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AFTER-USE REPORT ~ SITE D
HALTON REGION LANDFILL TECHNICAL STUDY

SCHEDULE E ~ D

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landplan
landscape architects
environmental scientists

AFTER-USE REPORT SITE D

Halton Region Landfill Technical Study

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AFTER-USE REPORT SITE D

Table of Contents

1.0 Executive Summary

The Site D After-use concerns the selection and description of the recommended after-use for the proposed Regional Landfill at a concept level of detail.

Review of Stage 2C Study

In Phase 2, Stage 2C of Halton's Environmental Assessment reference to possible after-use options for the recommended sites recognized the Environmental Protection Act requirement for Ministry of Environment approval for uses of lands on completed landfills for a minimum period of 25 years after closure. The after-uses suggested in the Stage 2C study identified for Site D included active recreation, golf course, agriculture, horticulture and a possible site for the Region's Museum and related facilities. These after-uses were generally consistent with after-uses on other landfills and comments from a range of persons not on the consultant team. They were also generally compatible with the current planning designations for the site.

Evaluation of Features

The features of Site D and its surrounding landscape were considered in the evaluation of the after-use concepts. Consultants identified site constraints for potential

limitations and guidelines for after-use. These constraints included measures to reduce impact on local intermittant watercourses, revegetation to establish habitat, soil and cover specifications to sustain plant growth, vegetation screens, final contour shape and grades, the height of the landfill, staged rehabilitation and the use of native plant material.

Site D has three heritage structures that were the subject of special measures proposed to maintain them. The site setting was predominately agricultural.

In addition to these site constraints the analysis recognized that there was little potential for linking after-use with existing features. The agricultural setting and the site's relative distance from significant population concentrations directed after-use towards concepts that were self-supporting or agricultural. The site was less suitable for locating industrial support and conservation oriented after-uses.

Evaluation of After-use Concepts

After use concepts were organized in a "long list" of potential activities consisting of conservation, passive recreation, active recreation, agriculture and commercial industrial categories. The specific after-use concepts in

each category were evaluated in two stages: screening, and concept evaluation.

The criteria were developed to evaluate and screen tne after-use concepts. After screening one passive recreation (picknicking) three active recreation (sports fields - including archery, golf course and botanical garden/museum) and one each of agriculture (agricultural rehabilitation) and commercial/industrial (greenhouses) after uses were retained.

The concept evaluation stage consisted of a reviеw of the strengths and weaknesses of each of the concepts in terms of five general objectives: compatibility, environmental disruption, public/municipal preference, flexibility and public benefit. The result of the evaluation was that agricultural rehabilitation was considered the most appropriate concept for after-use. Its major advantages were its compatibility with the surrounding land-use and landscape character; protection of agricultural resources; good planning and design flexibility. Both the selection of evaluation objectives and the concept itself were consistent with the Phase 2, Stage 2C Environmental Assessment

Recommended Mitigative Measures

The concept involves establishing a cash crop enterprize on the landfilled and buffer area. A program of soil rehabilitation, interim cover crops and a crop rotation schedule is proposed. No livestock will be included. Steeper slopes or areas that are not routinely cultivated will be planted with permanent forage or cover crop species.

Mitigative measures are proposed and include: a topsoil/subsoil depth of 1.5 m; contouring to avoid slopes over 5 percent; progressive rehabilitation, erosion control and perimetre screen plantings.

An economic analysis was undertaken to establish the long term viability of the agricultural enterprize.

2.0 Review of Phase 2, Stage 2C Study

Reference was made to landfill after-use in the study prepared for Halton Region as part of its Environmental Assessment, referred to as The Stage 2C Study Selection of Preferred Site. After-use was discussed in the following technical studies:

- Biophysical Assessment
- Agricultural Assessment
- Hydrogeologic-Hydrologic Assessment and Conceptual Design
- Visual Assessment
- Heritage Features Assessment
- Landuse and Planning Assessment .
- Evaluation and Summary Report

The Biophysical Assessment (Bird and Hale Ltd. 1985) identified general mitigation measures appropriate to after-use, for example:

- use local plant species as much as possible
- increase forest community cover locally
- provide suitable habitat for wildlife species
- establish linkages for wildlife movement
- maintain surface water quality

For Site D there were few identified biophysical concerns that could not be accommodated in after-use plans.

The Agricultural Assessment (Ecological Services for Planning Ltd. 1985) proposed general mitigative measures for all sites. These agricultural rehabilitation measures included:

- reduction of infiltrating water
- prevention of soil contamination
- prevention of the migration of landfill gases toxic to plants
- provision of 1. - 1.2 m of minimum soil cover over final lifts
- a series of measures to improve soil fertility and tillage
- a cropping program and series of monitoring requirements.

Site D was considered to be in an area with an established agricultural community on medium to high capability soils. The analysis identified a high suitability for potential agricultural after-use. A major concern for agricultural rehabilitation was to ensure an adequate soil and subsoil cover with appropriate gas and leachate control.

The Report of Hydrology Consultants of Trow Ltd. (1985), - Hydrogeologic - Hydrologic Assessment and Conceptual Design proposed a landfill design concept for Site D including after-use. A preliminary set of site design parametres included:

- landfilling to a maximum of 15 m above existing grade
- 4:1 final contour side slopes
- 100 metres buffer area around area to be landfilled within the property line.

Mitigative measures, as they relate to after-use were proposed and included a system to control landfill gas and odour emissions and the presence of a buffer zone.

The Visual Assessment (1985) prepared by The Landplan Collaborative Ltd. included recommendations to reduce visual impact that related to after-use. The need for vegetation buffering and screening was stressed. In the context of after-use the following general measures to mitigate potential visual intrusion were proposed:

- the final contours of the landfill should reflect the natural contours of the land in the area
- rehabilitation should occur as soon as possible after closure to establish a visually compatible land cover.

- screening vegetation should be designed to reflect existing patterns and slopes
- native species should be used for planting
- existing vegetation should be preserved and incorporated into after-use
- the height of the landfill should be kept as low as possible

For Site D it was recommended that the woodlot adjacent to the northern boundary of the site should be retained. Heavy screening was required on the north and south boundaries of the site. Both recommendations if followed would involve incorporating the existing and planned screening vegetation into after-use.

The Heritage Features Assessment, (The Landplan Collaborative Ltd. 1985) identified 3 heritage features on Site D. Options for mitigation were: 1) design the landfill to accommodate the heritage features or, 2) relocate the features. (In the case of the feature known as the "Ford Farm" the landfill contour was modified to retain the farmhouse at a later stage in the study. This structure could be incorporated in the after-use plan.

The Land-use and Planning Assessment, (Walker Wright Young Associates Limited 1985) reviewed potential

after-use/concurrent use of their landfill sites. This report noted the Environmental Protection Act authority to regulate after-use, "within a period of twenty-five years" after closure. The Region of Halton Official Plan considers landfill sites as interim uses until the land is rehabilitated. With respect to Site D it was noted that the Milton Official Plan did not include specific policies for the after-use of landfills.

Walker Wright Young and Associates (1985) suggested that there were significant advantages to concurrent use ie. rehabilitation of successive stages during the operational life of the landfill. Staged rehabilitation may be feasible with certain after-uses (eg. a golf course in concert with the use of adjacent property).

The Walker Wright Young Report (1985) identified the need for potential after-use concepts to be flexible to respond to changes in policy and technology. The primary forms of after-use included open space, recreation, and agricultural rehabilitation. Within these generic categories the advantages of progressive rehabilitation, and concurrent use opportunities were stressed. A range of possible constraints was discussed which included:

- gas generation and migration
- leachate generation

- settlement
- contour shape and relief

It was recommended that no built structures or servicing occur "on or in close proximity to, a landfill site". A variety of appropriate after-uses was discussed, comprising:

- natural revegetation
- recreational uses (supervised passive and active)
- energy from gas

The specific after-uses that were considered appropriate for Site D were: a golf course (possibly with driving range), agricultural rehabiliation, municipal greenhouses (heated by landfill gas). The golf course option would depend on demand and might involve staged construction combined with a course on property adjacent to Site D. The potential concurrent use of the Site for the Halton Regional Museum was considered less appropriate due to relative isolation from potential users. (Walker Wright Young Associates, 1985 pg 8-11).

The Evaluation and Summary Report, Walker Wright Young Associates (1985) indicated that Site D is in a moderately stable agricultural area. Agricultural after-use would aid in reducing potential incompatibility.

3.0 Methods

3.1 General Methods

The methods used to identify and recommend after-use concepts for the proposed landfill at Site D involved review of reports and published literature on the topics of landfill after-use, revegetation/ reclamation of landfills, and the Phase 2 Stage 2C studies of Halton's Environmental Assessment; discussions with practitioners in the field of landfill after-use, with municipal staff and other consultants; and, a review of identified consultants site constraints. In addition, a reconnaissance survey of examples of landfill after-use and post closure practices was undertaken in the local area.

The following sequence of steps was taken to identify potential after-uses and arrive at a recommended after use for each site:

- literature on landfill after-use and the reports from the earlier stages of the Environmental Assessment were reviewed
- potential site constraints were identified by each consultant involved witn after-use
- practitioners, agencies, municipalities with experience in landfill after-use were contacted

- the reconnaissance landfill survey was undertaken
- a "long-list" of potential after-uses was compiled
- methods to evaluate the potential after-uses and selected preferred after-use concepts were developed
- screening criteria were used to eliminate the less appropriate after-use options from active consideration
- after-use options remaining after screening were evaluated to select one or two recommended after-uses for each site
- the recommended after-use concepts were described and their impact on the site was assessed.

During this period an Agricultural Rehabilitation Report (Ecological Services for Planning 1986) was produced which evaluated the site for its potential for rehabilitation to a viable farming enterprise. The results of that assessment are included in the appendix to this document.

3.2 Methods Specific to Site D

The methods specific to Site D involved incorporating the results of the Agricultural Rehabilitation Report (Ecological Services for Planning Limited 1986). The latter included an assessment of on-site and surrounding agricultural characteristics, rehabilitation problems, post rehabilitation problems, and costs of rehabilitation.

4.0 Criteria for the Evaluation of After Use

The criteria for the evalution of after-use were developed from a range of published sources, examination of current practice and discussion among members of the project team. The following is a review of the characteristics of Site D that are relevant to after-use; a discussion of site constraints; opportunities for after-use; and the screening and evaluation criteria used in after-use selection.

4.1 Site D Features and Characteristics

Site D is located between Highway 25 and First Line, south of Britannia Road and north of Lower Base Line Road (Map 1). The site is southeast of the Town of Milton on parts of Lots 3 and 4, Concession II of the geographical Township of Trafalgar, Regional Muncipality of Halton. The total area of the site is approximately 126 ha and the estimated area to be landfilled is 53 ha (Hydrology Consultants 1986).

Site D lies in the west part of a relatively flat clay plain which extends throughout the centre sections of Peel and Halton Regions.

The soils are largely clayey silt tills in the Jeddo and Chingcousy series. A small drainage channel crosses the

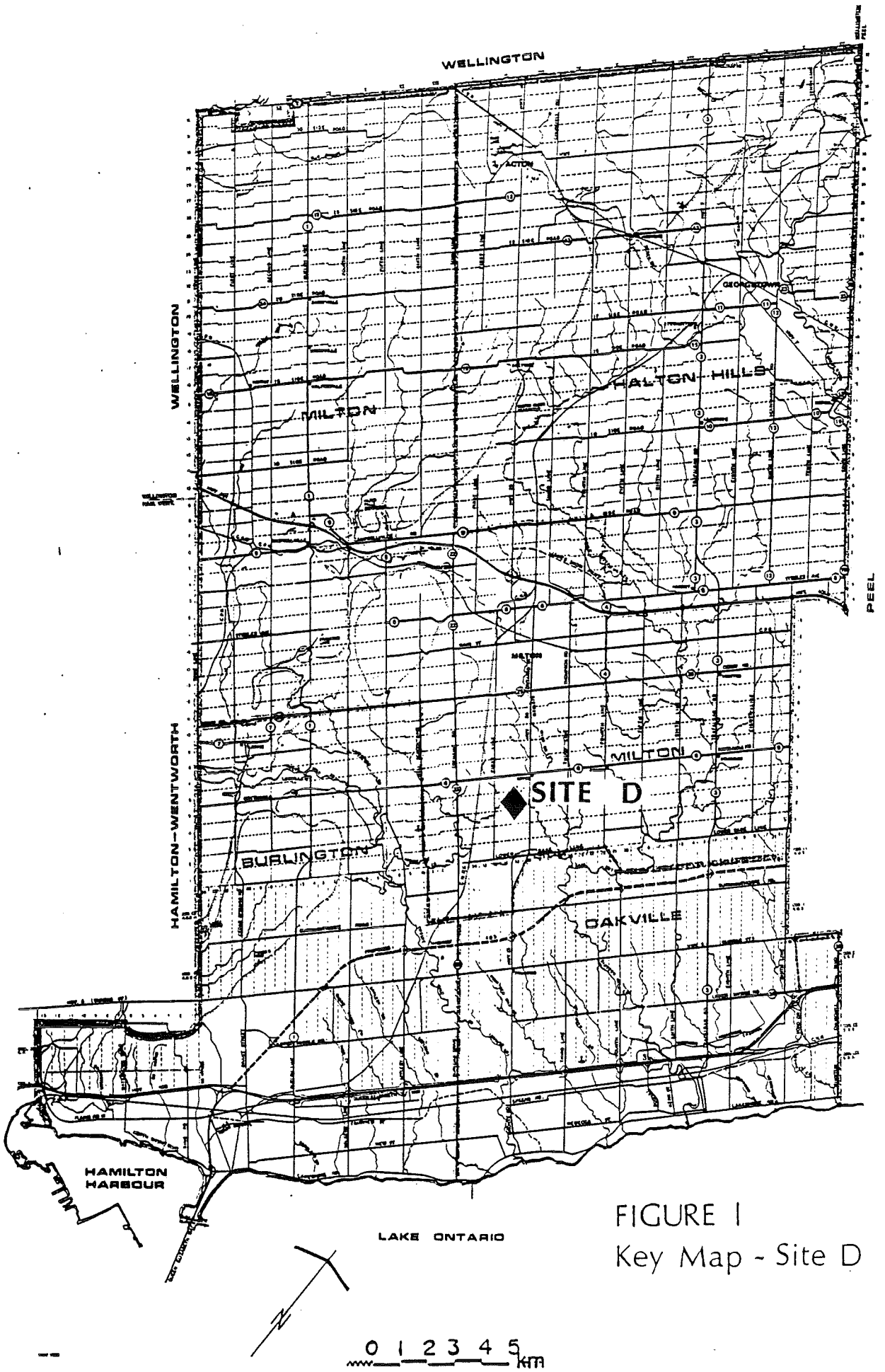


FIGURE 1
Key Map - Site D

site to a tributary of 16 Mile Creek. The site has been largely cleared for agriculture but two small remnant wooded areas still remain. One is a deciduous woods composed mainly of oak and basswood with some shrub areas. The second is an open association of oaks, maples, ash and hawthorn with some white pine. There are scrub and wet meadow associated with the second stand. Bird and Hale (1985) in their Phase 2, Stage 2C report provide a detailed description of vegetation. Ecological Services for Planning Limited (1985) describe the Site soils.

The on site land use includes four residential uses of which three are associated with agriculture. This is an unlicensed private airstrip. The predominant land use in the area is agriculture. Burlington Air Park is within 3.5 km from the Site on Bell School Line.

There is three heritage features in the south east corner of the site (The Landplan Collaborative Ltd., 1986).

4.2 Site Constraints

The consultants were asked to produce a summary of constraints to after-use in their areas of expertise. This information suggested design requirements to mitigate potential problems that concerned after-use. A summary of the identified constraints and relevant mitigation follows:

4.2.1 Engineering Design and Operations Constraints

Hydrology Consultants of Trow Ltd. (1986) Design and Operations Report for Site 'D' indicated that the after-use recommendations proposed by Ecological Services for Planning Ltd. (1986) would be followed for after-use. Final contours were set to accommodate man hole access to the site under drains, the resulting swales were a minor deviation from the flat surfaces requested by Ecological Services for Planning. The tip of the fill area has slopes ranging from 1.1 percent to 2.9 percent to accommodate agricultural after-use. It was noted, (pg. 84) that the large supply of cover material in general has the potential to increase depth of cover to 3.3 m and decrease slopes.

4.2.2 Land Use and Regional Planning

The planning constraints are from Walker Wright Young and Associates (1985, 1986).

Site D has frontage on both Highway 25 and the First Line in Milton. It is located 3.6 km south of the Milton Urban Area and 6.4 km north of the Oakville Urban Area. It is somewhat isolated from surrounding centres of population concentration.

4.2.2.1 Region of Halton

Section D.3.8 of the Regional Plan currently indicates that landfill is considered an "interim use until such time as the land is rehabilitated," and that end uses should be "suggested by local plans, in accordance with the requirements of the Ontario Ministry of the Environment", (Walker Wright Young and Associates 1985).

