

IN THE MATTER OF Sections 2, 3 and 6(3) of the
CONSOLIDATED HEARINGS ACT, 1981, S.O. 1981, C. 20;

- and -

IN THE MATTER OF the undertaking of the Regional
Municipality of Halton to provide facilities for the
purpose of receiving, dumping and disposing of waste
as required by section 137 of the **REGIONAL MUNICIPALITY
OF HALTON ACT, R.S.O. 1980, c. 436,** as amended, by
acquiring the land for, constructing, operating and
maintaining a landfill to contain 7.96 million cubic
metres of waste in the Regional Municipality of Halton.

**WITNESS STATEMENTS OF THE APPLICANT
THE REGIONAL MUNICIPALITY OF HALTON**

VOLUME II

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EVIDENCE OUTLINE

VOLUME I

- | | |
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| ✓ Panel 1: Waste Quantities/Need | - C.N. Watson |
| ✓ Panel 2: Biophysical/Agriculture | - Linda Hellas
- Dr. Erven MacKintosh |
| Panel 3: After/Use/Visual | - Denis Stevens
- Robert Wright |
| Panel 4: Heritage/Archaeology | - Owen Scott
- Dr. Robert Pierce |
| Panel 5: Air Quality | - Dr. Eugene Koczur |
| Panel 6: Traffic | - Paul McLeod |
| Panel 7: Noise | - John Coulter |
| Panel 8: Social | - Dr. Myra Schiff
- Stevens |
- After Use

VOLUME II

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| Panel 9: Hydrogeology | - A. Sobanski |
| Panel 10: Hydrology | - Ralph Crysler |
| Panel 11: Design & Operations | - J.A. Hiraishi |
| Panel 12: Leachate Treatment/
Toxicology | - Dr. J.D. Norman
- Dr. Robert Willes |
| Panel 13: Economic Analysis | - C.N. Watson
- Joseph Rinaldo |
| Panel 14: EFW/Resource Re-cycling | - Vicky Henderson
- Joseph Rinaldo |
| Panel 15: Land Use Planning/Process | - Peter R. Walker |



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**WITNESS STATEMENT
OF
ALFRED A. SOBANSKI, P. Eng.**

In the matter of the Consolidated Hearing for the Environmental Assessment of the Proposed Halton Region Landfill Component of Solid Waste Management.

ROLE AND RESPONSIBILITIES

I am a Professional Engineer, registered in the Province of Ontario with specialized skills in hydrogeology. I am a Senior Hydrogeologist and Head of the Landfill Approvals Section of **Trow Hydrology Consultants Ltd. (Trow)**. My resume is attached for further information.

My firm was engaged as a subconsultant to Walker Wright Young Associates Limited for the Phase 1, Phase 2 Stage 2A, Phase 2 Stage 2B and Phase 2 Stage 2C study components. We acted as a consultant to the Regional Municipality of Halton for the Technical Study Component of the Environmental Assessment.

The hydrogeologic studies undertaken by **Trow** were the combined effort of many staff members. As Senior Project Hydrogeologist, all of the work including the planning of the investigative programs, interpretation and preparation of reports and the conceptualization of leachate control systems was either done by me or was done under my supervision.

As a result of our hydrogeological investigations, we provided input into the following Walker Wright Young Associates Limited reports.

- a) General Overview Analysis, Final Report, Phase 2 Stage 2A (October 1983).
- b) Selection of Candidate Sites, Final Report, Phase 2 Stage 2B (February, 1984).
- c) Hydrogeologic-Hydrologic Assessment and Conceptual Design, Final Technical Report No. 7, Phase 2 Stage 2C, Selection of Preferred Site (June 1985).
- d) Hydrogeologic-Hydrologic Assessment and Conceptual Design Appendices, Final Technical Report 7A, Phase 2 Stage 2C, Selection of Preferred Site (June 1985).

In addition, the following hydrogeologic reports were prepared for the preferred Sites D and F for the Regional Municipality of Halton:

- a) Hydrogeologic Report Site D;
Hydrogeologic Report, Volume 1 of 3, Schedule B-D (September 1986)
Appendices, Volume 2 of 3, Schedule B-D (September 1986).
- b) Hydrogeologic Report Site F;
Hydrogeologic Report, Volume 1 of 3, Schedule B-F (September, 1986)
Appendices, Volume 2 of 3, Schedule B-F (September, 1986).

ASSESSMENT OF HYDROGEOLOGICAL CONDITIONS

Hydrogeologic studies were directed to assessing the impacts of the proposed undertaking on public health and safety and on the natural aquatic environment and to providing necessary mitigative measures.

From our general knowledge of the hydrogeology of the Region of Halton, factors that were considered important in locating a site that would be suitable from public health and safety aspects included soil type, soil thickness, the absence of municipal supply aquifers and hydrogeologic complexities. In addition, we examined the feasibility of establishing a highly engineered disposal site in one or more of the pits or quarries that exist in the Region.

The method of site selection that we used was an elimination process whereby, through a series of increasingly detailed study stages, areas deemed to be less suitable for landfilling were eliminated from further consideration. In the initial stages of the process, the entire region was assessed using a constraints mapping technique. In the final stage, site investigations were conducted on two preferred sites including drilling, observation well installation, field testing, chemical analyses, interpretations and computer modelling. Prior to each stage of the work, the work programs were reviewed and commented upon by interested parties. Following each stage, reports were prepared, meetings were held with interested parties and oral and written questions were answered.

PHASE 2, STAGE 2A

The methods used are described in pages 11 to 18 and pages 29 to 58 of the General Overview Analysis (October 1983).

The work program was directed to assessing the suitability of the entire Region for landfilling. It was intended to outline broad areas in the Region that had hydrogeologic attributes suitable for the establishment of a landfill. To this end a screening process was developed and evaluation factors were established to derive the most suitable areas.

Two types of sites were considered feasible, sites located in suitable overburden materials and sites located in pits and quarries. While the latter type of site may require more engineering works for environmental mitigation, it offered the opportunity to rehabilitate damaged lands.

*what about P+Q
dunes*

The studies were conducted in the office except for the pits and quarries which were site specific and were viewed in the field. All available data sources were used to develop overlay maps of factors that were judged to be important in siting landfills.

Transparent overlay constraint maps prepared by Trow for screening purposes included:

- Overburden Thickness
- Agricultural Capability
- Niagara Escarpment Face and Slope Limitations
- Drainage
- Type and Distribution of Aquifers: Overburden Aquifers
- Infiltration
- Buried Valley - Aquifer Complexes
- Type and Distribution of Aquifers: Bedrock Aquifers
- Soil Attenuation Capability

The maps when overlaid produced Figure 6 in the Phase 2, Stage 2A report entitled "Areas Hydrogeologically Suitable for Sanitary Landfilling".

Through reconnaissance, fifty-five quarries and pits were inventoried and considered. Most were rejected because of obvious deficiencies such as:

show more approach

- Site size too small
- Location in built-up areas
- Location over major municipal water supply aquifers.

Seven quarries were considered to be suitable for further investigation.

The constraint maps were provided to Walker Wright Young.

Trow staff subsequently presented the method used and the results obtained in a series of public work shops. Written interrogatories from various agencies and individuals were responded to.

PHASE 2, STAGE 2B

Methods and Results

In the report on the **General Overview Analysis** (October, 1983) Walker Wright Young Associates Limited selected areas and sub-areas as well as pits and quarries suitable for further investigation in the Stage 2B program.

The methods used in the Stage 2B program are described in pages 32 to 37 of the report on **Selection of Candidate Sites** (February, 1984).

In Stage 2B, Trow tasks were:

- To conduct site visits on all candidate sites identified in the Stage 2A study to determine whether any possessed obvious hydrologic impediments not identified through office studies. (Appendix D)



- To provide broad estimates of site engineering costs to assist in the economic comparison of candidate sub-areas. (Appendix E)
- To determine theoretical site waste disposal capacities. (Appendix F)
- To investigate the availability of sewers to receive and treat leachate. (Appendix G)
- To conduct a more detailed assessment on the use of pits and quarries for solid waste disposal. (Appendix B and Report Text - Section 5)

As a result of our field investigation, District G was recommended for elimination because of its coarser than expected soil grain size and its location immediately upgradient of numerous wells and a significant groundwater discharge area.

A more detailed assessment of the pits and quarries identified for further investigation in Phase 2, Stage 2A was undertaken. Sources of information for the study included pit and quarry owners and operators who were interviewed, additional visual inspections and a review of available background documents.

An evaluation and assessment procedure for the the pit and quarry sites was developed as well as a rating system for constraints (Appendix B). Evaluation factors included considerations related to:

- Hydrologic and hydrogeologic constraints
- Leachate generation
- Compatibility of simultaneously quarrying and landfilling
- Leachate collection constraints
- Leachate treatment constraints

Conclusions

The conclusions drawn are shown on page 37 of the report on Selection of Candidate Sites (February, 1984).

As a result of the assessment, it was concluded that Site P & Q1 (Site F - Burlington) and the Nelson Quarry, Site P & Q3, were more favourable for consideration as sanitary landfill sites than the other five.

These assessments were used in the overall site selection process.

Trow staff attended public work shops and responded to interrogatories from various intervenors.

PHASE 2, STAGE 2C

Methods and Results

Methods used for the hydrogeologic assessments are given in pages 10 to 17 of Final Technical Report 7 (June 1985).

As a result of the Phase 2 Stage 2B work, six (6) candidate sites were selected for more detailed investigation. These included three sites in Oakville (Sites A, B and C), two in Milton (Sites D and E) and one in Burlington (Site F). Sites A, B, C, D and E were generally considered to be glacial till sites and Site F is a licensed shale quarry site. Trow tasks in Phase 2, Stage 2C were to conduct preliminary hydrogeologic-hydrologic assessments and to prepare generic conceptual site development plans. In addition, the sites were assessed and ranked in their order of preference from the hydrogeologic perspective.



In Stage 2C, the sites were thoroughly inspected in the field. All available data for the sites were compiled and assessed. Drilling was undertaken on all of the Candidate Sites to examine site stratigraphy and to determine insitu hydraulic conductivity, groundwater flow directions and basic groundwater chemistry.

The results of the studies are given in pages 18 to 60 of **Final Technical Report No. 7** (June 1985). A brief summary of the findings for the six candidate sites is as follows:

Site A (Oakville) had overburden of variable thickness in the 5 to 15 m range. The stratigraphy was found to be complex. Numerous potential site constraints relating to the control of groundwater were identified. A conceptual landfill design was prepared for the easterly portion of the site.

Site B (Oakville) generally had a thin cover of overburden. Area residents obtain supplies from sole source water bearing zones in the upper weathered shale bedrock. It was considered necessary to incorporate a synthetic liner to protect area water supplies. The design was complicated by the need to install major groundwater controls to prevent uplift pressures on the liner.

Site C (Oakville) generally had thin overburden deposits and in areas where they were thicker, the stratigraphy was complex. As with Site B it was considered necessary to install a synthetic liner to protect the sole source bedrock aquifer in the area.

Site D (Milton) was found to have overburden that generally exceeded 15 m in thickness. It was concluded that glacial till at the site would provide a high degree of natural protection for local groundwater resources. The landfill would be provided with a tile underdrain system to control and capture leachate for treatment in a sewage treatment plant.

create a hydraulic trap



Site E (Milton) also had overburden exceeding 15 m in thickness. An east-west trending, buried bedrock valley, containing interbedded till and sand and gravel units occurs at the south end of the property. A landfill would be located in close proximity to numerous wells. The landfill would be underdrained with a tile collection system and leachate would be transported for treatment to a sewage treatment plant.

Site F (Burlington) was found to have thick glacial till on the north side of the site and exposed, weathered shale on most of the south part of the site. Groundwater flow was thought to be complex but the natural groundwater at depth was non-potable. [The area downgradient from the site is serviced with municipal water.] A leachate underdrain tile collection system would collect leachate for treatment at a sewage treatment plant.

how much collection

Ranking of Sites

In Section 4.0 of the Selection of Preferred Sites, Report No. 7, Pages 61 to 96, potential environmental effects and mitigative measures for each of the sites were discussed and assessed to arrive at a ranking of the sites from hydrogeologic, hydrologic and engineering perspectives. In Table 1, the sites are assessed in terms of the original site selection factors:

- Attenuation capability
- Stratigraphic complexity
- Overburden thickness
- Complexity of groundwater flow system
- Buried valley-aquifer complex
- Drainage
- Site capacity
- Complexity to engineer site
- Downgradient well users
- Ease of supply restoration



In Table 2, the potential impacts of engineered site development on water resources and uses are assessed.

Finally, in Table 3, the potential impact of an engineered landfill systems failure on water resources and uses is assessed.

The ranking in the order of the most preferred to the least preferred was; **F, D, E, A, B, C.**

HALTON REGION LANDFILL TECHNICAL REPORT - SITE D - MILTON (September 1986)

1. Nature and Scope of the Investigation

The purpose was to define the hydrogeologic-hydrologic setting of Site D with respect to its suitability to serve as a municipal waste landfill. Objectives included the assessment of long-term effects of landfilling on local water resources, identification of measures to minimize adverse impacts on water resources, and the development of design and operation criteria for a landfill at Site D.

2. Study Methods

A comprehensive two-phase field program which incorporated input from all concerned parties was undertaken at Site D. **Thirty-eight (38)** observation wells were installed at **ten (10) locations**. Two additional wells were constructed to water well specifications and were test pumped to determine **the continuity of granular units**. A variety of tests were performed on the observation wells. Information on study methods is contained in Section 2.0, Volume 1.

The above data were used to interpret the hydrogeology of Site D. A computer simulation was used to estimate the impact of landfilling on the groundwater chemistry at the property boundaries.

3. Geology

The regional and local geology are described in Section 4, Volume 1.

The site is underlain by reddish-brown, calcareous, siltstone and interbedded shale of the Queenston formation. The bedrock contains a narrow depression which trends east-west across the site.

The overburden consists of a variety of glacial sediments. Six units are noteworthy. From the bedrock to the ground surface these are; an intermittent basal gravelly till, a lower sandy silt till that contains within it a lower silty granular deposit and an upper sand and gravel unit, a thin silt bed overlies the lower till unit and it in turn is overlain by the sixth unit, an upper clayey silt till. The average overburden thickness is about 24 m.

4. Hydrology

The hydrology of the area, surface water and groundwater, is described in Sections 5 and 6, Volume 1.

4.1 Surface Water

The site is located on the surface water divide of the Bronte Creek watershed and the Sixteen Mile Creek watershed.

The surface water drainage in general is poor. Surface runoff is directed to the creeks through poorly defined channels, depressions, roadside ditches and man-made box culverts.

4.2 Groundwater

The site can be divided into six major hydrostratigraphic units.

- 1) The Upper Till - weathered
- 2) The Upper Till - unweathered
- 3) The Upper Granular Deposit
- 4) The Lower Granular Deposit
- 5) The Lower Till
- 6) The Shale Bedrock

The upper bedrock surface is weathered and fractured and is a source of water supply for many local residents. The estimated hydraulic conductivity is 10^{-5} cm/sec. Mean reported yield for the domestic wells penetrating about 5 m into the shale is 14 L/min.

The Upper and Lower Granular Units serve as a source of supply for some residents. These zones have hydraulic conductivities in excess of 10^{-4} cm/sec. About 17 percent of local residents utilize overburden zones for water supply. The mean reported water yield from these wells is 23 L/min.

The hydraulic gradient in the rock is very low at about 0.001. In general, the direction of groundwater movement is southward.

There are two dominant pathways for groundwater movement through the overburden. They are:

- a) through the shallow weathered zone of the Upper Till
- b) through the Upper and Lower Granular Units of the Lower Till.

The horizontal hydraulic gradient in the overburden is low which indicates slow, sluggish groundwater flow systems.

The site is in a groundwater recharge area. Vertical hydraulic gradients greatly exceed horizontal gradients. This indicates that vertical groundwater flux in the overburden is greater than the horizontal flux.

5. Groundwater Chemistry

The chemistry of groundwater at the site is discussed in detail in Section 7, Volume 1.

In general, the groundwater is sulphate and magnesium dominant. Sulphate, iron, magnesium, alkalinity and hardness decrease with increasing depth, while conductivity, chloride, calcium and potassium increase with depth.

Tritium analyses indicate that groundwater recharge by precipitation since 1952 has penetrated to a depth of about 5.4 m in the Upper Till. Tritium data also indicate that the Upper Till is massive and unfractured.

6. Contaminant Migration Mechanisms

Contaminant pathway analysis and interpretation indicates there are four main pathways by which leachate might migrate with groundwater.

- a) Lateral migration through the weathered Upper Till.
- b) Vertical migration to the Upper Granular Unit followed by lateral migration.

- c) Vertical migration to the Lower Granular Unit followed by lateral migration.
- d) Vertical migration to the bedrock followed by lateral migration.

The contaminant migration patterns described on the proposed site are complex. Contaminant transport and attenuation mechanisms are described in Section 8, Volume 1.

A 1-D analytical model based on the Ogata-Banks equation was used to simulate the effects of advection, hydrodynamic dispersion, diffusion and adsorption on contaminant migration. Using this model, the migration rates of non-adsorbed, moderately adsorbed and weakly adsorbed contaminants were calculated.

The first arrival time of a non-adsorbed or weakly adsorbed contaminant at the landfill's property boundary was calculated to be:

Weathered Upper till	- 5 years
Granular Units	- 60 years
Shale Bedrock	- 360 years

The results indicated that the most critical path for off-site contaminant migration was through the granular units because they serve as a source of supply for some domestic wells in the area.

The model indicated that the chloride concentration in the granular units could reach a value of up to 300 mg/L at the property boundary in about 100 years time. This would exceed the Ministry of the Environment's current reasonable use criteria.

As a result of the hydrogeologic assessment, it was concluded that a leachate collection system is required to protect groundwater and surface water quality.



7. Landfill Design Considerations

In developing a conceptual site operations plan, consideration was given to the depth of excavation, leachate control requirements and environmental impacts. The details of this assessment are given in Section 9, Volume 1.

The landfill would be founded in the surficial clayey silt till. Hydrogeologic conditions in this unit are suitable for siting the landfill because the soils are fine grained, have low hydraulic conductivity and contains no significant sand layers or fractures. Therefore, the soils have good leachate attenuation capabilities.

To protect groundwater and surface water resources, the site would be equipped with a primary leachate collection system. Leachate control is based on the concept of developing a "hydraulic trap" within the fill. A system of collector tiles will be installed at the base of the landfill at a depth such that a zone of low hydraulic potential is created within the landfill (i.e., the fluid level in the fill would be lower than in the surrounding water bearing zones). Leachate and some groundwater from all waterbearing zones will flow to the collection system and hence no flow of leachate would occur from the fill to the surrounding soils.

8. Contingencies

Natural attenuation in the clayey till would provide the primary contingency for the site. If monitoring showed unacceptable water quality deterioration, secondary contingencies such as perimeter drains and purge wells would be installed.



9. Monitoring and Reporting

Details concerning the monitoring program are given Section 11, Volume 1. Monitoring results of leachate quality, on-site and off-site surface water resources, on-site gas monitors, off-site private wells and on-site groundwater monitoring wells would be interpreted and reported annually. The efficiency of the hydraulic trap would be determined from liquid level measurements inside and outside the landfill and by monitoring for any water quality changes.

The suggested monitoring program covers a 40-year period comprising an active landfilling phase of 20 years and a post-closure phase of 20 years. Monitoring would be conducted for as long as the Ministry of the Environment deems necessary.

10. Summary and Conclusions

The summary and conclusions of the study are presented in Section ii, Volume 1 of **Landfill Technical Report** (September 1986). It was concluded that with proper leachate controls, as proposed, hydrogeologic conditions are suitable for establishing a municipal landfill at Site D.

Wastes would be deposited in the surficial clayey silt till which has excellent leachate attenuating capabilities. Uncontrolled leachate migration could affect groundwater and surface water quality in the area at some time in the future. Therefore, the site will be equipped with a primary leachate underdrain system. The tiles and the base of the disposal cells would be set sufficiently deep to form a "hydraulic trap" by lowering the fluid potential (water level) within the fill below the fluid potentials (water levels) in the surrounding water bearing zones. This will cause all leachate and some groundwater from the surrounding soils to flow into the collection system from where it will be transported for treatment to a sewage

treatment plant. Routine monitoring would be undertaken to ensure that the system is performing as predicted. Contingency systems (such as perimeter drains and purge wells) would be installed and operated if the need arose.

HALTON REGION LANDFILL TECHNICAL REPORT - SITE F - BURLINGTON

1. Nature and Scope of Investigation

The purpose was to define the hydrogeologic-hydrologic setting of Site F with respect to its suitability to serve as a municipal waste landfill. Objectives included the assessment of long-term effects of landfilling on local water resources, identification of measures to minimize adverse impacts on water resources, and the development of design and operation criteria for a landfill at Site F.

2. Study Methods

Information on study methods is contained in Section 2, Volume 1, **Landfill Technical Report** (September 1986) pages 8 to 28.

A comprehensive two-phase field program which incorporated input from all concerned parties was completed at Site F. It involved the installation of three or more observation wells, in two or more boreholes, at each of the eight on-site drilling sites and eight off-site drilling sites. A variety of tests were performed on these wells. Three test wells were also installed and test pumped.

The above data, augmented by data from Morrison Beatty Limited, Gartner Lee Associates Limited and the University of Waterloo, were used to interpret the hydrogeology of Site F. A computer simulation of the

groundwater flow system (based on hydrostratigraphic units interpreted from field and drill hole data) was calibrated to field conditions (Sections 6.6.2, Volume 1).

An evaluation of potential contaminant migration from a landfill at Site F was completed using a series of one-dimensional analytical models based on the Ogata-Banks equation and the information described above (Section 8.5.1, Volume 1, Appendix 15, Volume 2).

3. Geology

The geology of the area is described in Section 4, Volume 1. The bedrock beneath the site is composed of red Ordovician shale of the Queenston formation. It can be subdivided into four zones (from shallowest to deepest):

- an uppermost weathered fractured shale
- a massive, weakly fractured, calcite cemented shale
- a highly fractured permeable shale zone
- a moderately fractured shale with a lesser degree of calcite sedimentation.

The overburden on-site is composed of a fine-grained silt to clayey silt till which decreases in thickness from 18 m the north end of the site to 0 m in places in the central portion of the site. The discontinuous overburden cover of varying thickness can be attributed to natural erosion and shale extraction which have incised the shale bedrock leaving the surface of the site deeply gullied. The till is overlain by lacustrine sediments (sand) south of the site.

4. Surface Water

The regional and local surface drainage systems and surface water chemistry are described in Section 5, Volume 1.

The majority of the site is located on the western portion of the Indian Creek drainage basin. Indian Creek originates on the Niagara Escarpment, flows through a residential area downstream of Site F and discharges into Hamilton Harbour.

Results from temporary monitoring stations located at culverts along the North Service Road indicate that leachate from the Bayview Landfill adjacent to Site F is degrading surface water in Indian Creek southwards to at least the CN Railway.

5. Groundwater

Information on overburden and bedrock groundwater flow systems is contained in Section 6, Volume 1.

Although five residents report the use of groundwater from shallow wells downgradient of the site, existing piped and municipal supplies are available throughout the study area. *check with clients*

Five major hydrostratigraphic units of varying hydraulic conductivity (k) characterize the hydrogeology of Site F.

1) Overburden

- a) Till Unit at north end of the site ($k = 1 \times 10^{-7}$ cm/s)
- b) Discharge Zone Till south of the site ($k = 3 \times 10^{-6}$ cm/s)



- 2) Fractured (Weathered) Shale Unit, highly weathered at surface ($k = 1 \times 10^{-5}$ cm/s).
- 3) Weakly Fractured Massive Shale Unit ($k = 1 \times 10^{-7}$ cm/s)
- 4) Highly Fractured Shale Unit ($k = 1 \times 10^{-2}$ cm/s)

This unit which underlies the Weakly Fractured Massive Shale Unit, is interpreted to extend from the midpoint of the landfill to about 500 m south of the landfill, where it is thought to contact the overburden. The unit acts as a permeable underdrain to the upper flow system and contains unpotable mineralized groundwater with chloride concentration exceeding 10,000 mg/L in some cases.

- 5) Moderately Fractured Bulk Shale Unit ($k = 1 \times 10^{-6}$ cm/s) underlying the Highly Fractured Shale Unit.

