative daily covers was assumed to be offset by daily cover soil purchase savings.
-

The use of ADCs was incorporated into the conceptual development models.

TABLE 2-1

CHITTENDEN SOLID WASTE DISTRICT
LANDFILL SITE 21

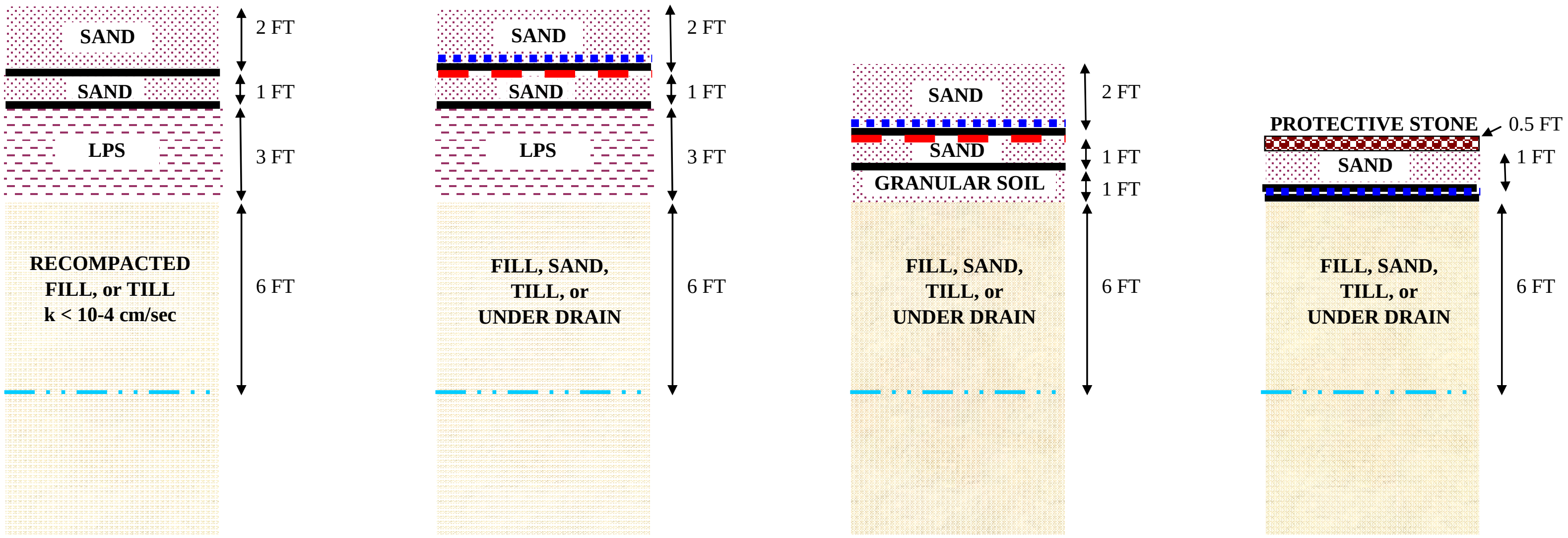
Alternatives Cost and Volume Matrix

Model Alternative	Air Space Volume (yd^3)	Waste Capacity (yd^3)	ΔWaste Capacity (yd^3)	Footprint Area (ft^2)	Final Cover Area (ft^2)	Additional Cost	ΔCapacity Value	Net Cost Benefit	Cost to Develop (\$/yd^3)
Current Base Model	6,131,729	4,905,383	0	2,302,316	2,376,568	$0	$0	$0	N/A
1.Perimeter Walls (10 foot)	6,851,793	5,481,434	576,051	2,302,316	2,376,568	$2,210,759	$27,524,199	$25,313,440	$3.84
2. Perimeter Walls (20 foot)	7,538,695	6,030,956	1,125,573	2,302,316	2,376,568	$4,421,519	$53,780,816	$49,359,298	$3.93
3. Slope Optimization	7,326,028	5,860,823	955,439	2,302,316	2,413,906	$590,650	$45,651,687	$45,061,037	$0.62
4. Site Geometry	6,869,137	5,495,310	589,927	2,581,347	2,662,135	$5,177,021	$28,187,181	$23,010,160	$8.78
5. Biostabilization	6,131,729	5,641,191	735,807	2,302,316	2,376,568	$103,612	$35,157,489	$35,053,877	$0.14
6. Geosynthetics	6,603,469	5,282,775	377,392	2,302,316	2,376,568	$0	$18,032,113	$18,032,113	$0.00
7. Alternative Daily Cover	6,131,729	5,518,556	613,173	2,302,316	2,376,568	$0	$29,297,908	$29,297,908	$0.00
8. Waste Processing	6,131,729	5,518,556	613,173	2,302,316	2,376,568	$0	$29,297,908	$29,297,908	$0.00
9. Lower Base Grades	7,278,429	5,822,743	917,360	2,302,316	2,376,568	$4,586,800	$43,832,219	$39,245,419	$5.00
10. Maximum Build Out *	10,352,818	8,282,254	3,376,871	2,302,316	2,413,906	$9,598,969	$161,349,696	$151,750,727	$2.84

