



**To** William Tigert, CAO, Town of Ingersoll  
130 Oxford Street, Ingersoll, Ontario, N5C 2V5

**Copy** Peter Klaassen, Vice President - Solid Waste Ontario, Tetra Tech Canada Inc.  
Jack Coop and Joel Farber, Partners, Fogler, Rubinoff LLP

**From** John Muller, MBA, P.Eng.

**Date** May 24, 2017

**Document No.** 734-1716291300-MEM-0001

**Project Name** Town of Ingersoll - Walker Environmental Group - Landfill EA Review

**Subject** Design & Operations Review of Walker Environment Group Southwestern Landfill EA Submissions

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## 1.0 Introduction

Tetra Tech was retained by the Town of Ingersoll to provide technical peer review services of the submissions made by Walker Environmental Group (WEG) for its Environmental Assessment Act approval of its Southwestern Landfill development.

The scope of work for this technical memorandum to provide a Design & Operations review of submissions made by Walker Environmental Group (“WEG”) for its proposed development of a landfill site at the Carmeuse Lime site in Zorra Township. The proposed landfill is directly adjacent to the eastern boundary of the Town of Ingersoll (“the Town”).

This review is limited to findings from reviewing the following documents relating to the Ontario Environmental Assessment Act approval process for the WEG Southwestern landfill proposal:

- Facility Characteristics Assumptions, Southwestern Landfill Environmental Assessment, Walker Environmental Group, Revision 02, March 28, 2017
- Walker Environmental Group Inc., Southwestern Landfill Proposal: Approved Amended Terms of Reference, May 10, 2016

A work plan specific to the design and operation aspects of the project has not been submitted by WEG. This suggests that no further site investigation work specific to

design and operations aspects of the proposed landfill is contemplated prior to proceeding with development of the conceptual and detailed design of the landfill development.

This review is limited to specific aspects relating to the engineering design for the landfill not otherwise covered under surface water management, hydrogeology, landfill gas management or leachate treatment. Review of these other aspects of the proposed landfill development are to be addressed by other members of the technical peer review team for the Town.

## **2.0 Background**

The purpose of this review was to determine if the proposed design of the waste disposal landfill facility is consistent with environmental regulatory requirements and guidance, and to identify any deficiencies in the proposed design and operational elements of the proposed development that could lead to off-site impacts. The review also addressed the assessment of potential environmental or other impacts to the Town and its residents posed by the proposed design and operation of the landfill, as well as any potential concerns relating to the scope and nature of additional investigations and engineering design.

## **3.0 General Observations and Comments**

Comments regarding the overall approach and information that has not been included in the report are provided in the following sections.

### **3.1 Depth of Fill**

The overall depth of fill of up to 55 metres is significant as it exceeds the depth of fill for other landfills proposed and approved since the introduction of the landfill design regulation Ontario Regulation 232/98 (Reg. 232/98) more than 18 years ago. This depth of fill represents a greater comparative load on the base liner than would occur at sites that have been previously developed since the introduction of the generic design elements included in Reg. 232/98. This, combined with the fact that a considerable thickness of fill is to be placed in the mined out quarry below the proposed elevation of the landfill base liner system, may lead to unprecedented loads on a liner system based on the Reg. 32/98 generic designs.

The above increases the potential for differential settlement and associated stresses on the liner and leachate collection systems, and negatively affects the slopes of the liner and leachate collection system piping, reducing their effectiveness in minimizing leachate heads on the liner system and the associated leakage rates through the base of the landfill.

The leachate collection system design can be significantly affected by the depth of fill, as the additional load results in greater consolidation and decreased hydraulic conductivity of the waste. The Ontario Ministry of Environment and Climate Change (MOECC) Guideline specifies that for fill depths exceeding 50 metres, a site-specific hydraulic conductivity value for the waste should be developed and used to model contaminant migration to the underlying aquifer to assess compliance with the MOECC's Reasonable Use Criteria for Concept for determining the limits of groundwater impacts to remain compliant with the Ontario Environmental Protection Act (MOECC Guideline B-7 and Procedure B-7-1). An estimate of the contaminating lifespan of the landfill site is also required to determine if sufficient protection is afforded to the underlying aquifer if the contaminating lifespan exceeds the service life of the base liner and of the leachate collection system.

### 3.2 Design and Installation of Geomembranes

Since O. Reg. 232/98 and the associated MOECC Guideline on landfill design standards were introduced, ongoing research into the performance and construction techniques for landfill liner systems incorporating geomembranes has indicated an unanticipated frequency of failure of membrane due to stress concentrations created during liner installation. These failures are associated with folding in the synthetic membranes. This can occur when ridges generated from thermal expansion of the membrane or poor installation techniques causes them to fold over when subsequent layers of the base liner and leachate collection system are installed over the geomembrane. These wrinkles are usually generated by poor installation techniques that do not adequately address the impact of the thermal expansion due to atmospheric temperature changes and thermal adsorption of sunlight prior to placement of overlying liner system components, including drainage media.