For Site D a Regional Plan amendment to permit a sanitary landfill would define a range of permitted uses to enable implementation of the proposed after-use.

4.2.2.2 The Town of Milton

The Town of Milton Official Plan (1984) designates the area proposed for Site D as "Agriculture" and as "Conservation Hazard Land". Sanitary Landfilling is not a permitted use in these designations. An amendment to change the Plan would be required to permit the landfill and anticipated after-uses. Zoning would also require amendment.

4.2.3 Provincial Policies

The Environmental Protection Act regulates the after-use of sanitary landfills.

Section 45 of the Environmental Protection Act requires the approval of the Minister for all uses of lands on completed landfills within 25 years of cessation of landfilling operations. The Ministry is giving active consideration to a requirement for control in perpetuity, rather than for 25 years.

The Ministry's position is stated in its Interim Guidelines for the Use of Land Adjacent to or on Completed Landfilled Areas (1981) which considers the potential effects of methane gas and requires the use of buffer areas to ensure that landfill gas does not create a hazard in developed areas. Where no artificial gas control facilities are in place, a buffer extending a distance of ten times the depth of the landfill from the edge of the fill area would be kept free of development, subject to any additional studies which may be undertaken. Where artificial gas control facilities are in place, the required buffer would be not less than twenty metres. The onus is placed on the person wishing to undertake the development to prove that no hazard will be created.

4.2.4 Air Quality

Control measures for dust and odour may affect concurrent use of the landfill particularly adjacent to any active areas of landfilling. The Phase 2 Stage 2C of Halton's Environmental Assessment Report on air quality did conclude that a high degree of permanent dust suppression can be achieved in the long term by revegetating areas when complete (Senes 1985).

4.2.5 Biophysical

The main constraint to after-use noted for Site D was the tributary of 16 Mile Creek on site near the north west boundary. This water course will need protection through the phases of landfill construction and after-use. (Bird and Hale 1985).

The report Halton Region Landfill Technical Study Biophysical Analysis, Site D, (Bird and Hale Limited 1986) indicated that the creek referred to for re-routing is located in the west side of the site (Map HL-D1) associated with Bronte Creek. In terms of after-use this report recommended that the buffer areas

should be planted with indigenous trees and shrubs for wildlife linkages and screening and that the site should be rehabilitated in stages.

The vegetation units on site are rated as not significant and fragmented. There are however portions of the woodlots that contain mature trees worthy of incorporation into screening plantings if feasible.

4.2.6 Agriculture

The agricultural constraints and rehabilitation requirements (Ecological Services for Planning Ltd.) addressed the need to ensure an adequate rooting medium (1 to 1.2 m); control potential soil and water contaminants, and provide surface drainage to allow tillage.

Slopes of the finished landfill were specified at no greater than 5% with side slopes at as shallow an angle as feasible. In addition large relatively flat fields were preferred over smaller, irregularly shaped ones. (Ecological Services for Planning 1986).

The soils of Site D were considered adequate for rehabilitation providing that subsoil and topsoil were reserved and protected in separate stockpiles.

The Agricultural Impact and Rehabilitation Report (Ecological Services for Planning 1986, pg. 18) indicated 1.5 m of cover would be needed (1 m of rooting medium over 0.5 m clay cap)

4.2.7 Visual

The proximity of the Site to the Niagara Escarpment was noted for special attention to attempt to mitigate views from Rattlesnake Point and Mount Nemo. Plantings were specified to screen the views from residences. In general after-use should incorporate screening plantings in the form of hedgerows and field borders that reflect current landscape patterns. The final contours of the landfill should be designed to gentle side slopes. Natural woody vegetation should be retained where feasible (The Landplan Collaborative Ltd., 1985).

4.2.8 Heritage

Heritage features consisted of three features; a house, barns and remnant plantings. It was recommended that after-use design incorporate the house, barns and plantings as an integrated unit where feasible. Landscape patterns and materials should reflect the heritage character of the area when used for screens or

border plantings. (The Landplan Collaborative Ltd. 1985).

The Heritage Features Assessment (The Landplan Collaborative Ltd. 1986) confirmed the desirability of conserving the three heritage features and potentially using them after site closure.

4.3 After-Use Opportunities

A number of potential after-uses for Site D have been identified and discussed during the course of the study.

4.3.1 Identified Potential After-uses

The Town of Milton staff in an interview on June 27, 1984 indicated that a golf course, sports playing field and landfill gas utilization for municipal greenhouses were appropriate after-uses for Site D. (Walker Wright Young Associates 1985).

Walker Wright Young (1985) also reports that: During the Phase 2 Stage 2C selection process the Consultant team was approached by the curator of the Halton Regional Museum. In a report submitted to Regional Council, the Museum outlined its requirements for building space and future requirements for expansion.

At present the site is on about 2 ha of land and would require an additional 5 ha for future expansion and parking. Site D was considered to be viable options, however, the supply of services (ie. a water line) and isolation from major points of public access were considered to be a liability. A subsequent conversation clarified that the Museum was looking at using land in association with the landfill. This land would have to be adequately buffered (berms and trees) to reduce the nuisance of noise and dust. The building would be subject to the provisions in Section 45 of the Environmental Protection Act (ie. not constructed on filled area)..

4.3.2 Site D Biophysical Features and Setting

Site D is located in a predominantly flat to gently rolling clay plain. It is relatively isolated from the urban centres of population of Milton. The surrounding land use is agricultural.

There are no obvious linkages to other recreational or physiographic features in the area. Consequently the after-uses planned for Site D will have to be more or less self-contained. As the surrounding landscape is highly modified for agriculture an agricultural after-use would be very compatible with the existing

landscape. Any other after-uses may have to be visually integrated with the agricultural character of the area - cleared and tilled land with hedgerows, remnant woodlots and scattered residences and built structures.

4.4 Evaluation of After-Uses

The after-use options that were considered for Site D are listed in Table 1. They have been grouped into categories based on the similarity of after-use activity.

This long list of potential after-uses was developed from review of the literature, the Phase 2, Stage 2C of Halton's Environmental Assessment and current practice.

The evaluation of the "long list" options was undertaken in two stages:

i) screening
ii) concept evaluation

Screening was designed to eliminate after-use options that were clearly inappropriate for a given site, or were, in the opinion of the consultants, problematical at the level of detail at the concept stage of the project.

Concept evaluation involved assessment of the after-use options that were retained from screening to select one or two preferred options for each site.

4.4.1 Screening of After-use Options

The consultant's approach to screening was to undertake a qualitative evaluation of each after-use with respect to its appropriateness for Site D. The objective of the screening was to leave as many options for after-use while removing from active consideration those that were unsuitable. Screening was an exercise of elimination.

The criteria used to screen the after-use options were developed from a review of secondary sources, discussions with the project consultants, Municipal staff and knowledge of the site and its surroundings. The criteria were not considered of equal weight, and their application was essentially based on best professional judgement.

4.4.2 Screening Criteria

The following criteria were used to screen the long list of candidate after-uses for Site D.

1) Screen out after-uses requiring functional area larger than available at Site D.
2) Screen out after-uses that require urban or high density population in the immediate vicinity of the site.
3) Screen out after-uses requiring relatively large amounts of contiguous natural area or linkage to natural forest vegetation.
4) Screen out after-uses requiring topographic variety and a setting in an area of varied relief.
5) Screen out after-uses that are incompatable with the rural, agricultural character of the site and its surroundings.
6) Screen out after-uses with need for a location with extensive mature vegetation and a variety of natural features and resources.
7) Screen out after-uses that are in conflict with Municipal or Provincial government policies.
8) Screen out after-uses with problematical or risky design, construction or operational characteristics.
9) Screen out after-uses with questionable or unresolved demand from potential users or an unestablished market.
10) Screen out after-uses with significant safety or public acceptability concerns.

TABLE 2 - SUMMARY OF AFTER-USE SCREENING

AFTER-USE	REQUIREMENTS	CRITERIA NOT SATISFIED	COMMENTS	SCREENING
i) Conservation				
1. Natural/Area	. topsoil suitable for tree growth; minimum depth of 1.5 m under reforested area of landfill . controlled access (eg. all terrain vehicles) . control of soil gas and contaminants . supply of native, indigenous plant material	Criterion 3	. isolated from other natural features of any size or significance, no linkage . predominately agricultural surroundings	eliminated
2. Buffer Area	. topsoil suitable for some tree growth; minimum 1.5 m depth to cover smaller area of reforest-ation . control of soil gas and contaminants . access control (e.g. no all terrain vehicles) . incorporate existing plant communities where feasible	Criterion 3	. no need for buffer as there are no natural features to integrate with or protect . predominately agricultural surroundings	eliminated

TABLE 2 - (Con't.)

AFTER-USE	REQUIREMENTS	CRITERIA NOT SATISFIED	COMMENTS	SCREENING
3. Wildlife Production and Hunting	. topsoil required for extensive natural planting; minimum cover depth 1.5 m under reforested area . strictly controlled and regulated access . municipal policies which allow firearms discharge . clubhouse, game management facilities, pens . varied topography and cover . control of soil gas and contaminants . supplemental food	Criterion 1	. problems with limited area to sustain natural populations of wildlife . safety and public acceptability	eliminated
ii) Passive Recreation				
1. Trails - hike and ski	. topsoil suitable for extensive natural plantings; minimum cover depth for reforested areas 1.5 m; for field areas 0.5 m . variety of topography and vegetation . control of soil gas and contaminants	Criteria 1, 3	. isolated from other natural features where activities could be physically integrated; no trail connections . terrain not very suitable . does not meet minimal area for trails and cross country ski runs	eliminated

TABLE 2 - (Con't)

AFTER-USE	REQUIREMENTS	CRITERIA NOT SATISFIED	COMMENTS	SCREENING RESULTS
	. minimum area for trail distances of 1-2 km 2-5 km, 5-10 km . adequate provision of snow cover retention and wind protection in winter . parking facilities for 30 cars . shelter for inclement weather			
2. Interpretive Trails and Outdoor Education; Viewing Areas	. topsoil suitable for extensive plantings over landfill areas; minimum depth 1.2 m for trees, 0.5 m for field . varied topography and vegetation . interpretive features . vistas for viewing . built facilities for gathering, orientation, administration and maintenance . potable water, services . parking for 50 cars . interpretive trails	Criteria 3, 6	. few indigenous interpretive features . isolated in highly modified agricultural setting . possible potential if combined with other passive recreation activities . better viewing areas on Escarpment	eliminated

TABLE 2 - (Con't)

AFTER-USE	REQUIREMENTS	CRITERIA NOT SATISFIED	COMMENTS	SCREENING RESULTS
3. Picnic Areas	. open field areas of 2-5 ha . washrooms, shelters, potable water . topsoil suitable for fields with scattered trees and shrubs . parking for 50 cars . varied topography and vegetation	none	. generally summer use only; would be integrated with other passive activities for all seasons . isolation from interesting natural features will be a constraint . feasible if integrated with other uses	retained
iii) Active Recreation				
1. Sport Fields	. large, flat, well drained open areas, minimum 2-5 ha . parking facilities, 30 cars minimum . spectator viewing and change facilities (preferred) . fields require good depth of topsoil, good sod base (0.5 m topsoil minimum) . controlled access, fencing . lighting (preferred)	none	. potential problem with demand for these types of facility at the location of Site D. (playing fields located in other areas of the municipality) . structures should be sited in buffer area . most suitable for adult sports activities	retained

TABLE 2 - (Con't)

AFTER-USE	REQUIREMENTS	CRITERIA NOT SATISFIED	COMMENTS	SCREENING RESULTS
2. Equestrian Facilities	. flat, well drained area for ring, showing, viewing and holding facilities - minimum area approximately 3 ha . parking facilities, 30 car minimum plus trailer storage . controlled access . trails of 3 m width and varying length over safe terrain . trail slopes not exceeding 15%	Criterion 9	. main constraint is the unresolved demand and interest for this type of facility . potential construction difficulties for viewing and holding facilities on or near landfilled area . possible potable water supply limitation	eliminated
3. Archery, Skeet	. strictly controlled and regulated access/activity . several flat, well drained open areas of 2-3 ha area each (eg. 6 ha total) . fenced buffer areas for safety . compliance with municipal by-laws on firearms and discharge of weapons . parking	Criteria 9, 10	. skeet trap and target shooting may not be compatible with local farming activities . archery may be possible as a well regulated activity with other recreational uses . questionable demand for this type of recreation facility	eliminated (archery may be retained as component activity for other retained after-use)

TABLE 2 - (Con't)

AFTER USE	REQUIREMENTS	CRITERIA NOT SATISFIED	COMMENTS	SCREENING RESULTS
4. Garden Plots	. flat to gently rolling well drained topography (area varies) . minimum 1.2 m soil cover plus topsoil of high quality . parking . proximity to user demand . controlled fenced access . potable water supply	Criteria 2, 10	. isolated from urban centres . potential problem with public acceptance of garden produce grown on a landfill (where produce is directly consumed by growers)	eliminated
5. Golf Course	. minimum area of 45 ha (18 holes) on flat rolling terrain . relatively flat terrain not exceeding 10-15% slopes in active area; to 20% slopes between fairways . potable water for irrigation of greens . parking for 200-300 cars (approx. 1 ha) . built facilities for clubhouse, maintenance, washrooms, retail space . topsoil: 1.2 m maximum on greens and planted areas; 0.5 m on fairways	none	. possible difficulties with construction and location of support facilities, servicing (eg. water supply) . interest expressed by municipality for this type of after-use	retained

TABLE 2 - (Con't)

AFTER-USE	REQUIREMENTS	CRITERIA NOT SATISFIED	COMMENTS	SCREENING RESULTS
	. tree cover, extensive planting . controlled access (fence) . no differential subsidence, no leachate springs . MOE requirements for watermain and sewer services			
6. Camping	. flat to rolling terrain for 10-12 ha. Slopes not to exceed 6% . parking for 30 cars . build facilities (washrooms, retail showers, laundry) . services . controlled access . services (electric, water, possible sanitary)	Criteria 2, 9	. isolated site location may be of limited potential to sustain viable level of use . no interest expressed in camping by local municipality . questionable market demand . water supply may be a problem	eliminated

TABLE 2 - (Con't)

AFTER-USE	REQUIREMENTS	CRITERIA NOT SATISFIED	COMMENTS	SCREENING RESULTS
7. Botanical Garden/ Arboretum, Museum	. topsoil of 1.2 m minimum depth cover . large area irrigation . built facilities (greenhouses, maintenance, retail administration) . parking for 300 cars, buses . services (electric, water, sanitary) . flat to gently rolling land	none	. feasibility for these facilities would largely depend on demand; some interest expressed by Town of Milton staff . Museum currently undergoing site selection study . supply of potable water may be a problem	retained (subject to Museum site selection study)
iv) Agriculture	. minimum of 1.5 m of soil cover over surface . final contours with no greater than 5% slopes . control of soil contaminants and gas	none	. Agricultural Rehabilitation Report recommends agriculture as an option for Site D.	retained
v) Commercial/ Industrial	. construction of greenhouse structure (est. 1000 m^2) on stable flat area . parking for 30 cars plus truck access/ loading facilities . management, maintenance and service facilities	none	. Acceptable at concept level, detailed design and servicing studies needed . supply of potable water may be a problem . construction over refuse problematical	retained

TABLE 2 - (Con't)

AFTER-USE	REQUIREMENTS	CRITERIA NOT SATISFIED	COMMENTS	SCREENING RESULTS
	. flat outdoor storage . full services . controlled access . possible integration with methane collection system for fuel		. greenhouses would not occupy entire site therefore they would have to be integrated with other uses . possible after-use in the long term with interim after-uses at time of closure	
2. Horticultural Production Area/Nursery	. parking for 30 cars plus truck access/ loading facilities . maintenance and service facilities . irrigation . flat outdoor storage area . full services . controlled access . minimum of 1.5 m soil cover over refuse . final surface contained to 1-5% slopes . control of soil contaminants and gas	Criterion 8	. potential difficulty of maintaining production of horticultural plant material on problematical soils . need for irrigation	eliminated

TABLE 2 - (Concluded)

AFTER-USE	REQUIREMENTS	CRITERIA NOT SATISFIED	COMMENTS	SCREENING RESULTS
3. Open Storage/ Parking AReas	. relatively flat well drained area with maximum 1-5% slopes . strict control on differentiable subsidence . controlled and regulated access (fenced security) . area for storage and parking variable according to demand (eg. 5-25 ha) . proximity to industrial/ commercial users.	criteria 2, 5 and 9	. the location of Site D and the unestablished demand for materials storage precludes this use . after use constrained by agricultural landuse and planning designation for area . no proximity to industrial/commercial users	eliminated

5.0 Evaluation of After Use Proposals

Table 2 summarizes the results of the screening process. Following screening, the evaluation of the after-uses that were not eliminated is described.

5.1 Results of Screening

A list of the after-use concepts for Site D that remained after screening are listed below:

Category		After-Use
i)	Conservation	none
ii)	Passive Recreation	. picnic areas
iii)	Active Recreation	. sports fields
		. archery (as a potential component of other related after-uses)
		. golf course
		. botanical garden/arboretum museum
iv)	Agriculture	. agriculture
v)	Commercial/Industrial	. greenhouses

The screening results generally reflect the strengths and weaknesses of the site and many ofthe preferences expressed

by Town of Milton staff. (Walker, Wright, Young Associates 1985 and undated).