* Combines Alternatives 2, 3, 6, and 9.

Figure 2-1

CHITTENDEN SOLID WASTE DISTRICT
LANDFILL SITE 21 BASE LINER ALTERNATIVES

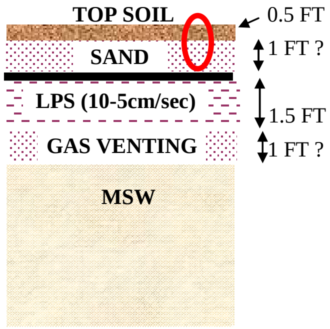


ANR Recommended Base Liner System	**CSWD Conceptual Base Liner System**	**1991 Weston Base Liner System**	**Minimum Double Liner Base Liner System**
THICKNESS = 6 FT	THICKNESS = 6 FT	THICKNESS = 4 FT	THICKNESS = 1.5 FT
CAPACITY GAIN = 0 CY/ACRE	CAPACITY GAIN = 0 CY/ACRE	CAPACITY GAIN = 3,227 CY/ACRE	CAPACITY GAIN = 7,260 CY/ACRE

▬▬▬ **GEOMEMBRANE**
‒ ‒ ‒ **GCL**
■■■■ **GEOCOMPOSI**
— · · — **WATER TABLE**

Figure 2-2

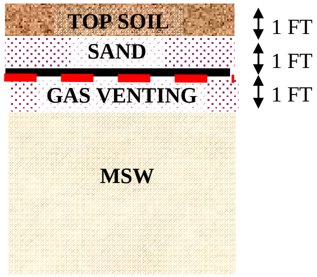
CHITTENDEN SOLID WASTE DISTRICT
LANDFILL SITE 21 FINAL COVER ALTERNATIVES



Vermont Standard
Final Cover System

THICKNESS = 4 FT

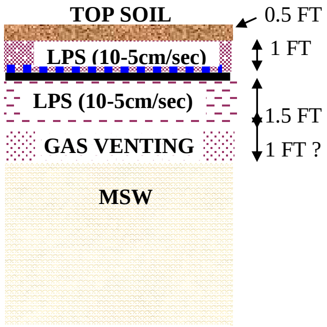
CAPACITY GAIN =
-1613 CY/ACRE



CSWD Conceptual
Final Cover System

THICKNESS = 3 FT

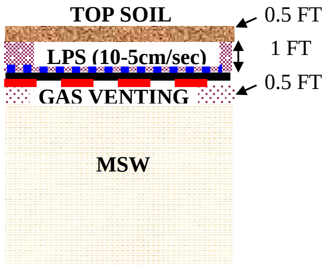
CAPACITY GAIN =
0 CY/ACRE



VT Modified
Final Cover System

THICKNESS = 4 FT

CAPACITY GAIN =
-1613 CY/ACRE



Minimum
Final Cover System

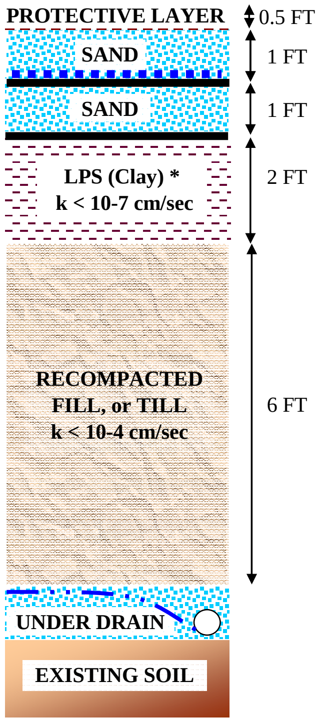
THICKNESS = 2 FT

CAPACITY GAIN =
1613 CY/ACRE

▬▬▬ **GEOMEMBRANE**
— — — **GCL**
■ ■ ■ ■ ■ **GEOCOMPOSI**
○ **TRICKY HYDRAULICS**

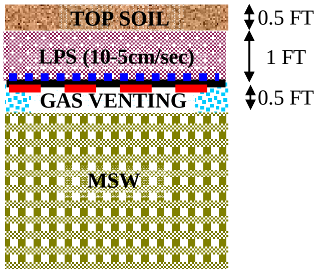
Figure 2-3

CHITTENDEN SOLID WASTE DISTRICT
LANDFILL SITE 21
SELECTED BASE LINER AND FINAL COVER ALTERNATIVES



CSWD Conceptual Base Liner System
(January 2005)

THICKNESS = 4.5 FT
CAPACITY GAIN =
2,420 CY/ACRE



CSWD Conceptual Final Cover System
(January 2005)

THICKNESS = 2 FT
CAPACITY GAIN =
1613 CY/ACRE

* A GCL will be proposed to ANR in lieu of the top foot of secondary LPS.

▬▬▬ **GEOMEMBRANE**
▬ ▬ ▬ ▬ **GCL**
▪▪▪▪▪▪▪▪▪ **GEOCOMPOSITE**
— · · — · · — **WATER TABLE**

3 CONCEPTUAL DEVELOPMENT MODELS

Three conceptual Development Models were selected by EMCON and CSWD for further evaluation (i.e., preparation of a cost model) as presented in Section 4. The Conceptual Development Models selected included the Base Model, Model 1 - Intermediate Build-out, and Model 2 - Maximum Build-out. Table 3-1 identifies the alternative used for the final models. Each is discussed below.

3.1 Base Model

The base model presented by CSWD prior to this study is used as a comparative model, using the slightly modified landfill capacity EMCON calculated. The concept of this model is based on the following:

- No changes are to be made to the current base model configuration other than reduce the Base Case clay layer in the secondary liner to 2 feet to correspond to the Model 1 & 2 scenarios.
- Minor changes were made to the base model data to reflect our interpretation of the mapping and make it more comparable with our alternatives calculations.