Regionally, groundwater in the upper 5 m of shale bedrock moves in a southeasterly direction towards Hamilton Harbour, under horizontal gradients of 0.009 to 0.02. A deep bedrock flow system may originate above the Escarpment, move beneath Site F at depths of greater than 30 m, and discharge into Hamilton Harbour.

Groundwater in the shallow flow system on-site moves southeasterly at horizontal gradients of 0.01 to 0.05, with discharge interpreted to occur to deeply incised gullies on-site.

Strong downward vertical gradients exist beneath Site F. Between Site F and Hamilton Harbour, weak upward gradients are present between the overburden and the shallow weathered shale, while lateral gradients exist between the shallow weathered shale and the deep shale formation.



Computer simulations indicate that much of the recharge in the study area occurs over the proposed landfill area, with an average annual infiltration rate of about 14 mm, equivalent to an annual volume of 10,000 m³ (4 Igpm). Most of the infiltrating groundwater moves horizontally through the Highly Fractured Shale Unit. The flow model suggests groundwater discharges at a rate of 14,000 m³/yr (6 gpm) to a marshy area south of Highway 403, where the Highly Fractured Shale Unit is interpreted to outcrop beneath the overburden. The simulation indicates that no groundwater originating in the landfill area discharges between this point and Hamilton Harbour.

There is a general decrease in tritium concentration with depth, with variable depths of tritium penetration due to various depths of vertical fracturing.

A significant deterioration of groundwater quality to levels below Ministry of the Environment drinking water standards occurs with increasing depth in the shale.

6. Impact of Contaminant Migration in Groundwater at Site F

An assessment of the effects of a landfill at Site F on the hydro-geologic and hydrologic regime is presented in Section 8, Volume 1. Descriptions of various contaminant transport and attenuation mechanisms and of landfill leachate characteristics are included in this section.

Advection, whereby contaminant transport is controlled by linear groundwater velocity, will likely be the principal mechanism for contaminant migration at Site F.

The main pathway of off-site leachate migration was interpreted to be:

- 1) Vertical migration through the Weathered Shale Unit and Weakly Fractured Massive Shale Unit to the Highly Fractured Shale Unit.



- 2) Lateral migration through the Highly Fractured Shale Unit.
- 3) Upward migration from the Highly Fractured Shale Unit through the Discharge Zone Till Unit.

Leachate migrating laterally through the Fractured Weathered Shale Unit will discharge and will be collected on-site for transmission to a sewage treatment plant.

The Weakly Fractured Massive Shale Unit is the dominant control on leachate migration and has good attributes for waste disposal, namely low hydraulic conductivity and good attenuation capabilities. The Discharge Zone Till Unit (about 8 m of clayey glacial till and lacustrine sediments) represents additional potential for contaminant attenuation. Heavy metals are expected to be strongly adsorbed and virtually immobile in the hydro-geologic setting at Site F.

When the hydraulic characteristics of a non-engineered landfill were superimposed on the calibrated computer simulation of the natural flow system, the average infiltration to the Weathered Shale Unit increased to about 23 mm/yr. Discharge from the Highly Fractured Shale Unit to the discharge area south of Highway 403 was calculated to increase to about 17,000 m³/yr. This analysis set the range for the estimated leachate migration rate into the Highly Fractured Shale Unit at 14 mm/yr under natural conditions to 23 mm/yr with significant leachate mounding above the zone.

Modelling of contaminant migration involved the coupling of component models based on the interpreted hydrostratigraphic units.

The first arrival of conservative contaminants (such as chloride) moving in the Highly Fractured Shale Unit to the property boundary is about 30 years. The maximum increase in contaminant concentration at the boundary in this unit was predicted to be about 500 mg/L. This does not constitute



a severe impact since naturally high chloride concentrations (exceeding 10,000 mg/L in some cases) make the water in this unit non-potable.

The first arrival of conservative contaminants, including weakly adsorbed organics, at surface through the Discharge Zone Till Unit south of Highway 403 is predicted to occur in 60 to 100 years, with a maximum increase in chloride concentration at this point of about 350 mg/L. This is not a severe impact because of the poor background water quality in the Highly Fractured Shale Unit. Other chemical impacts are considered unlikely because:

- 1) Groundwater discharge rates at the Discharge Zone Till are relatively low.
- 2) The contaminant model underestimates the natural attenuation capabilities of the rock and soil units.
- 3) Good performance of the hydrogeologic setting with respect to natural attenuation is evidenced from historical chemical data.

Test drilling and test pumping results show that an effective purge well system could be installed to prevent leachate migration from the landfill area should the need arise.

7. Landfill Design Considerations

A leachate underdrain system would be installed at 50 m spacings at Site F to collect landfill leachate and prevent lateral leachate breakout at the toe of the landfill. Of the annual infiltration of up to 305 mm of precipitation through the landfill cover, the model predicts that 13.7 to 23 mm would move downwards past the collection system to the Highly Fractured Shale Unit, giving a capture efficiency of the underdrain system of about 95 percent. The five percent (4.2 gpm) of the leachate not collected would



migrate downwards into a zone where background water quality makes the water unfit for human consumption.

Calculations indicate that a natural clay liner would only reduce the exfiltration of leachate to about 2.5 percent of the estimated 305 mm/yr total leachate production rate. Therefore, a clay liner would not provide significant additional environmental integrity to the site. A purge well system could collect, if necessary, all of the leachate moving in the permeable shale zone.

Since Site F is remote from dwellings and surrounded by existing landfill sites and buffer zones, landfill gas control is not believed to be necessary to protect buildings.

8. Contingencies

Contingency plans are addressed in Section 10, Volume 1, and in the Design and Operations Report (Volume 3). In addition to the primary collection system (underdrains) and the primary backup system (natural attenuation), a secondary backup system consisting of purge wells and perimeter tiles could be installed if required.

Based on pumping test results, three or four purge wells installed in the buffer zone north of the North Service Road and pumping about 15,000 m³/yr of leachate could control contaminant migration in the Highly Fractured Shale Unit and prevent leachate from coming to surface between Site F and Hamilton Harbour. A perimeter tile collector installed along the landfill edge and draining by gravity to the leachate pumping station could serve as a backup to the underdrain system, should monitoring indicate the need, by collecting leachate seeping to surface at the toe of the slope.



9. Monitoring

Details concerning the monitoring program are given in Section 11, Volume 1. Monitoring results of leachate quality, on-site and off-site surface water sources, on-site gas monitors, off-site private wells, and on-site groundwater monitoring wells would be interpreted and reported on annually. The suggested monitoring program covers a 40-year period comprising active landfilling and post-closure phases of 20 years each. Monitoring would be conducted for as long as the Ministry of the Environment requires.

10. Summary and Conclusions

Extensive hydrogeologic and hydrochemical studies of Site F show that with proper engineering works, the lands proposed for landfill are hydrogeologically suitable for waste disposal.

It is estimated that 95 percent of the leachate produced from landfill waste would migrate laterally and be collected by the leachate under-drain collection system, which will also prevent toe of slope leachate discharges. The remaining five percent will enter the Highly Fractured Shale Unit at depth which contains water unsuitable for human consumption due to high concentrations (up to 10,000 mg/L) of inorganic constituents such as chloride. Chemical data from adjacent landfill sites indicate no significant contaminant concentrations in groundwater beyond the limit of the landfills.

Long-term monitoring will be required to verify the integrity of the proposed landfill. In the event that monitoring indicates the need for contingency plans to be implemented, engineered systems such as purge wells, perimeter tiles, gas collection systems and gas incineration systems could be readily installed.

A handwritten signature in dark ink, appearing to read "A.A. Sobanski", written over a horizontal line.

A.A. Sobanski, P. Eng.,
Senior Hydrogeologist

GLOSSARY OF TERMS

Adsorption

- A process by which contaminants can be removed from the groundwater and bound onto the surface of soil and rock particles.

Advection

- The movement of chemicals in the subsurface due to the bulk movement of groundwater.

Aquifer

- A saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients (Freeze and Cherry, 1979).

Attenuation

- The retardation and reduction in strength of contaminants transported in groundwater.

Buried Valley - Aquifer Complex

- An overburden filled bedrock valley containing a significant overburden aquifer.

C/Co - The ratio of a pore water concentration at a distance 'x' from a source and at a time 't', to the source concentration of the chemical species of interest.

Contaminant Pathway Analysis

- The analysis of pathways by which contaminants can leave a sanitary landfill site.

Contingency System

- An engineered system to be installed in the event of unpredicted contaminant migration.

Diffusion

- Process of contaminant movement through geologic materials by concentration differences.

Downgradient

- Down slope (water table, land surface, etc.).

Flux - Rate of flow of any fluid across a given area.

Glacial Till

- A dense, poorly sorted, heterogeneous mixture of rock and mineral fragments of various sizes deposited from glacial ice.

Granular Unit

- Stratified water bearing deposits varying from well sorted silt to sand and gravel deposits.

Groundwater Discharge Area

- Area where water pressure (head) in the ground increases with depth creating a potential for groundwater to move upward.

Groundwater Recharge Area

- Area where water pressure (head) in the ground decreases with depth creating a potential for groundwater to move downward.

Hydraulic Conductivity

- A measure of the ease with which fluids will pass through porous media expressed in centimeters per second. It has high values for coarse grained materials such as sand, and sand and gravel (10^{-2} cm/sec or greater) and low values for fine grained materials such as clays (10^{-6} cm/sec. or less).

Hydraulic Gradient

- Difference in water head over a distance.

Hydraulic Potential

- A physical quantity, capable of measurement at every point in a flow system, whose properties are such that flow always occurs from regions in which the quantity has higher values to those in which it has lower, regardless of the direction in space (Hubert, 1940).

Hydrodynamic Dispersion

- The spreading of contaminants in the direction of groundwater flow due to heterogeneities in the geologic media.

Hydrogeologic

- As used in this report - pertaining to groundwater.

Hydrologic

- As used in this report - pertaining to surface water.

Hydrostratigraphic Units

- A significant geologic unit affecting the movement of groundwater.

Leachate

- A mineralized liquid formed when water contacts waste.

Sanitary Landfill

- An engineered method of disposing of solid wastes on land in a manner that protects the environment, by spreading the wastes in thin layers, compacting it to the smallest practical volume, and covering it with soil by the end of each working day (J. Reindl, 1977).

Stratigraphy

- Study of the character, relations, succession, variations, and fossil faunas of strata, both locally and over large areas.

Synthetic Liner

- A man-made material with very low water transmitting characteristics.

Leachate Tile Collection System

- A system of interconnected, perforated pipes installed in or near a waste disposal site to collect and move leachate to a central collection point.

Tritium

- A radioactive isotope of hydrogen that can be used to distinguish between pre-1952 and post-1952 groundwaters.

Underdrain

- A leachate tile collection system installed at the base of refuse.

Well Yield

- The pumping rate that a water well can sustain on a continuous basis.



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**WITNESS STATEMENT
OF
RALPH E. CRYSLER, P. Eng.**

In the matter of the Consolidated Hearing for the Environmental Assessment of Proposed Halton Region Landfill Component of Solid Waste Management.

A. ROLE AND RESPONSIBILITIES

I am a Professional Engineer registered to practice in the Provinces of Ontario and Alberta. My resume is attached and lists my qualification and experience in considerable detail. I am presently employed by **Trow Hydrology Consultants Ltd.** as Manager of Environmental Services. I have held this position since February of 1984.

As stated in the Introduction to Final Technical Report No. 7 of Phase 2, Stage 2C, "it was **Hydrology Consultants'** task to conduct preliminary hydrogeologic-hydrologic assessments and to prepare generic conceptual site development plans for Candidate Sites A, B, C, D, E and F". Using the general engineering criteria set forth in Section 1.6 of that report, it was my responsibility to prepare conceptual plans for each site, recognizing the hydrogeologic constraints and the leachate control methods determined by others. It was my responsibility to determine, in general, how surface water was to be handled and how collected leachate would be handled on-site or off-site. The level of design was sufficient to permit a basic comparison among sites.

In the Technical Studies for Sites D and F (referred to as EPA Level of Detail). Trow Hydrology Consultants Ltd. was responsible for hydro-geologic studies and engineering designs. The results of these studies and designs are described in the Design and Operations Reports. In this phase of the work, I was responsible for the design of surface water control features. Although this work was done under my direction, I was not able to provide direct supervision or review of all of that work. Subsequent to the completion of the Design and Operation Reports, I have reviewed that earlier work and have directed and participated in additional analyses to clarify a number of details and to satisfy myself as to the adequacy of the design.

B. HYDROLOGIC METHODS

All runoff calculations (i.e., calculation of stream flow and ditch flow) were undertaken using the Rational Formula which relates stream discharge to rainfall intensity, drainage area and basin characteristics. This is a method which has been in use for many years and which is considered to be reasonably accurate for drainage areas of less than 25 square kilometers (i.e., 25,000 ha). The rainfall intensity was determined from Intensity-Duration-Frequency (IDF) Curves produced by Environment Canada. For Site F, curves from two nearby stations (Burlington Fire Headquarters and Hamilton RBG) were averaged. For Site D, curves are available for four nearby stations: Hornby, Burlington Fire Head Quarters, Oakville SE OWRC, and Hamilton RBG. The Hornby curves are based on a relatively short period of record and are classed only as estimated for frequencies in excess of ten years. Hence, although the Hornby station is quite close to Site D, it could not be used reliably by itself and it was decided to average the four sets of curves.



The "Time of Concentration", which is a watershed characteristic used in conjunction with the IDF Curves, has been the subject of much research. We investigated four common formulae for the Time of Concentration: Kirpich, Airport, Bransby-Williams and SCS. In the pre-development conditions at Site F, the SCS method consistently gave high readings and the other three were reasonably close with Kirpich being on the low side. (Note that high Times of Concentration give lower or less severe flow figures.) In the post-development situation, the Airport formula gave the highest figures followed by the SCS method. MTC Hydrology Section¹ recommends the use of either the Airport or the Bransby-Williams formula in Southern Ontario, depending on site conditions. In the case of Site F, the Bransby-Williams criteria most closely suited the site and it was decided to use that formula exclusively.

For Site D, it was found in all cases that SCS was high and Kirpich was low. Considering the site conditions, it was decided to average the Bransby-Williams and the Airport values.

The runoff coefficient was developed from standard tables published by several references.^{2,3,4} Drainage areas were delineated and measured on the 1:2000 mapping prepared for this study. Stream gradients and valley slopes were interpreted from the same mapping.

In a response (January 13, 1986) to a request from Walker Wright and Young, the City of Burlington advised that they would require on-site channels to be designed for the 5-year storm (Q5). If retention or flood control ponds were to be used, those ponds would have to be designed for the 25-year storm (Q25) and checked for the 100-year storm (Q100).

In a letter dated February 17, 1986, the Halton Region Conservation Authority advised the consultants to the City of Burlington that any channel works undertaken in connection with the Bayview Park would have to be protected from erosion during the fifty year storm, but could be sized for some smaller flow (i.e., overtopping would be accepted, but not erosion).

Based on these two directives, it was originally decided to investigate the sites only for Q25. This was the basis for the designs set forth in the Design and Operations Report for Site F, dated September, 1986. In the later review, and additional analyses, the designs were checked for Q100 as well as for Q25. In addition, the Site D plans included a major stream diversion. This diversion was checked for the Regional Storm.

C. SITE F INVESTIGATIONS

C.1 Site Description

The Site Description is found on page 16 of the Design and Operations Report for Site F. Site F is situated almost entirely on the western portion of the Indian Creek watershed. The northernmost edge and the southwestern part of the site drain north and west, respectively, into Falcon Creek. The surface relief of the site can be described as being extensively dissected by ravines.

At present, there are three stream channels that drain from the northern part of the site, and two that drain the southeastern part, south of the Bayview site (formerly the Bayview Landfill). These five streams cross under the North Service Road and Highway 403 at three points. The most easterly stream crosses under the North Service Road at the King Road intersection. The other stream that drains the area south of the Bayview site crosses under the North Service Road about 230 m west of King Road. The three stream channels draining the northern part of the site flow through a single box culvert under the North Service Road about 430 m west of King Road. South of Highway 403, this stream swings to the east and joins the flow from the adjacent channel.

The stream channels draining from the northern part of the site each flow over three distinct types of terrain. The northern part of the site is relatively flat table land and the channel gradients are less than four percent. In the main part of the site, channel gradients are as high



as eight percent in gullies having side slopes as steep as 55%. In the southern part of the site, the stream gradients range from about three to five percent with relatively low side gradients.

In many reaches, the channel is obstructed with windfalls and other debris. The middle stream draining from the north has two dams on it, about 100 m apart. These dams were apparently constructed prior to 1935 and the ponds behind them have been so silted up that little storage capacity remains.

All streams on Site F are considered to be ephemeral. It should be noted that part of the existing Regional Landfill Site drains to the east into Indian Creek as well as east and south into Falcon Creek. The Bayview Park Site drains, in part, to the west and south into three of the Indian Creek streams.

C.2 Site Development

The proposed development of Site F has been described in the Design and Operations Report for Site F dated September, 1986. The development will affect the existing surface drainage patterns in several ways, as follows:

- i) The two more westerly stream channels that drain from the northern part of the site will be completely removed as the site is excavated for the landfill.
- ii) The northern half of the third stream channel draining from the north (and which receives drainage from Bayview) will also be removed by the landfill operation.
- iii) The runoff from the entire area of the Site F landfill will be collected into perimeter ditches that will lead through retention ponds to the box culvert under the North Service Road.



- iv) A portion of the runoff from the southwest corner of the site that now drains to Falcon Creek will be redirected to the east and will discharge through the South Retention Pond to Indian Creek. This existing portion of Falcon Creek now receives runoff from part of the Regional Landfill, and this flow will also be partially diverted to Indian Creek. This diversion will add 6.3 ha. to the drainage basin of Indian Creek.
- v) The northern portion of the ditch on the east side of Site F will also receive some runoff from the Bayview Site. This ditch will pass through the East Retention Pond and discharge into the remaining southern portion of the most easterly of the three existing streams. A part of this work has already been done by the City of Burlington in connection with their remedial work at the Bayview Site.
- vi) The southern portion of the ditch on the east side of the landfill will be separated from the northern portion, and will drain to the South Retention Pond.
- vii) The ditch on the west side of the landfill will also drain to the South Retention Pond.
- viii) The drainage from the east side of the Regional Landfill will be collected in a separate ditch leading eventually to the South Retention Pond. (This is a change to the details shown on the Site F Design and Operations Report drawings.)
- ix) The two existing streams that drain the area south of the Bayview Site will not be affected by the development.

C.3 Hydrologic Calculations

This section will present the results of the various hydrologic calculations, and will discuss the significance of those results. As set out in Section C-2, the two streams south of the Bayview Park will not be affected by the development, and hence, they are not considered in these calculations. The area draining to Falcon Creek will be slightly reduced, and there will be no adverse impacts. Hence, Falcon Creek was not considered in these calculations.

The three existing streams that will be affected by the development all pass under Highway 403 in one large concrete box culvert some 430 m west of King Road. In total, these three stream channels drain an area of 75.1 ha. In the pre-development condition, the flow off the property passing through the box culvert under the North Service Road and Highway 43 will be:

Q25 - 4.42 cms (cubic metres per second)

Q100 - 5.50 cms

In the post-development condition, the area draining through the box culvert will increase slightly to a total of 81.4 ha. mostly because of the diversion from Falcon creek. The drainage ditches will, in general, be gabion lined to prevent erosion. In addition, the channel will be stepped to limit the maximum channel gradient to one percent. The discharge exiting the property through the box culvert in the post-development condition was first computed without any retention ponds. These post-development flows are shown below, together with the pre-development flows for comparison. It should be noted that the original design of the ditches, as reported in the Design and Operations Report, was very conservative. So much freeboard had been allowed that the ditches were found to have adequate capacity for Q100.



	<u>Pre-Development</u>	<u>Post-Development</u>	<u>% Increase</u>
Q25	4.42 cms	4.99 cms	12.9
Q100	5.50 cms	6.21 cms	12.9

As this increase in flow was considered to be excessive, it was decided to use retention ponds. Two ponds will exist in the post-development condition. These are shown on the drawings in the Design and Operation Report.

Both the 25 and 100 year design storms were routed through these ponds. Since the Time of Concentration to the culvert under Highway 403 was relatively short at about 48 minutes, it was decided to route both a 48 minute and a three hour duration storm through the retention ponds. The 48 minute duration storm will quantify larger peak flows with a smaller total volume of water required to pass through the ponds while the three hour duration storm will quantify a smaller peak flow but a larger overall volume of water. It should be noted that the ponds used in this analysis are somewhat modified as to size and outfall characteristics from those shown on the drawings that accompany the Design and Operations Report. The following table summarizes our findings.

<u>Storm</u>	<u>Duration</u>	<u>Pre-Development</u>	<u>No Ponds</u>	<u>% Increase</u>	<u>Post Development With Ponds</u>	<u>% Increase</u>
Q25	48 min.	4.42 cms	4.99 cms	12.9	2.67 cms	-39.6
Q25	3 hr.	1.79 cms	2.02 cms	12.8	1.76 cms	-1.7
Q100	48 min.	5.50 cms	6.21 cms	12.9	2.73 cms	-50.4
Q100	3 hr.	2.23 cms	2.52 cms	13.0	2.05 cms	-8.1

With the retention ponds in place, the flows leaving the property are actually less than the pre-development flows.

As described in the Design and Operations Report, a third retention pond, the West Retention Pond, will be constructed and used during the first half of the site development. This pond will be removed during the second half of the work and will be replaced by the South Retention Pond. The East Retention Pond will be constructed at the beginning of the site development. In this way, retention ponds will be in place from the beginning to control the runoff from the site. The temporary West Retention Pond is also intended to assist in retaining the existing conditions of the south part of the site until it is disturbed for landfilling. Otherwise the South Pond could be built at once.

The design to date has established the size, gradient and location of the ditches. They will require lining or protection to prevent erosion under all conditions. The details of such lining or protection will be settled in the final design and the preparation of working drawings. In the same way, the exact location and size of channel steps is a matter, normally, of final design and is not addressed here.

Site drainage from within the working area has been described in the Design and Operations Report. In Section 5.10.1 on Page 79, reference is made to "temporary dykes to retain runoff from a 2-year storm". The intent of that statement requires clarification.

As stated in Section 5.5 (Page 66) the base contour design requires the infilling of some of the existing deep valleys. This infilling will be done with compacted native weathered shale and will be, generally three to five metres in depth. The upstream end of this fill will form a dyke across the valley of sufficient height to pond about the one hundred year storm behind it. This impounded water will be pumped to the perimeter ditches, which drain to the detention ponds.

The 2-year dykes referred to will be located further up the valley to provide drier conditions where the main infill is being placed.



C.4 Summary

The results of the further analyses has shown that discharges from the property will be less after development than before development. This has been shown to be the case for both the 25 year and the 100 year storms.

It is agreed that the channels will have to be protected from erosion at all flows. Details of the erosion protection are deferred until final design.

In the re-evaluation of the analyses, it was found desirable to re-size the ponds. This has been done and their locations determined. The outlet pipes have been sized to obtain the required impoundment-discharge relationships.

D. SITE D INVESTIGATION

D.1 Site Description

The site description is found on page 17 of the Design and Operations Report for Site D, dated September, 1986. The proposed site lies on a drainage divide between the Bronte Creek and the Sixteen Mile (or Oakville) Creek watersheds. Although both of these main creeks have their headwaters on or above the escarpment, the drainage courses crossing Site D all rise below the escarpment and are all ephemeral streams.

D.1.1 Bronte Creek Tributaries

A tributary of a branch of Bronte Creek rises north of Britannia Road and flows (intermittently) through Site D. It exits the site through a concrete box culvert under the First Line and drains to the west, past the CNR tracks and across Tremaine Road to join the much larger branch of Bronte Creek. Upstream of the First Line box culvert, this tributary drains



a total of 273.6 hectares of agricultural land, of which 67.3 ha are on Site D. Upstream of Site D, the stream channel is poorly defined, and for much of its length is little more than a shallow swale. Residents along First Line report frequent floodings and overtopping of the road adjacent to the box culvert (personal communication).

The extreme southwest corner of Site D drains to Bronte Creek through a 450 mm steel culvert under First Line. This culvert drains an area of 3.8 ha. The flow through this culvert joins the flow from the concrete box culvert upstream of the CNR tracks.