Agricultural rehabilitation is strongly supported by the site setting, existing land use and is in keeping with the policies of the Ontario Ministry of Agriculture and Food (eg. The Foodland Guidelines 1978, (under revision) - section 4A.4).

Active recreation, primarily sports fields and mixed passive/active recreation activities were not eliminated. These recreation activities were considered appropriate for the site and location providing that tney were planned to accommodate uses that did not require facilities close to residential areas.

The Botanical Garden/Arboretum, Museum concepts were retained; the buffer area is suitable for building. However, the servicing and construction needs for some facilities may be difficult to fulfill. These types of after-use will in part create their own demand, therefore site isolation is not as significant, however tne Museum is currently undergoing a Site Selection Study. The growing conditions for sensitive plants may present problems.

The golf course concept received the greatest support from the staff of the local municipality, (Walker Wright Young

Associates 1985). This reference was not supported by council resolution however. The site location is also less important with this type of after-use.

The after-use concepts that were eliminated were those relying on extensive natural vegetation, interesting terrain, large land areas to be self supporting, or linkages to other features such as major parks, the Bruce Trail or water. The conservation concepts were removed from these reasons as were many of the passive recreation after-uses. Hiking trails, cross country ski trails, viewing and outdoor education concepts were eliminated from further consideration for these reasons. Of the active recreation after-uses skeet and trap shooting, equestrian facilities (e.g. horse ring, trails), garden plots and camping were difficult to justify given site location, demand, the terrain characteristics and questions of public acceptability. (Activities such as archery that could be a component of other after-use concepts (eg. golf) were retained).

In the industrial/commercial category parking, open storage and related land uses that would not require large structures were eliminated because there was no established demand and incompatability with the agricultural setting.

A number of the proposed after-uses can be combined to take advantage of the site or overcome potential problems of user demand. There are also opportunities with the less structured after-uses for conversion to a higher use (e.g. passive/active recreation open spaces conversion to museum or greenhouses) to occur in the future once demand and detailed design characteristics are established.

5.2 Concept Evaluation

Concept evaluation involved an assessment of each of the after-use options retained from screening in terms of its relative strengths and weaknesses.

Specific criteria were not formulated for this stage of evaluation, rather, each option was assessed on relative terms on how it fulfilled the opportunities of the site and the general objectives of:

- maintaining compatibility with the landscape
- minimizing environmental disruption and protecting resources
- satisfying expressed public and municipal preferences
- maintaining planning and design flexibility
- producing an appropriate public benefit

Each of these objectives for after-use is self explanatory. They were interpreted witnin the context of the need to produce a publically acceptable, appropriate means of long term use of the landfill after closure. The after-uses were evaluated at a concept level of detail.

5.2.1 Picnic Areas

Picnic areas consist of open space of mowed grass, scattered trees and support facilities such as tables, shelters, washrooms, first aid facilities and parking.

At Site D there are few intrinsic opportunities in the area to actively support picnicking. The activity is compatable witn the landscape and has minimal environmental disruption. It fails to protect the agricultural resource as active agriculture would be precluded by picnicking. There has not been public or municipal support for this concept and demand is not established. Planning flexibility objectives would be met.

The concept is not considered as an appropriate after-use for Site D unless it is combined with other after-uses.

5.2.2 Sports Fields

Sports fields involve graded flat areas with good drainage. Parking, maintenance facilities, spectator areas, controlled access, washrooms and preferably stands with artificial lighting are preferred.

Sports fields would only be moderately compatible with the surrounding agricultural landscape. Depending on the farming enterprises in the area large numbers of people, noise and intensive artifical lighting may be disruptive. The major resources of the area, (ie. agriculture) would not be protected. Town of Milton staff originally expressed interest for playing field facilities for adult users where isolation from residential areas is considered a benefit. Planning and design flexibility would be compromised if there is a high level of investment in constructed facilities. The objective of producing a public benefit will be met if the special demand of adult sports facilities is realized.

5.2.3 Archery

Archery would be combined with sports fields and possibly the golf course to be retained as a potential after-use at Site D. For comments, see above (5.2.2.).

5.2.4 Golf Course

The golf course concept refers to a standard 18 hole design with parking, club house, and maintenance facilites. An additional option discussed in the Phase 2, Stage 2C Report involves developing a golf course on lands adjacent to Site D before landfilling is complete and integrating it with tne site as each part of the site is closed. For example, a 9 hole course could be developed on lands near the boundary of Site D closest to the landfill area scheduled for initial completion. As the completed landfill areas becomes available, an additional 9 holes would be added to the existing course.

The current agricultural designation permits golf courses, although active recreation activities with heavy use, noise and traffic may be disruptive to some agricultural activities.

In terms of protection of resources a golf course would displace agriculture from the Site and possible some adjacent lands. There was strong support for the golf course after-use from staff of the Town of Milton (Walker Wright Young Associates, 1985). Planning and design flexibility would be compromised for after-uses which require less site development than the

golf course. There is potential for future multiple use and conversion to some commercial or industrial uses. Potable water supply may be a problem and irrigation needs may conflict with the objective of reducing leachate production (Hydrology Consultants of Trow Ltd. 1986).

5.2.5 Gardens/Museum

Botanical garden/arboretum, museum are concepts which have been grouped to facilitate analysis. All will require detailed engineering and design studies to assess feasibility. The Halton Region Museum is, for example, undergoing a site selection study to facilitate its relocation.

The museum will require at most 5 ha of an approximately 140 ha site. As such it will have to be integrated with other uses to satisfy the after-use needs of Site D. A botanical garden and/or arboretum are a logical choice. Both the latter will require extensive soil modification and upgrading.

The complex of museum, botanical garden and arboretum will not be entirely compatible with the surrounding agricultural area. All of these land-uses will entail

large numbers of people at the Site. Servicing, including water supply may be difficult.

Agricultural resources will not be protected by the construction of a museum. The botanical garden, plots and arboretum facilities conflict less with this objective. Planning and design flexibility will be limited. There may be opportunity for multiple use (eg. picnicking). Other sites (ie. non landfill) may be better suited for these facilities.

5.2.6 Agriculture

Agriculture consists of a soil reclamation program followed by cash crop rotation. The detailed requirements are incorporated in the Agriculture Rehabilitation Report included in the Appendix (Ecological Services for Planning Limited 1986).

Agricultural rehabilitation for Site D would be very compatible with the surrounding landscape. It would minimize environmental disruption and protect soil resources. It is consistent with the goals of the Province's Foodland Guidelines (1978).

Planning and design flexibility would be high with this after-use concept. There would be an appropriate public benefit.

5.2.7 Greenhouses

Greenhouses as an after-use concept would involve construction of production greenhouses with parking, loading facilities, soil and equipment storage and possibly administration facilities. It has been suggested that a system for using landfill gas could be developed to heat the facilities. Detailed design and operation studies are required to determine the feasibility of this after-use. The limited size of the operation means that this concept would have to be integrated with other activities to provide an after-use for the entire site.

Greenhouse production facilties would be generally compatible with the surrounding landscape. There could be some problem witn services (eg. water) and siting on non fill areas.

There is an apparent need for horticultural production faciltities for the Town of Milton. The Town staff have earlier expressed interest in the concept (Walker Wright Young Associates 1985). Planning and design

flexibility would be limited although there would be opportunity for concurrent use for areas of the site that are not developed.

The major disadvantage of this concept is the need for more detailed information on feasibility. If other less complex after-uses are planned for Site D there may be opportunity in the future for developing greenhouse facilities and using landfill gas.

5.3 Results of Concept Evaluation

The recommended after-use concept for Site D is agricultural rehabilitation. This concept has clear advantages over the other concepts.

Agriculture is the current planning designation of both the Regiona and Town of Milton for the area occupied by Site D. There is no indication that this will change in the forseeable future. (Walker Wright Young Associates 1985). The concept represents the most compatible after-use with respect to surrounding land use. It supports Provincial policy (Foodland Guidelines). Site D is essentially isolated from all other land use activities supporting other concepts.

The Agricultural Rehabilitation Report concludes that "the main reason for returning Site D to an agricultural after-use is its present ongoing and future use for agricultural production in an agricultural area in the Town of Milton." (Ecological Services for Planning 1986). Compared to all other concepts the agricultural after-use protects the existing site resources (productive soils and agricultural resources) most effectively.

Finally, planning and design flexibility criteria are well satisfied with agriculture. If and when other land uses become appropriate in the future agriculture will produce little physical impediment to conversion to most other uses. In the interim it will assist in maintaining the area's existing agricultural community.

6.0 Description of After Use Design Concept

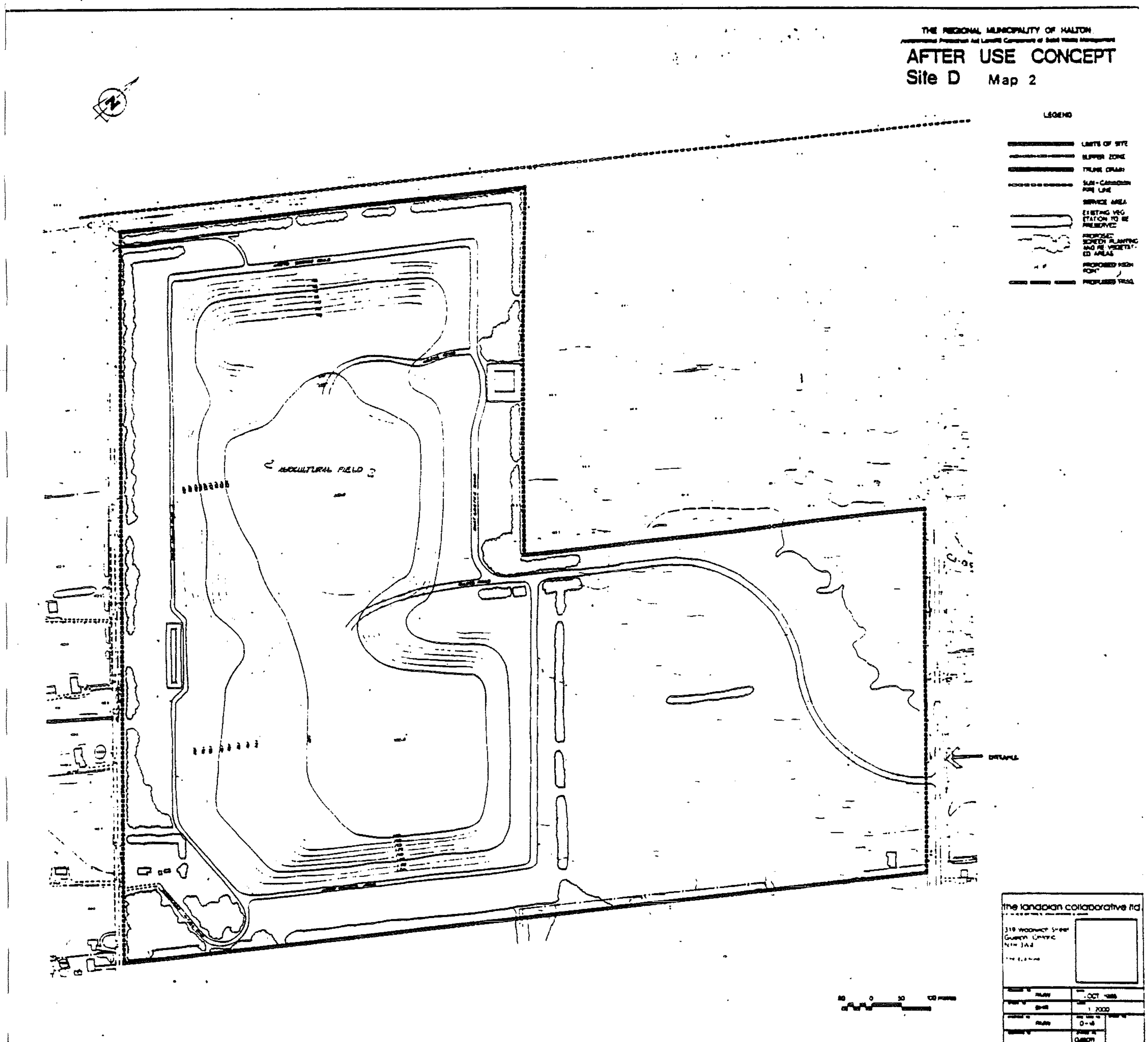
The attached plan illustrates the conceptual design for an intensive forage and cash crop rotation enterprise (Map 2). The agricultural rehabilitation concept is excerpted from Ecological Services for Planning (1986) which is included as an Appendix.

6.1 Rehabilitation

Following reapplication of soil material to the landfill surface, a program of tillage, fertilization and cropping is required to amend soil fertility and soil structure, and to return the site to full agricultural production.

The main limitations in establishing and maintaining agricultural production on the rehabilitated landfill site are the physical conditions of the soil reapplied to the landfill surface.

The site should be subsoiled (ie. broken up by means of deep tillage) following soil reapplication to a depth of 60 cm during June to September, depending on soil moisture levels. The natural sequence of soil horizons will be destroyed in the stripping and stockpiling operations. Soil structure is also destroyed, and as a result, the soils will be more susceptible to soil erosion and


THE REGIONAL MUNICIPALITY OF HALTON
AFTER USE CONCEPT
Site D Map 2
LIMITS OF SITE
BUFFER ZONE
TRUNK DRAIN
SERVICE AREA
PROPOSED TRAIL
AGRICULTURAL FIELD
the landplan collaborative ltd.
OCT
1 2000

crusting. The application of soil organic matter is, therefore, recommended to improve soil structure and the development of soil fertility. Livestock manure and/or sewage sludge could be utilized. Application of sludge treatments in the soil restoration program must be carried out in compliance with the Guidelines for Sewage Sludge Utilization on Agricultural Lands, (Ministries of Agriculture and Food, Environment and Health, 1978).

As each landfill cell is finished to near final grade, the soil should be cultivated and sown with a cover crop. The site should be fertilized according to soil test values and preferably seeded in the spring to a forage/legume mixture. Fall seeding is also suitable, but less desirable. The sod cover can be left until final grading and application of topsoil.

6.2 Long Term Cropping Program

As each cell receives the final reapplication of subsoil and topsoil and is graded, the long term cropping program can be implemented. Potential cropping sequences which provide an opportunity for both intensive and passive agricultural after-uses have been outlined for a 25 year period (Appendix Table 5). Discussions with the design consultants suggest rehabilitation of the site may not be feasible for 10-15 years into the landfill operations. A

forage (legume or legume/grass) crop should be grown on the site for the first 4-5 years following initial rehabilitation to add organic matter and improve soil structure and fertility.

The forage crop suggested for use in the intensive crop rotations is a red clover/timothy hay mixture. Timothy is generally easy to establish and maintain and will grow under a wide range of environments. It is well adapted to heavier soil types and variably drained fields. Red clover (a biennial) is useful in rotations to add nitrogen and organic matter to the soil and for breaking insect and disease cycles. A heavily branched rooting system which is usually concentrated in the top 20 cm of soil makes red clover valuable for improvement of soil structure.

6.3 Past Rehabilitation Management

Long term management and monitoring of soils and yields will help ensure a successful agricultural rehabilitation concept. A minimum of 25 years of restoration and cropping is required. A detailed monitoring program has been prepared to assist in management.

7.0 Conclusions

The results of the after-use analysis for Site D are that agricultural rehabilitation is the most appropriate after-use. This is consistent with proposals in the Phase 2, Stage 2C Environmental Assessment which indicated agricultural after-use as an appropriate concept for Site D. The major advantages are:

- it is highly compatible with the surrounding landscape
- it is consistent with provincial policy
- it maximizes the protection of important soil and crop resources
- it supports the local agricultural community and minimizes environmental impact on its surroundings
- it allows flexibility in long term land use planning for the site

7.1 Comparison with Phase 2, Stage 2C, Study

The Final Technical Report No. 4 - Agricultural Assessment (Ecological Services for Planning Ltd. 1985) indicated that Site D was in an area of long term agricultural stability. Site D had the second highest rating in land quality, presence of large blocks of land dedicated to agriculture and special farm enterprises. These results are supported by the current analysis.

In terms of after-use, Technical Report 12 - Land Use and Planning Assessment (Walker, Wright, Young Associates 1985) identified the generally rural farm areas surrounding Site D. The report suggested that agricultural rehabilitation was suitable for Site D. Agriculture was also considered suitable for "concurrent" use - staged rehabilitation.

In summary the Stage 2C Study identified agriculture as a potential after-use with few significant constraints. The analysis concluded that non-agricultural land use at Site D could result in high environmental impacts. These results are confirmed by this current study.

8.0 Mitigative Measures

The following mitigative measures for the recommended concept are extracted from Ecological Services for Planning 1985, 1986).