The ridges from membrane wrinkling can be pushed over during placement of overlying layers, creating concentration stresses that exceed the elongation properties of the membrane. This potential failure scenario can be mitigated by using alternative materials and membrane thicknesses and strict controls on installation techniques to minimize thermal expansion prior to placement of overlying layers of the liner system. Adjustments to the double liner generic design may be necessary to address this.

Some of these procedures have been adopted in other jurisdictions to minimize the failure risk associated with stresses caused by the creation of folds in geomembranes during placement of overlying layers of the liner system. Alternative materials can also be used to mitigate the risk of liner failure during construction of subsequent layers – such as the use of white HDPE geomembranes to reduce surface temperature increases due to solar absorption. These additional installation protocols or design alternatives

should be considered and addressed in the liner design, material sourcing and installation requirements.

### **3.3 Base Preparation and Liner Construction Material Importation**

No details are provided regarding the nature of the fill material to be placed below the base elevation of the liner system for the landfill cells. This material must be able to be effectively recompacted to a density comparable to that of undisturbed native in situ soils. Among other specific requirements, it must be free of large or angular stones that could lead to localized stresses and or could penetrate of the geomembranes used for the landfill cell liner system following loading with the remaining elements of the liner system and full depth of waste. If suitable material cannot be sourced on-site, or if significant excavation activities are required, this can have an impact in terms traffic impacts and air emissions. Significant additional truck movements on local roads would result from importing soils to place as fill below the level of the base liner system, creating additional fugitive emissions of particulates as well as engine exhaust emissions, as well as noise and public safety impacts.

### **4.0 Specific Observations and Comments**

Following are specific observations and comments on the documents reviewed.

#### **4.1 Review of “Facility Characteristics Assumptions, Southwestern Landfill Environmental Assessment”**

The report addresses the commitments in the Terms of Reference for the project of the conceptual design and operating assumptions for the proposed undertaking, identifying mitigation measures to mitigate environmental impacts, and to prepare a “facility characteristics report including figures and plans, where appropriate”. WEG indicates that the report was prepared by WEG in collaboration with Golder Associates.

Section 1.1.3: the list of facilities and activities within the buffer zone should include the installation, operation and maintenance of contingency measures to address offsite migration of environmental contaminants. Permanent structures constructed in buffer areas should take into account the potential future need to implement contingency measures, which may require construction of linear infrastructure within the buffer area, and expansion of existing facilities such as the leachate treatment plant.

Section 1.1.5: The basis for selection of the slopes on the base of the landfill and the final cover system should be presented. These slopes meet the minimum design requirements set out in O. Reg. 232/98, but the basis for the generic designs in the regulation does not account for potential effects on slope stability associated with active

quarrying in the immediate vicinity, and the potential impacts of ongoing blasting operations on slope stability.

Section 1.1.6: Specifics regarding the monitoring to be carried out to assess background concentration of chloride in the groundwater should be provided. If this is referenced in the work plan for hydrogeologic investigations proposed to determine baseline conditions and potential impacts, it should be referenced.

Section 1.2: The significant depth of fill results in large areas dedicated to temporary side slopes and limits the portion of filled areas that have reached final elevation so that the final cap system can be installed over each of the stages. The area of uncapped placed waste has an associated significant impact on the quantity of leachate and contact water generated, which must all be treated prior to discharge. The staging of final cover construction should be provided. It is indicated that liner construction will proceed on an annual or as needed basis. Final cover construction should also relate to liner construction and fill progression. Similarly, an indication of how leachate and contact water will be segregated from runoff from buffer areas and areas where the final cover system has been completed should be included.

Section 1.3.1: Haul routes appear to be only applicable to incoming waste loads. It should be clarified if this applies to imported fill and construction materials as well. A significant quantity of clayey soil will need to be imported for the construction of the liner system for example. There should be no need for any of this traffic to travel on Town of Ingersoll roads. On-site roads and travel routes for waste vehicles and frequent trips by construction vehicles and trucks bring materials for landfill infrastructure construction should be located at the maximum distance from the site boundary and should be constructed within the buffer area to mitigate off-site noise, dust and odour impacts from these mobile and fugitive emissions.

Section 1.5: The MOECC guidance for O. Reg. 232/98 indicates that the generic double liner system design has a service life of 360 years provided that a cover system with an infiltration rate of .15 metres per year is in place. The Proponent must demonstrate that the service life of the engineered facility exceeds the contaminating lifespan (period of time during which contaminants may be generated and need to be controlled in order to prevent unacceptable impacts; unacceptable impact to groundwater occurs if an increase in concentration greater than the maximum allowable concentrations determined by applying MOECC's Reasonable Use Guideline). Sufficient hydrogeologic data must be available to assess the contaminating lifespan of the landfill against the service life of the generic double liner design.