D.1.2 Sixteen Mile Creek Tributaries

A minor tributary of a branch of Sixteen Mile Creek crosses through the northeast corner of Site D and joins the branch about 400 m downstream of the site. This larger branch drains an area extending above Steeles Avenue into the built-up area of Milton. The combined flow then passes under Highway 25 in a large concrete culvert. The minor branch drains about 26.7 ha upstream of Site D and about 16.4 ha of Site D. At the point of confluence with the larger branch, the total combined drainage area amounts to 518.1 ha. The tributary crossing the corner of Site D does not have a defined channel.

An area of about 38.6 ha, most of which is on Site D, drains eastward through two culverts under Highway 25 directly to the branch of Sixteen Mile Creek. A further area of 13.8 ha along the southern limit of the site drains southward toward Sixteen Mile Creek. Neither of these last mentioned areas contains any defined creek channels.

D.2 Site Development

The proposed development of Site D has been described in the Design and Operations Report. The development will affect the existing surface drainage patterns in several ways, as follows:



- i) The tributary of Bronte Creek that drains from the north will be directed into a shaped and graded channel as it enters the site. The channel will flow westward adjacent to the north boundary and then southward between the screening berm and First Line and will discharge under First Line through the existing concrete box culvert.
- ii) The small tributary of Bronte Creek at the extreme southwest corner of the property will not be affected by the development.
- iii) The tributary of Sixteen Mile Creek that crosses the northeast corner of the site will be diverted around the actual working area in minor ditches.
- iv) That area of the site that drains to the east directly across Highway 25 will be, essentially, untouched. The site access road passes through this area and will require minor roadside ditches.
- v) Part of that area at the south of the site that drains southward to Sixteen Mile Creek will be within the working area. The runoff from this affected area will be redirected to the west through the site drainage system to join the flow to Bronte Creek.
- vi) The surface runoff from the actual working area will be collected in ditches and discharged from the site through retention ponds. The ditches will drain a total of 52.5 ha. to Bronte Creek and 15.3 ha. to Sixteen Mile Creek.
- vii) These various diversions and the distribution of runoff from the landfill itself affect the total drainage areas of the two principal tributaries that cross the property. The pre-development and post-development drainage areas of these two tributaries, measured at the point where they leave the site are:

	<u>Bronte Creek</u>	<u>Sixteen Mile Creek</u>
Pre-Development	273.6 ha	43.1 ha
Post-Development	258.8 ha	58.4 ha

D.3 Hydraulic Calculations

This section will present the results of the various hydrologic calculations and will discuss the significance of those results. As set out in Section D.2 above, the flow of only two streams (Items (i) and (ii) of Section D.2, leaving the property will be affected by the development. Hence the calculations and this discussion are restricted to those two streams.

D.3.1 Bronte Creek Tributary

As stated earlier, the tributary of Bronte Creek that traverses the site now drains a total area of 273.6 ha before exiting the property under First Line. In the pre-development condition, it was found that the 25 year flow (Q25) exiting the property would be 6.28 cubic metres per second (cms). This flow is directed through a concrete box culvert, 2.4 m wide by 1.2 m high. A check of the culvert capacity showed that its inlet would surcharge (i.e. overtop) and the nearby road would be overtopped at a flow of 5.34 cms which is about the ten year flow (Q10). Immediately north of the culvert, there is a long sag in the road grade. At Q25, it was found that a length of about 300 m of road would be flooded to a depth of about 0.1 m.

A similar calculation showed that the 100-year flood (Q100) would be 8.17 cms, and the road would be overtopped for a length of about 350 m to a maximum depth of slightly less than 0.2 m. This means that under existing conditions, the water level at First Line will rise by only 0.2 m as flows increase from Q10 to Q100 despite the very low capacity of the concrete box culvert, because of the very long sag in the road.



Downstream of the culvert under First Line, the stream channel has been straightened, widened and deepened by the property owner. This channel improvement apparently extends only to his downstream property line in a woodlot midway between First Line and the railway tracks. We are advised by the residents (personal communication) that flooding of their land is not infrequent and they attribute this to a lack of adequate downstream outlet.

The CNR tracks are approximately parallel to First Line and about midway between First Line and Tremaine Road. The MNR 1:10,000 mapping indicates that the railroad embankment where it crosses the Bronte Creek tributary has a top elevation of 182.5 m ASL (above sea level). By comparison, the elevation of First Line at the box culvert is shown to be 182.0 m ASL. This means that the railroad embankment is higher than First Line. The tributary flows through the embankment in two 1500 mm round steel culverts. Since these two culverts have approximately the same capacity as the upstream concrete box culvert, it is reasonable to expect some considerable damming of water by the embankment. However, the mapping and field reconnaissance indicate that overland flow would occur parallel to the embankment to discharge through other culverts both north and south of the tributary itself, thus relieving some of the possible flooding of the properties between the tracks and First Line. Based on available mapping, it would appear that this relief flow could occur at water levels of about 181.0 m ASL, or about one metre below the First Line, and one and a half metres below the top of the railroad embankment.

In the post-development situation, the flow from the area upstream of the site is diverted in a new channel around the screening berm. The discharge of the drainage from the actual landfill area joins the upstream flow shortly before the combined flow passes under the First Line. The flow from upstream is essentially unchanged for the pre-development flow, but the flow from the landfill area will be increased. Without a retention pond, the pre-development and post development flows at the First Line culvert are:



	<u>Pre-Development</u>	<u>Post-Development</u>	<u>% Increase</u>
Q10	5.55 cms	5.83 cms	5.0
Q25	6.33 cms	6.65 cms	5.1
Q100	7.95 cms	8.46 cms	6.4

It was considered that these increases were too great, and a retention pond was added to the landfill drainage system. When the various flows are routed through the retention pond, the post-development flows are reduced to the following:

	<u>Pre-Development</u>	<u>Post-Development</u>	<u>% Increase</u>
Q25	6.33 cms	6.39 cms	1.0
Q100	7.95 cms	8.07 cms	1.5

The effect of these very modest increases in peak flows will be mitigated very quickly by additional tributary flows downstream. A rough calculation indicates that at the CNR tracks the increases will be reduced to 0.67% for Q25 and 1.0% for Q100. At Tremaine Road the increases would be further reduced to 0.5% for Q25 and 0.85% for Q100. Downstream of Tremaine Road, the tributary joins a much larger branch and the effects of the flow increase will be negligible.

The diversion channel was also checked for the Regional Storm. This storm is so large that the pre-development and post-development flows are unchanged.

The diversion channel has been sized such that the water depth at the downstream end, in all storms, will be below the road level if it were not for the constraint of the existing concrete culvert. This means that if, or when, the capacity of the culvert under First Line is increased,

the diversion channel will be correctly sized. In the interim, the existing flow restriction at First Line will cause a backup of water and there will be some greater depth of water in the diversion channel. The channel banks could be set high enough to contain this greater depth. An alternative would be to allow the diversion channel to overtop its west bank to retain the present situation of road overtopping.

The original design of the diversion channel was very conservative. So much freeboard had been allowed that the Regional storm can be accommodated with no change in design.

D.3.2 Sixteen Mile Creek Tributary

As stated earlier, that tributary of Sixteen Mile Creek which crosses the northeast corner of the site drains a total of 43.1 ha before exiting the site. In the pre-development condition it was found that the flows off the site would be:

Q25 - 1.58 cms

Q100 - 1.98 cms

Where the tributary joins the larger channel, some 400 m downstream (and upstream of Highway 25), the combined pre-development flows were determined to be:

Q25 - 10.71 cms

Q100 - 13.09 cms

In the post-development condition, there will be an increased area draining to this tributary because of on-site grading and drainage. This will result in increased flows at the site boundary as follows:



	<u>Pre-Development</u>	<u>Post-Development</u>	<u>% Increase</u>
Q25	1.58 cms	2.60 cms	64.6
Q100	1.98 cms	3.22 cms	62.6

However, 400 m downstream, the tributary joins the larger branch and the increase in the combined flow is much less apparent, as follows:

	<u>Pre-Development</u>	<u>Post-Development</u>	<u>% Increase</u>
Q25	10.71 cms	10.94 cms	2.1
Q100	13.09 cms	13.38 cms	2.2

If these very modest increases a short distance downstream, or the larger increases at the property boundary are not acceptable, the flows can be routed through a retention pond on site, as shown on the Site Plans. This will result in flows as follows:

	<u>At Site Boundary</u>			<u>At Downstream Confluence</u>		
	<u>Pre-Development</u>	<u>Post-Development</u>	<u>% Increase</u>	<u>Pre-Development</u>	<u>Post-Development</u>	<u>% Increase</u>
Q25	1.58 cms	1.55 cms	-1.9	10.71 cms	10.71 cms	0.0
Q100	1.98 cms	1.95 cms	-1.5	13.09 cms	13.09 cms	0.0



D.3.3 Erosion and Scour Control

It will, of course, be necessary to protect all of these man-made channels from scour and erosion during various storm events. It will also be necessary to prevent scour and meanders during the low flow conditions. The form of that scour protection will be determined during the final design stage.

D.3.4 On-Site Storm Drainage

Storm drainage from within the working area has been described on page 68 of the Design and Operations Report for Site D, dated September, 1986, and is not repeated here.

D.4 Summary

Based on our calculations, as described in the Design and Operations Report for Site D, dated September, 1986, and as further expanded above, the design of the Bronte Creek Diversion and of the on-site drainage ditches and retention ponds will result in insignificant increases in flow from the site under all storm conditions.

Since the increases in peak flow are insignificant, there can be no problems of increased downstream erosion or flooding resulting from the proposed development.

Ralph E. Crysler, P. Eng.,
Manager, Environmental Services

REC/ird

REFERENCES

1. **MTC Drainage Manual**; Chapter B, Design Flood Estimation for Small Watersheds, Drainage and Hydrology Section, Highway Design Office, Ontario Ministry of Transportation and Communications, 1984.
2. **Handbook of Applied Hydrology**; Van Te Chow, Chapter 21, First Edition.
3. **Applied Hydrology and Sedimentation for Disturbed Areas**; B.J. Barfield, R.C. Warner and C.T. Hoan, Oklahoma Technical Press, 1981.
4. **SCS National Engineering Handbook**; Section 4, Hydrology, Soil Conservation Service, U.S. Department of Agriculture.

GLOSSARY

Intensity-Duration-Frequency Curves

Curves expressing rainfall intensities (measured in millimeters per hour) for specified durations (measured in minutes or hours) and frequencies (measured in years of the return period). These curves are developed from historical rainfall data recorded at meteorological stations.

100-Year Storm

Refers to the storm that is considered to occur on average once in one hundred years. Similarly, the 50-year storm or the 25-year storm will occur, on average, once in 50 years or 25 years respectively.

Q100 is the computed flow that would occur in a stream channel or ditch as a result of the 100-year storm. Q50, Q25, etc., signify the stream flow resulting for the 50-year or 25-year storm, respectively.

Regional Storm

A very high intensity storm which has been designated by the Province of Ontario and which results in the Regional Flood.

Gradient

Refers to slope, as in a stream channel or ditch. If it is expressed as a percentage, it is equivalent to metres of fall (or rise) per hundred metres of length.



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**WITNESS STATEMENT
OF
JAMES A. HIRAISHI, P. Eng.**

In the matter of the Consolidated Hearing for the Environmental Assessment of the Proposed Halton Landfill Component of Solid Waste Management.

ROLE AND RESPONSIBILITIES

I am a Professional Engineer in the Province of Ontario. As well, I am a designated Consulting Engineer under the provisions of a Regulation made under the Professional Engineers Act. My area of speciality is in the field of waste management with particular emphasis in solid wastes and landfill design. My Curriculum Vitae is attached for reference.

For the last two years, I have provided consulting services as an independent consultant under the incorporated firm of J.A. Hiraishi Consultants Inc. For this project, I have been retained by **Trow Hydrology Consultants Ltd.** on a contract basis to provide assistance in the preparation of reports for Site D and Site F in the Landfill Technical Study segment of Halton's Environmental Assessment. As a Senior Project Engineer, my responsibilities with **Trow** included:

- Providing direction to **Trow's** engineers and draftsmen in preparing engineering designs;
- Providing liaison and co-operation as necessary with other members of the consulting team;



- Attending meetings with the Regional staff and other consultants; and
- Preparing reports for Site D and Site F on the proposed conceptual engineering design and operations as applicable under the Landfill Technical Study Phase of this project.

My involvement in the project began in August, 1985 at the start of the Halton Region Landfill Technical Study Phase of the Environmental Assessment and has continued to the present. I was responsible for preparing the following reports:

1. Design and Operations Report; Volume 3 of 3 (Schedule A-D), Halton Region Landfill Technical Report, Site D - Milton, **Trow Hydrology Consultants Ltd.**, September, 1986.
2. Design and Operations Report; Volume 3 of 3, Part 1 of 2 (Schedule A-F), Halton Region Landfill Technical Report, Site F - Burlington, **Trow Hydrology Consultants Ltd.**, September, 1986.
3. Design and Operations Report; Volume 3 of 3, Part 2 of 2 (Schedule A-F), Halton Region Landfill Technical Report, Site F - Burlington, **Trow Hydrology Consultants Ltd.**, September, 1986.

In addition, I prepared cost estimates for Site D and Site F which were submitted to C.N. Watson and Associates Ltd. The cost estimates can be found as an Appendix in the report:

Economic Impact and Affordability Analysis (Schedule K), Region of Halton Landfill Technical Study, C.N. Watson and Associates Ltd., November, 1986.

APPROACH TO LANDFILL DESIGN AND OPERATIONS CONCEPTS

I was responsible for preparing the Design and Operations Report for Sites D and F to satisfy some of the requirements outlined in the Environment in the Environmental Protection Act, Part V and Regulation 309 of that Act. To provide general guidelines and to establish some of the technical contents of Design and Operations Report, I referred to the document prepared by the Ministry of the Environment entitled **Guidelines for the Establishment, Operation, Management, Maintenance and Closure of Landfilling Sites in Ontario**, (Undated). Although this document is currently undergoing updating and revision, I, nonetheless, relied on these guidelines to provide a basis for the work contained in the Design and Operations Reports.

The intent of a design and operations report is to document conceptual engineering design and operations proposed to be implemented for a specific site. Along with reports prepared by other members of the consultant team, it provides a basis for an application to the Ministry of the Environment for a Certificate of Approval to operate a Waste Disposal Site.

In general, a design and operations report is technical and site specific in nature. However, it is emphasized that the report contains concepts only. This means that once the Certificate of Approval is obtained, detailed designs must be completed, submitted and approved to the satisfaction of all the applicable approval agencies prior to the implementation of the landfill site.

There are two major sections in a design and operations report:

- a) a conceptual engineering design of the proposed landfill, and
- b) a conceptual operations plan.

A conceptual design proposes engineering works to be implemented at the site to ensure that it provides a safe environment for the disposal of the wastes.

A conceptual operations plan provides the methods to operate the site so that the intent of the conceptual design is met.

DESIGN CONSIDERATIONS

There is a broad range of factors considered in developing a conceptual design and operations plan for a landfill. Many of these factors were investigated by other members of the consultant team and were used to identify and opportunities and constraints of each site. Section 4 of the Design and Operations Report should be referred to for a full description of the design considerations.

The following were the major factors considered.

Waste Quantities

Total quantities of wastes to be disposed of are used to identify the general size, areal extent and height of the landfill. Characteristics of wastes to be received and the expected daily quantities establish the operational needs of the landfill.

Site Characteristics

The terrain, topography, geology, area available, access to the site, on-site drainage, are the primary characteristics used to develop a sense of the landfill design in terms of geometry and operational methods.



Hydrogeology

The hydrogeological investigations dictated the depth of excavations, quantity of available cover material, configuration of the leachate collection system and the needs related to gas migration and contaminant monitoring programs. In addition, requirements for contingency systems and operational constraints were developed from these investigations.

Visual

I used the findings from the visual analysis to develop constraints to design and operations to limit potential heights or landform and to establish the needs for berms and screening to mitigate visual impacts of the sites.

Noise

The noise analysis was used to assist in designing mitigative measures such as berms as well as to assist in developing operational constraints to minimize noise impact.

Transportation

Findings from the transportation study were used to determine cell size, bulk bin area, equipment needs, hours of operation, internal road design and location of entrance.

Heritage

Findings from the heritage analysis assisted in the design of the site.



Biophysical

The biophysical analysis was used to identify suitable areas for landfilling and was a factor in the decision to limit the areal extent of the filling in Site F.

Site Rehabilitation and After Use

Recommendations were used to design the final cover for the sites as well as to establish the final contours and landforms of the completed sites.

Air Quality

The analysis was used to determine the need for dust control and to assist in developing operational guidelines.

These factors along with others were used in conjunction with engineering constraints to develop the conceptual design and operations of the sites.

RELATION TO PHASE 2 STAGE 2C REPORTS

In addition to the factors stated above, I also considered the report, Hydrogeologic-Hydrologic Assessment and Conceptual Design, (Report No. 7) prepared for Phase 2 Stage 2C by Trow (see page 9). The report outlined a set of "general parameters" which were used as a basis in the development of the conceptual plans for the six sites considered in the assessment. The parameters were used for the purpose of comparing the opportunities and constraints of each of the sites in relation to the other sites.



In preparing the Design and Operations Reports for Sites D and F, I referred to the parameters used in Phase 2 Stage 2C as a basis for the more technical and site specific investigations required in the Landfill Technical Study Phase. Although I am aware that the parameters used previously are significant in that the selection of the preferred landfill sites were partly based on the engineering criteria, I did not consider these parameters to be binding. This is to say that engineering parameters used in the Phase 2 Stage 2C Report would not take precedence over the parameters developed through more technical and site specific investigations at this stage of the study. Similarly, other opportunities and constraints used during the Phase 2 Stage 2C were used as a guide in the development of the design and operations concepts of the sites.

The engineering criteria as presented in the Phase 2 Stage 2C Report have been modified as follows:

- 1) **100 m Wide Buffer.** The Phase 2 Stage 2C Report No. 7 stated that the intent of the buffer is to provide adequate separation between the actual landfill operations and the surrounding land use to provide visual and noise separation, leachate attenuation zone and area for monitoring and installation of environmental control works. Berms could be located in the buffer zone but service areas were to be located within the landfills.

In the Site D Design and Operations Report, I have kept the buffer zone to at least 100 m from the actual fill area. However, within the buffer zone, I have located the service area including the scales and the scale-house and the office and maintenance structures. Although these facilities are within the 100 m buffer zone, they have also been relocated further from the service area near Highway 25 as identified in the Phase 2 Stage 2C report. This was done primarily because the east portion of the site (originally envisaged as part of the landfill area), was no longer required. Therefore, I believe that the present location meets the intent and purpose of the buffer zone in providing an adequate separation of the landfill from the surrounding land uses.



In Report No. 7 of Phase 2 Stage 2C for Site F, the buffer zones separating the fill area from the existing Regional landfill site and the closed Bayview landfill site were eliminated since the use and intent of the buffer was believed to be redundant in light of the current uses of these areas. However, for the design and operations of Site F, I have modified this and have incorporated a buffer to accommodate some specific needs.

Along the boundary separating Site F and closed Bayview site, a 50 m buffer is provided to allow for the installation of the leachate control system by the City of Burlington. Along the boundary separating Site F from the existing Regional site, a narrow, varying width buffer is proposed for the location of the access road.

- 2) **Depth of Cut and Maximum Height of Fill.** Phase 2 Stage 2C Report No. 7 suggested an average depth of cut of 4.5 m and a maximum height of 15 m. The depth of cut and the maximum height are related in that the volume created by the geometry with respect to the excavated materials would represent a balance of the needs of cover material to the quantity of wastes disposed. The depth of cut and the height were intended to be used for comparison purposes among the candidate sites.

In the Design and Operations Reports for Sites D and F, I have modified these figures to better reflect the site specific conditions found at both of these locations. The depth of cut was determined as a function of the geological and the hydrogeological constraints that were established during the investigations carried out subsequent to the Phase 2 Stage 2C level of work. For site F, the variable terrain was also considered.

For Site D, the depth of cut varied from about 1.9 m in the southwest part of the fill area to about 7 m in the southeast with the depth averaging about 3.8 m over the entire site. For Site F, depths of cut varied from about 14 m near the centre of the site to a condition which required filling of up to 5 m in the stream valleys.



The final heights of the landfills were a function of the base contours developed as a result of the depths of cut, total expected waste quantities and area required for waste disposal. In addition, constraints developed by other consultants, notably the noise and visual concerns, were used to limit the final height and landforms. The final maximum height for Site D is about 17 m above existing ground. While this is about 2 m above the height proposed in the Phase 2 Stage 2C Report, the visual and noise concerns have been mitigated and the needs in terms of volume and the cover material requirements have been met.

For Site F, the final height was determined as a function of the factors discussed above. However, I also considered that the existing topography of the proposed area was extremely variable differing by more than 58 m in height from north to south. Since I could not determine a 15 m height from existing ground, I established a final top elevation at about 185 m. This height is about 5 m below the proposed final contours at the adjacent Regional landfill site.

- 3) **Cut Slopes at 1:1, Final Landfill Slopes at 4:1.** These criteria were generally adhered to. The exceptions to these figures can be found in the design for Site D where subsequent visual concerns dictated that the final slopes in the north and the west sides of the fill be reduced to the less steep grade as noted in the Report (Schedule A-D) in Section 4.2.
- 4) **Final Cover to be 1 m in Thickness.** This criterion was improved upon by increasing the depth of cover to reflect the subsequent revegetation needs proposed in the after-use concepts for both sites.
- 5) **Waste to Cover Ratio at 4:1.** The waste to cover ratio of 4:1 in the Phase 2 Stage 2C Report was assumed to be exclusive of final cover. In the Design and Operations Reports, I have modified this by initiating a more efficient use of cover material. In this design, the waste to cover ratio of 4:1 will be inclusive of final cover.



- 6) **Site Capacity to be a Minimum of 8.6 million m³.** As explained in the Design and Operations Reports (Section 3 of Schedule A-D and Schedule A-F), the estimated waste quantities expected at the landfill site were reduced from 11.3 million cy (about 8.6 million m³) to about 8 million m³. The reduction in the estimated volume requirements was one of the reasons for the subsequent reduction in the areal extent of the landfill sites.

TECHNICAL STUDY PHASE - METHODS AND RESULTS

The following outline summarizes the methods and results of the Design and Operations Reports for Site D and Site F. The full text can be found in the Design and Operations Reports in Sections 5, 6, and 7 in Schedules A-D and A-F.

- 1) **Base Mapping.** The initial work involved the preparation of suitable contour mapping from recent air photos. A scale of 1:2000 was selected as the most suitable for carrying out the work and presenting the results.
- 2) **Site Visits.** Site visits were made to the two sites to determine the general landform, topography and the site characteristics. Specific attention was given to such features as wooded areas, streams, access roads, existing structures on and off site, and other considerations described in the various reports completed for Phase 2 Stage 2C.
- 3) **Volume Requirements.** Updated quantity estimates were reviewed to determine the minimum site capacity requirements for the landfills. Using assumed density and waste to cover ratios, a 20 year volume requirement of about 8 million m³ was calculated.
- 4) **Development of Opportunities and Constraints.** Input was solicited from other members of the consultant team as well as outside interests (e.g., Town of Milton, City of Burlington, Halton Region Conservation Authority), to establish preliminary engineering and design parameters.



- 5) **Initial Site Development Plan.** Using the preliminary criteria, a first concept was developed showing base and final contours. For Site D, the plan involved the reduction in the area of landfill from that shown in the Phase 2 Stage 2C reports to an area that eliminated the eastern portion of the site.

For Site F, several viable options were investigated. Option 1 comprised the use of the total site. Option 2 proposed a site use that will save most of the significant areas of the oak-hickory complex by segmenting the landfilling areas into two distinct and separate landfills. Option 3 retained some of the oak-hickory area while limiting the fill area to one contiguous landform.

Option 3 was selected as the preferred option for the following reasons:

- it met the 20 year capacity requirement,
- it retained a part of the oak-hickory complex,
- it reduced the area of landfilling resulting in reduced leachate quantities,
- it optimized the opportunities for the extraction of shale,
- other concerns such as noise and visual could be satisfactorily mitigated, and
- the proposed fill area did not interfere with the remedial works undertaken by the City of Burlington at the adjacent Bayview landfill site.

- 6) **Design Refinement.** Once the areal extent and geometry of the landfills for Site D and for Option 3 of Site F were accepted by the Region, design refinements were undertaken on such details as base contours, final contours and cover material excavation and availability. At the same time, design concepts were initiated for such items as entrance and internal access road, service area, bulk bin area, weigh scales and scalehouse, fencing and berms.