- The current base model data is included in the revised economic model.
- A cost of $0.20 per gallon to treat leachate is used based upon the average costs of 1996 and 1997, when leachate strength was most representative of newer waste.
- A 25% contingency is used for construction costs and a 15% contingency is used for operating costs. These have been accounted at the end of the calculations rather than by line item.

3.2 Model 1 – Intermediate Build-out

The following alternatives/assumptions have been incorporated into Model 1:

- Final grades for a 10-foot perimeter wall will be used, above the base model.
- Slopes consistent with base model.

- No change in site geometry from the base model.

- Biostabilization assumes 15% by volume settlement of the in place waste due to the accelerated decomposition of the putrescible waste.

- Base liner as described in Section 2.3.

- Final Cover as described in Section 2.3.

- Lower Base Grades with Groundwater Control System as described in Section 2.5.

- Alternative daily cover will be used in both Models 1 and 2 at a rate of 10% of total volume.

- No waste processing.

3.3 Model 2 – Maximum Build-out

The following alternatives/assumptions have been incorporated into Model 2:

- Final grades for a 20-foot perimeter wall will used for Model 2 above the base model.

- Final grades for the slope-optimized alternative will be extended at a 3H:1V slope 10 feet higher than the added effects of the walls (base model plus 20 foot walls), i.e. the final grades will be 30 feet higher than the Base Model and 20 feet higher than Model 1.

- No change in site geometry from the base model.

- Biostabilization assumes a 15% by volume settlement of the waste in place due to the accelerated decomposition of the putrescible waste.

- Base liner as described in Section 2.3.

- Final Cover as described in Section 2.3.

- Lower Base Grades with Groundwater Control System as described in Section 2.5.

- Alternative daily cover will be used in both Models 1 and 2 at a rate of 10% of total volume.

- No waste processing.

Table 3-1

Chittenden Solid Waste District
Regional Landfill Site 21
Landfill Model Technology Options

	Base	Model 1	Model 2
10 foot Perimeter Walls		x	
20 foot Perimeter Walls			x
Slope Optimization			10' higher
Geosynthetics		x	x
Alternative Materials			
Lower Base Grades		x	x
Site Geometry			
Biostabilization		x	x
Waste Processing			
Alternative Daily Cover		x	x

4 COST MODELS (TASK 2)

CSWD had previously established an economic model comparing transfer station with landfill options. EMCON reviewed the CWSD model but determined the alternatives analyses were sufficiently different and required the development of a new model.