8.1 Guidelines for Mitigation

1. Seal

   provide a seal, preferably of low permeability material, immediately over the final lift to reduce water infiltration into the landfill site and prevent potential migration of metal and gas contaminants into the plant root zone;

2. Topsoil/Subsoil

   Provide an adequate topsoil/subsoil depth of 1.5 m overlying the seal to ensure adequate rooting medium for crop growth;

3. Contour Surface

   Contour the final surface, exclusive of side slopes, to 1 to 5 percent slope. This will ensure proper surface

drainage of depressional areas created by differential subsidence. Slopes of 1-5% will minimize soil erosion problems and still allow for drainage of surface waters to reduce water infiltration into the landfill;

4. Venting System

Development of a passive gas venting system to avoid uncontrolled venting into the plant root zone would be desirable. Gas venting will naturally take place along failures in the clay seal due to subsidence. Additional measures for passive gas venting on the arable surface may be required;

5. Progressive Rehabilitation

Progressive rehabilittion of the cells with final grading and application of topsoil following after a period of 1-3 years to allow for subsidence; and

6. Side Slope Grading

Side slope grading to as low an angle as possible to slow surface runoff and erosion and to maximize the area available for arable crop production.

7. Erosion Control

Immediately following progressive rehabilitation, an erosion control program should be implemented in order to stabilize surface soils and prevent undue sediment production and gully formation. An erosion control program, together with a post-rehabilitation management program will be outlined in subsequent phases.

8. Native Planting

Use native plant material where planted shelter belts, hedgerows or other plantings are required.

9. Perimeter Screening

Establish perimeter screenings around the site of vegetation as soon as possible

9.0 References

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HALTON REGION LANDFILL
TECHNICAL STUDY

AGRICULTURAL IMPACT AND REHABILITATION REPORT

ECOLOGICAL SERVICES FOR PLANNING LTD.

OUR FILE: GRH03
July, 1986

TABLE OF CONTENTS

APPENDICES

FIGURES

TABLES

MAPS

HALTON REGION LANDFILL TECHNICAL STUDY
AGRICULTURAL IMPACT AND REHABILITATION REPORT

1. SUMMARY AND RECOMMENDATIONS

This study was undertaken to address the following objectives:

(1) To assess the feasibility of restoring the two proposed candidate landfill sites, D and F, to an agricultural afteruse.

(2) To develop a detailed agricultural rehabilitation program for restoration of site(s) to an agricultural afteruse.

(3) To develop a post-rehabilitation land management and monitoring program.

The feasibility of restoring the two proposed candidate landfill sites, D and F, to an agricultural afteruse was assessed by examining surrounding land use, agricultural capability, rehabilitation problems, ongoing post-rehabilitation problems and relative costs of rehabilitation. On the basis of this analysis, it is recommended that Site D be rehabilitated to an agricultural afteruse, whereas Site F should not be rehabilitated for arable agricultural purposes. why ever consider it for agric?

The reasons are as follows:

- Site D is located in an area where the surrounding land use activities are primarily agriculture, whereas land use activities adjacent to Site F are primarily non-agricultural in nature.

- Site D is located on lands with medium to high soil capability for agriculture, whereas Site F contains lands that are mostly marginal or non-productive for arable agriculture.

- Adequate topsoil and subsoil materials are available for rehabilitation of Site D to an agricultural afteruse,

whereas large volumes of topsoil and subsoil will have to be imported for Site F. The importation of additional topsoil/subsoil materials will add approximately $4,890,800 to the cost of rehabilitating Site F as compared to Site D.

A detailed agricultural rehabilitation program has been developed and is presented for Site D. The program consists of a series of fifteen recommendations which address specific aspects of soil stripping and stockpiling, reapplication of soil material, soil restoration, post-rehabilitation land management and post-rehabilitation monitoring.

Implementation of the proposed program will lead to satisfactory rehabilitation of Site D for arable agricultural production.

2.0 BACKGROUND AND STUDY OBJECTIVES

This study was undertaken at the request of the Region of Halton and addresses the agricultural impact and rehabilitation component of the Halton Region Landfill Technical study. The agricultural rehabilitation of a landfill site is a concept involving a land use change, in order to accommodate two separate resource utilization objectives.

Two sites, Site D and Site F, are presently under consideration for a municipal landfill site for the Halton Region. Site D is located southeast of First Line and Britannia Road in the Town of Milton while Site F is located at Highway 403, North Service Road and King Road in the City of Burlington (Map 1).

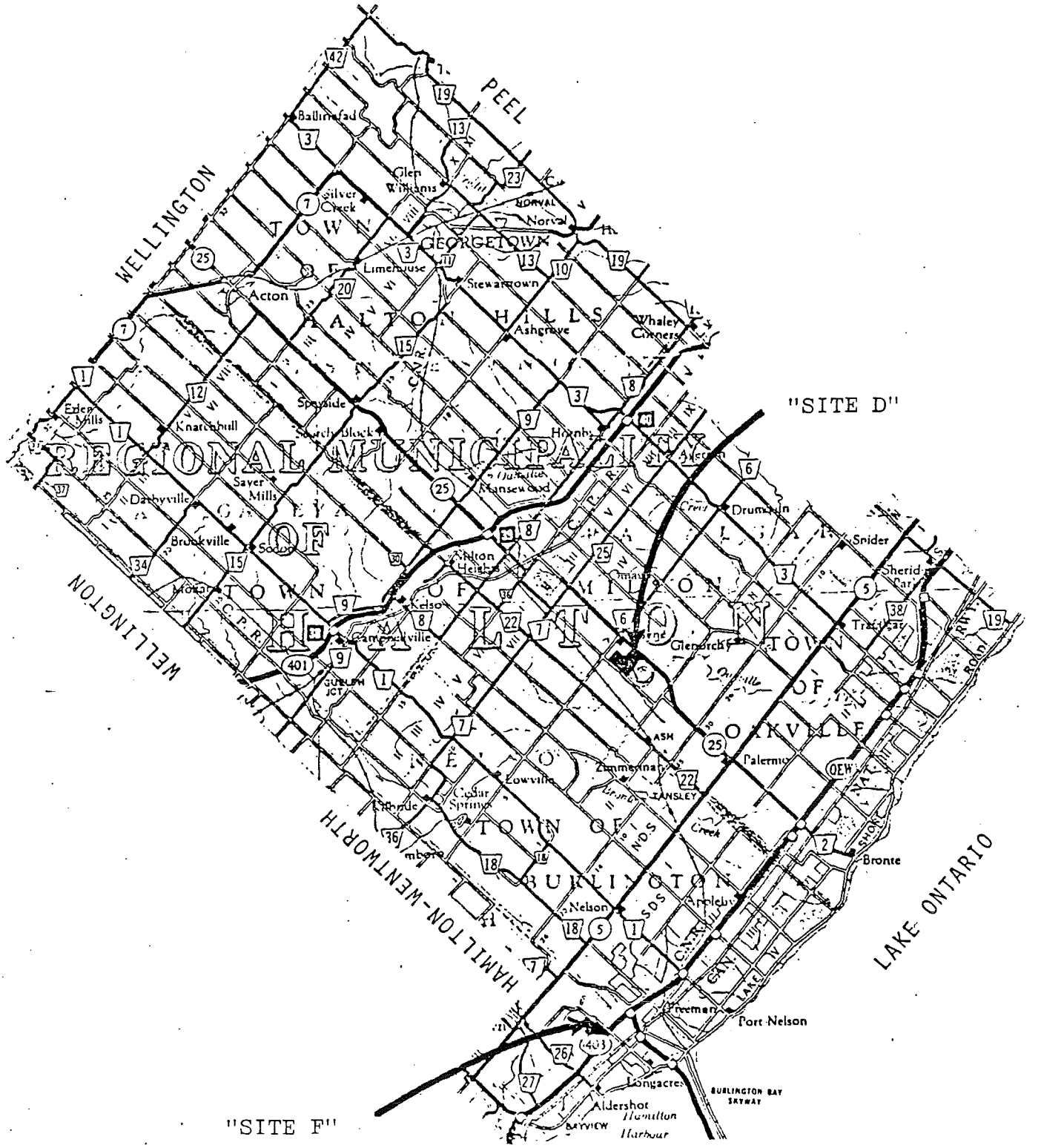
The objectives of this study are as follows:

(1) To assess the feasibility of restoring the two proposed candidate landfill sites, D and F, to an agricultural afteruse.

The specific objectives are:

- to examine onsite and surrounding land use and agricultural characteristics;
- to carry out a detailed analysis of onsite soil conditions and agricultural capability;
- to examine rehabilitation problems;

Map 1 - LOCATION MAP



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- o to examine ongoing post-rehabilitation problems; and,
- o to examine cost of rehabilitation.

(2) To develop a detailed agricultural rehabilitation program for restoration of site(s) to an agricultural afteruse.

The specific objectives are to address:

- o overburden removal;
- o soil stripping and stockpiling;
- o reapplication of soil material; and,
- o soil restoration.

(3) To develop a post-rehabilitation land management and monitoring program.

3.0 FEASIBILITY OF RESTORING SITES D AND F TO AN AGRICULTURAL AFTERUSE

3.1 Onsite and Surrounding Agricultural Land Use

Site D is situated in an area designated as agriculture in the 1984 Town of Milton Official Plan. Land use activities surrounding Site D are primarily agriculture (Table 3).

The Stage 2C Environmental Assessment report ranked Site D as having a high impact on agriculture.

Site F is situated entirely within the Parkway Belt West. It lies adjacent to the existing Regional landfill site, a closed landfill site (Bayview Park), Highway 403 and a hydro corridor. The urban area of Burlington is located south of Site F, below Highway 403 and an active quarry is in operation just east of the site, adjacent to King Road.

Agricultural activities near Site F occur primarily to the north of the site, immediately above the escarpment face.

The Stage 2C Environmental Assessment report ranked Site F as having a low impact on agriculture.

3.2 Soil Inventory and Agricultural Capability

3.2.1 Site D

The soils on Site D have developed in a slightly stony, fine textured glacial till. They consist of two soil series, the Chinguacousy and Jeddo, which differ in morphology and are the imperfectly drained and poorly drained members of the catena, respectively. These soils are described by Gillespie et al, 1970, The Soils of Halton County.

Soils of the Chinguacousy Series are imperfectly drained and occur primarily on undulating topography in this area. These soils have a 20 to 30 cm very dark, greyish brown, clay loam surface A horizon overlying a mottled brown, clay B horizon which is 20 to 25 cm thick. The soil parent material (C horizon) is a mottled grey, clay loam till.

Soils of the Jeddo Series are poorly drained and occur primarily on nearly level topography within Site D. These soils contain an A horizon which is 15 to 25 cm thick, dark brown in colour and clay loam in texture. The B horizon is a mottled, dark greyish brown, and is 20 cm thick. The soil parent material is a mottled grey, clay loam till.

The Chinguacousy soils are rated as CLI Class 1 while the Jeddo soils are rated as CLI Class 3 for agriculture due to low permeability and wetness limitations.

The Soil Series and slope categories form the basis for the site map of Soil Capability for Agriculture (Map 2). Using a planimeter, the relative occurrence of the soil capability classes was calculated (Table 1). Class 1 and 3 soils are almost equally represented within Site D. Class 1 soils occupy the slightly undulating areas while Class 3 soils are found in the depressional areas.

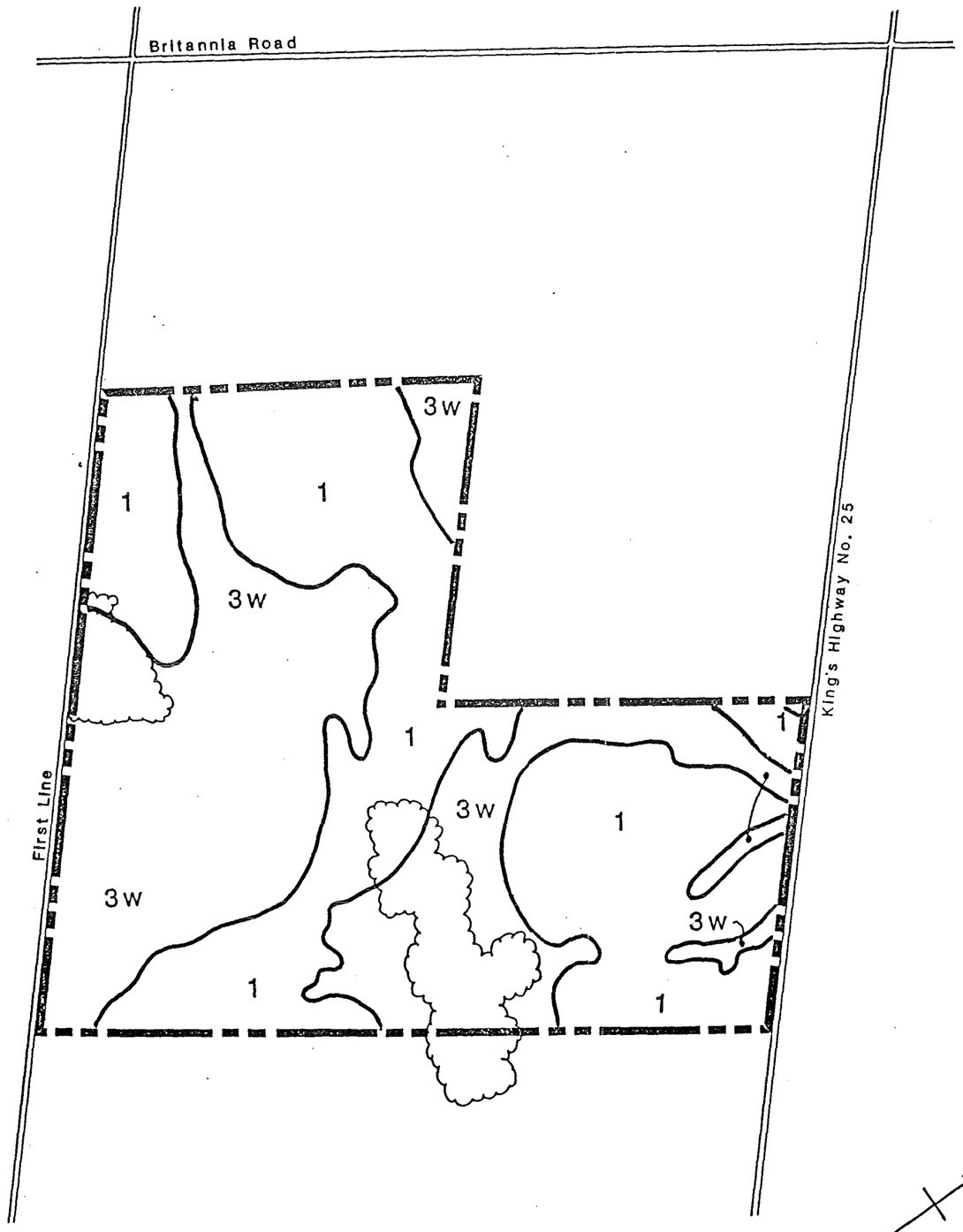
3.2.2 Site F

The soils on Site F have developed in slightly stony, fine textured,

TABLE 1: PERCENTAGE OCCURRENCE OF AGRICULTURE CAPABILITY CLASSES - SITES D AND F*

Capability Class	SITE D		SITE F	
	Area (ha)	Per Cent	Area (ha)	Per Cent
1	71.2	51	---	---
2	---	---	17.8	19
3	68.4	49	---	---
4	---	---	23.5	25
7	---	---	52.5	56
TOTAL	139.6	100	93.8	100

* as per Maps 2 and 3, respectively



LEGEND

site plan area

wooded

capability class → 3W ← capability subclass

CAPABILITY SUBCLASS	LIMITATION TYPE
W	excess water

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THE REGIONAL MUNICIPALITY OF HALTON

Halton Region Landfill
Technical Study

SITE D - SOIL SAMPLE POINTS
SOIL CAPABILITY
FOR AGRICULTURE

Ecological Services for Planning Ltd.