The geomembrane in the liner design should be assessed against the anticipated amount of consolidation of the fill placed in the quarry prior to liner construction. The current work plan contains no requirement for such an assessment. The generic designs set out in O. Reg. 232/98, referenced in the work plan, are based on construction of a liner on

undisturbed native soils. These designs may not be suitable for this application where the liner system is to be constructed on fill. The depth of fill to be placed to achieve the base elevation above which the liner system will be constructed is quite substantial for this proposed development. Consolidation and differential settlement that would not otherwise occur when constructing on undisturbed native soil must be proven to be sufficiently low to ensure that the elongation of the membrane at changes in slopes and differential settlement does not exceed the elongation properties of the membrane. Additional measures to minimize consolidation and differential settlement or the use of alternative materials in the liner design should be assessed to ensure that the liner system could accommodate the stresses that are unique to this development. It is currently unknown if the generic designs are adequate for this application involving liner construction over fill without performing additional geotechnical analysis and investigations.

Section 1.7: Peer review comments relating to this section area addressed in a separate submission prepared by Tetra Tech.

Section 1.8: Peer review comments relating to this section area addressed in a separate submission prepared by Tetra Tech.

Section 2.2.1: Topsoil or any soil with significant organic content should not be used as backfill to minimize long-term consolidation and subsidence. Topsoil or any materials with significant organic content should also be avoided to prevent generation of methane from further degradation of the organic content over time, creating another potential source of methane that could migrate offsite through the subsurface, including the fractured zone of the upper portion of the bedrock.

Section 2.2.2: As noted above, modification of the generic design may be necessary to address the potential for membrane failure due to buried wrinkles and increased levels of consolidation, subsidence and differential settlement associated with placement of significant depths of fill below the liner.

Section 2.2.4: The final cover design needs to be developed to the level of detail necessary to determine its hydraulic conductivity relative to the infiltration rate of 0.15 meters per year that is the basis for the generic designs and the associated service lives as set out in O. Reg. 232/98.

Section 3.2.3: It is indicated that approved waste materials may be used as daily and intermediate cover. Specifics regarding the materials proposed should be determined to determine if contaminants in these soils have an impact on the contaminating lifespan of the landfill, as well as ensuring that the criteria will not create air and odour impacts prior to placement of the final cover system. If specific materials are not identified, concentration thresholds for specific contaminants should be determined to prevent an additional air, odour and groundwater impacts, and to ensure that the liner design,

leachate collection system and leachate treatment plant designs are all compatible with the additional contaminant loading that may result from the use of waste materials for daily and intermediate cover.

Section 3.3: Fugitive dust emissions from truck traffic to and from the site should be assessed, evaluating worst-case scenarios coinciding with peak traffic volumes, which will not be consistent through the year and will vary significantly over the course of the week or day during construction activities.

Section 3.7: Dust mitigation measures are included in this section as a nuisance impact. Air emissions are not considered to be a nuisance impact. While removal of dirt and dust is valuable, wetting of roads and application of dust suppressants should also be included as mitigation measures. Potential surface water impacts of dust suppressant chemicals and watering of roads should be assessed and mitigation measures developed.

#### **4.2 Review of Approved Amended Terms of Reference**

Section 4. p. 5, last paragraph (“Size”):

It is indicated that a minimum site area of 80 hectares is required. This should presumably take into account the volume of waste that can be accommodated with that area. As a quarry landfill, the greater potential depth of waste should be accounted for in determining the area requirements for the landfill development.

Section 5.2, p. 12, first paragraph, last sentence:

It is stated that “the landfill would occupy the completed quarry area after Carmeuse...has backfilled all of a portion of the mined quarry”. The properties and manner of placement of the quarry backfill can have a direct impact on the ability to ensure minimization of the potential for liner failure and to maximize the service life of the engineered systems for containing and collection landfill leachate. The agreement between WEG and Carmeuse should allow for sufficient control on the part of WEG regarding the nature and placement of fill to ensure that it is compatible with the construction of the landfill liner and leachate collection system.

Section 5.2, p. 12, 5<sup>th</sup> paragraph:

Site-specific designs options may be compatible with O. Reg. 232/98 landfill design standard, but would require some reliance on the natural features of the site, particularly the subsurface soil, geological and groundwater conditions. No work plan for additional geotechnical investigations has been submitted for review. This may limit the ability to prepare site-specific designs, or may result in a need for additional site investigations to ensure that the performance standards for site-specific designs set out in O. Reg. 232/98 will be met. Site-specific characteristics and concurrent operation of the quarry would need to be addressed by a site-specific design approach.