In reviewing and verifying CSWD's model, we examined the cost assumptions within the model and modified those assumptions as appropriate. We also examined EPA's Full Cost Accounting economic model as an alternative approach to the CSWD's existing model, but we did not use it. The Full Cost Accounting program is a much broader tool which does not pertain to the specific aspects of landfill development. Costs for extending three-phase power and municipal water to "Site 21" were estimated and incorporated into the model.

The models were prepared such that varying annual tonnage inputs can be entered to evaluate the cost impacts of waste acquisition options by the CSWD. Model output for each of the conceptual development models (each run at 2 different waste tonnage input rates) are included in Appendix B (Base Model), Appendix C (Model 1 - Intermediate Build-out) and Appendix D (Model 2 - Maximum Build-out). Table 4-1 summarizes the results of the six model runs. As would be expected, the cost of waste disposal is inversely proportional to the waste rate and the landfill size. The lowest waste rate and smallest landfill capacity yielded the most expensive waste disposal costs. The highest waste rate and the largest landfill capacity resulted in the least expensive waste disposal costs. Figure 4-1 demonstrates the average tipping fee will drop as the size of the landfill is increased and, even more significantly, as the incoming waste rate increases.

Table 4-1

Regional Landfill Site 21
Landfill Cost Model Summary

Landfill Model	**Base**		**Model 1**		**Model 2**	
INITIAL WASTE ACCEPTANCE RATE	Full	Half	Full	Half	Full	Half
(tons per year)	132,700	66,350	132,700	66,350	132,700	66,350

LANDFILL MODEL

Initial Waste Acceptance Rate	132,700	66,350	132,700	66,350	132,700	66,350
Landfill Waste Capacity (yards)	4,975,792	4,975,792	8,472,578	8,472,578	9,521,706	9,521,706
Landfill Waste Capacity (tons)	3,731,844	3,731,844	6,354,433	6,354,433	7,141,280	7,141,280
Landfill Life (years)	18	30	27	42	29	45
Average Tip Fee ($ per ton)	$ 72.94	$ 88.46	$ 65.86	$ 76.25	$ 64.81	$ 75.07
Low Tip Fee Range ($ per ton)	$ 67.18	$ 80.74	$ 62.99	$ 69.49	$ 62.13	$ 68.81
High Tip Fee Range ($ per ton)	$ 78.77	$ 96.66	$ 78.09	$ 90.29	$ 76.17	$ 90.24
Total Cost (real dollars)	$ 262,742,613	$ 323,703,388	$ 412,441,559	$ 481,050,585	$ 450,825,950	$ 535,396,823
Total Cost (NPV)	$ 134,072,839	$ 122,106,966	$ 169,555,232	$ 139,490,066	$ 176,245,210	$ 144,226,871

TRANSFER STATION MODEL

Initial Waste Acceptance Rate	132,700	66,350	132,700	66,350	132,700	66,350
Average Tip Fee ($ per ton)	$ 122.06	$ 142.54	$ 136.90	$ 169.17	$ 140.62	$ 176.98
Low Tip Fee Range ($ per ton)	$ 101.02	$ 101.02	$ 101.02	$ 101.02	$ 101.02	$ 101.02
High Tip Fee Range ($ per ton)	$ 141.46	$ 179.40	$ 169.05	$ 227.52	$ 175.88	$ 241.45
Total Cost (real dollars)	$ 439,660,959	$ 521,614,054	$ 857,362,084	$ 1,067,301,995	$ 978,190,660	$ 1,262,165,703
Total Cost (NPV)	$ 220,249,912	$ 184,173,221	$ 331,227,078	$ 258,730,845	$ 355,966,252	$ 277,450,248