DATE: July/86
PROJECT NO.: GRH03

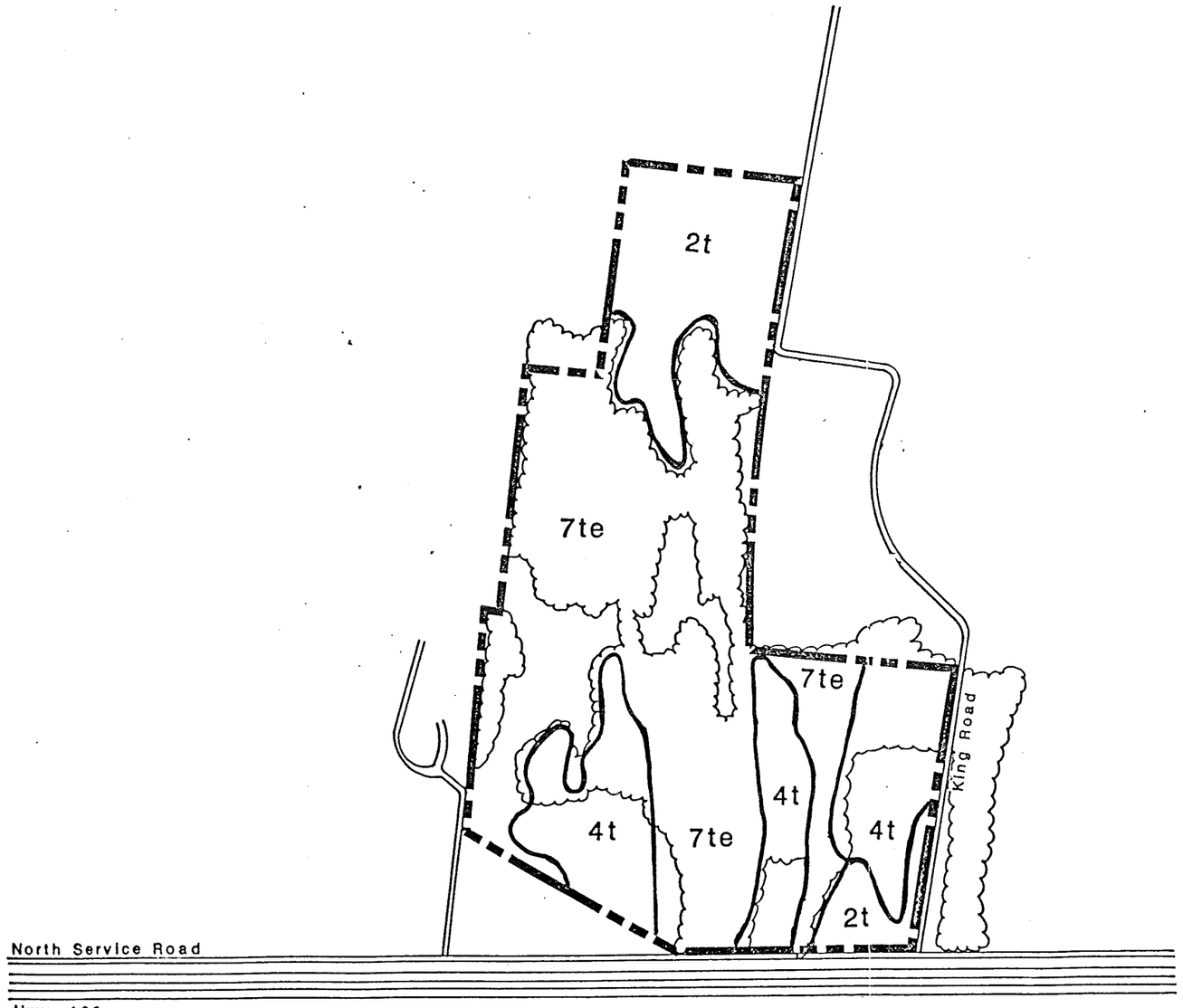
MAP NO. 2

glacial till. Bedrock, consisting of reddish Queenston shale, outcrops at the surface in steeply sloping areas. Elsewhere onsite, bedrock is generally found within 10 meters or less of the soil surface.

Only one Soil Series, the moderately well drained Oneida Series, is found on Site F. The Oneida soils are moderately well drained and occur on very gently to very strongly sloping, complex topography. These soils normally have a 15 to 20 cm thick, dark brown, loam to clay loam surface A horizon overlying a 40 to 45 cm thick, brown to reddish brown, clay loam B horizon. The C horizon is a slightly stony, dark brown to dark yellowish brown, clay loam till.

Oneida soils are high in natural fertility, and are rated as CLI Class 1 for agriculture where slopes are not a limiting factor. In the southern part of the Site F lands, just north of the Ontario Hydro corridor, Oneida soils are found on moderate sloping complex topography. They do not appear to be severely eroded and have been rated CLI Class 4. In the extreme northern part and in the southeast corner of Site F, Oneida soils have developed on very gently sloping topography and are rated as CLI Class 2. Within Site F, there is a significant area of highly eroded soils which occur primarily on very strong sloping, complex topography. The soils found on these slopes are rated as CL1 Class 7 due to topography and erosion limitations.

The Soil Series and slope categories form the basis for the soil capability for agriculture ratings (Map 3). The relative occurrence



LEGEND

site plan area

wooded

capability class 7te capability subclass

CAPABILITY SUBCLASS	LIMITATION TYPE
t	topography
e	erosion damage

scale – 1:10,000

THE REGIONAL MUNICIPALITY OF HALTON

Halton Region Landfill Technical Study

SITE F – SOIL SAMPLE POINTS SOIL CAPABILITY FOR AGRICULTURE

Ecological Services for Planning Ltd.

DATE: July/86
PROJECT NO.: GRH03

MAP NO. 3

of the soil capability classes was calculated with a planimeter (Table 1). Site F consists of 56 percent Class 7 soils, 25 percent Class 4 and 19 percent Class 2 lands. Sample points and a more detailed analyses of physical and chemical soil characteristics for Sites D and F are found in Appendix B and C, respectively.

3.3 Rehabilitation Problems

On both sites, replacement of an adequate rooting medium consisting of one meter of topsoil plus B and C horizons overlying 0.5 m of clay cover is recommended for agricultural restoration. Minimum total thickness of the cover materials should be 1.5 m.

Sufficient topsoil and subsoil are available for restoration purposes at Site D (Hydrology Consultants of Trow Limited). A shortage of existing topsoil and subsoil will create major rehabilitation problems at Site F, since large quantities of these materials have to be trucked from off site (Table 2).

Calculations to determine the availability of topsoil and subsoil for rehabilitation purposes on Site F were done using the areas of Class 2 and 4 lands which contain a complete soil profile (Class 7 areas usually lack A and B horizons due to erosion). Since soil is not being stripped from the buffer zones, these areas were subtracted from the area of soils having a complete solum. Table 2 shows the amount of soil material available on Site F which could be used for restoration purposes, and provides a means for estimating the amount of material to be imported to provide 1 m of rooting medium, in addition to the 0.5 m clay cover (Figure 1).

TABLE 2. SOIL COVER REQUIREMENTS FOR REHABILITATION-SITE F

	Ap horizon* (m^3 x 1000)	B+C horizon** (m^3 x 1000)	Total (m^3 x 1000)
Soil required (69.8 ha)	139.6	558.4	698.0
Soil available onsite (27.0 ha - exclusive of buffer zones)	54.0	216.0	270.0
Soil required from offsite	85.6	342.4	428.0

*assume Ap horizon (topsoil) depth-20 cm
**assume B+C horizon depth-80 cm

Natural gas venting will occur along fissures and failure planes in the clay cover at both sites and localized impacts on plant growth can be expected. Further, provision is included in the final design for installation of a gas venting system at Site D, if required.

3.4 Ongoing Post-Rehabilitation Problems

Ongoing post-rehabilitation problems will be similar on both sites. These include differential settlement and regrading for maintenance of surface drainage and farm machinery operations.

Monitoring programs are required on both sites.

3.5 Relative Costs of Rehabilitation

The relative costs of rehabilitation are shown in Table 3. These costs are based on the amount of soil material available for restoration at each site, agricultural subsoiling and negative returns to cropping. Other costs of rehabilitation, e.g. soil grading, fertilization, etc., have not been included since they will be similar for both sites. Table 2 outlines the soil cover requirements while Table 4 itemizes the relative costs for initial land rehabilitation. The cost estimates are based on a minimum rooting zone of 1 m. The 0.5 m clay cover (Figure 1) is not included in the cost estimate. Costs for topsoil/subsoil are excluded at Site D since adequate materials are available onsite.

TABLE 3: FEASIBILITY OF AGRICULTURAL REHABILITATION- SITES D AND F

CHARACTERISTICS	SITE D	SITE F
1. On-site and Surrounding Agricultural Characteristics		
o Area of Site	139.6 ha	93.8 ha
o Land Quality		
Class 1 and 2	51%	19%
Class 3	49%	--
Class 4	--	25%
Class 7	--	56%
o Depth of Overburden	>15 m	0-1 m in south part increasing to 10 m in north part
o Present surrounding activity	agriculture	quarry, active landfill site, closed landfill site, hobby farms
o Surrounding agricultural activity (1981 Census data)		
Number of farms	32	14
Farmed area	1479 ha	233 ha
Number of owner operated farms	17	12
Owner operated farm area	237 ha	175 ha
Farm area rental	932 ha	58 ha
o Road access to site	Hwy. 25; Concession roads	Off Hwy.403 via North Service Road; back entrance from escarpment via King Road
o Agricultural Ranking from Environmental Assessment Report	High agricultural impact	Low agricultural impact

Table 3 (cont'd)	SITE D	SITE F
2. Rehabilitation Problems		
o Site design requirements Minimum cover over garbage- 1.5 m	Material available (CL-SiC)	Material available (SiCL-weathered Queenston shale)
o 1m topsoil/subsoil over clay cover to ensure adequate rooting medium	Topsoil/ subsoil available on site	Large quantities of topsoil/ subsoil required from off-site
o Gas venting system	Natural gas venting restricted to failures in clay seal; minimizes cropping area exposed to injury	Similar to Site D
o Final surface contoured to 1-5% slopes	Site presently flat	Present slopes 5-10% up to 20-25% on valley side slopes
3. Ongoing Post Rehabilitation Problems		
o Subsidence	Ongoing	Ongoing
o Differential Settlement	Levelling or grading required for drainage and farm machinery operation	Same as Site D

Table 3 (cont'd)	SITE D	SITE F
3. Ongoing Post Rehabilitation Problems	(cont'd)	
o Monitoring Program for soil chemical and physical properties and crop production	Required	Required
4. Relative Cost of Rehabilitation*		
o Soil replacement:		
Topsoil & Subsoil	----	$3,077,300
Hauling	----	1,813,500
o Agricultural Subsoiling	$ 31,500	29,900
o Negative returns to cropping (forage over 25 year period)*	107,200	101,900
	$138,700	$5,022,600
o Monitoring program	similar on both sites.	

* See Appendix A for details of cost/benefit analysis related to alternative cropping systems for site rehabilitation.

Table 4: Relative Land Rehabilitation Cost Requirements by Site*

	Site D	Site F
	(1985 dollars)	
Additional Topsoil/Subsoil - 428,000 cu.m. @ $7.19	**	3,077,300
Topsoil Haulage - 725,417 tonnes @ 5c/tonne/km assuming 50km round trip	**	1,813,500
Agricultural Subsoiling - 72.9ha @ $432	31,500	
- 69.3ha @ $432		29,900
Total Investment Cost	31,500	4,920,700

* Cost estimate based on a minimum rooting zone of 1 m, exclusive of the 0.5 m clay cover. The cost of spreading topsoil/subsoil is not included in these estimates.

** Adequate topsoil/subsoil available onsite.

Soil replacement costs for Site F will be extremely high and are a major constraint to rehabilitating the landfill site to an agricultural afteruse. A cost/benefit analysis for restoring Sites D and F to an agricultural afteruse is found in Appendix A. The analysis has been developed for three alternative cropping systems.

3.6 Summary

A summary of the characteristics used in assessing the feasibility of rehabilitating Sites D and F to an agricultural afteruse is presented in Table 3. There are several obvious differences between the two sites:

- Site D is located in an area where the surrounding land use activities are primarily agriculture, whereas land use activities adjacent to Site F are primarily non-agricultural in nature.

- Site D is located on lands with medium to high soil capability for agriculture, whereas Site F contains lands that are mostly marginal or non-productive for arable agriculture.

- Availability of soil material for rehabilitation purposes significantly adds to the cost for Site F (Table 4). Relative rehabilitation costs for Site D,

including the cost of subsoiling and negative returns on crops, vary from $138,300 to $190,800 (Appendix A) depending on the crop rotation used. Large quantities of topsoil/subsoil suitable for agricultural rehabilitation must be imported for Site F. This increases the costs of rehabilitation to an estimated $5,022,600 over the 25 year period (Table 3).

Given the foregoing, rehabilitation of Site F to an agricultural after use is not recommended.

4.0 DETAILED AGRICULTURAL REHABILITATION PROGRAM - SITE D

A series of guidelines and recommendations have been formulated to ensure that agricultural rehabilitation of Site D can be achieved. Site F is not considered in this section, since an agricultural after use is not recommended for the site. The guidelines outlined in the following sections describe aspects of soil stripping and stockpiling, reapplication of soil material, soil restoration, post-rehabilitation land management and post-rehabilitation monitoring requirements.

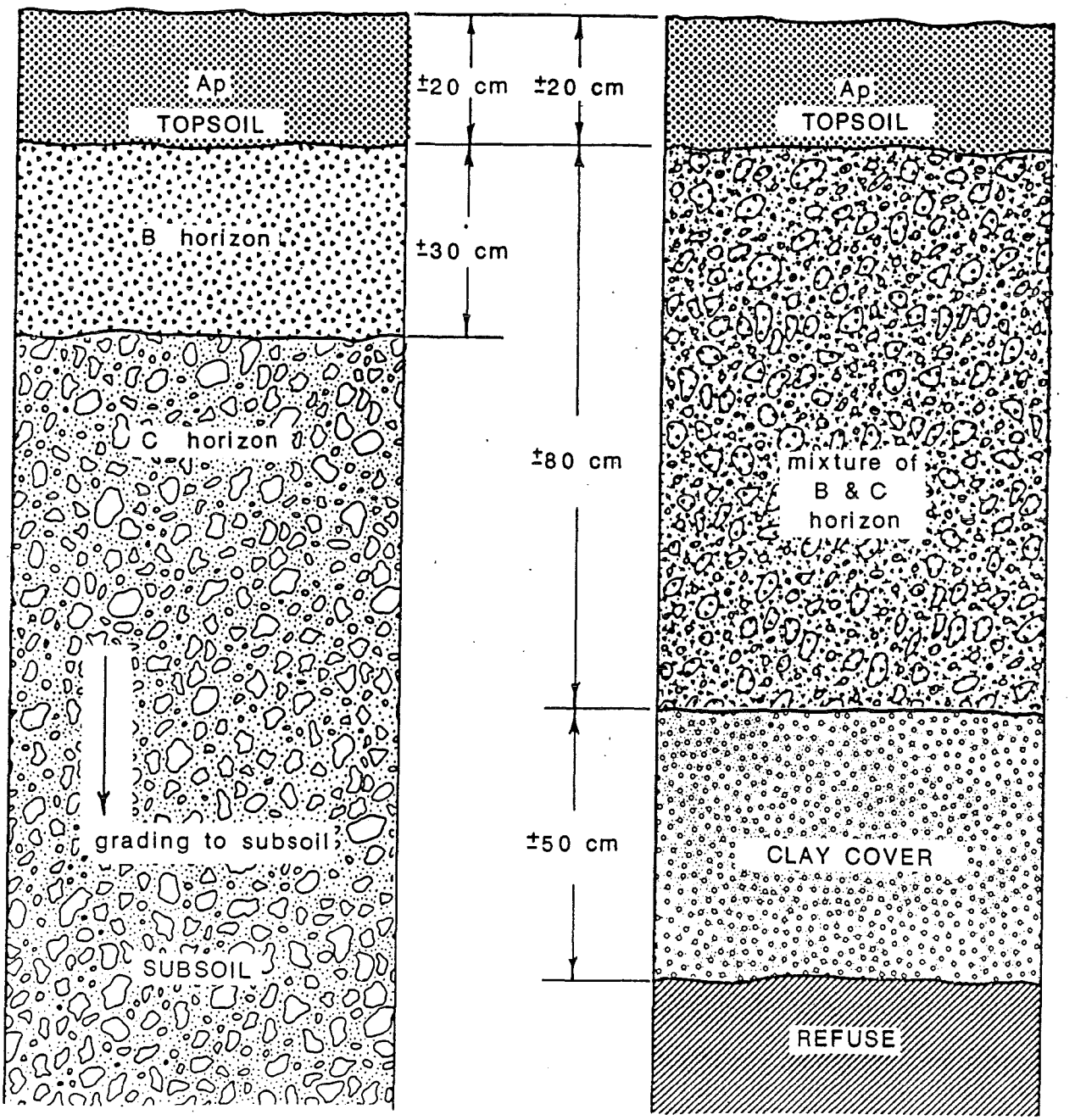
Recommendations developed for each specific section are numbered consecutively.

4.1 Soil Stripping and Stockpiling

A major concern is that sufficient quantities of topsoil and subsoil materials are stockpiled and available for reapplication during the various stages of site rehabilitation.

A minimum of 1.5 m is recommended for reapplication over the final lift of garbage (Figure 1). This should consist of 1 m of rooting medium plus 0.5 m of clay cover. All replacement material is available onsite. The 20 cm of Ap horizon (topsoil) and 80 cm of B plus C horizons should be stripped and stockpiled separately.