- 7) **Environmental Controls.** Using the landfill geometry, concepts for environmental controls were established for leachate collection and disposal, surface water and landfill gas. For both sites, landfill gas migration was not determined to be a problem and thus was not included as part of the primary control systems of the sites.

For Site D, the leachate collection system was envisaged to occur using perforated pipes leading to a storage tank. Because of the remote location of the nearest sewer connection and considering that the leachate build-up will occur as the landfill is developed, it was decided to initially truck the leachate rather than to build a dedicated sewer line to the treatment plant.

For Site F, the close proximity of a sewer line allowed the leachate to be collected and disposed of as it was being produced.

- 8) **Landfill Progression and Operations.** The landfill design concepts were then analysed in terms of how the sites could be developed and operated. Some of the evaluations resulted in the concept of cells and cell progression, filling and daily operations, cell configuration, landforms during operations, initial site preparation needs, site equipment, staffing, litter control, site maintenance and monitoring.
- 9) **Further Refinements.** As the various concepts were proposed and analyzed, further refinements were made to the design and operations. Some of these included base and final contour modifications, confirmation of site capacities and cover material availability, leachate collection system and site operations. In addition, contingency plans were formulated to mitigate any problems arising out of the proposed concepts.

**TECHNICAL STUDY PHASE - CONCLUSIONS**

The conceptual design and operations for Sites D and F as presented in my reports, meet all the requirements as set forth in the Environmental Protection Act and Regulation 309 as well as meeting the intent of the document prepared by the Ministry of the Environment, Guidelines for the Establishment, Operations, Management, Maintenance and Closure of Landfilling Sites in Ontario. Both of the sites are technically sound in terms of the engineering concepts applied and can be implemented and operated in an environmentally safe manner.

DESIGN REFINEMENT FOR SITE F

Subsequent to the completion of the design and operations concepts for Site F, the financial and market feasibility of the shale resource extraction was revised. Initially, the site was intended to be operated in conjunction with the removal of some of the shale resources at the site. As a result of the feasibility study, it was agreed to refine the site design assuming the shale resource would not be excavated for storage or sale. The refinement was to limit the changes to the Design and Operations Report submitted in September, 1986 to minor modifications. The essential intent of the design would not be altered. Any refinements in the site design will be distributed upon completion or as soon thereafter as practically possible.

J.A. Hiraishi, P. Eng.

JAH/ird

GLOSSARY OF TERMS

Site Plan Area

- Area of the total proposed site including the actual area to be used for fill, buffer zones and site facilities.

Buffer

- Area of land controlled by landfill owner surrounding the actual fill area of a landfill.

Waste Compaction Density

- The density to which wastes are compacted in the landfill.

Leachate

- Liquids that result when water comes in contact with wastes.

After Use

- The intended use of land after the landfill site has been completed.

Cells

- Commonly used to identify a unit of landfilled wastes in a physically separated environment. In this report, the term daily cell is used to identify that unit of wastes that are disposed of in a given day.

Daily Lift

- Height of one day of landfilled wastes.

4:1 Waste to Cover Ratio

- Four volumes of wastes disposed to one volume of cover material.

4:1 Side Slopes

- Slope defined by four units horizontal length to one unit of vertical length.

Cell Progression

- Direction of landfilling.

Working Face

- Area of active landfilling where wastes are deposited, compacted and covered.

Perched Water

- Water ponded on top of unsaturated soil.

Progressive Rehabilitation

- A concept to rehabilitate the landfill as the filling is completed.

Dedicated Sewer

- A sewage line dedicated solely to the transmission of leachate produced at the landfill site.

Field Capacity

- The degree of saturation at which leachate will begin to move from the waste.

Spotter

- On-site staff who directs traffic at a landfill site.

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WITNESS STATEMENT OF

John Duncan Norman, B.Sc., M.Sc., Ph.D.

President, POLLUTECH LIMITED

In the matter of the Consolidated Hearings Act and with respect to the proposal by the Regional Municipality of Halton to provide facilities for disposal of waste as required by Section 37 R.S.O. 1980 c.436, the firm of Pollutech Limited, of which I am President, was contracted to carry out a Leachate Treatability and Toxicology study.

ROLE AND RESPONSIBILITIES

I was technical director on this project. As such, the technical program was carried out under my supervision and our report, "Leachate Treatability and Toxicology Report" (September 9, 1986) was prepared under my supervision.

APPROACH TO THE PROBLEM

The work was undertaken to determine whether the leachate expected to be generated by a new landfill at either Site D or Site F could be treated at existing Halton water pollution control plants and to determine whether or not there would be any potential toxic effect, particularly with respect to drinking water, since the treatment plants discharge to Lake Ontario.

The major tasks undertaken during the study were as follows:

- A detailed literature review was undertaken to determine what was reported elsewhere with regards to the quantity and quality of leachates, the treatability of leachates and the health or toxicity impact of leachate.

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- Detailed characterization of landfill leachate produced in the Regional Municipality of Halton through collection and analysis of landfill leachate at the closed Oakville site, the closed Georgetown site, the closed Bayview Park site and the operating Burlington landfill site. On the basis of these results a synthesized leachate was prepared, from the existing leachates, to represent the expected leachate.
- Detailed laboratory scale treatability studies were undertaken to determine the impact of the sanitary landfill leachate on three Regional Municipality of Halton Water Pollution Control Plants, giving due consideration to plant operation, effluent quality attainable, trace organic and trace metal contaminants and the impact on the Region's sludge utilization program.
- An ecological assessment was conducted utilizing fish bioassay procedures to compare the effluent from a treatment plant with and without treated leachate.
- Health risk assessments were carried out for the major compounds of an organic or inorganic nature that were identified in the leachate.

As a result of the original work carried out dealing with the raw waste characterization, treatability studies, ecological assessment and the health risk assessment, a number of clear guidelines were developed for the handling of the leachate from either Site D (Milton) or Site F (Burlington).

CHARACTERIZATION OF REGIONAL LEACHATES

Collection and analysis of landfill leachate from four existing landfill sites within the Regional Municipality of Halton provided information on what type of landfill leachate could be expected at varying ages of the landfill sites from within Regional boundaries. Results reported include:

- The analyses of the raw leachate from the four landfills studied to date showed a wide variation in trace organic species present. The major classes of organics isolated were: ① straight chain chlorinated hydrocarbons; ② chlorinated benzene derivatives; ③ straight chain organic acids and phthalates.
- The major inorganic species isolated were: zinc, boron, iron, manganese, calcium, silica, magnesium, sodium. Trace amounts of cobalt, aluminum, nickel, chromium, barium, arsenic, antimony and mercury were also detected.
- For organics the ① Burlington leachate was five times stronger than Bayview leachate and fifteen times stronger than Oakville or Georgetown leachate. Burlington leachate was approximately three times more concentrated relative to the major inorganic species present.

DETAILED TREATABILITY STUDIES

The treatability studies incorporated several physical, chemical and biological treatment procedures to determine the best way to treat the collected leachate. The prime purpose of these tests was to determine whether the leachate can be collected and treated at existing or proposed Regional water pollution control plants or whether pretreatment or separate treatment of the leachate would be required.

The work program was started with the collection of typical leachate samples from the four (4) existing Regional landfills in Burlington (operating), Oakville (closed), Georgetown (closed) and Bayview (closed). Using these samples a mixture of the leachates to synthesize one leachate sample for further study that would be typical of leachate discharged to the Regional sewage treatment plants was prepared. This typical leachate was characterized for organic contaminants, inorganic contaminants, biodegradability (ability of natural microorganisms to consume the waste) and toxicity (impairment of survival rates of test fish and microorganisms).

In the bench-scale biological treatability studies there were six biological sewage treatment plant simulators used to evaluate the impact of the leachate on the Region's water pollution control plants. These test units consist of three pairs of units representing the three pollution control plants where the leachate could ultimately be discharged (SKYWAY, OAKVILLE SOUTH-WEST, MID HALTON). In each test unit pair there was a "control", which was operated without leachate, and a "test" which contained leachate. Each pair of the models was operated under conditions to simulate closely the operation of the full scale plant. This included retention time in the process, chemical addition, and several operating conditions (pH, oxygen, temperature).

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Each model unit consisted of a "biological reactor" (where the waste is mixed with active microorganisms in the presence of air) and a "settling tank" (where the microorganisms were settled out from the liquid). The solids-free liquid (effluent) overflowed into a collection tank from which samples were taken for analysis. The settled microorganisms were recycled from the bottom of the settling tank back into the biological reactor to maintain an actively growing population in the biological reactor. Excess microorganisms were harvested or removed from the system, samples of which are also analyzed. In a full scale system the clear liquid (effluent) would typically be discharged into Lake Ontario, and the settled solids (sludge) concentrated for disposal.

On the basis of the treatability study the following observations were recorded:

- The bench scale biological treatability study, utilizing the mixture of sanitary sewage and landfill leachate, indicated that a leachate similar in nature to that used in the study could be treated effectively at both the Skyway and Oakville S.W. water pollution control plants at levels as high as 2.5 percent of the hydraulic flow into the water pollution control facility.
- Specific water pollution control plants already receiving sanitary landfill leachate (Skyway) or a mixture of industrial waste (Oakville S.W.) acclimatized more readily to the sanitary landfill leachate.

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- Although the effluent quality can be maintained, some modifications to existing operating procedures will be required. These include: providing increased sludge handling and disposal; ensuring adequate aeration is available; implementing solids control and monitoring for sludge settleability.

HEALTH RISK ASSESSMENT

On the basis of trace organic and trace metal contaminants found in representative samples of leachate, a health risk evaluation was conducted to look at the scenario of raw sewage containing leachate escaping into Lake Ontario in an untreated form. Where a health risk was identified on the basis of untreated leachate, the risk evaluation was also reviewed for leachate treated at the water pollution control plants.

The procedures that were used in assessing the potential health risks consisted of the identification of potential hazards from a selected group of chemicals identified as important components arising from the landfills, the evaluation of the potential exposure levels of human populations to these chemicals, and the estimation of the potential risks of adverse health effects based on the potential hazards and the exposure levels anticipated.

In order to identify the potential hazards associated with chemicals in various effluents and emissions from the landfills, a detailed toxicity profile was developed on each of the selected chemicals. These toxicity profiles provided a procedure for the systematic collation and critical review of the toxicological and epidemiological data available on each chemical. Particular attention was given to the assessment of the validity of the available data and its interpretation relative to current knowledge on the mechanisms of action of chemicals on biological and human systems.

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The results indicated that:

- As a result of this detailed treatability and toxicity evaluation it became apparent that there would be minimal change in the effluent quality with discharge of this landfill leachate into the sanitary sewer system for subsequent treatment at select water pollution control plants at acceptable organic loading rates.
- The majority of the contaminants are at acceptable levels in the influent to the treatment plants. Many of the components are not associated with the new leachate but are in the background sewage.

ECOLOGICAL ASSESSMENT

A part of the treatability and toxicology program involved a review of the ecological data and determination of the impact of the leachate quality on the natural environment in the event of leachate escape from the sanitary landfill site.

Results include:

- Testing of leachate for fish toxicity (LC₅₀ bioassays) indicate that a dilution of 270 to 1 would be required for the raw leachate, based on LC₅₀ dilutions of 13.3.
- Provided that the leachate attains adequate biological treatment then the fish bioassay testing indicates that there would be no significant difference between effluent toxicity from the municipal sewage plant effluent with or without sanitary landfill leachates.

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GENERAL CONCLUSIONS AND RECOMMENDATIONS

On the basis of all available information from the leachate treatability and toxicology study it became evident that:

- Provided that quantity of leachate flow is regulated within the limits prescribed, there would be no concern with discharge of this landfill leachate into the sanitary sewer system for subsequent treatment at select Regional water pollution control facilities. With such treatment there should be no associated health risks from the effluent from the treatment plant and no associated ecological impacts.
- The loading of leachate to the Regional water pollution control plants should be controlled so that no more than 2.5 percent of the volumetric loading to the plant is from the leachate.
- The addition of the leachate at any of the treatment plants will result in as much as a 100 percent increase in oxygen demand and a 55 to 100 percent increase in sludge production. Routine testing of the leachate impact will be required (i.e. microbiological examination, settling tests) to ensure acceptable full-scale levels of leachate are not exceeded.

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- Providing that loading rates and process operating conditions are controlled, the effluent quality at the water pollution control plants can be kept within Ministry of the Environment guidelines for BOD₅, suspended solids and phosphorus.
- The level of trace organic contaminants in the effluent of the test units did not show a significant increase over that for the control units at levels of leachate addition of 2.5 percent by volume.

D.87/1

CANTOX INC.

Consultants in Toxicology

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WITNESS STATEMENT of:

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CanTox Inc.
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in the matter of an application by The Regional Municipality of Halton

1.0 EXPERTISE

I have a Ph.D. in human physiology (University of California, Davis) with over 19 years of experience as a toxicologist in research and evaluation of the potential adverse effects of chemicals on humans and other animals. I was employed as a toxicologist by the Health Protection Branch, Health and Welfare Canada for 12 years (1967-1979). Since 1979 I have been a consultant toxicologist, working primarily in the assessment of the potential risk of adverse effects of the exposure of humans and other animals to chemical substances. My academic qualifications and accomplishments in the field of toxicology are documented in my curriculum vitae.

*What about
EFW waste*

2.0 ROLE AND RESPONSIBILITY

On behalf of the Regional Municipality of Halton, and under subcontract to Pollutech Limited, I conducted detailed toxicological evaluations on selected chemicals that would be found in the landfill leachate. The results of these evaluations were summarized in a report by Pollutech Limited entitled Schedule M, Leachate Treatability and Toxicology Report, The Regional Municipality of Halton, Site D and Site F, September 9, 1986. This work was conducted between about November 1985 and July 1986.

The primary objectives of the toxicological evaluations were to identify the major chemicals of potential concern in the landfill leachates and to assess the potential adverse effects of these chemicals, primarily through potential exposure of populations to drinking water that may be taken from Lake Ontario.

3.0 TOPICS ADDRESSED

3.1 Overview

The principal steps taken in my toxicological evaluations were:

- a) The selection of chemicals for evaluation.
- b) The identification of potential hazards associated with the selected chemicals.
- c) The estimation of acceptable levels of exposure (safety levels) for the selected chemicals.
- d) The comparison of the estimated safety levels with those expected in the landfill leachate.

3.2 Selection of Chemicals for Detailed Evaluation

An extensive literature review was conducted by Pollutech Limited to identify chemicals that had been identified in landfill leachates worldwide. The details of this literature review are outlined in the Pollutech Limited entitled Schedule M, Leachate Treatability and Toxicology Report, The Regional Municipality of Halton, Site D and Site F, September 9, 1986. The criteria outlined below were used to select chemicals from this general list for detailed evaluation of their potential health hazards.

The objective of the selection criteria was to focus evaluation efforts on those chemicals that were likely to be found in the landfill leachates and that represent the greatest potential hazards to health and the environment. Chemicals not selected for detailed evaluation by the criteria represented those of lesser potential hazard to health. The criteria were developed and applied within the limitations of the data available in the published scientific literature. Three criteria were applied in the selection of chemicals for detailed evaluation:

- a) Chemicals not found in the literature survey, or not detected by chemical analysis were excluded from further consideration.
- b) Chemicals that were known as proven or suspect carcinogens, mutagens or teratogens were included for detailed evaluation, regardless of their estimated concentrations in the leachate.
- c) Chemicals with high concerns regarding other general toxicological effects were also included for detailed evaluation. Such chemicals were selected based on a comparison of their estimated concentrations in the leachate and the levels of exposure to the chemical generally regarded as permissible. This comparison was facilitated by the calculation of S_w -values (Safe water values). Those chemicals with S_w -values greater than 0.1 were included for detailed evaluation. S_w -values were estimated as follows:

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$$S_w = C/F_w, \text{ where}$$

C = the estimated concentration of the chemical in the leachate,

$F_w = (\text{oral-TLV})/(3 \times 100)$.

(TLV is an abbreviation for Threshold Limit Value)

These criteria applied factors indicative of the potential health effects of the chemicals. A discussion of the basis for the calculation of F-values for atmospheric pollutants can be found in Wetherold and Rosebrook (1980, p 417). The Threshold Limit Value (TLV) forms the basis of the calculation. The TLVs represent the maximum allowable 8-hour time-weighted-average concentration of a substance in the work environment involving exposures for five days per week.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends TLVs for occupational settings, but specifically warns against their use as relative indices of hazard or toxicity in the evaluation of community air pollution or in estimating the toxic potential from continuous, uninterrupted exposure (ACGIH, 1985). However, as pointed out by Wetherold and Rosebrook (1980), no other sources of quantifiable toxicity levels are available for many chemicals that relate to acceptable human health standards. Therefore, despite the limitations of TLVs in evaluating the safety of chemical exposures, TLVs were used in the current project to incorporate an indicator of biological effects into the criteria for the selection of chemicals that would subsequently be evaluated in greater detail. It should be emphasized that their subsequent evaluation was not based on TLV values.

The primary concern for the current project is the potential hazards to health and the environment associated with estimated concentrations of various chemicals in effluents from the proposed landfill sites. Therefore, the potential hazards to health and the environment from these chemicals would relate to their concentrations in water, particularly drinking water. TLVs, however, provide estimates of acceptable levels of chemicals in air in occupational

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settings where inhalation is the major route of exposure. Therefore, to use TLVs for the selection of chemicals that are found in water, the TLVs were transposed from inhalation exposure to an estimated oral exposure value (denoted as an oral-TLV). This conversion was based on an average 70 kg person respiring 20 m^3 of air per day (RTECS, 1982) and consuming 2 litres of water per day (NRC, 1980). The oral-TLV (in units of mg/litre) was calculated from the inhalation TLV (in units of mg/m^3) as follows:

$$\text{oral-TLV} = (\text{TLV} \times 20) / 2 = [(\text{mg/m}^3/\text{day}) \times \text{m}^3] / [\text{L/day}] = \text{mg/L}$$

Two additional factors were also applied in the calculation of F -values for the selection of chemicals for further assessment. Since TLVs are established based on 8-hour, 5-day per week exposures, the calculated oral-TLV was divided by a factor of 3 to apply the exposure to a 24-hour period. In addition, it is generally believed that noncognizant exposure levels for the general public should be lower than the cognizant exposures associated with occupational settings where TLVs are usually applied (Wetherold and Rosebrook, 1980). To take these concepts into account, the calculated oral-TLV was divided by a factor of 100 in calculating the F_w -value.

$$\text{Therefore, } F_w = (\text{oral-TLV}) / (3 \times 100).$$

Finally, an S_w -value was calculated by dividing the concentration of the chemical in the drinking water by the F_w -value. An S_w -value of 1 would indicate the chemical was present in drinking water at a level 300-fold below its estimated oral-TLV. An S_w -value of 0.1 would identify chemicals present in drinking water at concentrations 3000-fold below their calculated oral-TLVs. Those chemicals with an S_w -value of 0.1 or greater were included for more detailed assessment of their potential health and environmental hazards. Chemicals with S_w -values less than 0.1 were considered of low toxicological concern and therefore, were excluded from further evaluation (i.e., chemicals present at concentrations 3000 times less than the estimated oral-TLV).

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If the available data on a particular chemical were inadequate for the calculation of an S_w -value, a value was estimated using the TLV for the most toxic chemical identified with similar physical/chemical characteristics.

3.3 Identification of Potential Hazards of Selected Chemicals

In order to identify the potential hazards associated with chemicals in various effluents from the landfills, a toxicity profile was developed on each of the selected chemicals. These toxicity profiles provided a systematic collation and critical review of the toxicological and epidemiological data available on each of the selected chemicals. An outline of the information reviewed in a toxicity profile is presented in Appendix B. The critical information from the toxicity profile of each chemical was compiled into a health evaluation summary. In the preparation of the health evaluation summary, particular attention was given to the assessment of the validity of the available data and its interpretation relative to current knowledge on the mechanisms of action of chemicals on biological and human systems. An outline of the information considered in a health evaluation summary is presented in Appendix C.

3.4 Estimation of Acceptable Exposure

The toxicological characteristics, combined with the total intake into the body (determined by the level and duration of exposure) of a chemical are the major considerations in the assessment of the potential risk of adverse health effects. The critical toxicological characteristics (e.g., those occurring at the lowest levels of exposure and representing the most serious effects) were selected from the toxicity profile of each chemical. For purposes of this assessment, it was assumed that exposure would be continuous over a persons lifetime.

A permissible level of exposure for each selected chemical was estimated based on the exposure level at which the risk of toxic effects was considered incon-

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sequential. These estimates were derived using either an "acceptable daily intake" (ADI)-Safety Factor approach or a "virtually safe dose" (VSD)-Risk Assessment approach. The choice of the approach was based on the weight of the scientific evidence available on the effects of the substances of concern. Generally, chemicals known as suspect carcinogens were evaluated using the VSD-Risk Assessment Approach, whereas non-carcinogens were evaluated using the ADI-Safety Factor approach. If the data available were inadequate for the estimation of such a permissible exposure level, available data of a substance with similar structure and chemical/physical characteristics was used to estimate an acceptable exposure level.

If estimates of permissible exposures were proposed by various regulatory agencies (e.g., MOE, HPB, U.S. EPA, U.S. FDA, WHO, OECD) for particular chemicals, these estimates were generally adopted unless there were scientific reasons for doubting their validity (e.g., new information was available that was not considered in the original assessment). Similarly, as new data become available in the future, the current assessment will require updating.

There are a variety of sources for the input of chemicals into the environment, however, this evaluation considered only inputs arising from the proposed landfill sites.

It was also assumed, as a worst-case scenario, that none of the chemicals would be removed from the drinking water by water treatment procedures used on Lake Ontario water.

4.0 RESULTS AND CONCLUSIONS OF THE ASSESSMENT

The chemicals selected for evaluation, their maximum and likely concentrations, permissible exposure levels, and rankings are summarized in the Table 1.

The information presented in Table 1 differs in several respects from that presented in Summary Table 6 of the Schedule M Pollutech Report. These differences arise primarily from the addition of data identified since the completion of the Pollutech Limited report entitled Schedule M, Leachate Treatability and Toxicology Report, The Regional Municipality of Halton, Site D and Site F, September 9, 1986. The additions to the Summary Table 6 included in Table 1 are as follows:

- a) The safety level for benzene, and compounds evaluated as equivalent to benzene, is expressed as a range (5.7 - 18.2 ppb). The 5.7 ppb value is based on an assessment by the EPA (1986) that was not available for the original report.
- b) An interim estimated safety level of 39000 ppb for camphor was calculated based on the application of a 1000-fold extrapolation factor to acute lethality data (LD₅₀) data from mice.
- c) The safety level for ethane, 1,2-dichloro-, and compounds evaluated as ethane, 1,2-dichloro-, is expressed as a range (3.5 - 43 ppb). The 43 ppb value is based on an assessment by the EPA (1986) that was not available for the original report.
- d) The safety level for ethylene, 1,1,2,2-tetrachloro-, and compounds evaluated as ethylene, 1,1,2,2-tetrachloro-, was expressed as a range (8.6 - 9 ppb). The 8.6 ppb value is based on an assessment by the EPA (1986) that was not available for the original report.