Section 6.2:

The study areas for groundwater and landfill gas impacts should extend at least 3 km beyond the site boundary, to address the requirements of MOECC Guideline D-4 “Land Use On or Near landfills and Dumps”, which is a direct application of Guideline D-1: “Land Use Compatibility”. These guidelines apply to all proposed land uses on or near landfills and dumps, and are to be used by MOECC staff in reviewing land use proposals and for undertakings subject to the Environmental Assessment Act.

Guideline D-4 states that adverse effects could be experienced at distances of up to 3 kilometres from the limit of waste disposal depending on site-specific conditions. The Guideline also points out that in hydrogeological situations that involve fractured rock, that leachate or gas impacts can cause migration of contaminants beyond the standard 500-metre study area applied to approval of proposed land uses in the vicinity of landfills. In Figure 5, the study area for groundwater appears to be limited to within 2 km of the site boundary. This should be increased to 3 km.

Section 8.1, p. 29 and section 8.2, item 5., p. 29:

Evaluation of alternatives should also consider the nature and the ease and certainty of successfully implementing contingency measures in the event of failure of engineered systems. Landfills located in areas where the subsurface soil, geological and hydrogeological conditions facilitate implementation of contingency measures to address failures of landfill cell liner and leachate collection systems (which cannot practically be replaced in the event of a failure). At a minimum, natural attenuation of leachate should be evaluated, and locations with conditions that provide a high level of natural attenuation of containment of leachate should be preferred in assessing alternatives.

#### **4.3 Review of Interim Report - Alternative Methods Working Draft**

Comments relating to aspects of the landfill design alternatives are provided below.

Table 1, p.2:

- The reference to liner design options should include options for leachate collection (the leachate collection infrastructure may be considered to be part of the liner design, but if that is the case, it should be explicitly stated)

Section 4. (“Landfill Footprint Alternatives”):

- The rationale for sectioning the Carmeuse property into 5 separate parcels is not clear and appears to be relatively arbitrary; the overall objective should be to minimize and mitigate off-site environmental and human health impacts, which can typically be most readily achieved by maximizing the buffer distance
- An alternative to locating the waste fill area to mitigate offsite impacts could include maximizing the distance between the boundaries of the waste fill area and the downgradient boundary as determined by groundwater flow and/or the maximum distance between the edge of the fill area and the property boundary along the downwind distance based on the predominant wind direction

- It almost appears that all but the preferred alternative were designed to fail – it would have been simple enough to screen out locations that would not comply with applicable legislation or regulations

#### Section 5.1.2 (“Landfill Design Alternatives”):

- “Fill and Rock Wall”, page 16, first paragraph: The location and dimensions of the rock “wall” referenced here; this makes it difficult to understand why this is a constraint and that relocating the wall is not feasible
- Figure 5, p. 19: While it is noted that it is not to scale, the differences in the slopes shown is quite misleading (the 3:1 liner slope is shown as being very much steeper than the 4:1 cover sideslope), and provide a poor representation compared to a scaled figure
- “Landfill Orientation”. p. 19 – 20: It is not clear as to why a west-to-east orientation is not feasible, since a narrower footprint could yield a larger overall volume if the overall depth of the waste is increased proportionally. The west-east orientation would be expected to benefit from an increased buffer distance between the limits of the waste fill area and the Carmeuse property boundary, providing an additional contingency in the event that there is a failure of mitigation measures or engineered infrastructure for the landfill.

#### Section 5.1.3:

- p.20: categorizing the landfill design into these three configurations is arbitrary and would normally be dictated by physical constraints, engineering considerations, mitigating visual, fugitive air emission, and hydrogeological impacts; in Ontario
- engineering and site-specific considerations such as the elevation of the water table, balancing soil/rock excavation and fill requirements, and the leachate management requirements and the suitability of utilizing an inward gradient liner design, as well as geotechnical considerations such as basal heave in deep excavations in low permeability soils; this section suggests that this is an arbitrary decision independent of these site specific factors and engineering considerations
- the value of the exercise of creating and screening among these options is limited, and while it may be necessary to address Environmental Assessment Act requirements, can be more adequately addressed in the design concept development and detailed design submitted for Environmental Protection Act approval and there is no need to eliminate any of these alternative “concepts”, as there are all potentially compatible with a feasible design that
- Table 4, p. 23: why are there entries in only 5 of the 15 cells in this table?; screening out the above-ground design alternative is not warranted, as a lack of backfill and a lesser volume are not technical or technological obstacles to implementing this design concept; screening this option out as prohibitively costly would not be a valid argument if the landfill were sited within an area of

the property where quarry restoration has been completed or which have not been quarried

Section 5.3.2, p. 24:

- Reference is made to MOECC Guideline D-4; Guideline D-4 states that adverse effects could be experienced at distances of up to 3 kilometres from the limit of waste disposal depending on site-specific conditions. The Guideline also points out that in hydrogeological situations that involve fractured rock, that leachate or gas impacts can cause migration of contaminants beyond the standard 500-metre study area applied to approval of proposed land uses in the vicinity of landfills. Individual properties and land uses within 3 km of the Active quarry area should be inventoried, rather than within only 500 metres.