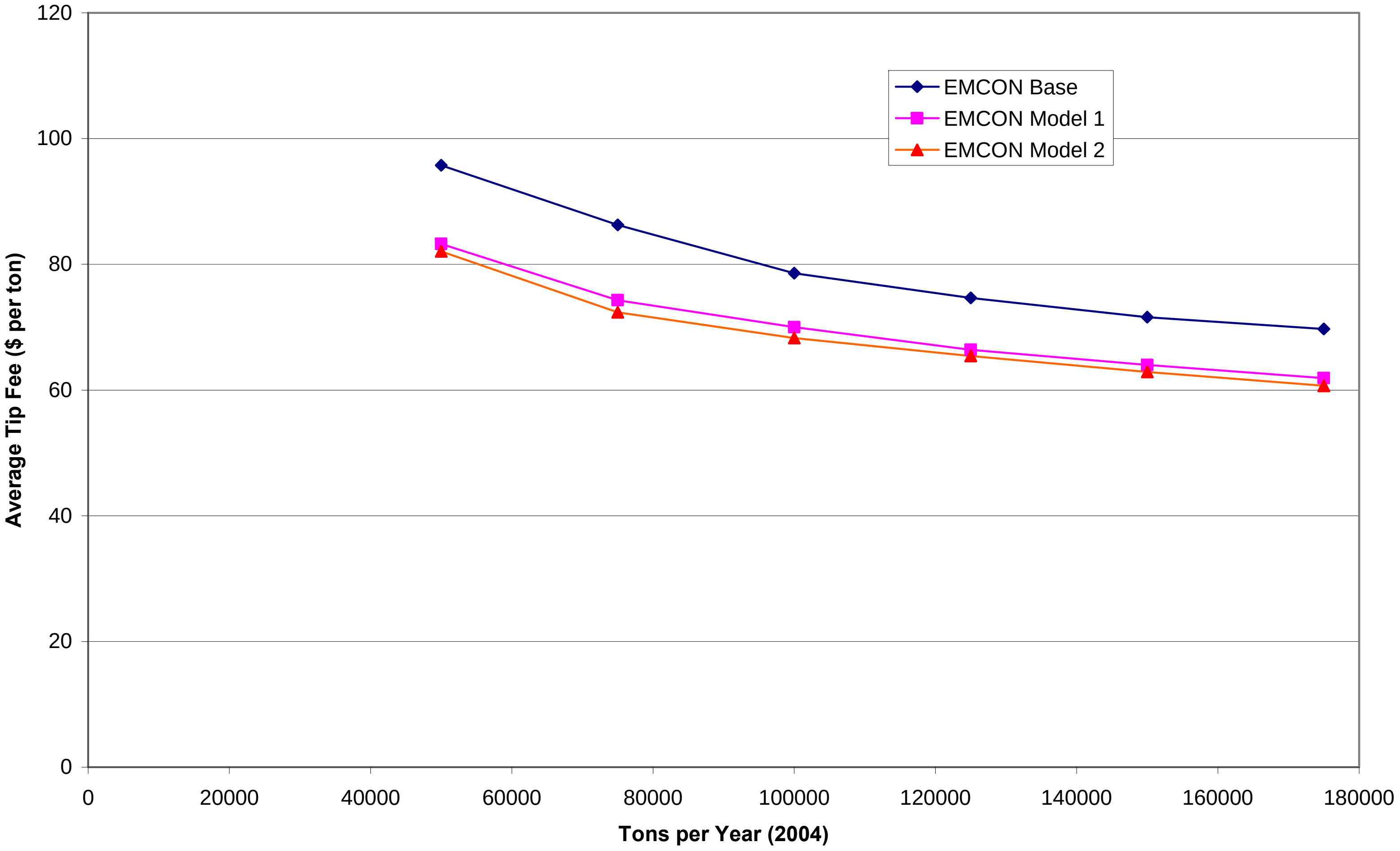
DIFFERENCE

Average Tip Fee ($ per ton)	$ 49.12	$ 54.08	$ 71.04	$ 92.92	$ 75.81	$ 101.91
Total Cost (real dollars)	$ 176,918,346	$ 197,910,666	$ 444,920,525	$ 586,251,410	$ 527,364,710	$ 726,768,879
Total Cost (NPV)	$ 86,177,074	$ 62,066,255	$ 161,671,846	$ 119,240,778	$ 179,721,042	$ 133,223,377

ASSUMPTIONS

Year Construction Begins	2008
Year waste placement / transfer begins	2009
Borrow Rate	5.75%
Waste Inflator Rate	3%
Landfill Cost Inflation	3%
Transfer Station Cost Inflation	2%
Discount Rate	3%

Figure 4-1
Landfill Model Comparison



APPENDIX A

LANDFILL TECHNOLOGY REVIEW

APPENDIX B

COST MODELS – BASE MODEL

APPENDIX C

COST MODELS – MODEL 1 (INTERMEDIATE BUILDOUT)

APPENDIX D

COST MODELS – MODEL 2 (MAXIMUM BUILDOUT)