Table 1 Summary of Safety Evaluations for Selected Chemicals

CONTAMINANT	CONCENTRATION (ppb) maximum	likely	ACCEPTABLE Level (ppb) ^a	RANKING
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Trace Organics (ug/L)

acetic acid, phenyl	n.d.	n.d.	*	1
acetophenone	5.30	0.82	*	*
aldehyde, indoline carbox	n.d.	n.d.	*	1
benzene	1.20	n.d.	5.7 - 18.2	2
benzene, ethyl	2.31	n.d.	47.6 X 10 ³	2
benzoic acid	n.d.	n.d.	5.7 - 18.2 ^b	1
butanone-2 (MEK)	5.96	n.d.	6.3 X 10 ⁵	1,5
camphor	56.0	n.d.	39.0 X 10 ^{3c}	2
cresol, o-, m-, p-	120.0	n.d.	7.7 X 10 ³	2
ethane, 1,1-dichloro-	6.95	1.95	3.5 - 43 ^d	3
ethane, 1,2-dichloro-	10.9	n.d.	3.5 - 43	3
ether, diethyl	28.8	2.58	1.12 X 10 ³	2
ethylene, 1,1,2,2-tetrachloro-	12.4	0.79	8.6 - 9	3,5
ethylene, 1,1,2-trichloro-	6.29	1.64	12.2 - 15.8	2
ethylene, 1,1-dichloro-	1.13	0.52	2.0 - 3.5 ^d	2
ethylene, cis-1,2-dichloro-	n.d.	n.d.	2.0 - 3.5 ^d	1
ethylene, trans-1,2-dichloro-	n.d.	n.d.	2.0 - 3.5 ^d	1
ethylene, tris-1,2-dichloro-	n.d.	n.d.	2.0 - 3.5 ^d	1
indole, 3-methyl	62.5	0.24	30.0 X 10 ³	2
methylene chloride	l.c.	l.c.	48	2
norboranone, 1,3,3-trimethyl-	65	<1	*	*,5
phenol	85.2	n.d.	1 X 10 ³	2
phthalate, bis(ethylhexyl)	62.9	n.d.	98 - 1750	2
phthalate, butylbenzyl	24.1	n.d.	98 - 1750	2,5
phthalate, diethyl	18.1	n.d.	98 - 1750	2,5
phthalate, dimethyl	23.8	n.d.	98 - 1750	2,5
styrene	56	<1	93	2,5
xylene	24.2	<0.3	11.4 X 10 ³	2,5

Trace Metals (mg/L)

			(ppm)	
arsenic	0.003	<0.002	0.05 ^e	2,5
barium	0.16	0.05	1.0 ^e	2,5
chromium	0.16	0.072	0.05 ^e	4,5
cobalt	0.01	<0.01	1.320 ^e	2
magnesium	43.6	40.0	*	*
manganese	0.54	0.04	*	*
nickel	0.15	0.15	0.3 - 5	2,5

(continued)

Table 1 Summary of Safety Evaluations for Selected Chemicals

Footnotes to Table 1:

- a Lower value indicates minimum safe value estimate using a linear non-threshold model, higher value indicates safe value estimate using either a linearized multistage model, or a NOAEL/extrapolation factor estimate.
- b Estimated as benzene
- c Estimated safe level based on LD₅₀/500, therefore, must be considered interim value.
- d Estimated as ethane, 1,2-dichloro-
- e Based on MOE (1984) drinking water guidelines or tolerances.

Ranking Codes:

- 1 No health risk, none detected
- 2 No health risk at maximum concentrations possible (untreated)
- 3 No health risk at likely concentration (treated)
- 4 No health risk after lake dilution
- 5 Significant portion of contaminant not associated with leachate
- * Inconclusive health data
- n.d. Below analytical detection limit
- l.c. Indicates laboratory contaminant

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- e) The safety level for ethylene, 1,1,2-trichloro-, and compounds evaluated as ethylene, 1,1,2-trichloro-, is expressed as a range (12.2 - 15.8 ppb). The 15.8 ppb value is based on an assessment by the EPA (1986) that was not available for the original report.
- f) A safety level for 3-methylindole was not included in the original report. An assessment based on recently obtained data indicates a safety level of 30,000 ppb.
- g) A safety value for methylene chloride was not included in the original report. An assessment based on recently evaluated data indicates a safety level of 48 ppb.
- h) A safety value for cobalt was not included in the original report. A value of 1320 ppb has been recommended by the MOE (1984) as an "undefined tolerance limit" for cobalt levels in water.
- i) The safety level for nickel is expressed as a range (0.3 - 5 ppb). The 0.3 ppb value is based on an assessment by the EPA (1986) that was not available for the original report.

Based on the data in Table 1, seven (7) chemicals could not be detected in untreated leachate from the landfill sites and therefore were not considered of concern. Twenty (20) of the chemicals were detected in the untreated leachate at concentrations at or below the estimated permissible level for drinking water and therefore were not considered of concern. The concentrations of three (3) chemicals (ethane, 1,1-dichloro-, ethane, 1,2-dichloro- and ethylene, 1,1,2,2-tetrachloro-) exceeded the estimated permissible drinking water level in the untreated leachate, however, were below the permissible drinking water level in the treated leachate leaving the sewage treatment plant. One contaminant (chromium) remained above the permissible drinking water level in the treated leachate, however, it was estimated that this chemical would be below the estimated permissible drinking water level after dilution in Lake Ontario. In addition, significant portions of 12 con-

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taminants, including chromium, were not associated with the landfill leachate, rather were derived from sewage. The health data available were inadequate to enable an assessment for four chemicals; of these, a significant portion of norboranone, 1,3,3-trimethyl was not associated with the leachate; manganese and magnesium are essential trace elements and are toxic only at high exposure levels; and acetophenone would not be expected to be notably toxic based on its structure.

From the evaluation of these data, it was concluded that the leachate from the proposed landfill sites would not present a significant risk to human health if present in drinking water, even prior to lake dilution.

A handwritten signature in dark ink, appearing to read "Robert Willes", written over a horizontal line.

Robert Willes, Ph.D.

APPENDICES

APPENDIX A REFERENCES

ACGIH. 1986. Threshold limit values for chemical substances in the work environment adopted by ACGIH with intended changes for 1985-86. American Conference of governmental Industrial Hygienists, 6500 Glenway Ave., Bldg. D-7, Cincinnati, OH, 45211.

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MOE. 1984. Water management. Goals, policies, objectives and implementation procedures of the Ministry of the Environment. November 1978, revised May 1984. Ministry of the Environment, Government of Ontario, Toronto, Ontario.

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RTECS. 1982. Registry of Toxic Effects of Chemical Substances, Microfiche Edition. R.J. Lewis and R.L. Taken, (eds), US Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH.

Wetherold, R.G. and D.D. Rosebrook. 1980. Assessment of atmospheric emissions from petroleum refining: Volume 1. Technical Report. Environmental Protection Agency, Office of Research and Development, Industrial Environmental Research Laboratory, Research Triangle Park, NC. 27711. EPA-600/2-80-075a.

APPENDIX B OUTLINE OF TOXICITY PROFILE

- 1.0 CHEMICAL NAME
- 2.0 CAS NUMBER
- 3.0 SYNONYMS/TRADE NAMES
- 4.0 PHYSICAL CHEMICAL PROPERTIES
 - 4.1 Chemical Characteristics
 - 4.2 Chemical Reactivity
- 5.0 SOURCES/USES
 - 5.1 Production and Use
 - 5.2 Environmental Releases and Behaviour
 - 5.3 Principal Exposure Routes
- 6.0 REGULATORY INFORMATION
 - 6.1 Occupational Standards
 - 6.2 Drinking Water Guidelines
 - 6.3 Air Emission Guidelines
 - 6.4 Other Regulations
- 7.0 ACUTE TOXICITY
- 8.0 METABOLIC DISPOSITION
 - 8.1 Absorption
 - 8.2 Distribution and Metabolism
 - 8.3 Interactions with Other Compounds
 - 8.4 Excretion
- 9.0 GENERAL SYMPTOMS/SIGNS OF EXPOSURE
 - 9.1 Summary of Symptoms and Signs of Exposure
 - 9.2 Ecological Effects
 - 9.3 Biochemical Toxicology
 - 9.4 In vitro Test Systems
 - 9.5 Laboratory Studies
 - 9.6 Human Studies
- 10.0 REPRODUCTION TOXICITY/TERATOGENICITY
 - 10.1 Summary of Reproduction Toxicity/Teratogenicity
 - 10.2 In vitro Test Systems
 - 10.3 Laboratory Animals
 - 10.4 Human Studies

(continued)

APPENDIX B OUTLINE OF TOXICITY PROFILE

- 11.0 MUTAGENICITY/GENOTOXICITY
 - 11.1 Summary of Mutagenicity/Genotoxicity
 - 11.2 In vitro Test Systems
 - 11.3 Bacteria
 - 11.4 Yeasts
 - 11.5 Drosophila melanogaster
 - 11.6 Laboratory Animals
 - 11.7 Human Studies
- 12.0 CARCINOGENICITY
 - 12.1 Summary of Carcinogenicity
 - 12.2 Laboratory Animals
 - 12.3 Human Studies
 - 12.4 Carcinogenic Mechanisms
- 13.0 REFERENCES

APPENDIX C HEALTH EVALUATION SUMMARY

- 1.0 CHEMICAL CHARACTERISTICS
 - 1.1 Structure
 - 1.2 Major Exposure Routes
 - 1.3 Pharmacokinetics and Biotransformation
- 2.0 TOXICOLOGICAL EFFECTS
 - 2.1 Functional Effects
 - 2.2 Morphological Effects
 - 2.3 Observed Effect and No-effect Levels
- 3.0 GENOTOXIC EFFECTS
 - 3.1 Mutagenicity/genotoxicity
 - 3.2 Tests for Cell Transformation, Tumour Promotion and Cocarcinogenicity
- 4.0 NEOPLASTIC EFFECTS
 - 4.1 Test Data Available
 - 4.2 Histogenic Tumor Sites
 - 4.3 Histologic and Biologic Characteristics of Tumors Observed
 - 4.4 Latency Period and Dose-response Relationships
 - 4.5 Background Tumor Incidence Rates
- 5.0 HUMAN STUDIES
 - 5.1 Case Studies
 - 5.2 Epidemiologic and Health Surveillance Data
- 6.0 SUMMARY AND ASSESSMENT OF POTENTIAL HAZARDS
 - 6.1 Summary of Critical Data
 - 6.2 Estimation of Acceptable Exposure
 - 6.2.1 General Overview
 - 6.2.2 Selected Data Extrapolation Procedure
 - 6.2.2.1 ADI-Safety Factor Approach
 - 6.2.2.2 Multistage Model
- 7.0 REFERENCES

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WITNESS STATEMENT - FINANCIAL AND ECONOMIC IMPACT
OF
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OF
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in the matter of the Consolidated Hearing for Environmental Assessment
of the proposed Halton Region Landfill

ROLE AND RESPONSIBILITIES

I am an economist and a management consultant, specializing in economic analysis and forecasting for municipalities. Since 1982, I have been President of the economic consulting firm, C.N. Watson and Associates Ltd.

My responsibilities in this project included the following items, for which separate witness statements have been prepared:

1. the long range forecasting of waste quantities;
2. the financial and economic impact analysis of alternative potential landfill site locations and a number of related policy areas, including off-site property owner compensation, multi-site operations, and potential shale extraction for Site F.

I began work on this project in September, 1982. From that date until June, 1985, my firm was a sub-contractor to Walker, Wright, Young Associates Ltd. From August, 1985 to the present, I have been working under contract to the Region of Halton. The reports (or sections of reports) prepared by myself, together with my staff under my direct supervision, are listed in Table 1.

Table 1
Region of Halton Landfill
Environmental Assessment Work and Landfill Technical Studies
Prepared by C.N. Watson and Associates Ltd.

<u>DATE OF PUBLICATION</u>	<u>SCHEDULE NO.</u>	<u>TITLE</u>	<u>C.N.W. SECTIONS</u>	<u>PAGE NO.</u>
May, 1983	4	Phase 2, Stage 1 - Waste Needs and Systems Analysis - Consolidation	-Waste Quantities Forecast -Costing of Waste Disposal Options and Systems	3-20 & 25-47 119-157
October, 1983	8	Final Report: Phase 2, Stage 2A, General Overview Analysis	-Economic Analysis -Waste Projections by Zone	94-105
April, 1984	16	Consolidation Report, Phase 2, Stage 2B, Selection of Candidate Sites	-Economic Analysis -Single vs. Multi-Site Analysis	108-117 143-149
February, 1984	15	Appendices, Phase 2, Stage 2B Selection of Candidate Sites	-Appendices J & K - Haul Cost Analysis by Sub-Area for Multi and Single Site Options	not paginated
November, 1984	21	Review and Supplement to Stage 2B, Selection of Candidate Sites, Final Report	-review of waste quantities forecast -review of single vs. multi-site analysis -economic analysis -Waste Quantities Forecast, October, 1983 Update	1-19 20-24, 34-36 & 38-40 45-49 Appendix C, pages 1-23
June, 1985	30	Final Technical Report No.3, Economic Analysis, Phase 2, Stage 2C, Selection of Preferred Site	-complete report	I to II 1-1 to 14-4 A-1 to F-3
June, 1985	40	Final Report, Phase 2, Stage 2C, Selection of Preferred Site, Evaluation and Summary Report	-economic analysis -Input into evaluation process methodology	Chart 5 14-15
February, 1986	L	E.P.A. Review of Waste Quantity Projections	-entire report	7-106
November, 1986	K	Region of Halton, Landfill Technical Study, Economic Impact and Affordability Analysis	-entire report	I to II 1-1 to 3-26 B-1 to C-1

APPROACH TO ECONOMIC FINANCIAL IMPACTS ANALYSIS

My approach to the preparation of economic and financial impact analysis is based on the following premises:

- Use of data ranges in order to recognize the volatility of events which potentially influence growth, development, solid waste creation and disposal and the variability which is possible over time;
- Consideration of the "sensitivity" of the output or results to possible changes in the variables used, in order that research may be focused on the most important and the full range of possibilities considered;
- Careful reconsideration of the model and assumptions where the unfolding future differs from the forecast;
- Consideration of the full range of cost impacts - direct and indirect - rather than simply the proponent's anticipated costs;
- Consideration of the many implications of financial consequences in terms of the population, or wealth base over which costs may be spread, the present value of the cost, cash flow implications, risks and uncertainties, the range of accuracy involved and the probable cost of alternative measures.

SUMMARY OF INVOLVEMENT

Phase 2, Stage 1, Waste Needs and Systems Analysis

The costing of waste disposal options and systems was published in May, 1983 in "Stage 1: Waste Needs and Systems Analysis - Consolidation" on pages 119 to 157. We undertook this research to provide information relative to Evaluation Criterion 3 "Net Cost (Cost Per Ton of Waste Handled), Including Generated Revenues for Energy and Resource Conservation" to be used in the assessment of alternative waste disposal options and subsequently, waste disposal systems, defined by the consulting team.

We developed cost ranges for haul costs, transfer station costs, and the various disposal alternatives, through a research process which involved a review of the literature, interviews with Halton local and Regional staff, staff from other Regions, Metropolitan Toronto, the Ministry of Energy, and officials in private firms as well as input from other team members.

Net annual capital and operating costs (excluding revenues) for the major waste disposal options, were estimated as follows:

	<u>1982 \$ per ton</u>
Steam Production (EFW)	\$15-39
Incineration	\$31-48
Resource Recovery	\$19-27
Export to Hooker Chemical	\$27-31
Sanitary Landfill	\$12-20
Source Separation	\$20-23

The application of these per ton costs to the projected landfill tonnage, using the alternative systems defined by the consulting team provided a comprehensive cost range for each option. The results in terms of net present value on a 20 year cash flow (1982-2001) are summarized as follows:

<u>System</u>	<u>Present Value</u> <u>(1982 \$000,000)</u>
1A Incineration with Recovery (EFW)	54.9 - 128.9
1B Incineration without Recovery	99.9 - 154.2
2 Resource Recovery	66.1 - 95.2
3 Export to Hooker Chemical	88.6 - 106.4
4 Sanitary Landfill in Halton	46.5 - 75.5

Phase 2, Stage 2A, General Overview Analysis

The economic factors included in the initial screening process were included in "Final Report: Phase 2, Stage 2A, General Overview Analysis", published in October, 1983 on pages 94 to 105. At this stage, land and haul costs were considered. A number of other economic variables were included in subsequent phases but there was no satisfactory basis for estimating values for these variables at this stage when the whole Region was being considered (i.e. there were no sites or even sub-areas).

Land costs were developed based on information from the Regional Property Manager, staff from the Ministry of Revenue, Peel-Halton Assessment Office and published sources. The non-urban areas of Halton Region were divided into zones and an average land price per hectare was estimated. The zones were assigned a level of impact based on the rating scale (low, medium, high) set out in the report. The existing and planned urban areas were all assigned a high level of impact since urban land prices are considerably higher than those outside the designated areas.

The Stage 2A haul cost analysis represented a refinement of the Stage 1 analysis, since the haul costs for 1986 and 2001 from the four municipalities' waste centroids to 19 zones representing potential site locations were used. The zones were assigned a level of impact based on the rating scale (low, medium, high) set out in the report.

We also undertook a brief preliminary analysis of the impact of multiple (more than one) landfill sites on haul costs.

The evaluation of the Stage 2A land and haul costs for each of the 19 zones in Halton Region is summarized in Table 37 of the General Overview Analysis. We concluded that land costs represented only a fraction of the haul costs and accordingly, of the two components, attention should be directed to minimizing the latter.

Phase 2, Stage 2B, Selection of Candidate Sites

The economic analysis for the candidate sub-area screening process is set out in "Consolidation Report, Phase 2, Stage 2B, Selection of Candidate Sites", published in April, 1984, on pages 108 to 117. The single vs. multi-site analysis is set out on pages 143 to 149.

Our economic analysis evaluated a full range of economic factors to a level of detail appropriate for the 55 candidate sub-areas. The work program identified three major objectives relating to the cost criterion:

- Objective 1 - To minimize the present value of upper and lower tier municipal expenditures on waste haulage and landfill disposal in Halton over the 20 year planning period.
- Objective 2 - To minimize the impact on property values (immediate loss or future reduction) in the vicinity of potential candidate site(s) and haulage routes.
- Objective 3 - To produce the most favourable economic impact on the Halton economy.

Our approach to the economic analysis in this phase consisted of totalling the costs for the significant economic factors, arranging them in ascending order of costs and grouping them into four impact levels (low, moderate, high and severe). The impact levels were established at that point, since costs are relative and there is no generally accepted definition of impact levels.

Our method consisted of calculating the theoretical capacity of each of the 55 candidate sub-areas, based on information from Walker, Wright, Young Associates Ltd. and Hydrology Consultants and dividing the sites into two groups - single site options (which could accommodate the total Regional waste) and dual site options. To create an equitable comparison among the various sizes of sub-areas, the single site options were compared as a group, and similarly, the dual site options. The best from each was then compared directly.

The analysis was completed on a cost per ton basis, due to the differing site sizes. All costs in this report represented January 1, 1983 present value of the total estimated cost over a 20 year period divided by the tonnage to be handled at each site.

Our work program identified 24 sub-factors relating to the three economic objectives mentioned previously. The initial stage in the analysis was a review of these sub-factors to determine if there were costs, if these costs were significant, if they would assist in differentiating sub-areas and if they could be investigated at an appropriate level of detail for 55 sub-areas. Seven sub-factors were not considered further.

The cost components considered for each of the single site and dual site options were site capital costs, operating costs, haul costs, and other costs.

The results are shown in Tables 9 to 17 in the Stage 2B Report. The ratings are summarized in Table 19 with the cost figures expressed as Cost Index Ranges (lowest cost per ton equal to 100).

This economic impact rating formed a component in the selection of candidate site plan areas, undertaken by Walker, Wright, Young Associates Ltd.

In addition, in concert with Walker, Wright, Young Associates and based on consultation with other team members, we also undertook an evaluation of a single vs. multi-site landfill system to determine the most optimal arrangement on a "generic" basis. Five broad alternatives were identified: a Concurrent Program (one site throughout; two sites throughout; three or more sites throughout); and a Consecutive Program (one site for a portion of the period and a second site for a later portion; one site for a portion, a second site for a later portion and a third site for the final portion).

The following criteria were used: cost, social and cultural, natural environment, transportation, regional waste disposal operations and user convenience. The analysis is summarized in a figure following page 149 of the Stage 2B Report.

Our analysis concluded that, on a general basis, the single site system appeared to be favoured due to ease of administration, cost and reduction of the area of impact. However, in the event that a candidate sub-area within the multi-site group ranked extremely favourably from other factors, a dual site system may be more attractive. This was not, however, the case when the candidate sub-areas were evaluated.

The results of this analysis were used by the consultant team as the basis for the decision to pursue a single site for landfilling.

Phase 2, Review and Supplement to Stage 2B, Selection of Candidate Sites

A review of the Stage 2B economic impact analysis is included on pages 45 to 49 of "Review and Supplement to Stage 2B, Selection of Candidate Sites - Final Report" and a review of the multi-site analysis on pages 20 to 40. This report was published in November, 1984.

The economic impact analysis in Stage 2B was reviewed in order to take into consideration the increase in the required landfill capacity and the revised scheduling for EFW. Our analysis concluded that the increased waste volume for landfilling in Halton would not affect the ranking of the single site option candidate sub-areas to any significant degree, except for the addition of B3 which would probably receive a moderate ranking under "Costs". For the dual site options, there might be some minor shifts in costs per ton and the ranking on Table 19 of the Stage 2B Report, particularly for the 22 single site options. However, it was highly unlikely that the ratings for any candidate sub-area would change due to the wide difference (12 points) between the top rated site ranked as low (Q2) and the second site ranked as moderate (A1). In addition, there were four points separating the lowest ranking "moderate" site (B4a) and the highest ranking "high" site (B4b).

Our review of the Stage 2B economic analysis was considered by Walker, Wright, Young Associates Ltd. as part of the overall review of the Stage 2B findings.

Our review of the Stage 2B single vs. multi-site analysis consisted of a redefinition of the options as follows: single site option; a concurrent program whereby two sites are operated for the first eight years and one thereafter; a concurrent program whereby two sites are operated for the entire forecast period; a consecutive program whereby an initial site handles 100% of the waste, followed by a second site handling a reduced waste volume.

The evaluation methodology was similar to that used in Stage 2B, with the exception of the addition of more input from the consulting team members. The single site option represented the base case, with the concurrent and consecutive dual site options evaluated against it, using the following system: no effect; positive effect (advantages over single site system); and negative effect (disadvantages over single site system).

The results of this review of the single vs. multi-site system are summarized in Table 12 of the Stage 2B Review Report. The analysis concluded that the consecutive or concurrent dual-site landfill system had a significant number of potential disadvantages and few potential advantages over the single-site system. Provided that the ratings for the individual dual site alternatives were not clearly superior to the ratings for the single site alternatives, it was considered to be inevitable that a single-site approach would be preferable to a dual site system.

The results of this analysis were used by the consultant team to confirm its previous decision to pursue a single site for landfilling.

Phase 2, Stage 2C, Selection of Preferred Site

The economic analysis at the preferred site selection stage is documented in "Final Technical Report No. 3, Phase 2, Stage 2C, Selection of Preferred Site, Economic Assessment", published in June, 1985.

8.

The Stage 2C economic analysis evaluated the six site plan areas (identified in Stage 2B) based on the following cost components: property acquisition; site development costs; road reconstruction costs; site operating costs; haul costs; and property value impact. The cost analysis employed an annual cash flow approach for each of the components, culminating in a present value for each of the site plan areas as of January 1, 1985.

The annual rates assumed in the Stage 2C analysis were 7% inflation and a 12% percent discount rate over the long term (24 year period). They differed from the figures used in Stage 1 (9% inflation, 12% discount rate) and Stage 2B (6% inflation, 11% discount rate) due to changes in forecast economic conditions. The real rate of interest, however, remained constant at 5% in the Stage 2B and 2C analyses.

In Stage 2B, seven economic sub-factors were excluded from the analysis due to their insignificant impacts or their inability to contribute to the differentiation among the sites. These sub-factors were again reviewed at this stage. Six were again rejected for the same reasons. One (impact on land values bordering major haul routes) was included in the Stage 2C analysis.

The Region of Halton, the area municipalities and the private sector will each bear part of this total landfill cost. The distribution of the cost burden is shown in Table 10 of the Stage 2C Report. From the Regional perspective, Sites A, D and E would be the lowest cost alternatives, Site F's costs 22-41% higher, and Sites B and C's costs almost twice as high. The cost differential between the highest and lowest cost site was considerably greater for the Region (\$25.4 million) than for the area municipalities (\$2.2 million) or the private sector (\$2.1-2.9 million).

The ranking of the site plan areas from an economic perspective was based on two criteria: total costs and public sector costs, with the latter receiving more weight due to their greater significance in a public sector decision and the difficulty in predicting private sector costs. The present value (as of January 1, 1985) for total and public sector costs for each site is as follows:

Site Plan Area	Present Value (\$000,000)		Index	
	Total	Public Sector	Total	Public Sector
A	48.6	35.6	100	100
D	50.9	37.4	105	105
E	52.7	37.7	108	106
F	58.7	45.6	121	128
B	73.0	60.1	150	169
C	74.0	60.9	152	171

The rank order of the site plan areas was identical for both total and public sector costs. The percentage cost differences also did not vary significantly. Consequently, the final ranking of the sites from a cost perspective was established as follows:

A	-	1
D	-	1
E	-	1
F	-	4
B	-	5
C	-	5

Sensitivity analysis was also undertaken using real rates of interest of 3% and 7%. The rankings remained the same, with similar percentage margins.