Appendix B, Table B-1

- Row 3 – air emissions other than fine particulates should be considered; concentrations of other contaminants from the active disposal area as well as landfill gas that is not captured by the landfill gas management system should also be addressed (landfill gas collection system are estimated to only capture on the order of 70 percent of total landfill gas quantities)
- Row 4 – the elevation of the base liner relative to the groundwater level (after dewatering for quarrying has ceased) may create an inward gradient, which will increase leachate quantities through leakage into the liner system drainage layers; diffusion of contaminants will also vary for designs with the base of the liner system below the water table versus a design for which the water table will be below the elevation of the bottom of the liner system
- Row 5 – the concepts with a larger proportion of the waste above grade will necessarily incorporate steeper slopes for the landfill cover system, which will increase stormwater runoff and reduce infiltration, as well as increase flow velocities and associated erosion impacts
- Row 7 – there may be a difference in the movement of soil for backfilling the quarried area, which may or may not require importing fill to the site, but will certainly require differing number and frequency of on-site truck and heavy equipment activities that generate fugitive particulates emissions as well as engine exhaust and noise emissions
- Rows 10, 11, 13, and 23 – the visual impacts and nuisance impacts (i.e. litter) of the above-grade landfill concept can be effectively mitigated through the use of landscaping, tree plantings, fencing and berms, and would typically be integral design elements for this concept.

## 5.0 Closure

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,

Tetra Tech Canada Inc.

Prepared by:



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## EXPERIENCE SUMMARY

Mr. Muller has more than 25 years of experience in solid waste management facility planning, approvals, design and construction, extensive experience in environmental site assessment and remediation, renewable energy project approvals and greenhouse gas emissions assessment and reduction project projects. He has extensive project management experience and eight years of industry experience in the Canadian waste management industry in addition to his 24 years of consulting engineering experience.

## KEY PROJECT INVOLVEMENT

### WASTE MANAGEMENT INFRASTRUCTURE ENGINEERING

- **Solid Waste Feasibility Study and Preliminary Transfer Station Design, Barren Lands First Nation, Brochet, MB** Project Manager and technical lead for feasibility study for the Barren Lands First Nation for expansion or replacement of existing WDG disposal facility, and preparation of preliminary design for new waste transfer and recycling facility.
- **Ontario Landfill Expansion Environmental Assessment Act Approval, Confidential Client** Lead for existing condition assessment for air and odour emissions, and senior reviewer for conceptual design and design and operation
- **Peer Review of Landfill Development Approval, Ingersoll, ON** Landfill design and operation Subject Matter Expert for peer review team for a large regional landfill development.
- **Detailed Design, Approvals and Construction Contract Administration for Landfill Expansion (confidential client), ON.** Project Manager for detailed design, Environmental Compliance Approval and services during construction of an expansion of a hazardous waste landfill facility. Obtained ECA approval within 3months of approval of Environmental Assessment by MOECC for a 4 million cubic metre/25-year expansion of the site, including an update of the operations plan for the waste processing and incineration facilities at the site. Optimization of the conceptual design resulted in savings of more than \$12 million in future capital costs.
- **WMI West Edmonton Landfill Gas System Retrofit and Expansion Design, Edmonton, AB.** Technical lead for design of repairs and upgrades to the existing active gas collection and flaring system at an active landfill site.
- **Northwest Territories Department of Environment and Natural Resources Review of Yellowknife Landfill Compost Pad, Yellowknife, NWT.** Technical review of potential impacts of composting pad construction at the City of Yellowknife landfill site.
- **Audit Review for Municipal Waste Transfer Facility, Continuous Improvement Fund, Cochrane, ON** Review of capital costs for construction of a small municipal waste transfer facility in northern Ontario.
- **City of Winnipeg, Brady Road Landfill Expansion Cell Design, Winnipeg, MB.** Technical lead for design of fully engineered disposal cell for Brady Road landfill expansion
- **City of Thunder Bay, Leachate Management System Upgrade, Thunder Bay Landfill, Thunder Bay, ON.** Project Manager for assessment of leachate treatment option and conceptual design for treatment system upgrades and expansion at the City's active waste disposal landfill.
- **City of Calgary, Blackfoot Landfill Gas Management System, Calgary, AB.** Provided senior review and technical input for gas migration remedial system upgrades for a closed landfill with no engineered systems.