Figure 1 - GENERAL DESCRIPTION OF SOIL CONDITIONS - SITE D



Specific recommendations for stripping and stockpiling include:

1) To avoid erosion and loss of materials, it is preferable that only small areas are stripped and exposed for excavation at any one time as part of an overall progressive rehabilitation program;

2) Stripping should be carried out in such a manner so as to ensure separation of the A horizon (topsoil) from the underlying B and C horizons;

3) To avoid mixing of topsoil and subsoil, topsoil should be stored in stockpiles separate from other subsoil or overburden materials. Seeding or mulching of all stockpiles should be carried out to avoid loss by soil erosion;

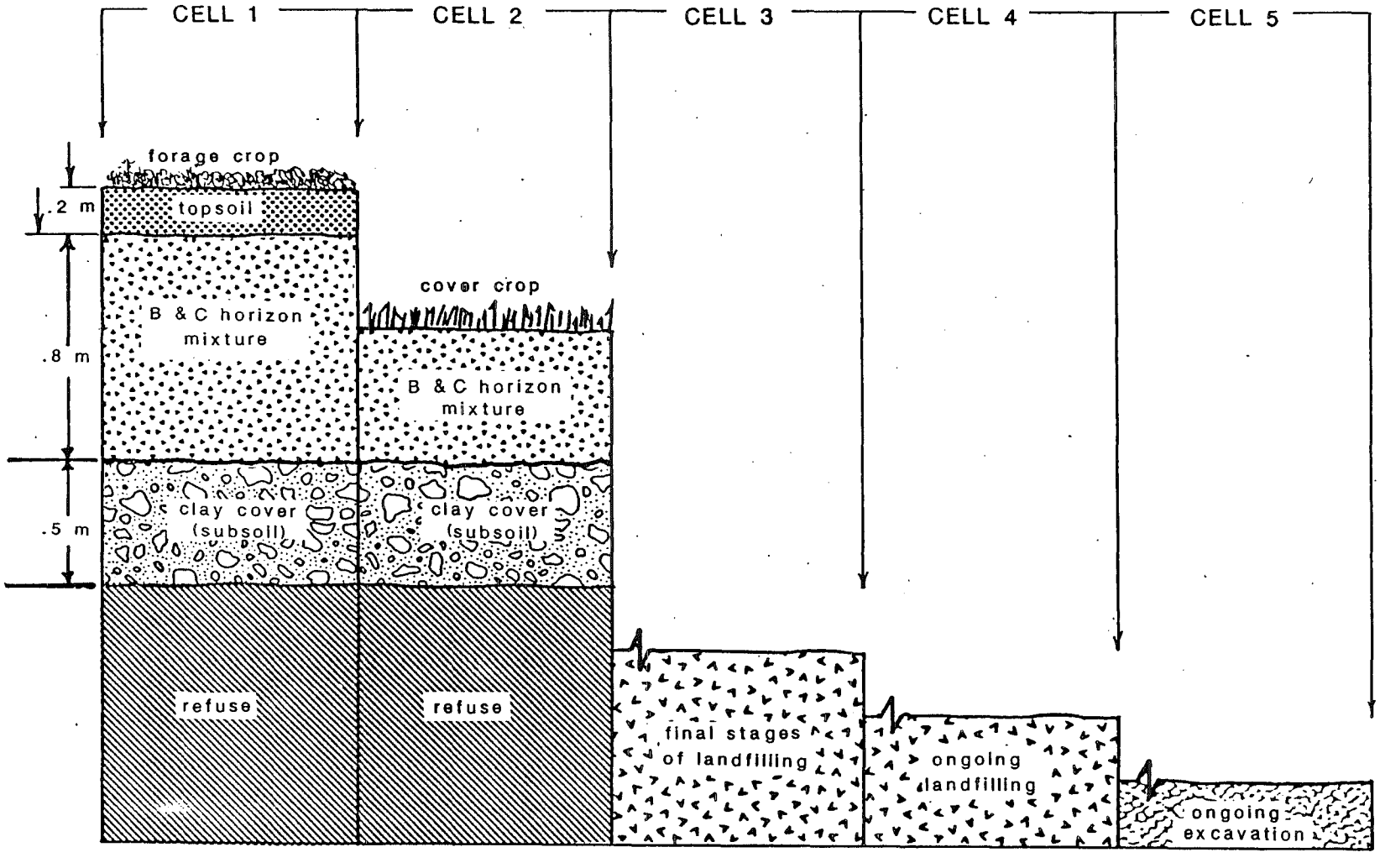
4) The initial development works will include construction of a berm. The berm could be covered with topsoil stripped from the first cell and retained for topsoil cover and reapplication on the final cell.

4.2. Reapplication of Soil Material

The degree of soil compaction can be minimized by spreading the clayey subsoil material and the topsoil when the materials are as dry as possible.

The sequence of filling (i.e. cell design), will also reduce the impact of differential settlement on rehabilitation for agricultural purposes. Final design contains 5 cells. As cell 1 is being filled with refuse, cell 2 is being excavated. Thus at the end of 3-5 years, cell 1 can be completed to near final grade with the application of 1 m or more of subsoil. Final application of subsoil and topsoil can follow at a later date, once subsidence is minimized (Figure 2).

Figure 2 - IDEALIZED REHABILITATION SEQUENCE



* minimum depth

Final surface grading should ensure adequate surface drainage without contributing to a soil water erosion hazard. The final grade on top of the landfill should contain slopes 5 percent or less.

The following recommendations refer to reapplication of soil materials:

(5) Application and spreading of the final 1 m of cover consisting of topsoil and the B+C horizon mixture should be conducted during the dry summer months where possible.

(6) The final grade on top of the landfill should not exceed approximately 5 percent.

Filling and rehabilitation of the cells will be progressive and final grading and reapplication of topsoil will allow for an adequate period of subsidence.

4.3 Soil Restoration

Following reapplication of topsoil/subsoil onto the clay cover, a program of tillage, organic matter additions and cropping is required to amend soil fertility and soil structure, and to return the site to full agricultural production.

The program outlined in this section is a long term venture designed to achieve several objectives:

- to ameliorate adverse soil physical and chemical conditions;
- to allow sufficient time for the cropping program to ameliorate adverse impacts;
- to allow for effective management of soil erosion and drainage and correction of microrelief associated with differential settlement; and
- to allow monitoring of progress and adjustments to the program, as required.

4.3.1 Tillage

The main limitations in establishing and maintaining agricultural production on the rehabilitated landfill site will be the physical condition of the soil reapplied to the clay cover (Figure 1).

Spreading the subsoil and topsoil over the clay cover could result in soil bulk densities of 1.6 to 1.9 gm/cm^3. Existing onsite bulk densities range from 1.5 - 1.7gm/cm^3 in the B and C horizons. Root penetration and growth of corn is progressively reduced at bulk densities greater than 1.4 gm/cm^3 and is severely restricted at densities in excess of 1.7 gm/cm^3. Good soil structural development in the B and C horizons compensates for root growth at progressively higher bulk densities. However, soil structure will be destroyed during stripping and reapplication procedures. It will be necessary, therefore, to subsoil the compacted layers to promote the development of a good rooting medium.

Subsoiling with an agricultural subsoiler will reduce soil compaction in the surface 60 cm. Shattering of compacted soils by subsoilers is most effective at soil moisture levels below field capacity.

(7) It is recommended, therefore, that the site should be subsoiled following final grading to a depth of 60 cm during June to September, when the soil moisture levels are at or below field capacity levels.

4.3.2 Soil Structure Development

The natural sequence of soil horizons will be destroyed in the stripping and stockpiling operations. Soil structure is also destroyed, and as a result, the soils will be more susceptible to soil erosion and crusting.

(8) The application of soil organic matter is, therefore, recommended to improve soil structure and the development of soil fertility.

Livestock manure and/or sewage sludge could be utilized. Application of sludge treatments in the soil restoration program must be carried out in compliance with the "Guidelines For Sewage Sludge Utilization On Agricultural Lands", (Ministries of Agriculture and Food, Environment, and Health, Revised January, 1986). Sufficient quantitities of processed sewage sludge may be available from Municipal Water Pollution Control Plants in Halton Region, including the Oakville, Georgetown, Acton and Milton plants.

4.3.3 Interim Cropping

Cell 1 will be filled and brought to near final grade with the application of approximately 1 or more metres of subsoil (Figure 2) 3-5 years after the landfill site is opened. Similarly, cell 2 will be completed in 6-8 years and so on.

(9) It is recommended, therefore, that as each cell is finished to near final grade, the soil should be cultivated and seeded with a forage and cover crop of oats or rye. The site should be fertilized according to soil test values.

TABLE 5: ALTERNATIVE CROP ROTATIONS FOR AGRICULTURAL REHABILITATION OF LANDFILL SITE

	INTENSIVE		PASSIVE
Year	Cropping System - 1	Cropping System - 2	Cropping System
1	Red clover/timothy hay	Red Clover/timothy hay	Bird'sfoot Trefoil
2	"	"	"
3	"	"	"
4	"	"	"
5	Corn	Corn	"
6	Corn	Corn	"
7	Barley	Red Clover/timothy hay	"
8	Winter wheat	Red Clover/timothy hay	"
9	Red Clover/timothy hay	Corn	"
10	Red Clover/timothy hay	Corn	"
11 to 25	Repeats sequence of years 5-10	Repeats years 7-10 sequence	"

The forage/legume mixture should be seeded in the spring, if possible. Fall seeding is also suitable, but less desirable. The sod cover can be left until final grading and application of topsoil.

4.3.4 Long Term Cropping

As each cell receives the final reapplication of subsoil and topsoil and is graded, the long term cropping program can be implemented. Alternative cropping sequences which provide an opportunity for both intensive and passive agricultural after-uses have been outlined for a 25 year period (Table 5).

(10) It is recommended that a forage (legume or legume/grass) crop should be grown on the site for the first 4-5 years following rehabilitation to add organic matter and improve soil structure and fertility. The side slope of the landfill should remain in permanent forage.

Following the initial period of forage production, several alternative crop rotation sequences can be implemented. Those shown in Table 5 are examples and they have been used as the basis for the economic analysis (Appendix A). Corn and coarse grains will be the common cash crops used in these rotations. The forage crop suggested for use in the crop rotations is a red clover/timothy hay mixture. Timothy is generally easy to establish and maintain and will grow under a wide range of environments. It is well adapted to heavier soil types and variably drained fields. Red clover (a

biennial) is useful in rotations to add nitrogen and organic matter to the soil and for breaking insect and disease cycles. A heavily branched rooting system which is usually concentrated in the top 20 cm of soil makes red clover valuable for improvement of soil structure.

4.4 Post Rehabilitation Land Management

The concept of the proposed landfill operation as an interim land use places responsibility on the Region of Halton to ensure successful completion of the proposed soil restoration and associated cropping program at Site D. Options available for management of the restoration program and subsequent agricultural enterprise, must fulfill these long term agricultural use objectives and guarantee against future land abandonment. The options available are also subject to the following constraints:

- the soil restoration and cropping program covers a minimum time period of 25 years following closure of each stage of landfilling;
- the first eight years of the proposed cropping program involve the initial phases of tillage and fertilizer adjustment, stringent cropping procedures, regular monitoring of progress and related specialized operations to remediate fertilization, compaction and settlement problems. Implementation is best accomplished by working in conjunction with a local farmer through a leasing or rental agreement;
- in the first few years of the program, costs will be higher than average, while yields will be below average.

The above factors lead to the following recommendations:

(11) The Region of Halton should retain ownership of the site, after the period of active landfilling, and for the duration of the 25 year soil restoration and cropping program.

(12) The Region of Halton should retain the services of a local area farmer to undertaken onsite agricultural activities and operations during this period.

track record of doing this?

(13) Upon completion of 25 year program, the Region of Halton could consider options for sale of the lands for agricultural purposes or could engage in long term lease agreements with area farmers.

4.5 Post-Rehabilitation Monitoring Program

To ensure the success of the proposed landfill agricultural reclamation project, it will be necessary to monitor and supervise various stages of the program. Various references to monitoring have been made in earlier recommendations concerned with specific aspects of the program. The following recommendations deal with the monitoring and supervisory activities required to ensure successful rehabilitation:

(14) Supervision of the agricultural rehabilitation program should be carried out under the direction of a qualified pedologist and/or agronomist.

(15) Onsite supervision during stripping and reapplication of soil should include the following responsibilities, among others:

- to advise on stripping depths of A and B soil horizons and ensure maximum volume of topsoil is stripped;
- to ensure material reapplication is carried out when materials are as dry as possible and in such a way as to minimize compaction; and

- o to ensure adequate and consistent depths of soil are reapplied over the landfill surface and that grades are consistent with recommended guidelines for proper soil drainage and erosion control.

(15) Onsite supervision during soil restoration should include the following responsibilities:

- o to assess post rehabilitation (base line) soil compaction and soil fertility;
- o to monitor progress in relieving soil compaction and identify problem areas for ongoing subsoiling;
- o to monitor site drainage, soil fertility, soil erosion and subsidence or settlement for recommendation of site specific requirements for land levelling or planing;
- o to carry out a regular program of soil testing to ensure that sufficient levels for phosphorus and potassium are attained and maintained;
- o to monitor crop rotation sequences and record annual crop yields;
- o to carry out tests in zones of apparent crop injury or low yield, to determine the presence of harmful concentrations of landfill gases and/or adverse soil physical conditions; and
- o to monitor runoff in perimeter ditches for sediment and contaminants indicative of soil erosion or leachate runoff problems.

5.0 REFERENCES CITED

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Gillespie, J.E., R.E. Wicklund and M.H. Miller. 1970. The Soils of Halton County. Report No. 43 of the Ontario Soil Survey.

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A P P E N D I X A

"Economic Analysis of Rehabilitating Landfill Sites for Agricultural Production"

A Report Submitted to

Ecological Services for Planning Ltd.

by

Farm Analytics

(D. Peter Stonehouse, Ph.D.)

January, 1986

Problem Situation, Scope and Objectives

Landfill on agricultural lands is one of the more common methods of municipal waste disposal in Ontario. With appropriate treatment, landfill sites can be rendered free from environmental hazards and made suitable for a wide variety of uses in agriculture. These uses include the commonly-grown field crops, such as cereal grains, corn and pasture/forage crops, vegetable crops and any fruit crops that are shallow-rooted. Excluded would be any deep-rooted crops, such as fruit trees, other trees and alfalfa, whose root systems would be capable of penetrating the landfill cover material.

The objective of this analysis is to evaluate the longterm economics of rehabilitating and using the landfill site in an agricultural capacity only. Attention is centered on cash cropping of field crops commonly grown in Ontario. Specifically, the objectives are:

1. to compile the investment outlays necessary for initial rehabilitation of two different sites (Site D and Site F), in the first year following completion of landfill disposal of municipal wastes;

2. to estimate the present value of the future flow of annual net benefits of these two sites over an assumed Halton Region ownership horizon of 25 years, using several crop rotation alternatives;

3. to estimate the net present value (annual net benefits minus investment outlays) for each crop rotation alternative, compare them and make recommendations.

Investment Outlays for Rehabilitation

Regardless of eventual agricultural use, certain operations are required for initial restoration of each site. Additional topsoil may be needed to supplement that preserved at Site F during the landfilling process. The topsoil has to be transported and spread. Subsoiling with an agricultural subsoiler will be a necessary operation at Sites D and F for improvement of aeration and drainage in the plant rooting zones. The rehabilitation operations required for each of Sites D and F, together with their estimated costs, are shown in Table A-1.

Selection of Crop Rotational Systems

Forage crops (grasses and clovers) should be grown for the first few years following rehabilitation to improve soil structure and soil fertility. Red clover (a biennial) and timothy are recommended, with reseeding every two years. Further reliance on forage crops over a longer term horizon would no doubt engender a more complete restoration of the topsoil, so that permanent forage cropping becomes one candidate cropping system. Perennial clovers like trefoil are to be preferred over biennials such as red clover, to obviate the costs of re-seeding every two years.

Table A-1: Initial Land Restoration Investment Requirements, by Site*

	Site D	Site F
	(1985 dollars)	
Additional Topsoil - 428,000 cu.m. @ $7.19	-	3,077,300
Topsoil Haulage - 725,417 tonnes @ 5c/tonne/km for 50 km	-	1,813,500
Subsoiling - 72.9ha @ $432	31,500	
- 69.3ha @ $432		29,900
Total Investment Cost	31,500	4,920,700

*as per Section 4.3.4, Table 4.

One of the principal cash crops in southern Ontario currently is grain corn. This crop should be grown only in conjunction with forage crops on a rotating basis, because of grain corn's propensity to cause structural breakdown of and net loss of organic matter in topsoils. Part of the cultural practice characterizing grain corn is the use of the broad-spectrum weed killer, atrazine, whose residual effects are typically felt for two years. Hence corn is most frequently grown for two years in succession.

Other major cash crops in southern Ontario are soybeans and cereal grains such as barley and winter wheat. A fairly typical rotation would be two years of corn followed by one year each of soybeans and winter wheat. However, soybeans do not grow well on rehabilitated clay sites. Therefore, soybeans are replaced by barley as the third-year crop in the rotation for purposes of this study. The potentially damaging effects of two years of corn on the topsoil could again be offset by two years of red clover and timothy, following the four years of other crops. The grass/clover crop can be seeded down with the winter wheat during the fourth year of this six-year rotation.