An affordability analysis was completed following the selection of Site F as the recommended site by the consulting team. An overview analysis, using data supplied by the Region, showed that Site F was affordable based on both Region and O.M.B. guidelines. However, it represented a major capital undertaking for the Region and would reduce funding flexibility for other projects.

The results of the economic analysis were used by the consulting team as input to the overall preferred site selection process.

In addition, we were involved in devising the general approach used by Walker, Wright, Young Associates Ltd. to rate the site alternatives.

Landfill Technical Study, Economic Impact and Affordability Analysis

This economic and affordability analysis is set out in "Region of Halton Landfill Technical Study, Economic and Affordability Analysis", published in November, 1986.

Sites D and F were analysed with respect to their twenty year cost implications and affordability to the Region (impact on the tipping fee, average household costs in the context of other Regional programs, and required debt capacity) and financial impact on the area municipalities and the private sector.

The rate assumptions used in this report were 5% per annum for inflation and 10% for discount purposes, with a real rate of interest of 5%. This is identical to the real rate used in the Stage 2B and 2C analyses.

The Technical Study cash flow spanned the years 1988 to 2008, with present value calculated as of January 1, 1987.

At both this stage and the earlier Stage 2C, we undertook research related to possible off-site property value impacts and made an allowance in our comparison for such possible impacts.

Site D

The financial impact of developing a landfill at Site D, based on a twenty year site operation, would be as follows:

10.

	Present Value as of January 1, 1987 (\$000,000)
Regional Approval, Site Purchase, Construction and Operation Costs	37.9
Area Municipal Haul Costs	10.4
Private Sector Haul and Other Costs	<u>14.6</u>
	62.9

It was concluded that Site D was potentially affordable for the Region. Average household charges, including solid waste, sewer and water rates and all other Regional services, were projected to increase at a rate lower than inflation over the 1987-1996 period (Table 6). Total Regional debt charges, as a percent of Regional expenditures were within the O.M.B. guideline of 20% for each year, although in the initial period of the landfill construction, the Region's flexibility to fund additional debt would be reduced (Figure 1). Site D was also found to be affordable from the perspective of the area municipalities and private haulers, since it represented a slight improvement over the existing haul situation.

Site F

The economic impact of developing a landfill at Site F, based on a twenty year site operation, would be as follows:

	Present Value as of January 1, 1987 (\$000,000)
Regional Approval, Site Purchase, Construction and Operation Costs	37.3
Area Municipal Haul Costs	10.6
Private Sector Haul and Other Costs	<u>13.2</u>
	61.1

It was concluded that Site F was potentially affordable for the Region. Average household charges, including solid waste, sewer and water rates and all other Regional services, were projected to increase at a rate lower than inflation over the 1987-1996 period (Table 12). Total Regional debt charges, as a percent of Regional expenditures were within the O.M.B. guideline of 20% for each year, although in the initial period of the landfill construction, the Region's flexibility to fund additional debt would be reduced (Figure 3). Site F was also found to be affordable from the perspective of the area municipalities and private haulers, since it represented no change from the present situation.

11.

As part of the economic impact analysis of Site F, the impact of extracting and selling the excess shale resource was investigated. The report examined Statistics Canada and Provincial government documents on the shale resource and the brick industry to provide information on trends in consumption and production. In addition, interviews were held with staff from the Ontario Geological Survey, the Ministry of Natural Resources, the Ministry of Northern Development and Mines as well as officials from several brick companies. The report concluded that the excavation of shale at the site by Halton Region was not an economically feasible undertaking. The small number of purchasers, the large reserves involved and the volatility of the market would make such a venture inherently risky.

The information in this Landfill Technical Study has been submitted to the Region of Halton Finance Department to support, as is our understanding, their application to the Ontario Municipal Board to secure authority to issue debentures, and to Walker, Wright, Young Associates Ltd. to complete a comparative analysis of Sites D and F.



Cameron N. Watson, CMC

GLOSSARY OF TERMS

Current Dollars - a sum of money adjusted to incorporate the effects of inflation.

Constant Dollars - a sum of money not adjusted for inflation and, therefore, applicable only to the year in which it was earned or expended.

Cash Flow - a statement of annual revenue and expenditures with designated expenditure/receipt dates, normally in current (inflated) dollars.

Present Value - a present value (PV) analysis (or discounted cash flow) incorporates adjustments to revenues or expenditures to account for the fact that they are made at different points in time and are not of equal value as a result of both inflation and the time value of money. It, therefore, puts cost and revenue entries, incurred over time, on a comparable basis.

Real Rate of Interest - the difference between the inflation rate and discount rate employed, which is normally the debt rate or the reserve fund earnings rate.

Sensitivity Analysis - the use of varying inflation, discount and other rates in an analysis to determine the way in which the results of an analysis will vary with these changes.

Annualized Capital Costs (Stage 1 Report) - the stream of annual payments over a set period which is equivalent to a particular capital cost incurred at a point in time, based on a selected rate of interest.

O.M.B. Debt Capacity - a quota for long term borrowing of funds established annually by the Ontario Municipal Board for each municipality which requests it. The basis of establishing the quota is the guideline that no municipality should spend more than 20% of its revenue fund expenditures on debt payments.

Tipping Fee - fee charged to dispose of refuse at a landfill site (usually on a per tonne or per cubic metre basis).

Scenario - a defined set of assumptions about the future, normally analyzed as one of a number of possible alternatives.

WITNESS STATEMENT OF JOSEPH L. RINALDO, C.M.A.

DIRECTOR OF FINANCE AND REGIONAL TREASURER
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OAKVILLE, ONTARIO.
L6J 6E1.

**In the matter of the Consolidated Hearing for the
Environmental Assessment of the proposed Halton Region
Landfill Component of Solid Waste Management.**

Roles and Responsibilities

I am a Certified Management Accountant and am empowered to carry out the statutory duties of the Treasurer for the Regional Municipal of Halton. As Director of Finance and Regional Treasurer I am charged with responsibility for providing Regional Council with sound advice regarding the financial stewardship of the Corporation and ensuring that the state of the Region's financial resources adequately meets the existing and future needs of all Regional services.

My responsibilities with respect to this Environmental Assessment project are to ensure:

- The affordability of the capital and operating costs of the total Solid Waste Management System as presented in this undertaking.
- The adequacy of the financial resources required for this undertaking (both in the near and long term), without impeding the mandate of other Regional services.

Synopsis of Halton's Financial Position

Since 1982, Halton's financial position has been significantly strengthened due to continued economic growth and Council's commitment to the development of sound fiscal policies. During this period, Halton's economy has demonstrated strong growth resulting in annual tax assessment increases between 2% and 5.3%. In conjunction with this growth, Halton has been able to expand its level of service while maintaining combined tax and utility rate increases below inflation.

A strong commitment to sound fiscal policies has enabled Halton to strengthen its financial position providing flexibility to meet unforeseen future demands. The outstanding debt liability has decreased from \$67.4 million in 1982 to \$60.3 million in 1986. At the same time, the average term to maturity on this debt has been reduced from 5.5 years to 3.7 years. In 1982 external debt financed 48% of the Capital Expenditure while this financing has been reduced to 21% in 1986.

Reserves and Reserve Funds may be described as the equity of Halton residents. Reserves play a useful role in developing fiscal policy and planning short and long term programs. They also provide the Region with financial liquidity and protection against erratic fluctuations in taxation or as insurance against unforeseen events. Halton's Reserve position has increased from \$13.5 million in 1982 to \$44.3 million in 1986. The reserves to outstanding debt ratio has increased from 20% in 1982 to 73.4% in 1986.

Sound fiscal policy and the strengthening of Halton's financial position has led to Halton increasing its credit rating from 'AA' to 'AAA' in 1985. This rating represents an independent review of Halton's financial position and recognizes the diversification and strength of our underlying economy.

Conclusion

The continuing improvement in Halton's financial position has enabled Council to gradually reduce the Region's dependence on external debt while ensuring that sufficient fiscal capacity is available to meet the capital requirements which are being generated by the economic expansion in Halton. The capital cost estimates associated with the Landfill component of the Solid Waste Management System have been incorporated into Halton's Capital and Operating Budget projections. It is my opinion that this undertaking is affordable and will not impair the future level of service provided to the residents of Halton.


J. L. Rinaldo, C.M.A.
Director of Finance
and Regional Treasurer

JLR:mab

WITNESS STATEMENT OF VICKY HENDERSON, B.A.
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**In the matter of the Consolidated Hearings for the
Environmental Assessment of the proposed Halton Region
Landfill Component of Solid Waste Management.**

Roles and Responsibilities

My involvement with this Environmental Assessment began in 1983 when I was hired as Energy from Waste Project Officer. Initially, it was envisaged that I would act as a research assistant to the Project Coordinator, who at the time was Dave Birkett, the Senior Policy Analyst with the Finance Department. Approximately six months later, I was made Project Coordinator. Responsibilities included the day to day work on the project, liaison with Consultants, public consultation, presentations, and report writing. Direction for work undertaken, and final approval was at the discretion of the Chief Administrative Officer (CAO) and Council.

In February of 1985 I became Assistant to the Chief Administrative Officer. In this capacity, I continued to manage the project. In April of 1986, responsibility for Energy from Waste was transferred from the Office of the C.A.O., to the Waste Disposal Division of the Public Works Department. Subsequent to this time, I have continued to offer assistance and advice on Energy from Waste, to both the Manager of Waste Disposal, and Chief Administrative Officer.

Reports

As Project Coordinator, I was responsible for the production of the following reports;

1. EFW - Market Phase Report - Regional Municipality of Halton. Final Report approved in February, 1984.
2. EFW - Preliminary Feasibility Study Summary Report - Regional Municipality of Halton. Final Report approved September, 1984.
3. EFW - Preliminary Feasibility Study Submissions Report - Regional Municipality of Halton. Approved September, 1984 (Coordinated responses prepared by Consultants and Staff).

4. Proposal for a Separation at Source Program for Halton - Regional Municipality of Halton. Final Report approved in February, 1985 (Based on draft report and research undertaken by Margaret Weightman, the former Assistant to the C.A.O).
5. EFW - Interim Report - Prepared by the Citizens' Solid Waste Advisory Committee for the Regional Municipality of Halton. Report released in October, 1985 (Prepared text for review and approval by SWAC).
6. Energy from Waste - A Citizens' Perspective - Final Report of the Citizens' Solid Waste Advisory Committee for the Regional Municipality of Halton. Report released in March, 1986 (Oversaw preparation of text for review and approval by SWAC).
7. Submissions Report - Prepared by the Citizens' Solid Waste Advisory Committee for the Regional Municipality of Halton. Report released in April, 1986 (Oversaw preparation of responses for review and approval by SWAC).

Study Process

One of the components of an Environmental Assessment for a new Regional landfill site was a Waste Needs and Systems Analysis Study prepared by Walker, Wright, Young and Associates in 1983. This study indicated that a twenty year planning period should be used for waste disposal and that the preferred disposal system should be one utilizing Energy from Waste (EFW). More specifically, it was recommended that one or a number of EFW plants should incinerate 75% of available solid waste. This was accepted, in principle, by Council.

Following this recommendation, a Staff Task Force was created to evaluate the feasibility of EFW as a component of Halton's Waste Management System. It was to be directed by the Chief Administrative Officer but included members of the Finance, Planning and Public Works Departments. As the Project Officer, I coordinated the Task Force on behalf of the CAO.

The Task Force prepared and Council approved a work program that outlined the major steps that would have to be completed before a final decision on the project could be made. They were:

1. Identification of potential markets;
2. Preliminary evaluation of feasibility; and
3. Detailed evaluation of feasibility.

Upon completion of these three levels of study, it was anticipated that Halton would be in a position to take a specific

project through the environmental approvals process and begin construction of a plant.

Market Study

Upon receipt of funding from the Ministry of Energy, the Task Force began preparation of its Market Phase Report. Its purpose was to identify potential and specific steam and electricity users that would be suitable and willing, to participate in Halton's Energy from Waste Program.

The initial phase of the Market Study involved the surveying of over 1300 businesses and institutions to identify their current energy requirements. This preliminary information was reviewed to identify those customers, who, on a daily basis, would be able to consume the amount of energy produced by a 75 tonne per day Energy from Waste plant.

With the assistance and advice of an engineering consultant, Alex Juchymenko of Cogeneration Associates, it was determined that the following energy customers had energy requirements suited to EFW:

1. Ford Assembly Plant (Oakville);
2. Union Carbide (Linde) Gas Production Plant (Oakville);
3. Petro-Canada Refinery (Oakville);
4. F.W. Fearman Meat Producing Plant (Burlington);
5. Leaver Mushrooms Farm (Milton);
6. Beardmore Tannery (Halton Hills).

In addition to meeting the energy consumption criteria, it was also necessary for the potential customer to meet a number of other criteria. These additional criteria involved consideration of the following:

1. Social acceptability - social impact of the EFW plant;
2. Customer self sufficiency - availability of back-up system;
3. Suitability of energy customer - fluctuation in and predictability of energy consumption;
4. Suitability of physical environment - sensitivity to air, water and noise considerations, distance from residential areas, topography;
5. Compatibility with adjacent land uses - Official Plan designation, surrounding land uses, traffic patterns, etc.;
6. Suitability of location - proximity to supply of waste and possible landfill sites;
7. Flexibility of timing - customer's plans for future expansion and/or replacement of equipment;
8. Reliability of customer's operation - customer's financial stability, age of plant and history of labour relations.

Upon completion of this very preliminary, in-house review of the six potential energy customers, it was determined that all were suitable for inclusion in the Preliminary Feasibility Study.

These dedicated customers, as they were referred to in the Market Study, formed an integral part of the three markets that were identified and recommended for further consideration. They were:

1. Dedicated customer;
2. Dedicated customer with oversizing for electricity;
3. Electrical grid only.

Preliminary Feasibility Study

In accordance with the Market Study, two market alternatives were to be studied for each dedicated customer. First was an EFW plant designed to meet the needs of a single dedicated industry which would use all of the steam and/or electricity produced. The second alternative was an oversized plant which would not only serve the dedicated industry, but would also produce extra energy for converting into electricity and transmission to the electrical grid. The idea of this concept was to assist in achieving Halton's goal of disposing of 75% of available solid waste through incineration with energy recovery.

As mentioned earlier, the Preliminary Feasibility Study was also to examine the electrical grid only option. It was proposed that the power produced from a 600 tonne per day (tpd) plant would be fed into the Ontario Hydro grid at one of four existing transformer station locations. The reason for including this electricity only alternative was in case no dedicated customer was available or willing to participate in the project. As Ontario Hydro had previously agreed to purchase any energy produced, the market for electricity was guaranteed.

The four transformer stations that were recommended for consideration in the Preliminary Feasibility Study were selected based on their potential to minimize:

1. Emissions;
2. Traffic impacts;
3. Haulage costs; and
4. Connection costs.

The location of the Burlington, Palermo, Trafalgar and Milton Transformer Stations as well as the dedicated customers is shown on Page 5 of the preliminary Feasibility Study Final Summary Report (August, 1984).

In the staff report that accompanied the Market Study, it was recommended that Halton concentrate its efforts on those alternatives that were located within its jurisdiction and involved a single energy customer. This recommendation was made on the basis that it was anticipated that these alternatives would be significantly less complex and therefore would be able to be implemented more quickly.

In the event that the three market alternatives identified previously, did not prove to be feasible or that there was a significant change in the environment in which the market study was conducted, outside Halton alternatives and/or district heating facilities (referred to as "clusters" in the reports) would be considered further.

As the result of the Marketing Study recommendations, first the Task Force solicited and reviewed proposals from consultants who were capable of carrying out the technical and environmental studies necessary to complete a Preliminary Feasibility Study. Council adopted the recommendation of the Task Force and selected the SNC Group, in association with I.E.C. Beak and W.P. London Associates. Regional Finance Department staff, with some additional outside expertise, were directed to evaluate the costs of the various waste management systems.

The purpose of the Preliminary Feasibility Study was to investigate the alternatives previously identified in the Market Study and determine which were technically, environmentally and financially feasible. In addition, it was also recommended that the alternatives be prioritized. The Preliminary Feasibility Study was to be completed in time for a final decision on the capacity of the proposed new landfill site.

The technical analysis of the Preliminary Feasibility Study was undertaken with two main objectives. The first was the accurate prediction of the customer's energy requirements and the second was the design of a facility that was suitable for both waste disposal and energy production.

The Technical Consultant SNC and the Environmental Consultant I.E.C. Beak concluded that an Energy from Waste plant could be designed to meet air emissions standards as well as the needs of the energy customer. As a result of this, it was determined that the differences between the various alternatives would be reflected in relative efficiency (cost) of each plant and waste management system being considered.

The main instrument for comparison of the alternatives in the financial analysis was "net present value". As stated earlier, this figure was calculated for each possible Waste Management System. It included provision for haulage, the construction and operation of a landfill site, the

construction and operation of the EFW plant and debt charges. It also made provision for changes in Regional waste stream projections and took into account the six candidate landfill sites identified as part of the Phase 2, Stage 2B Walker, Wright, Young Candidate Sites Report for the Landfill Environmental Assessment.

In evaluating the results of the study, each of the alternatives was ranked in order of environmental and financial preference. (Technical preference was incorporated into a cost then included in the financial analysis.) The scores were then combined with the six best candidates being selected for a more detailed risk and sensitivity analysis.

In the Draft Feasibility Study, five alternatives involving three sites were selected for detailed financial analysis. When the Ford Motor Company asked to withdraw from the study, the alternative of selling electricity to Union Carbide was also included in the detailed financial analysis.

The Preliminary Feasibility Study concluded that Energy from Waste is technically, environmentally and financially feasible for Halton. The Ford, Petro-Canada, Union Carbide and F.W. Fearman locations were recommended for further study. The Beardmore, Leaver Mushroom and transformer station locations were not.

Shortly after this decision was made and as a result of public opposition, all of the recommended energy customers indicated an unwillingness to proceed with the project to the detailed feasibility phase. For this reason, the goal of achieving an EFW facility which would incinerate 75% of Halton's waste stream by 1988, had to be reassessed. As a result, Council adopted a new policy for EFW, namely to postpone the introduction of EFW in Halton's Waste Management System from 1988 until 1996. It also recommended that the quantity of waste to be diverted be reduced from 75% (600 tonnes per day) to 50% (363 tonnes per day).

Solid Waste Advisory Committee

In assessing the future direction for the Energy from Waste project, Council determined that the Region must gain a wider acceptance and understanding of the need for Energy from Waste before such a project could be implemented. To address this need, it was recommended that a Solid Waste Advisory Committee (SWAC) be established. This Committee of volunteers from the community was asked to re-examine the waste disposal issue in Halton with particular emphasis on comparing Energy from Waste to landfill. Upon completion of this study, their conclusions would then be used by Council to reconsider its goal of having a 50% of the waste produced in Halton disposed of by incineration by the year 1996. SWAC's report would also be used to

provide direction on environmental issues and site selection criteria that should be considered in any future studies.

In March of 1986, the SWAC's Final Report was produced. It recommended the following:

- There should be a single, privately owned, centrally located, electricity producing plant constructed in or near Halton.
- A health risk assessment should be undertaken once a specific site is chosen.
- With the proper use of air pollution control technology, emissions from a well built and operated plant would be well below the Ontario Standards and Guideline.
- A new modern plant can be architecturally designed to blend in with its surroundings.
- The Committee's site selection criteria should be considered in locating a plant.
- Citizen involvement should be on an ongoing basis, from the time of site design, through to completion, for the life of the plant.
- On purely economic grounds, Energy from Waste is the more expensive option than landfilling. However, in SWAC's opinion, the benefits appear to outweigh the costs of such a project.
- The Ministry of Energy and Ontario Hydro should be encouraged to increase the rates paid to small, electricity generating facilities.
- An inter-regional project (in excess of 2,000 tonnes per day) may provide a solution to the current, relatively poor economics of selling electricity to Ontario Hydro.
- Extensive research demonstrates that well burned municipal refuse will result in fewer contaminants in the resulting leachate than when raw refuse is buried.
- Given the current public awareness and sensitivity to Energy from Waste issues, the most appropriate approval process for EFW would be under the Environmental Assessment Act.

At a special meeting of the Solid Waste Management Committee, SWAC presented its Final Report. This resulted in a commitment from Council to incorporate wherever possible SWAC's recommendations in any project being considered in Halton.

Strategy for Implementation of EFW

A strategy put forward by staff and approved by Council in April of 1986, recommended that, in addition to improvements in staff resources for the project, a new site selection study should be undertaken. The purpose of this study was to identify sites that would be suitable for the construction of an electricity producing plant. It would not be limited to

consideration of only the four transformer station sites that were identified as part of the Preliminary Feasibility Study.

In February of 1987, a more comprehensive strategy was adopted by Council. Consistent with the previous EFW Market Study, this strategy recognizes and adjusts to the problems that have arisen with the lack of immediate availability of a steam customer and the changing circumstances of existing facilities outside Halton such as St. Lawrence Cement, the Solid Waste Recovery Unit (SWARU) in Hamilton-Wentworth and the Occidental Chemical EFW plant in New York. The strategy involved Halton undertaking a comprehensive evaluation of alternative EFW options, including a comparison of costs for options both inside and outside of Halton.

VICKY HENDERSON

1981 - 1983 University of Western Ontario

- 1974 - 1977 Fanshawe College, School of Design

- ## EMPLOYMENT

Assistant to Chief Administrative Officer (1985 - Present)

- Energy from Waste Project Officer (1983 - 1985)

- 1980 - 1981** **Jean Monteith and Associates Ltd.**
(Urban and Regional Planning Consultants)

- Part-time researcher
- Assisted in preparation of background studies for development of official plans

WITNESS STATEMENT OF JOSEPH L. RINALDO, C.M.A.

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L6J 6E1.

**In the matter of the Consolidated Hearing for the
Environmental Assessment of the proposed Halton Region
Landfill Component of Solid Waste Management.**

Roles and Responsibilities

I am a Certified Management Accountant and am empowered to carry out the statutory duties of the Treasurer for the Regional Municipality of Halton.

My responsibility on this Environmental Assessment project was to undertake a comprehensive study on the financial feasibility of building an Energy from Waste Plant as part of Halton's Solid Waste Management System.

The directive for this undertaking was originated by Halton's Regional Council as described in CAO Report 65/84, "Submissions and Final Marketing Phase Report - Halton Energy from Waste Project" whereby at the completion of Marketing Phase, Feasibility Studies would be undertaken on the Financial, Technical and Environmental aspects of energy from waste. The Financial Study was carried out in tandem with each of the other studies. The results of all three studies were consolidated in the final Summary Report (Regional Municipality of Halton, August, 1984).

REPORT

The report produced as part of my responsibility was the Energy from Waste Preliminary Feasibility Study - Final Financial Report dated August 24, 1984.

Scope of the Financial Analysis

The purpose of the Financial Feasibility Study was to assess the financial viability of an Energy from Waste Plant as an integral part of Halton's total Solid Waste Management System. The report undertakes a financial and economic analysis of total Solid Waste Disposal System costs which would result from the utilization of the various potential energy from waste plants (15 possible plants) identified in the Market Study in conjunction with the six candidate landfill sites

identified by Walker, Wright Young and Associates in their Consolidation Report Phase 2, Stage 2B - Selection of Candidate Sites. This Study addressed only the impact of Energy from Waste in association with Landfill and in no way attempted to suggest or predetermine the appropriateness of any one Landfill location in Halton.

Study Summary and Conclusions

The initial financial ranking of all EFW/Landfill configurations was based upon the system analysis of fifteen energy from waste plants in conjunction with the possible selection of any one of six possible landfill sites. All were considered using two possible waste generation forecasts over the 1988-2007 forecast period.

The initial analysis sought a ranking based on the total economics of the solid waste management system. Therefore, all system costs, regardless of their source or ultimate burden, were included. Specifically, the analysis was undertaken on a cash flow basis to include:

- | | |
|----------------------|--|
| Regional Costs | - Capital/operating costs of EFW/landfill |
| | - Off Site Costs (Regional responsibility) |
| | - Transportation costs (EFW residue) |
| Area Municipal Costs | - Transportation costs from waste generation source to EFW Landfill. |
| Private Hauler Costs | - Transportation costs from waste generation source to EFW/Landfill. |

The analysis was undertaken for a twenty year planning period beginning in 1988. Capital and operating costs for energy from waste plants, landfill sites and for the components of the transportation system were assumed to increase over the planning period at a rate of 7% per annum. In addition, the debenturing of capital costs incurred were over a 10 year term with a coupon rate of 12%.