## EDUCATION

Schulich School of Business, York University, Masters of Business Administration (Business and the Environment concentration), 1995

University of Waterloo, Bachelor of Applied Science (Civil Engineering), 1985

## AREA OF EXPERTISE

Solid Waste Management, Environmental Site Assessment and Remediation, Environmental Sustainability, Greenhouse Gas Emission Reduction, Renewable Energy

Landfill design: landfill gas collection systems, leachate collection systems, leachate recirculation systems, leachate transfer and treatment facilities, liner and cover systems

Landfill and site remediation construction contract oversight and administration

Contaminated site and landfill hydrogeological assessments and remedial investigations

Hydrogeological and gas migration monitoring programs – groundwater surface water and gas migration

Waste transfer and processing facility conceptual design and permitting/approvals

Phase I, II and III Environmental Site Assessments

Remediation Option Feasibility Studies and Remedial Action Plans

## REGISTRATIONS/ AFFILIATIONS

Professional Engineers of Ontario (PEO) since 1987

Association of Professional Engineers and Geoscientists of Alberta

- **City of Lethbridge, Centresite Landfill Gas Control System, Lethbridge, AB.** Provided senior review and design input for gas migration remedial system upgrades for a closed landfill to address subsurface gas migration under adjacent buildings and properties.
- **City of Vancouver, Vancouver Landfill Phase I Closure and Landfill Gas Collection System, Delta, BC.** Project manager for landfill final cover system and gas collection and flaring system design and construction management services.
- **Resort Municipality of Whistler, Whistler Landfill Off-Site Gas Migration Monitoring and Mitigation Plan, Whistler, BC.** Project Manager and technical lead for a proposed program for landfill gas monitoring and contingency measures for urban development adjacent to closed municipal waste landfill as part of development of athletes' village facilities for Vancouver/Whistler 2010 winter Olympics.

- **Brantford Generation Inc. Mohawk Street Landfill Gas Utilization Project Brantford, ON.** Project sponsor and senior subject matter expert for the technical oversight and contract administration for the design/build contract for a 5 megawatt power plant and landfill gas collection system
- **Dow Chemical, Waste Disposal Site Financial Assurance Plan, Sarnia, ON.** Prepared estimates of contaminating lifespan and all operation and potential environmental remediation costs for an industrial landfill site to comply with Certificate of Approval requirements and provision of a letter of credit to guarantee sufficient funds.
- **City of Brantford, Landfill Gas Collection System Design, Brantford, ON.** Project sponsor and senior technical reviewer for the design of an extension to a landfill gas collection system incorporating horizontal collection trenches to facilitate immediate gas collection for a power generation facility utilizing landfill gas, and for future leachate recirculation for a potential bioreactor landfill cell operation.
- **Fundy Region Solid Waste Authority, Landfill Gas Collection System Design, St. John, NB.** Reviewer and project sponsor for the design of an expansion of an active landfill gas collection system for a regional landfill site incorporating state of the art composite geomembrane liner and cover systems, leachate management systems, and landfill gas flaring.
- **Dow Chemical, Scott Road Landfill Investigation, Sarnia, ON.** Senior engineer and subject matter expert for the investigation of leachate generation rates and potential for loss integrity of cover system. Subsequently identified and selected preferred options for remediation of cover system.
- **Graftech (formerly Union Carbide), Landfill Closure Plan and Permit Amendment, Welland, ON.** Project Manager and senior engineer for a geotechnical investigation, groundwater monitoring program review, and conceptual design for final cap and surface water management for an industrial landfill site following closure of the Union Carbide plant site adjacent to the Old Welland Canal. Included preparation of a closure plan and liaison with MOE approvals and regional technical support staff for approvals.
- **Dow Chemical, LaSalle Landfill Closure Design and Approvals, Sarnia, ON.** Senior engineer for the development of conceptual design and closure plan for hazardous industrial waste landfill site for the Dow Chemical complex as part of plant decommissioning activities. Included preparation of approvals applications and liaison with MOE regional and Approvals Branch staff.
- **Township of Pelee, Landfill Hydrogeology and Gas Migration Investigation, Pelee Island, ON.** Hydrogeological and gas migration assessment study to address regulatory concerns regarding migration of contaminants from a natural attenuation landfill site, and prepare recommendation regarding closure or expansion of the facility.
- **City of Toronto, Keele Valley Landfill Site Leachate and Landfill Gas Consulting Services, Maple, ON.** Project manager for a multi-year contract to manage reporting, monitoring, and all compliance and approvals issues for all aspects of leachate collection and landfill gas management at the Keele Valley landfill site.
- **Halton Region, Halton Region Waste Management Site Landfill Gas Collection and Flaring System, Milton, ON.** Project manager for contract administration for the design/build of a landfill gas collection and flaring system; provided technical review of design deliverables and onsite review of construction activities components.
- **Lanxess (formerly Bayer), Financial Assurance Update, Sarnia, ON.** Prepared estimates of contaminating lifespan and all operation and potential environmental remediation costs for an industrial landfill site to comply with Certificate of Approval requirements and provision of a letter of credit to guarantee sufficient funds.
- **McCoy Foundry, Closure Plan and Financial Assurance, Troy, ON.** Senior engineer for preparation of a closure plan, including comprehensive groundwater monitoring program for an inactive foundry waste industrial landfill site, including preparation of closure and post-closure care costs for the financial assurance submission to MOE.
- **Graftech (formerly Union Carbide), Waste Disposal Site Financial Assurance Update, Welland, ON.** Prepared estimates of contaminating lifespan and all operation and potential environmental remediation costs for an industrial landfill site to comply with Certificate of Approval requirements and provision of a letter of credit to guarantee sufficient funds.
- **Gemtec Engineering, Crane Mountain Landfill, St. John, NB.** Project sponsor and senior reviewer for the oversight of landfill gas generation study and collection and flaring system design for a solid waste landfill cell closure.
- **Waste Management Inc., Landfill Impact Litigation Support, West Gwillimbury, ON:** Provided technical assistance for mediation of action against landfill owner by adjacent property owners for contaminant migration to groundwater onto adjacent property.