Crop Yields

Reduced crop yields can be expected during the initial years following rehabilitation due to adverse soil physical problems and

imbalances in soil nutrients. For the first year following replacement of topsoil and initial rehabilitation work, a grass-legume crop is expected to yield only 60 percent of the Halton Region average for hay crops (see Table A-2). Thereafter, yields can be expected to rise gradually through the fifth year, when 90 percent of the Halton Region average is anticipated.

Average crop yields over a number of recent years be used as a basis for assessing economic benefits and costs. With annual fluctuations in excess of 20 percent, as indicated in Table A-3, it is much safer to rely on a composite crop yield figure than on any one single year's figure, which may under- or overestimate the yield that can be reasonably expected on a long-term basis.

Crop Prices

Analogous to the case with crop yields, prices received by farmers for crops sold generally vary greatly among years. It is realistic to base economic benefits on an average of prices for a series of years and in this analysis, an average for the last five years is used (see Table A-4).

Production Costs and Gross and Net Returns

With some inflation still evident in the costs of resource inputs and services purchased by farmers, it is felt that reliance should be placed on the most recent set of crop production costs available from

Table A-2: Expected Hay Yield Profile Following Initial Restoration

Year following Initial Restoration	Percent of Halton Region Yield Expected	5-Year Average* Halton Region Hay Yield	Hay Yield on Landfill Site
		(tonnes/ha)	(tonnes/ha)
1st	60	6.63	3.98
2nd	70	"	4.64
3rd	80	"	5.30
4th	85	"	5.64
5th and Subsequent	90	"	5.97

*See Table A-3

Table A-3: Average Yields for Field Crops - Region of Halton

	Grain Corn	Barley	Winter Wheat	Hay
		(tonnes/ha)		
1980	5.27	3.28	2.56	5.58
1981	5.59	3.28	3.03	7.17
1982	4.14	3.28	2.42	6.73
1983	4.58	2.21	2.69	6.95
1984	5.52	3.50	3.70	6.73
5-Year Average	5.02	3.11	2.88	6.63
90% 5-Year Average	4.52	2.80	2.59	5.97

Source: Ont. Min. Agric. & Food, Publication 20, "Agricultural Statistics for Ontario". Annual.

published sources. One reliable and frequently used source is the Ontario Ministry of Agriculture and Food's (OMAF) "Crop Budgeting Aid", published annually as a guide to production costs for the most commonly produced crops in Ontario, including all the crops being considered in this study. The most recently available edition is that for 1985. The method by which the OMAF compiles its estimates of crop machinery overhead costs is based on reigning custom hire charges for the machinery, plus the full cost of wages and benefits for labour used in operating the machinery.

Table A-5 depicts all production costs for each of the crops under consideration, under the sub-headings of direct and indirect costs, in dollars per hectare. Toward the bottom of Table A-5, expected gross revenues are calculated for each crop, based on the expected crop yield data from Table A-3 and crop price data from Table A-4. The net returns per crop are then calculated by difference, on a dollars-per-hectare basis. These net returns are in theory required to furnish compensation for the farm operator's own physical labour, management and risk inputs, plus compensation for investment in the cropland. The fact that negative net returns figures are indicated for three of the crops in Table A-5 should not be regarded with too much surprise, because only 90 percent crop yields are being expected on these landfill sites. In addition, the use of custom hire rates for machinery charges ensures that such non-cash costs as

TABLE A-4: Average Prices For Field Crops - Ontario

	Grain Corn	Barley	Winter Wheat	Hay
		($/tonne)		
1980	151	133	164	49
1981	115	122	157	50
1982	112	107	165	52
1983	159	140	146	56
1984	134	136	143	55
5-Year Average	134	128	155	52

Source: Ontario Ministry of Agriculture and Food, Publication 20, "Agricultural Statistics for Ontario". Annual.

TABLE A-5: Estimated Crop Production Costs, Gross Revenues and Net Returns

	Grain Corn	Barley	Winter Wheat	Red Clover/ Timothy Hay	Trefoil/ Timothy Hay
			($/ha)		
Direct Costs					
Materials (seed, etc.)	250	128	166	69	69
Establishment	-	-	-	78(a)	9(b)
Machinery Operating	94	64	62	98	98
Drying	79	-	-	-	-
Storage	42	12	-	-	-
Crop Insurance	17	12	15	15	15
Interest on Operating	37	12	27	16	16
Marketing	2	-	2	-	-
Subtotal Direct Costs	521	216	272	276	207
Indirect Costs					
Machinery Overhead	114	77	77	136	136
Miscellaneous	37	37	37	35	35
Total Costs	672	330	386	447	378
Gross Revenue (Tables 3 & 4) (Years 5 to 25)	606	358	401	310	310
Net Returns(c)	-66	28	15	-137	-68

Source: adapted from Ont. Min. Agric. & Food, "Crop Budgeting Aid, 1985".

a Amortized at 2.5% interest over 2 years.
b Amortized at 2.5% interest over 25 years.
c Net returns to Operator Labour, Land Investment, Managment & Risk.

depreciation and interest on capital investment are embodied on an "as-new" basis. Such an approach may overestimate machinery overhead charges for many farm businesses that purchase their machinery and equipment second-hand, and that have a large enough land base to reduce their overhead costs per hectare significantly.

Present Value of Investment in Agricultural Alternatives

The net returns estimates per hectare of each crop shown in Table A-5 on an average annual basis are incorporated into a 25-year profile in Table A-6, using the different crop rotational systems selected earlier for consideration in this study. In order to compare this profile of expected future annual net benefits on a realistic basis with the rehabilitation investment outlays made at the beginning of the 25-year benefits period, the annual net benefits must be transformed to present (1985) value terms. The discount rate selected for calculating the present values in this study is 2.5 percent, the rate traditionally employed by federal government departments in similar studies, and the rate generally acknowledged as representative of long-term real interest rates in Canada. The present value (discount) factors, together with the discounted annual net benefits for each crop rotation alternative, as displayed in Table A-6. For each rotation, the first four years' net benefits are shown based on clovers/grasses cropped for hay, using the gradually rising yields depicted in Table A-2. The cumulative net benefits for the 25-year horizon are also shown in Table A-6, for each rotation.

TABLE A-6: Expected Net Returns Profiles, by Crop Rotation

Year	Crop Rotation			Present Value Factor (2.5%)	Present (1985) Value		
	Corn, Barley, Wheat, Hay	Corn Hay	Continuous Trefoil Hay		Corn, Barley, Wheat, Hay	Corn, Hay	Trefoil Hay
	($/ha)				($/ha)		
1	-240 a	-240 a	-171	.9756	-234	-234	-169
2	-206 a	-206 a	-137	.9518	-196	-196	-130
3	-171 a	-171 a	-102	.9286	-159	-159	- 95
4	-154 a	-154 a	- 85	.9059	-140	-140	- 77
5	- 66	- 66	- 68	.8838	- 58	- 58	- 60
6	- 66	- 66	- 68	.8623	- 57	- 57	- 59
7	28	-137	- 68	.8413	23	-115	- 57
8	15	-137	- 68	.8207	12	-112	- 56
9	-137	- 66	- 68	.8007	-110	- 53	- 54
10	-137	- 66	- 68	.7812	-107	- 52	- 53
11	- 66	-137	- 68	.7621	- 50	-104	- 52
12	- 66	-137	- 68	.7435	- 49	-102	- 51
13	28	- 66	- 68	.7254	20	- 48	- 49
14	15	- 66	- 68	.7077	11	- 47	- 48
15	-137	-137	- 68	.6905	- 95	- 95	- 47
16	-137	-137	- 68	.6736	- 92	- 92	- 46
17	- 66	- 66	- 68	.6572	- 43	- 43	- 45
18	- 66	- 66	- 68	.6412	- 42	- 42	- 44
19	28	-137	- 68	.6244	18	- 86	- 43
20	15	-137	- 68	.6103	9	- 84	- 42
21	-137	- 66	- 68	.5954	- 82	- 39	- 40
22	-137	- 66	- 68	.5809	- 80	- 38	- 40
23	- 66	-137	- 58	.5667	- 37	- 78	- 39
24	- 66	-137	- 68	.5529	- 36	- 76	- 38
25	28	- 66	- 68	.5394	15	- 36	- 37
Total					-1,559	-2,186	-1,471

a Based on Red Clover/Timothy.

Using these net benefits figures and the rehabilitation investment outlays developed in Table A-1 for each of Sites D and F, the net present value figures can be derived according to the following formula:

$$N.P.V. = -I + \sum_{t=1}^{n} \frac{NR_t}{(1+i^t)}$$

where NPV represents Net Present Value, in 1985 real dollars,
-I represents the total investment outlay per Site,
NR represents the annual net benefits for each of t years to a total of n years, where n in this case is 25 years,
and $\frac{1}{(1+i)^t}$ represents the discount factor for each of t years with i in this case equal to 2.5 percent.

For Site D, the net present values for each rotation alternative in turn would be:

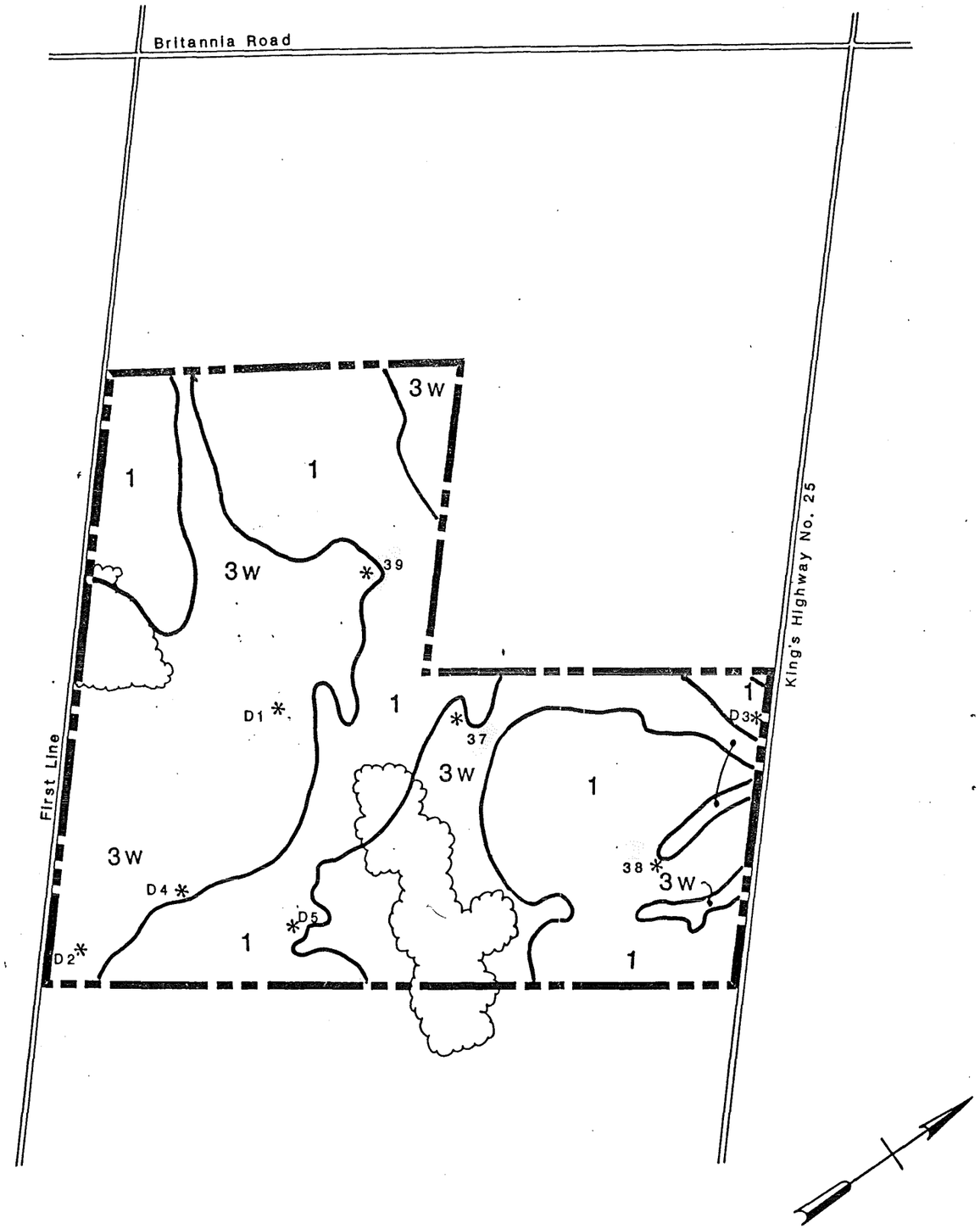
NPV (Corn/Barley/Wheat/Hay) = -31,500 + (-1,559/ha x 72.9ha)
= $145,151.
NPV (Corn/hay) = -31,500 + (-2,186/ha x 72.9ha)
= $190,859.
NPV (Continuous Trefoil Hay) = -31,500 + (-1,471/ha x 72.9ha)
= $138,736.

For Site F, the net present value for each rotation alternative in turn would be:

NPV (Corn/Barley/Wheat/Hay) = -4,920,700 + (-1,559/ha x 69.3ha)
= $5,028,739.
NPV (Corn/Hay) = -4.920,700 + (-2,186/ha x 69.3ha)
= $5,072,290.
NPV (Continuous Trefoil Hay) = -4,920,700 + (-1,471/ha x 69.3ha)
= $5,022,640.

APPENDIX B

SAMPLE SITE LOCATIONS



LEGEND

site plan area

wooded

capability class → 3W ← capability subclass

CAPABILITY SUBCLASS	LIMITATION TYPE
W	excess water

scale - 1:10,000

THE REGIONAL MUNICIPALITY OF HALTON

Halton Region Landfill
Technical Study

SITE D - SOIL SAMPLE POINTS
SOIL CAPABILITY
FOR AGRICULTURE

Ecological Services for Planning Ltd.

DATE: July/86
PROJECT NO.: GRH03

MAP NO. 2a

LEGEND

site plan area

wooded

capability class 7te capability subclass

CAPABILITY SUBCLASS	LIMITATION TYPE
t	topography
e	erosion damage

scale - 1:10,000

THE REGIONAL MUNICIPALITY OF HALTON

Halton Region Landfill Technical Study

SITE F - SOIL SAMPLE POINTS SOIL CAPABILITY FOR AGRICULTURE

Ecological Services for Planning Ltd.

DATE : July/86

PROJECT NO. : GRH03

MAP NO. 3a

APPENDIX C

SOIL CHEMICAL AND PHYSICAL ANALYSES

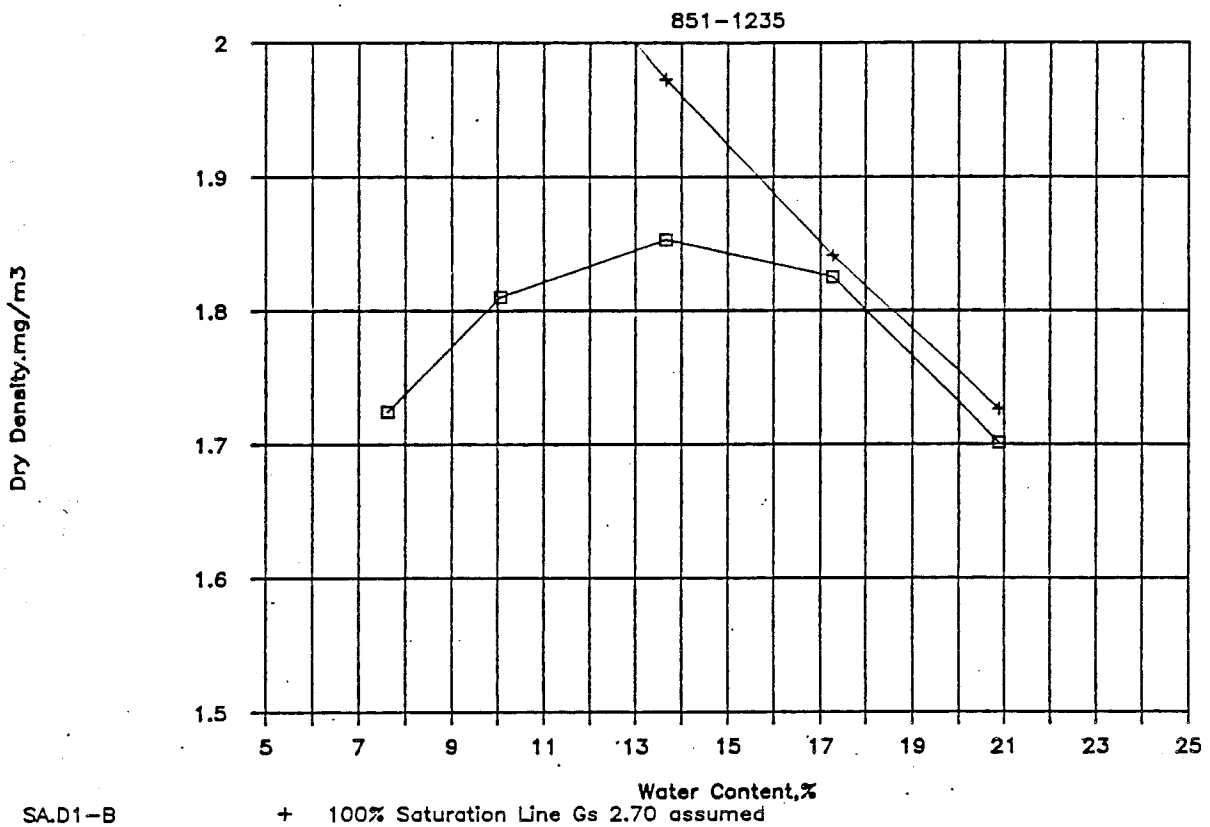
SUMMARY OF PHYSICAL AND CHEMICAL SOIL CHARACTERISTICS FOR SITES D AND F

Sample #	Horizon	Sand	Silt	Clay	Ph	Organic Matter (per cent)	Carbonate (per cent)	Soil Test Results			Liquid Limit %	Plastic Limit %	Maximum Dry Density mg/m^3	Bulk Density	
								Phosphorus	Potassium	Magnesium				Depth	g/cc
D1	Ap	23	46	31	6.3	2.9		14	110	230				10–15	1.57
	Btg	16	39	45	6.5			5	88	232	52	30	1.85	10–15	1.54
	CKg	16	46	38	7.5		23.51	4	68	290	38	24	1.908	45–50	1.69
														45–50	1.61
D2	Ap	24	49	27	7.4	3.2		14	68	244				15–20	1.58
	Btgj	11	39	50	7.6									15–20	1.50
	CKg	10	43	47	7.8		21.99							45–50	1.56
														45–50	1.65
D3	Ap	19.5	51	29.5	7.2	3.5		11	94	196				15–20	1.44
	Btgj	10.5	41	48.5	7.6									15–20	1.36
	CKgj	20.5	48	31.5	7.4		7.58							45–50	1.76
														45–50	1.79
F1	Ap	19	54	27	7.4	2.6		7	68	150				10–15	1.62
	Bt_1	9.5	39.5	51	6.9			17	100	188	57	35	1.833	10–15	1.62
	Bt_2	8	42	50	7.2									45–50	1.73
	CK	15.5	46.5	38	7.8		15.17				40	25	1.925	45–50	1.66
F2	CK	—	—	—	7.8		8.34	4	344	315	26	17	2.183		
F3	Ap	19	64	17	7.3	6.8		10	274	272					
	Bt	3.5	49.5	47	6.3			17	100	272					
	CK	8	60	32	7.6		9.86	4	110	148					