Revenue from the sale of steam produced at energy from waste plants was based upon 85% of equivalent natural gas prices, which was inflated over the period at an average rate of 9.3%, in accordance with forecasts prepared by the Ontario Ministry of Energy. Electricity produced at energy from waste plants would be sold at

prevailing prices escalated on average at 6.3% per annum over the planning period (as per the Ministry of Energy forecast).

The application of senior government grant funding was included in the analysis, based upon information which indicated that approximately 35% of EFW land, building and equipment costs would be eligible for capital grant funding. No grant existed or was anticipated to be available in the future for landfill capital costs at the time the feasibility study was conducted. Therefore, grant funding was calculated only on EFW capital costs which would occur over the forecast period. The application of Regional reserves for EFW/Landfill capital funding was not included in the analysis used to rank the EFW/Landfill configurations examined in the Study. However, reserves were incorporated into the more detailed fiscal analysis which was undertaken on six specific EFW plants.

The initial financial ranking was undertaken by determining the 1984 net present value of the twenty-year cash flow developed for each possible alternative analyzed. The ranking of the fifteen EFW plants is given below based upon the higher of two possible waste generation forecasts used in the analysis. The data is presented on the basis of receipt of a 35% capital grant from other governments, and alternatively assuming no such grants are received. The comparison assumes the utilization of the least costly landfill site, but identical information on the cost for any of the six candidate landfill sites was presented within the report.

				(Millions)	
				\$1984 - NPV	
				With	Without
				Cap. Grants	Cap. Grants
EFW Plant					
1 Ford	600	tonnes/day		\$15.0	\$31.4
2 Ford	400	"	"	32.3	43.9
3 Ford	363	"	"	38.7	46.1
4 Petro Canada	600	"	"	66.4	84.5
5 Fearman's	91	"	"	67.2	70.2
6 Leaver	91	"	"	69.4	72.3
7 Beardmore	91	"	"	69.5	72.4
8 Union Carbide	400	"	"	77.9	90.5
9 Fearman's	600	"	"	79.6	95.1
10 Palermo Trans.	600	"	"	84.3	99.3
11 Trafalgar Trans.	600	"	"	88.3	103.3
12 Burlington Trans	600	"	"	91.1	106.1
13 Milton Treans.	600	"	"	92.2	107.2
14 Leaver	600	"	"	100.3	115.8
15 Beardmore	600	"	"	106.3	121.8

From the ranking undertaken on the basis of net present value, six plants were chosen for detailed financial evaluation. Specifically, this involved:

1. The possibility of private sector financing/ownership of each EFW facility.
2. A risk analysis associated with various modifications to the revenues anticipated from each EFW facility.
3. The impact that public sector ownership of each facility would have on Regional costs (as measured on a total cost per tonne basis) and on the Region's debt capacity (according to the method used by the Ontario Municipal Board).

Within the detailed analysis, considerable testing of the sensitivity of results to changes in key assumptions was undertaken. The sensitivity analysis examined:

- high versus low waste steam being realized.
- reduced revenue based on steam sales priced at 85% of equivalent natural gas prices where gas prices would increase at the general inflation rate (7%) rather than the Ministry of Energy forecasted rate (9.3%).
- Reduced revenues and increased expenses assuming the loss of a dedicated steam user after the termination of a five year contract. This option assumed the steam customer cash flow for five years, after which time the plant would be retrofit to produce electricity for supply to the Ontario Hydro grid. Therefore, after the initial five year period, additional capital costs were incurred, and from the fifth to the twentieth year, revenues were based on sale of electricity rather than the sale of steam to a dedicated customer.
- Extensive sensitivity analysis of the private sector ownership option was undertaken by an external consultant (PerCor Financial Consultants).
- Within the analysis of EFW impact on the Region's fiscal capacity, the implications of a one-year delay in revenues were examined.

The results of the detailed analysis lead to the following conclusions:

- Substantial risk is involved in the selection of the larger 600 and 400 tonnes/day facilities, if such facilities are built and financed by the Region. These risks could be mitigated only with the infusion of significant capital funding from senior governments, or by private sector ownership.

With respect to private sector ownership, the external consultant concluded that the larger plant configurations generating steam to a dedicated customer would be necessary to produce a rate of return sufficiently attractive for private investors.

- Public ownership of the large plants would require Regional debenture-financing at the limits currently allowed by the Ontario Municipal Board, and would eliminate the Region's financial flexibility with regard to other required municipal services.
- Financial risk associated with the smallest plant considered (Fearman's 91 tonnes/day) is low. However, this positive attribute is outweighed by the very small portion of the waste stream that the plant would be able to process in producing energy for sale to the dedicated EFW customer.
- Of the mid-sized plants, the Ford 363 tonnes/day is superior to the Ford 400 and Union Carbide 400 tonnes/day plants due to the lower debt service cost per tonne of waste processed.

On the basis of these factors, the initial financial ranking of the six plants (on the net present value basis) was altered as follows:

1.	Ford	363 tonnes/day
2.	Ford	400 tonnes/day
3.	Ford	600 tonnes/day
4.	Fearman's	91 tonnes/day
5.	Union Carbide	400 tonnes/day
6.	Petro Canada	600 tonnes/day

This financial ranking was combined with an environmental ranking to determine an overall preference (P.67 - Final Summary Report).

Conclusion

It is my opinion that a municipally owned EFW plant of the size of the Ford 363 or Ford 400 is financially feasible for the Regional Municipality of Halton. Although from a financial perspective, the larger plants (600 tonnes/day) are less expensive on a cost per tonne basis, the capital construction cost is too large relative to risk and Halton's financial capacity. However, a larger plant may be feasible with infusion of funding from other governments or if it were privately owned and operated.

ENERGY FROM WASTE RESERVE FUND

In March 1984, Regional Council approved a report submitted by the Regional Treasurer to establish a Reserve Fund for Energy from Waste. Council recognized that a long term financial strategy was essential if Halton's commitment to pursue other methods of Solid Waste disposal was to be achieved. Specifically, the establishment of this Reserve Fund reconfirmed Halton's commitment to the objective stated in the Regional Official Plan:

Implement resource recovery techniques including the use of recycled wastes as an energy source.

The fund was initially established by making a \$250,000 contribution and establishing an annual special tax levy equivalent to 1% of total Regional taxation requirements (1984 - \$225,000). In addition, the unused portion of the Resource Utilization Investigation Fund (estimated at \$100,000 per annum) charged to new residential development would be applied.

Once all aspects of the Preliminary Feasibility Study - Energy From Waste was completed, the financing plan was revised to recognize:

- That Council had instructed Halton's Landfill consultants to pursue the approval for the landfill component on the basis of 100% landfill capacity for the first 8 years of the planning period (1988-1996) with the next 12 years' capacity being on the basis of 50% Landfill and 50% Energy from Waste.

The revised financing strategy increased the Special EFW tax levy equivalent to 1% of the Regional taxation requirements to 2% of Regional taxation requirements (estimated at \$460,000 in 1985).

With this revision, the Energy From Waste Reserve Fund is estimated at \$19 million by 1996.

Conclusion

It is my opinion that the fiscal policies adopted by Regional Council will ensure that Halton will have sufficient fiscal capacity to undertake a Solid Waste Management System which will meet the commitment of diverting 50% of the solid waste stream to an Energy From Waste facility beginning in 1996.



J. L. Rinaldo, C.M.A.,
Director of Finance
and Regional Treasurer

JLR:mab

WITNESS STATEMENT OF
PETER R. WALKER, M.Sc., MCIP

LAND USE PLANNING

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M5R 2M9

in the matter of the Consolidated Hearing for
Environmental Assessment of the Proposed Halton
Region Landfill

ROLE AND RESPONSIBILITIES

I am a consulting land use planner, and President of the firm of Walker, Wright, Young Associates Limited.

My responsibilities as consultant to the Regional Municipality of Halton in its search for a sanitary landfill site fall generally within two areas--the coordination of the Environmental Assessment process, and the land use planning related aspects of the project including the evaluation of land use impact, and assistance with the required processes under the Planning Act.

This Witness Statement deals with our land use planning role. Our coordination role is dealt with in a separate Witness Statement. All work undertaken by the firm on this project was done by myself, or under my supervision. The firm began work on this project in September 1982, when Halton Regional Council retained a study team, with this firm as the prime consultant, to undertake Halton's Environmental Assessment for Landfill.

TECHNICAL INPUT TO THE ENVIRONMENTAL ASSESSMENT

Walker, Wright, Young Associates Limited contributed technical input, within its own areas of expertise, at various stages of the Environmental Assessment. The technical input of the firm began in Stage 2A with broad-based evaluations of land use, heritage features, and archaeological features using secondary sources. The ~~land use~~^{archaeological} and heritage activities were undertaken by other consultants at later stages of the process, as the level of detail and the requirement for specialized input increased.

In examining the land use implications of a major new use such as a sanitary landfill site, the planning consultant must take into consideration both the statutory planning controls which apply to any given potential site and its surrounding area, and the actual land uses that may potentially be displaced or affected.

The statutory planning controls contained in Official Plans and Zoning By-laws indicate whether a landfill (or a proposed after-use) is a permitted use, as well as the types of land uses that are permitted or likely to develop in that area in the future. On a larger scale, this information may indicate proximity to a designated urban or settlement area.

The actual land uses in and near areas under consideration for sanitary land-filling provide a more specific basis upon which to evaluate land use impacts.

Compatibility between land uses is a basic consideration in land use planning. Any planning document which designates land for certain uses, or addresses relationships between land uses, assumes certain principles as to land use compatibility. While such principles may be flexible in their interpretation, they represent a body of general opinion which reflects public perceptions as to the conditions under which land uses can operate effectively. Wherever a land use has characteristics which affect the function or enjoyment of another land use, there is potential for the issue of land use compatibility to be raised. The issue is usually determined based on the magnitude and duration of any effects, the ways in which these effects

impinge upon the particular type of land use, and whether such effects are reasonable given the context and circumstances of each case.

The land use analysis in the Halton Environmental Assessment for Landfill addresses the existing and potential use of land and the way this may be affected by landfilling, by applying the general expectations which are associated with any given use. While this cannot be seen in isolation from the individual technical impacts and the identified social impacts, the land use analysis identifies the potential for landfilling to change the character and conditions of an area in such a way as to make existing or potential land uses more or less appropriate than they are now. For the purpose of evaluation, the extent of such impact depends on the types and numbers of land uses affected, their proximity to a potential landfill site and the presence or absence of intervening buffer features. In general, residential uses are considered to have a higher potential impact from sanitary landfilling than commercial or industrial uses, although all land uses can potentially be affected. It is very often a matter of differing degrees. Agricultural uses were considered separately from the land use compatibility analysis, but were taken into consideration in the land use analysis. In common with the Environmental Assessment process as a whole, the Land Use evaluation makes use of secondary information at the first level of screening, and uses progressively more detailed, site-specific information as the process proceeds towards the identification of particular sites. There was no technical input from a land use perspective in Phase 2 Stage 1, Waste Needs and Systems Analysis. The following is a summary of the type of information and analysis that was utilized at each subsequent stage.

Phase 2, Stage 2A: General Overview Analysis

The "Land Use" factor was among the "Physical" category of evaluation factors utilized in Stage 2A. This firm developed the Land Use factor described in Section 2 of the "Phase 2, Stage 2A Halton Environmental Assessment Final Evaluation Factors," and undertook the analysis described in Section 6 of the "Final Report, Phase 2, Stage 2A, General Overview Analysis (October 1983)." In addition, an evaluation was undertaken with respect to the "Cultural" evaluation factors, as described in Section 10.

The intent of the Land Use analysis at this first, general level of screening was to reflect the higher impact that landfilling would have in or near settlement or urban areas. This is based on the premise that, in general, the higher concentration of land uses in urban and settled areas would give rise to higher impacts from landfilling through displacement and off-site impacts. A draft "Land Use" factor was generated to reflect this premise, and the factor was refined through the public participation process.

Areas located within or immediately adjacent to ^{built up} ~~designated~~ Urban Areas, Hamlets or Rural Clusters were rated "Unacceptable" for landfilling, and were excluded from further consideration. The analysis also indicated areas that were subject to lesser impacts, based on proximity to existing or future built-up areas, Hamlets and Rural Clusters.

The "constraints map" which indicates the identified land use impacts, and which was used in the overall screening process to identify Candidate Areas for Landfilling, comprises Figure 2 of the Final Phase 2, Stage 2A General Overview Analysis Report (October 1983). In addition to the above, the Land Use Analysis in Stage 2A incorporated a review of Provincial, Regional and Area Municipality planning policies and designations applying within areas of Halton Region, to determine their applicability to the landfill site selection process. These policies and designations were not utilized in the screening process, other than as a source of information regarding the types and extent of settlement areas.

Walker, Wright, Young Associates Limited provided further technical input in Stage 2A, with respect to evaluation of potential impacts on the cultural environment. This input is described in Section 10 of the "Final Report: Phase 2, Stage 2A, General Overview Analysis (October 1983)" report. This work comprised a review of Provincial policy and available documentation regarding heritage and archaeological features in Halton Region. Heritage features which had been designated under the Ontario Heritage Act were identified. It was found that only two such features were located outside existing built-up areas, and that these two features were in areas proposed as future urban areas. No areas were excluded from future consideration for landfilling at this stage of the analysis, based on the cultural environment factors.

The firm discussed its technical input to Stage 2A at Public Information Centres, and responded to written submissions received from Ministries, agencies and members of the public.

4.5 Phase 2, Stage 2B: Selection of Candidate Sites

The technical input of this firm to Phase 2, Stage 2B comprised development of the generalized evaluation factors and evaluation of "Compatibility with Existing and Future Land Use," "Significant Heritage Features," "Significant Archaeological Sites," and "Aesthetic Visual Features," as indicated in the "Final Evaluation Factors, Stage 2B" report (January 1984). The firm carried out these evaluations as reported in the "Consolidation Report, Phase 2, Stage 2B, Selection of Candidate Sites (April 1984)," and contributed to the "Multi Sites Analysis," also contained in this report. The firm responded to questions and submissions concerning its work at public meetings, and in the "Submissions: Stage 2B Evaluation Factors (January 1984)" and "Analysis of Submissions, Phase 2, Stage 2B (April 1984)" Reports.

The "Compatibility with Existing and Future Land Use" ^{Factor} category was included within the "Social Environment" category of factors for the purpose of the Stage 2B analysis. The development and ranking of the new evaluation factors contained in the "Final Evaluation Factors, Phase 2, Stage 2B Selection of Candidate Sites (October 1983)" report included consideration of public and agency input received through the three Public Information Centres held to review these factors, and through the consultation process.

The firm provided technical input in reducing the extensive "Candidate Areas" identified in Stage 2A, using such constraints as roads and hydro corridors and a minimum site size to delineate forty-eight "candidate sub-areas" which were evaluated individually in Stage 2B, along with seven pit-and-quarry sites.

Our major information gathering exercise for the Stage 2B Land Use analysis was a survey of land uses lying on candidate sub-areas and within study areas. The study areas included lands lying within approximately 0.8 km

(1/2 mile) of candidate sub-areas; boundaries were delineated according to individual local conditions and the existence of buffer features such as major roads, railway lines and hydro corridors. The land use analysis also used air photos and more detailed mapping than was used in Stage 2A. The information collected in the land use survey was used in the preparation of maps 4-11 inclusive of the "Consolidation Report, Phase 2, Stage 2B," and was incorporated into the work of other consultants on the study team. In addition, existing planning documents and records of proposed and approved development were consulted to determine future land uses in the candidate sub-areas and study areas.

The individual candidate sub-areas were evaluated using the above information and the Stage 2B land use compatibility evaluation factor. The methodology is described in more detail in Section 8, and the impacts assigned to the candidate sub-areas are indicated in Tables 22-25 of the Phase 2, Stage 2B Consolidation Report.

High impacts with respect to land use compatibility were identified for nine of the candidate sub-areas considered large enough to operate as single sites. In two of these cases (sub-areas C1c, C1d), the "Social Environment" category of factors (which includes land use compatibility) was the highest ranking category in which a "high" impact was identified. Therefore, the Land Use Compatibility factor had a relatively important role in rejecting these candidate sub-areas. These "high" impacts were mainly due to the presence of highway and utility corridors which reduced the effective area for sanitary landfilling. Seven of these nine sites were rejected based on higher ranking factors; therefore, the "high" impacts identified for the Land Use Compatibility factor were not instrumental in the rejection of these sites.

Walker, Wright, Young Associates Limited also developed generalized evaluation factors and conducted analyses with respect to the "Significant Heritage Features," "Significant Archaeological Sites" and "Aesthetic Visual Features" analyses in Stage 2B, within the "Cultural Environment" category of factors (Section 10 of the Stage 2B Consolidation).

The "Significant Heritage Features" analysis utilized information contained in "The Halton Heritage Study" (Region of Halton, 1981), and further information provided by Local Architectural Conservation Advisory Committees (LACACs). Impacts were assigned, based on significant heritage features identified on or in close proximity to candidate sub-areas.

The "Significant Archaeological Sites" analysis was based on confidential information which was provided by the Museum of Indian Archaeology. Impacts were based on the presence and status of archaeological sites within the candidate sub-areas.

The "Aesthetic Visual Features" analysis was based on proximity of candidate sub-areas to the Niagara Escarpment.

"High" adverse impacts under any of these three factors were considered sufficient to justify rejection of sub-areas. In all cases where "high" impacts were identified in this category, one or more "high" or "severe" impacts in higher ranking categories determined that the sub-area concerned would, in any case, have been rejected. There were no instances of sub-areas for which impacts in the "Cultural Environment" category were the primary reason for rejection.

The Stage 2B analysis reduced the forty-eight candidate sub-areas and the seven pit and quarry sites to a total of ~~seven~~^{01X} "Candidate Areas" for further evaluation and comparison. Three of the "Candidate Sites" (C2c, C2d, and C2e) were located in the Town of Oakville, two (D4a and D4g) in the Town of Milton, and one (P&Q1) in the City of Burlington. These Candidate Sites were given the designations "A", "B", "C", "D", "E" and "F" respectively at the beginning of Stage 2B.

2C.

Walker, Wright, Young Associates Limited provided further technical input, contained in references to Social and Cultural Impact in the "Multi-Sites Analysis" which comprises Section 13 of the Stage 2B Consolidation.

Phase 2, Stage 2B Review and Supplement

The firm's technical contribution to the Stage 2B Review and Supplement Report (November 1984) comprised a review of the input to the social and cultural analyses and the multi-site analysis that had been conducted for Stage 2B. The input and resultant findings in Stage 2B were found to be still valid, notwithstanding the increased waste quantities and required site area that had been identified.

Phase 2, Stage 2C Selection of Preferred Site

The technical input of Walker, Wright, Young Associates Limited in Stage 2C comprises development of the approach to the Land Use and Planning Assessment described in the "Stage 2C Final Work Program (May 1984)", participation in the delineation of the "Site Plan Areas," the carrying out of the analysis reported in Stage 2C Technical Report No. 12: "Land Use Planning Assessment (June 1985)," and responses to concerns raised at public meetings and through submissions (contained in the Submissions Reports with regard to the Work Program and the findings of Stage 2C).

The Heritage and Visual analyses which had formerly been conducted by this firm were undertaken at a higher level of detail in Stage 2C by the Landplan Collaborative and the Museum of Indian Archaeology also conducted its own archaeological analysis in Stage 2C.

The delineation of a "Site Plan Area" (i.e., the boundary of a potential land-fill site) within each of the Candidate Sites identified in Stage 2B was undertaken jointly with the hydrology/hydrogeology, traffic, economic and social consultants. The firm provided a land use perspective on the selection of the Site Plan Areas and the location of access points, and this input was considered according to the established hierarchy of categories of evaluation factors, with hydrogeologic considerations being given first priority.

The Stage 2C Land Use and Planning Assessment report considers three aspects of land use planning with respect to each of the six Site Plan Areas:

existing and future land uses and potential impacts on these uses from land-filling, potential after-uses following sanitary landfilling on each Site Plan Area, and planning policy considerations including the need for specific planning approvals.

The analysis of potential land use conflicts was the only one of these aspects that was related to an evaluation factor, for consideration as part of the comparison of Site Plan Areas. The sub-factors that were applied are as follows:

- . Existing Local Context.
- . On-Site Land Use.
- . Existing and Future Land Uses in the Study Area.
- . Summary of Potential Land Use Conflicts.

The evaluation was based on an inventory of land uses in the "study areas" which were established for each Candidate Site. Some of the study area boundaries that had been utilized in Stage 2B were further refined for the purpose of Stage 2C, to reflect the pattern of surrounding land uses and potential buffer features. In general, the study areas incorporate land lying within approximately 0.8 km (1/2 mile) of each Candidate Site. They were not reduced in extent when the Site Plan Areas within each Candidate Site were defined.

The six Site Plan Areas were ranked, based on potential for land use conflicts. Site "F" in the City of Burlington was identified as the most preferred site, Site "A" in the Town of Oakville was ranked second, Sites "D" and "E" in the Town of Milton were ranked in joint third position, and Sites B and C in the Town of Oakville were ranked last. This ranking, together with the findings of the land use analysis, was incorporated in the overall comparison which is contained in the Stage 2C Evaluation and Summary Report. The land use compatibility factor, as a factor within the "Social Environment" category, was considered in combination with other factors as part of the final pairing analysis. The analysis resulted in an overall ranking of the six Site Plan Areas in order of preference: Site "F", the highest ranking site, and Site "D", the second highest, were selected by Halton Council for further detailed evaluation.

There are no instances in which impacts under the land use compatibility factor were solely responsible for the rejection of sites; however, they added weight to impacts identified for the "Social Environment" category of factors.

The Stage 2C Land Use and Planning Assessment incorporates a review of the generic constraints to the rehabilitation and after-use of sanitary landfill sites, and the after-uses which may be appropriate on each of the site plan areas. The potential after-uses were not identified as firm proposals at this stage, and they were not considered as part of the Stage 2C site comparison.

The third and final element of the Land Use and Planning Assessment is a review of the planning policies that would apply to sanitary landfilling on each of the six site plan areas. This entailed review of Provincial and municipal plans and zoning by-laws. The resulting information, which was contained in Section 9 of the Land Use and Planning Assessment, forms a basis for the approvals process under the Planning Act, that was subsequently undertaken. Although the Land Use Compatibility Analysis considered proposed and future land uses with respect to each site, the Planning Approvals evaluation was not, in itself, utilized as part of the Stage 2C site comparison.

APPROVALS UNDER THE PLANNING ACT

The approval by Halton Council on July 23, 1985, of a work program submitted by this firm initiated applications for an Official Plan Amendment and rezoning to permit sanitary landfilling on Site "D" in the Town of Milton. No Official Plan Amendment or rezoning would be required to permit sanitary landfilling on Site "F" in the City of Burlington, since the site is located within the area of the Parkway Belt West Plan (1978). By letter dated June 24, 1986, the Minister of Municipal Affairs confirmed that the proposed undertaking would be in conformity with the Parkway Belt West Plan as it affects Site "F".

Town of Milton: Official Plan and Zoning By-law

I met with the Chief Planning Officer of the Town of Milton on October 1, 1985, to discuss planning approvals required to permit a Regional sanitary landfill site on Site "D".

On December 17, 1985, an application for the required amendments was submitted by this firm, on behalf of the Regional Municipality, to the Town of Milton. At the request of the Town, the package included draft amendments to the Official Plan and Zoning By-law that would remove a designation and zoning to permit sanitary landfilling on the "former Site "F", identified through a previous site selection process, as well as amendments to permit the proposed undertaking on Site "D". Two sets of draft zoning by-law amendments were submitted. The first related to two separate General Zoning By-laws which were in effect at the time the application was submitted, and the second set related to a new General Zoning By-law (61-85) which was expected to be adopted shortly, and is now in effect. We therefore attempted to assist the Town in providing documentation for the processing of the Region's application.

A Public Meeting under the Planning Act was held on July 21, 1986, to consider the Region's application. A recommendation that the necessary amendments be prepared to redesignate the former Site "F" was carried; however, Council deferred consideration of the Region's application for amendments to permit sanitary landfilling on Site "D". The Regional Municipality subsequently requested that its application in regard to Site "D" be referred to the Ontario Municipal Board, for consideration at the Joint Board hearing.

WITNESS STATEMENT OF
OF
PETER R. WALKER, M.Sc., MCIP
COORDINATION OF THE ENVIRONMENTAL ASSESSMENT

WALKER, WRIGHT, YOUNG ASSOCIATES LIMITED
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M5R 2M9

in the matter of the Consolidated Hearing for
Environmental Assessment of the Proposed Halton
Region Landfill

ROLE AND RESPONSIBILITIES

I am a consulting land use planner, and President of the firm of Walker, Wright, Young Associates Limited.