#### REGISTRATIONS/ AFFILIATIONS (CONT.)

Association of Professional Engineers and Geoscientists of Manitoba

Qualified Person (QP ESA), Regulation 153/04, Ministry of the Environment (MOE)

#### OFFICE

Mississauga, Ontario

#### YEARS OF EXPERIENCE

30

#### YEARS WITHIN FIRM

3+

#### CONTACT

[Jonh.Muller@tetratech.com](mailto:Jonh.Muller@tetratech.com)

- **Waste Management Inc., Design of Expansion Cell, Petrolia, ON.** Senior Engineer and reviewer for the design and contract document preparation for an expansion of a landfill with full capability for operation as a bioreactor cell, including leachate recirculation and gas collection using horizontal collectors in multiple layers.
- **Oakville Hydro Energy Services, Landfill Gas Power Generation Feasibility Study, Milton, ON.** Project manager for a feasibility study for the utilization of landfill gas for the production of electrical power, including an economic analysis of capital, operating and maintenance costs. Financial analysis included both a rate of return and net present value sensitivity analysis based on a range of values in the market price for the electrical power produced and the premium for a green power designation.
- **WMI Waste Management of Canada Inc., Landfill Monitoring Program Approvals, Stouffville, ON.** Project manager for municipal and MOE approvals regarding changes to landfill monitoring program and construction of leachate management facilities, including presentations to municipal council.
- **Waste Management Inc., Groundwater Monitoring Program Assessment, Stouffville, ON.** Developed proposal for significant reduction in scope and frequency of groundwater monitoring program for large co-disposal landfill and liaison with MOE for approval of C. of A. amendment approval.
- **Waste Management Inc., Landfill Leachate Discharge Permitting, Stouffville, ON.** Obtained approvals for discharge of landfill leachate from co-disposal landfill facility to the York-Durham sewer system.
- **Waste Management Inc., Landfill Leachate Forcemain Design, Stouffville, ON.** Project manager for the design, regulatory approvals, and construction management of a leachate forcemain for a landfill leachate collection system incorporating an innovative butt-welded double containment HDPE design and robust automated leak detection system at substantially lower cost than conventional double-walled piping systems
- **Waste Management Inc., Landfill Post-closure Permitting, Tottenham, ON.** Project manager for post-closure permitting and completion of final closure of inactive landfill site, including amendment to site Certificate of Approval.
- **Waste Management Inc., South Simcoe Sanitation Landfill End Use Approvals, Tottenham, ON.** Led public meetings with local residents as required by MOE to obtain approvals for post-closure Certificate of Approval for closed landfill site
- **WMX Technologies, Mohawk Valley Landfill Leachate Management Study, Utica, NY.** Performed a feasibility analysis for an upgradient groundwater cut-off wall to decrease leachate volumes and increase landfill gas collection rate for electrical power generation facility, including financial feasibility using capital cost model
- **WMI Waste Management of Canada, Closed Landfill Maintenance and Rehabilitation Program, various locations, ON and QC.** Project manager for the repair of leachate seeps and landfill cap rehabilitation and maintenance programs for nine inactive landfill sites
- **WMI Waste Management of Canada, Landfill Remedial Investigations, Stouffville, ON Trois Rivieres, QC.** Project manager for feasibility studies for pre-treatment systems for landfill leachate for inactive landfill facilities
- **WMI Waste Management of Canada, Design and Construction of Watermain for Alternate Water Supply, Aurora, ON.** Project Manager for the design, approval and construction of watermain extension to provide alternate water supply to downgradient groundwater users
- **WMI Waste Management of Canada, Landfill Leachate Management, Becancour, QC; Stouffville, ON; Utica, NY.** Management of ongoing landfill leachate collection system operation and maintenance programs
- **WMI Waste Management of Canada, Groundwater and Landfill Gas Monitoring Programs, Aurora, ON; Stouffville, ON; Utica, NY; Rochester, NY; Scottsville, NY.** Management of ongoing monitoring, operation and maintenance of landfill gas management systems for five regional landfills, including preparation and submission of reports to NYSDEC and MOE
- **WMI Waste Management of Canada, Landfill Hydrogeological Investigations, York Region and Simcoe County, ON.** Project manager for several hydrogeological characterization investigations for four inactive landfill facilities in York Region and Simcoe County, Ontario
- **WMI Waste Management of Canada, Closed Landfill Hydrogeological Investigations, Aurora, ON; Stouffville, ON.** Project manager for multi-phased remedial investigations and feasibility studies for groundwater contamination for two co-disposal landfill sites
- **WMI Waste Management of Canada, Landfill Collection and Flaring System, Aurora, ON.** Project manager for design and construction of active gas collection and flaring system for 26 ha landfill site.
- **Dufferin Aggregates, Feasibility Study for Disposal Site Development of Quarry, Milton, ON.** Lead engineer for the conceptual design and feasibility study for redevelopment of aggregate quarry as waste disposal landfill site.