SHEET OF

FIGURE
D1 - B+g

MODIFIED PROCTOR TEST



SA.D1-B + 100% Saturation Line Gs 2.70 assumed

Maximum Dry Density	1.853 mg/m^3
Optimum Water Content	13.7%
Natural Water Content	24.1%
Liquid Limit	52%
Plastic Limit	30%

Date

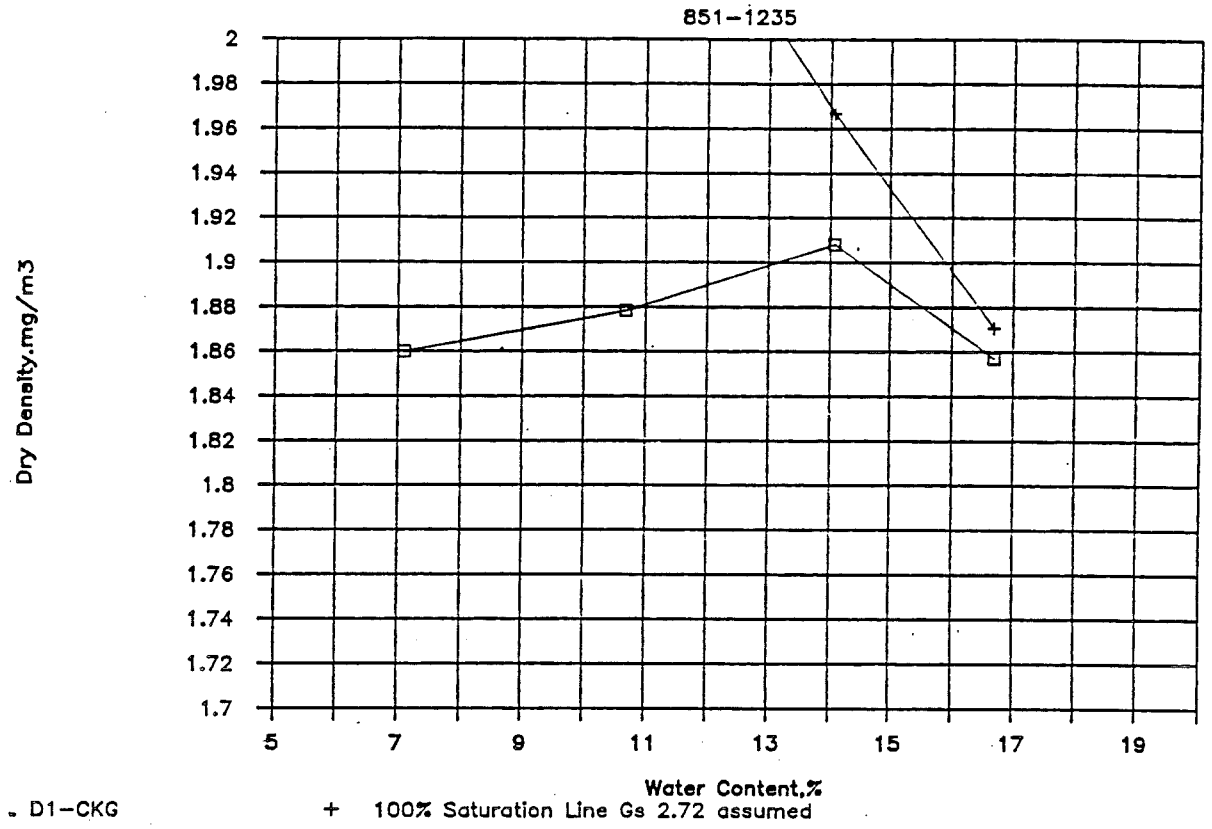
Data by

SHEET OF

FIGURE
D1 - CKG

MODIFIED PROCTOR TEST

851-1235



- D1-CKG + 100% Saturation Line Gs 2.72 assumed

Maximum Dry Density	1.908 mg/m^3
Optimum Water Content	14.1%
Natural Water Content	18.6%
Liquid Limit	38%
Plastic Limit	24%

Date

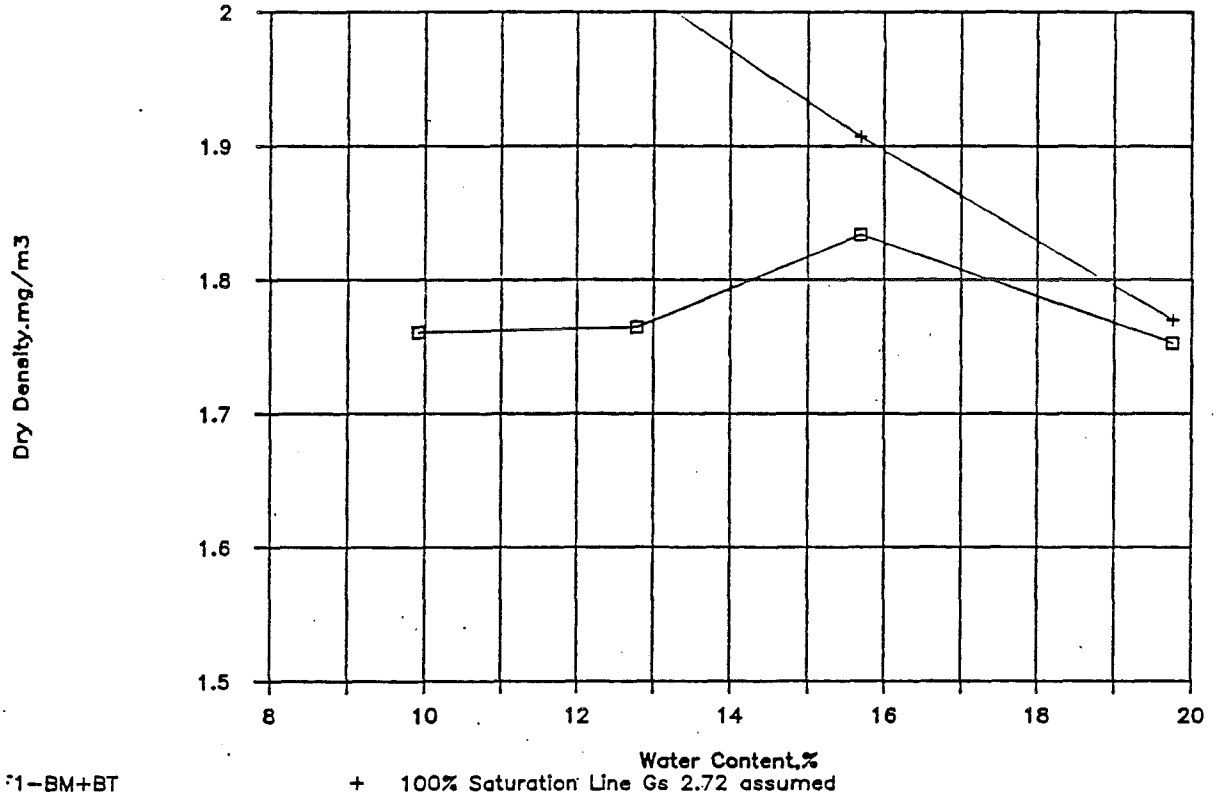
Data by

SHEET OF

FIGURE F1 - B+

MODIFIED PROCTOR TEST

851-1235



F1-BM+BT

\+ 100% Saturation Line Gs 2.72 assumed

Maximum Dry Density	1.833 mg/m^3
Optimum Water Content	15.7%
Natural Water Content	15.6%
Liquid Limit	57%
Plastic Limit	35%

Date

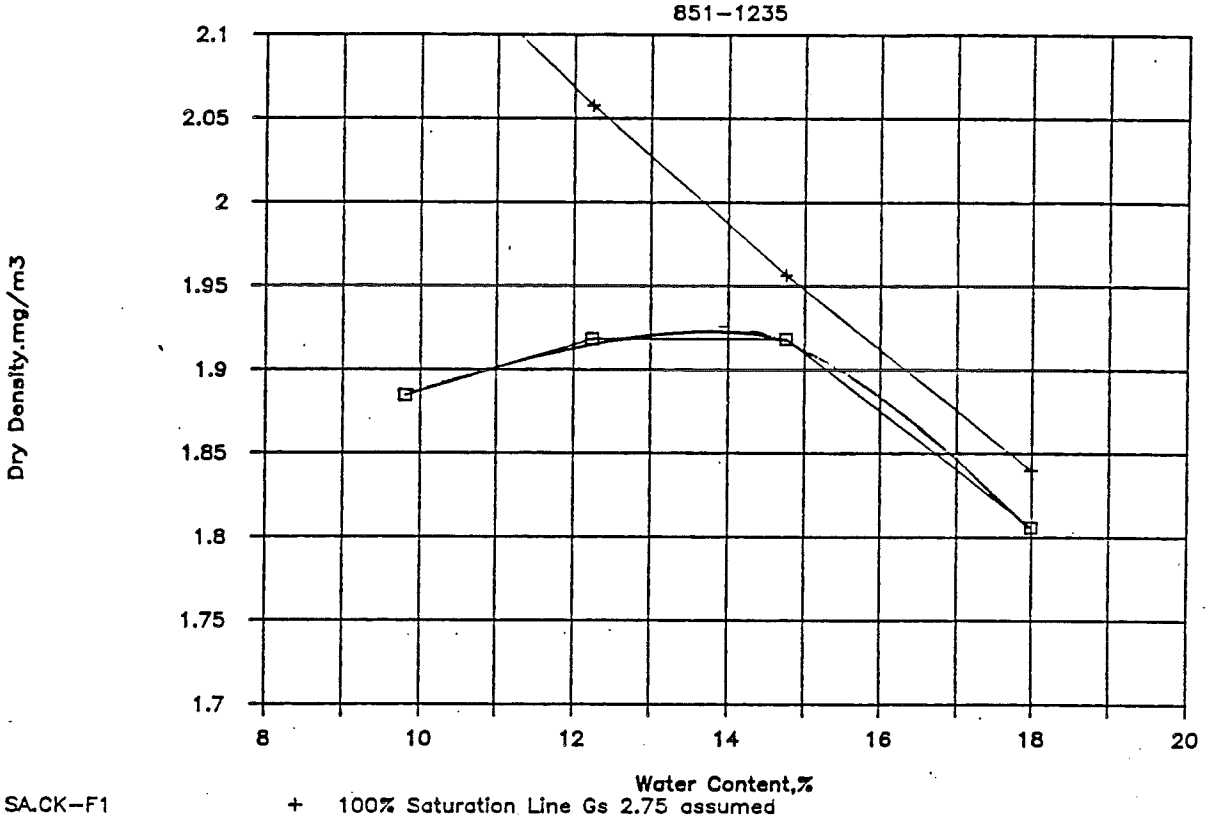
Project

Golder Associates

Data by

MODIFIED PROCTOR TEST

851-1235



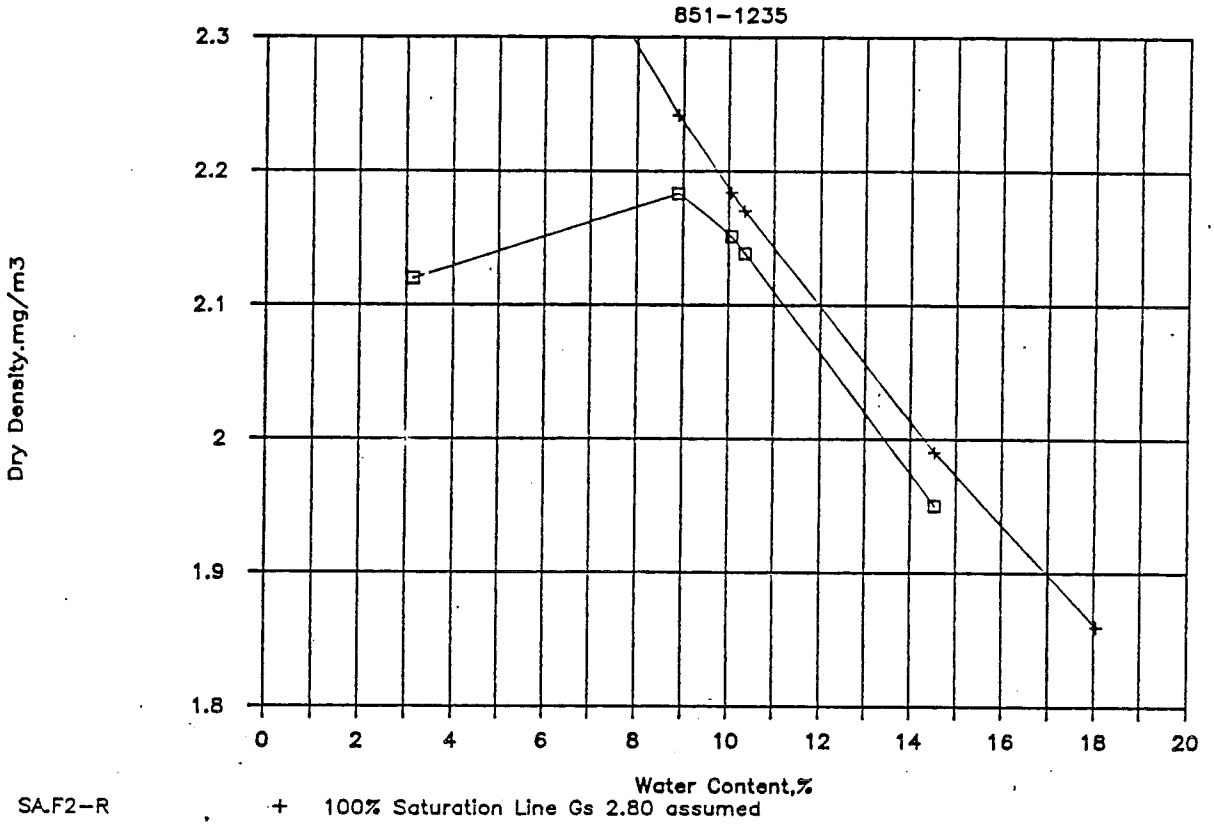
SA.CK-F1 + 100% Saturation Line Gs 2.75 assumed

Maximum Dry Density	1.925 mg/m^3
Optimum Water Content	13.5%
Natural Water Content	11.5%
Liquid Limit	40%
Plastic Limit	25%

SHEET OF

FIGURE
F2-CK
(Shale)

MODIFIED PROCTOR TEST



SA-F2-R

\+ 100% Saturation Line Gs 2.80 assumed

Maximum Dry Density	2.183 mg/m^3
Optimum Water Content	8.9%
Natural Water Content	2.8%
Liquid Limit	26%
Plastic Limit	17%