This firm's responsibilities as consultant to the Regional Municipality of Halton in its search for a sanitary landfill site fall generally within two areas--the coordination of the Environmental Assessment process, and the land use planning related aspects of the project including the evaluation of land use impact, and assistance with the required processes under the Planning Act.

This Witness Statement deals with the coordination role. The firm's land use planning role is dealt with in a separate Witness Statement. All work undertaken by the firm on this project was done by myself, or under my supervision. The firm began work on this project in September 1982, when Halton Regional Council retained a study team, with this firm as the prime consultant, to undertake Halton's Environmental Assessment for Landfill.

COORDINATION OF THE ENVIRONMENTAL ASSESSMENT

The firm coordinated the work of Halton's landfill consultants, from the preparation of the "Draft Work Program" in 1982 to the completion of the final Stage 2C documents including the Evaluation and Summary Report (June 1985). The Environmental Assessment process generated a ranking of six potential landfill sites. The two highest ranking sites were selected for further study by Halton Council.

By coordination, I mean that the firm was involved in the selection of consultants, the determination of the overall approach for the project and the drawing together of consultants' input in reports, in consultation with the client, the client's solicitor, Government ministries and agencies, interest groups, and members of the public. The firm also prepared the Environmental Assessment Summary Report (October 1985), pursuant to Section 5(3) of the Environmental Assessment Act. We were responsible for the overall conclusions reached at the end of each stage of the study.

In January 1987, the firm completed a "Comparative Analysis" at the request of Halton Region. This document compares the two alternative sites for sanitary landfilling, based on a more detailed level of information than had been available when the sites were originally selected as part of the Environmental Assessment.

The coordination role of the firm may be further explained by reference to a typical cycle of the activities undertaken to complete one stage of the Environmental Assessment:

- . In consultation with others, including the client and the Ministry of the Environment, establish the appropriate range of investigation and level of detail.
- . Retain consultants as required, and with the approval of Halton Region.
- . Coordinate consultants' input in preparing a draft (proposed) work program and/or evaluation factors.

- . Present draft (proposed) work programs and/or evaluation factors to Halton committees and/or Council.
- . Arrange public forum(s) to provide information and receive input regarding draft (proposed) work programs and/or evaluation factors.
- . Coordinate preparation of a "Submissions Report" on the draft (proposed) work program and/or evaluation factors which report comprises the input from the public forums and written submissions, and the study team's responses to those concerns expressed by circulated agencies, interest groups, and individual members of the public.
- . Prepare final work programs and/or evaluation factors, for adoption by Halton Council.
- . Present final work programs and/or evaluation factors to Halton Council and Committees.
- . Undertake the required work, in consultation with other consultants.
- . Prepare a draft report utilizing consultants' investigations and conclusions.
- . Present the draft report to Halton committees and/or Council.
- . Arrange public forum(s) to provide information and receive input regarding the draft report.
- . Coordinate preparation of a "Submissions" document on the draft report, comprising the input from the public forums and written responses, and the Study Team's responses to concerns expressed by circulated agencies, interest groups and individual members of the public.
- . Prepare a final report, incorporating changes based on the consultation process, for adoption by Halton Council.
- . Present final report to Halton Committees and Council.

The above cycle of activities is generally applicable to each of Phase 1, Phase 2, Stage 1, Stage 2A, Stage 2B, the Stage 2B Review and Supplement (in part), and Stage 2C of the Environmental Assessment. The specific consultants, reports, and public participation events associated with each stage are indicated in Chart 1. The approximate timing of each phase and stage of the Environmental Assessment is illustrated in diagrammatic form in Chart 2.

Phase 1: Preparation of Work Program (September 1982 - November 1982)

The study team, led by this firm, that was involved in Phase 1 was retained on the basis of a Proposal submitted in response to Terms of Reference prepared by the Regional Municipality and following a two-stage interview process. We were engaged to undertake the Environmental Assessment in September 1982. The approach described in the Proposal was further refined in the preparation of a Draft Work Program which was circulated to Ministries and agencies. This consultation process led to the preparation of a Revised Work Program which was released in November 1982. The Revised Work Program makes reference to the Terms of Reference's direction to use site specific information generated by earlier site selection activities; however, it was subsequently agreed in consultation with the Region that the use of the earlier-generated site specific information was not appropriate, and that screening of the entire Region at a uniform level of detail would be necessary to enable comparison of the alternatives to the undertaking and the alternative methods of carrying out the undertaking.

The Revised Work Program was further refined by several subsequent work programs during the course of the Environmental Assessment, as indicated in the fourth row of Chart 1.

Phase 2, Stage 1: Waste Needs and Systems Analysis

The purpose of the Waste Needs and Systems Analysis was to evaluate the quantity and types of municipal waste that might be generated in Halton over a 20-year planning period, and the various technologies and solid waste management systems that might be utilized in dealing with this waste. The work was undertaken in response to the stated requirement in the Environmental Assessment Act to provide "a description of and a statement of the rationale for . . . the alternatives to the undertaking."

The role of this firm in Phase 2, Stage 1 comprised discussion and consultation with the other consulting firms, outside agencies, and the public to establish evaluation criteria and to coordinate the preparation of the various

reports referred to in the first column of Chart 1. Information was disseminated through circulation of draft and final documents, and through presentations to Committees (at which "public" attendance was permitted), Regional Council, and Public Information Centres, also referred to on Chart 1. The Regional Municipality compiled a mailing list for circulation of written material and notification of public forums, and this list was maintained and expanded and used throughout the Environmental Assessment process.

It was our conclusion in the final "Phase 2, Stage 1 Waste Needs and Systems Analysis Report (May 1983)" that a resource recovery (waste incineration) component to Halton's Waste Management System should be further investigated, but that, whatever waste management system is utilized, some sanitary landfilling component would be required.

On June 22, 1983, Regional Council resolved to proceed with investigation of a resource recovery component which would process 75% of the Region's waste, with a maximum of 7.2 million cubic yards of waste to be disposed of at one or more sanitary landfill sites. This latter volume figure was increased in November 1983 to 8.7 million cubic yards, in response to proposals for the interim use of the existing Regional Landfill site, which would require some landfilling at a selected site(s) prior to the actual commencement of the new comprehensive waste management system. The Regional Municipality subsequently conducted its own investigations with respect to waste incineration, and the remainder of the work program for the Environmental Assessment which was of concern to this firm was confined to the sanitary landfill component. The 8.7 million cubic yard waste volume figure was utilized in Stages 2A and 2B of the Environmental Assessment as an assumption for the purpose of site selection for landfill purposes.

Phase 2, Stage 2A: General Overview Analysis

Phase 2 was the beginning of the search for the sanitary landfill component of comprehensive ^{waste} ~~work~~ management system for the Region. Stage 2A comprised the first step in this sanitary landfill site selection process. Physical, Social, Economic and Cultural evaluation factors were developed and ranked in

consultation with agencies and the public, in the manner outlined in the typical cycle of activities outlined above. These evaluation factors were utilized in conjunction with published information to screen the Region as a whole at a macro level through a "constraint mapping" process. The constraint mapping process used published data concerning hydrology, hydrogeology, biophysical features, transportation zones, land use, population density, topography, agricultural land, and land values. Areas with "unacceptable" levels of impact according to each of the evaluation factors were identified. By "overlaying" the constraint maps, generalized areas which were not subject to unacceptable impacts were identified. These generalized areas were designated as "Candidate Areas for Sanitary Landfill Site(s)," for further investigation at subsequent stages of the Environmental Assessment. The Candidate Areas were grouped into seven 'Districts' (A-G), and were indicated on Figure 7 of the Phase 2, Stage 2A Final Report.

All of these Candidate Areas were identified as having high impacts on agricultural lands. Potential for displacement of agricultural lands had been identified as an important issue during the preceding consultation process, and the Ontario Ministry of Agriculture and Food requested that quarries be investigated as potential landfill sites in response to the draft Stage 2A Report. Stage 2A incorporated a preliminary investigation of fifty-five pits and quarries in Halton Region to determine those which might be suitable for sanitary landfilling, and identified seven quarries which were considered to merit further investigation as Candidate Areas. These seven pits and quarries are indicated on Figure 7 contained in the Phase 2, Stage 2A Final Report (October 1983).

Walker, Wright, Young Associates Limited coordinated the development of the work program and evaluation factors for Stage 2A, the preparation and circulation of the various reports, and was involved in the public participation programme. We developed the conclusions of Stage 2A based on input from other members of the study team. We also prepared the report text and responded to submissions concerning the site selection process as a whole. The Stage 2A reports and public participation events are listed in the second column of Chart 1.

Phase 2, Stage 2B: Selection of Candidate Sites

In Stage 2B, the Candidate Areas that had been identified in the first step (2A) of the site selection process were examined in a greater level of detail, in order to further narrow the scope of the search to a smaller number of potential areas for landfilling.

Consistent with the outline of typical cycle of activities noted earlier, a Work Program was prepared, and approved by Council in October 1983, and in November 1983 Public Open Houses were held in Milton, Burlington and Georgetown to disseminate information and to receive input on the Stage 2B draft evaluation factors and a proposed ranking of categories of factors that would establish priorities for the site selection process. Final evaluation factors were circulated for information in January 1984, and the categories were ranked in the following order of priority:

- Public Health and Safety
- Natural Environment (including Agriculture)
- Social Environment
- Cultural Environment
- Costs
- Design and Operations

This ranking remained generally intact, subject to minor adjustments, for the balance of the Environmental Assessment process.

The first step of the Stage 2B evaluation involved identification of "Candidate Sub-Areas" within the earlier-determined Candidate Areas, based on a minimum site size for landfill and on features which would affect site boundaries such as rights of way for roads, railways and utilities. A total of 48 Candidate Sub-Areas were identified by the study team for evaluation, together with the seven "Pits and Quarries" sites that had been selected in Stage 2A for further consideration.

The firm, in discussion with other members of the study team, established a "Study Area" around each Candidate Sub-Area for the purpose of assessing potential impacts of landfilling. Study Area boundaries were generally

located approximately 0.8 km from candidate sub-areas; however, this was adjusted to reflect specific features such as settlement areas, natural areas, cultural features, and features which would assist in buffering a landfill from other uses.

The Candidate Sub-Areas were surveyed in greater detail by the consultants, and large-scale maps and air photos formed a basis for gathering and recording the information necessary to screen the sites based on the evaluation factors.

An evaluation of the relative merits of the use of a single site or multiple sites for landfilling was undertaken by the economic consultant. A recommendation that a single site be utilized was incorporated into the report, and a number of the smaller candidate sub-areas were rejected on this basis.

This stage of the site selection process was intended to minimize the need for measures to mitigate the effects of sanitary landfilling; mitigation measures were addressed in Stage 2B at a generic level of detail in Section 14 of the Stage 2B Consolidation Report.

The study team met when their individual analyses were complete, and provided summaries of their findings, with recommendations from their individual perspectives as to which sites should be retained or rejected based on identified impact levels in each ranked category of factors. Six "Candidate Sites" were identified--including one "pit and quarry"--which, at this level of analysis, had positive attributes for landfilling and would therefore be carried forward to the next and more detailed-analysis stage of the site selection process. The Candidate Sites were not ranked in order of their suitability for landfilling at this stage. The identified impacts of each Candidate Sub-Area with respect to each of the evaluation factors was summarized on Table 22 of the Stage 2C Consolidation Report.

2B

Three Candidate Sites were located near the intersection of Trafalgar Road and Dundas Street in the Town of Oakville; two were located near Britannia Road in the Town of Milton; and one was located in the City of Burlington.

Consistent with the outline of the typical cycle of activities noted above, the Stage 2B report was circulated in draft form, and was presented and discussed at public meetings in Milton, Burlington and Georgetown. Submissions were taken in and responded to by the study team in the Stage 2B Submissions Report (April 1984); and were considered in preparing the final "Consolidation: Stage 2B" report.

Walker, Wright, Young Associates Limited coordinated the elements of Stage 2B, including some of the liaison with outside agencies, supply of mapping and land use information to consultants, arrangements for Public Information Centres and compilation of team reports. In addition, this firm prepared the report text relating to the process and conclusions, and responded to submissions with regard to the study process as a whole. The Stage 2B reports and public participation events are listed in the third column of Chart 1.

Review and Supplement to Stage 2B

On September 5, 1984, Regional Council approved a new solid waste management system, which superseded the system identified at the end of Stage 1. The new system assumed the introduction of an Energy from Waste (incineration) component in the year 1996 and incorporated a revised waste quantity projection prepared by the economic consultant on the study team. The volume of waste that would be handled at a landfill facility was increased from 8.7 million cubic yards to 11.32 million cubic yards.

The Review and Supplement to Stage 2B was undertaken as a "reiteration" of the Stage 2B process, to evaluate the effects of this waste volume change--and the resultant increase in the size of landfill site required--on the Stage 2B evaluation factors and site selection process, and on the single site vs. multi-site system analysis. The conclusions of Stage 2B were generally confirmed, and the six Candidate Sites were carried forward for evaluation in Stage 2C.

Walker, Wright, Young Associates Limited coordinated the efforts of the landfill consultants in undertaking this Review and Supplement evaluation,

prepared written text regarding the site selection process, compiled the Stage 2B Review and Supplement reports, and were responsible for the overall conclusions. The consultation element of this work was more streamlined than in previous stages of the Environmental Assessment as indicated in the typical cycle of activities referred to above; however, agencies and public interest groups were afforded an opportunity to comment on a draft version of the report, and a "Submissions" report was prepared based upon submissions received and responses provided. The reports generated by the Review and Supplement to Stage 2B are indicated in the fourth column of Chart 1.

Phase 2, Stage 2C: Selection of Preferred Site

Stage 2C was the last stage of the site selection process, prior to the submission of an Environmental Assessment Summary Report to the Ministry of the Environment. The level of detail of information on each of the Candidate Sites was increased through further site-related research, geological drilling and on-site investigations. Additional consultants were retained at the request and with the agreement of the Region to undertake further investigation of noise (Barman, Coulter, Swallow Associates), air quality (Senes Consultants), agricultural (Ecological Services for Planning), heritage and visual (The Landplan Collaborative) impacts of sanitary landfilling. The technical input of Walker, Wright, Young Associates Limited comprised evaluation of land use compatibility, required planning approvals and potential after-uses on landfill sites.

The six "Candidate Sites" identified in Stage 2B were designated as Sites A, B and C (in the Town of Oakville), D, E, (Town of Milton), and F (City of Burlington). "Site Plan Areas" were defined within each of the "Candidate Sites," to enable preparation of conceptual designs for landfilling and comparison of the alternative Site Plan Areas based on identified impacts of landfilling and mitigation measures.

The site comparison was based on a further refinement of the evaluation factors and ranking of factor categories which had been developed during the Environmental Assessment process. The comparison took the form of a "pairing

analysis," which was designed to enable a consistent comparison of Site Plan Areas, based on the established factors and priorities and the actual findings of the consultants with respect to each site. Combinations of paired sites were evaluated in such a way as to enable an overall ranking to be determined. Site "F", located in the City of Burlington, was identified as the preferred site. Site "D" in the Town of Milton was considered to have a number of positive attributes for sanitary landfilling, but was ranked second. The overall ranking, from most to least preferred, was "F", "D", "A" and "E" (equal), "B" and "C".

Walker, Wright, Young Associates Limited coordinated the activities required to complete Stage 2C, including some of the liaison with outside agencies, organization and presentations at public meetings (in conjunction with the social consultant), provision of mapping and land use data, chairing consultant site selection meetings, and compilation and writing the Stage 2C "Evaluation and Summary Report" (June 1985) based upon information provided by the consultants. The Stage 2C process was interrupted by the need to undertake the Stage 2B Review and Supplement, and was continued once the original findings of Stage 2B had been confirmed with the new information. The pairing analysis methodology was developed in cooperation with C.N. Watson and Associates Ltd., and was conducted by Walker, Wright, Young Associates Limited in consultation with other members of the study team.

Halton Council resolved to proceed with further investigations of both Site "D" and Site "F", to the extent necessary to gain a Certificate of Approval under the Environmental Protection Act for either site. The Regional Municipality coordinated the detailed technical work that was required to secure environmental approvals for Site "D" or Site "F", subsequent to the end of Stage 2C.

PREPARATION OF THE ENVIRONMENTAL ASSESSMENT SUMMARY REPORT

The Environmental Assessment Summary Report comprises a description of the proposed undertaking (i.e., Site "D" and Site "F" as alternative sites for sanitary landfilling), and a summary of the process by which it was

identified. It was prepared and submitted to the Ministry of the Environment in order to meet the requirements of Section 5(3) of the Environmental Assessment Act, which requires the proponent of an undertaking to describe the purpose of the undertaking, the alternative methods of carrying out the undertaking, and the alternatives to the undertaking, together with a description of environmental effects and mitigation measures.

The Summary Report describes the purpose of the undertaking, the work undertaken in "Phase 2, Stage 1 Waste Needs and Systems Analysis" (the evaluation of "alternatives to" the undertaking), the site selection process which culminated in Phase 2, Stage 2C (evaluation of "the alternative means of carrying out the undertaking"), and the identified environmental effects and mitigation measures associated with the two sites. No additional technical analysis was carried out specifically for the preparation of the report. A number of the documents which had been prepared during the course of the Environmental Assessment process comprise "Schedules" to the Summary Report. The schedule numbers of the documents prepared by Walker, Wright, Young Associates Limited are indicated in squared brackets, thus: [] in Chart 1.

The work program for the preparation of this document was approved by Halton Council on July 23, 1985. A draft was submitted to Solid Waste Management Committee which, after modifications, was adopted in final form by Halton Council on October 23, 1985, for submission to the Ministry of the Environment.

COMPARATIVE ANALYSIS

The Comparative Analysis was completed by this firm in January 1987. It comprises a comparison of Site "D" and Site "F" using a much more detailed level of information than had been available when the Stage 2C site comparison was conducted in 1985. The more detailed information is contained in "Technical Studies" and supplementary material prepared by some of Halton's landfill consultants to support an application for approval of either of the two alternative sites, under the Environmental Protection Act. Members of the study team that had participated in the Environmental Assessment, but had not

conducted the subsequent Environmental Protection Act work, were asked to review their original conclusions based on the Technical Studies and updated information, for the purpose of the Comparative Analysis.

Regional Council had anticipated a need to conduct a new comparative analysis when the Technical Studies were first commissioned in July 1985. Walker, Wright, Young Associates Limited was not involved in the preparation of the Technical Studies. This firm was requested, however, as the prime consultant for the preceding Environmental Assessment process, to review the new information and form an opinion as to which site was preferred on the basis of this work. A work program for the preparation of a Comparative Analysis by this firm was approved by Regional Council on November 6, 1986.

The first task undertaken for this analysis was a critical review of the Technical Studies and supplementary material from the standpoint of clarity of information, consistency of facts, and continuity with the work that had been undertaken for the Environmental Assessment. Discussions were held with the consultants who had prepared the Technical Studies or had participated in Stage 2C, to ensure that this material was being correctly interpreted, and to confirm the need for changes to evaluation factors and identified impact levels where required. Obviously, we were not assessing the validity of techniques used, or other technical matters. The consultants confirmed their individual site comparisons in separate "comparative analyses" which form appendices to the main Comparative Analysis report which was produced by this firm. The revised evaluation factors and impacts were utilized in carrying out another "pairing analysis" to compare Site "D" and Site "F"; Site "F" in the City of Burlington was identified as the preferred site in this comparison.

The Comparative Analysis corresponds closely in approach with the site comparison undertaken in Stage 2C of the Environmental Assessment, and changes in evaluation factors and impacts are explained wherever they occur. This was done to maintain continuity with the Environmental Assessment process, wherever possible, and to assist in the reader's understanding of the comparison.

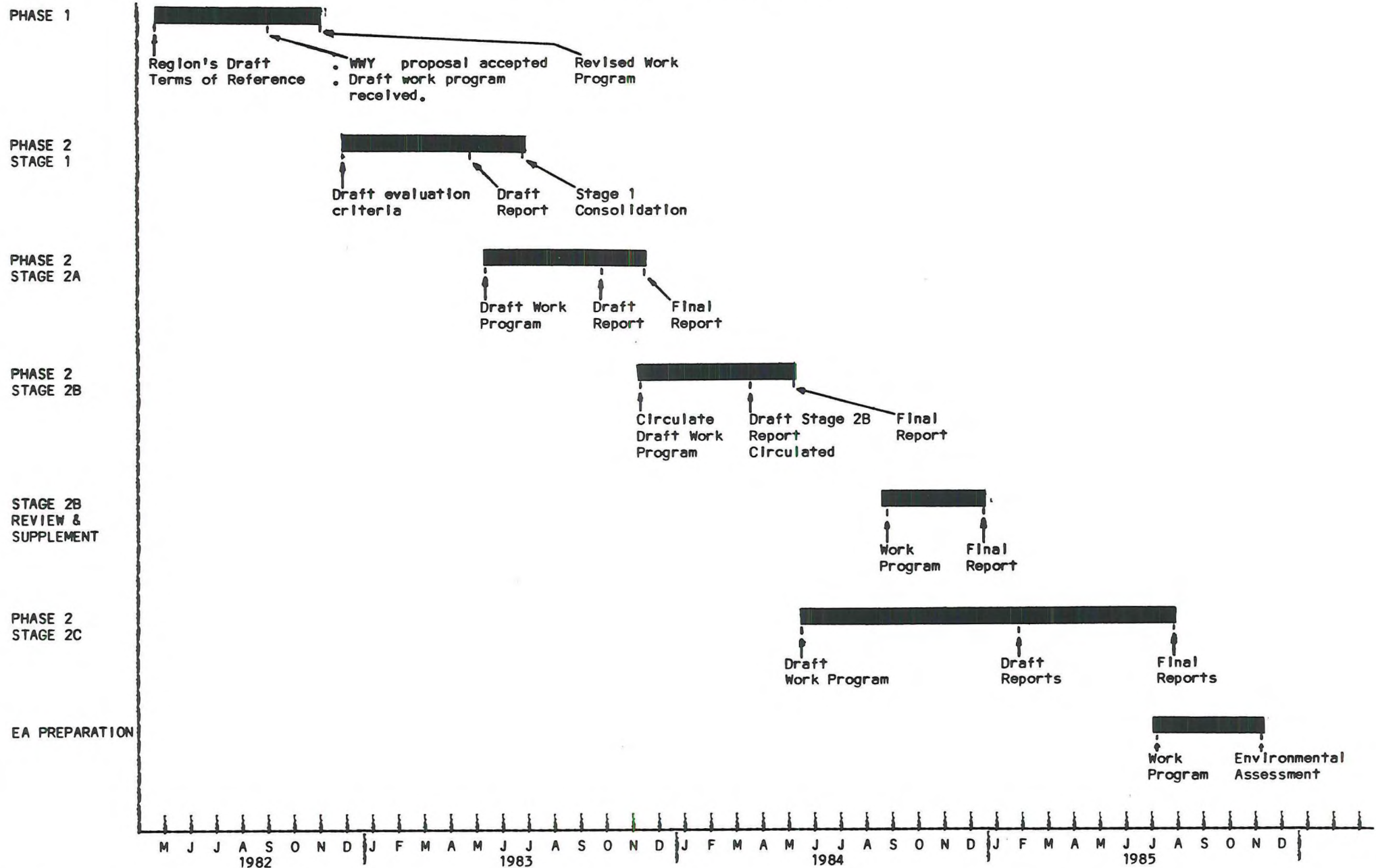
Although Site "F" was selected as the preferred site, the degree of preference over Site "D" was not as great as it had been in Stage 2C.

Site "D" was preferred under the "Natural Environment" category of evaluation factors (biophysical and agriculture) which category was the second in priority; however, the degree of preference was relatively small and difficult to define.

Site "F" was preferred under the first, third and fourth priority categories of factors ("Public Health and Safety," "Social Environment" and "Cultural Environment"), and the Social Environment category shows the strongest preference.

There was no preference with respect to the fifth most important category-- "Costs".

CHART 2
ENVIRONMENTAL ASSESSMENT OF THE LANDFILL COMPONENT
OF HALTON'S SOLID WASTE MANAGEMENT SYSTEM
TIMING OF PROJECT PHASES AND STAGES



*Note: References to reports indicate time of receipt or adoption by Halton Council.