## WASTE MANAGEMENT PLANNING AND RESOURCE MANAGEMENT

- **Ontario Waste Study for Alternative Fuels for Bath Cement Plant, Geocycle/LafargeHolcim, Bath , Ontario** Market study to assess potential sources of alternative fuels to displace petcoke and coal fuels as well as wastes that could be used as alternative raw materials.

- **PanAm Games Project Corp., Waste Management Performance Specification Development Hamilton, ON and Toronto, ON.** Developed performance specification for design/build/operate projects for redevelopment of Hamilton soccer stadium and Scarborough aquatics centre for Pan Am Games.
- **Township of Pelee, Pelee Island Waste Management Plan, Pelee Island, ON.** Project manager for the development of an integrated waste management plan for the Township to accommodate closure on the landfill and transfer of waste off of an island community.

## ENVIRONMENTAL SITE ASSESSMENT AND REMEDIATION

- **Salvation Army Building Soil Vapour Venting System, Whitehorse, YK.** Design engineer and subject matter expert for a soil gas vapour venting system for a new building to be constructed adjacent to a site with VOC contamination of groundwater. Construction specifications were prepared, as well as an active gas extraction contingency were addressed in the design. The system included a geomembrane barrier system below the foundations and a piping network to collect and vent vapours migrating from the groundwater.
- **Newalta Landfill and Waste Transfer Facility Environmental Site Assessment, Hamilton, ON.** Senior technical lead for due diligence assessment of environmental liabilities for an active landfill site and industrial waste transfer facility related to potential acquisition review.
- **Phase II Environmental Site Investigation, KDC Ltd. Production Plant, Mississauga, ON.** Project Manager and technical lead for site investigation for due diligence review related to refinancing.
- **Cameco, Uranium Processing Site Remedial Investigations, Port Hope, ON.** Senior review engineer for site remediation pre-feasibility study to address options for remediation of low-level radioactive soil and groundwater impacts at an active uranium fuel processing facility.
- **Ontario Ministry of the Environment, Deloro Mine and Processing Plant Remediation, Deloro, ON.** Senior review engineer for the design of tailings cover system and on-site containment cell for impacted soils from historic mining and smelting operations at the Deloro Mine site remedial site. Included approvals for waste disposal cell for contaminated soil including low-level radioactive waste requiring demonstration that engineered containment system would address extended contaminating lifespan of radiological materials.
- **Waterfront Toronto, Soil Processing Site Approvals Toronto, ON.** Prepared of waste site Certificate of Approval application package for treatment and transfer of impacted soils generated from redevelopment activities for the West Donlands, Portlands and East Bayfront precincts of the Toronto waterfront lands redevelopment.
- **Dow Chemical, Interim Cover System and Groundwater Remediation, Ft. Saskatchewan, AB.** Senior technical lead for a secure cover system and groundwater remediation options for impacted soils and groundwater in an area of an extensive plant site previously decommissioned.
- **Accenture (formerly Arthur Anderson), Petrolia Hazardous Waste Landfill and Incinerator Environmental Liability Due Diligence Review, Petrolia, ON.** Project manager and technical lead for a review of operations, assets and current and potential future environmental impacts and regulatory compliance of Ontario only hazardous waste landfill and disposal facility for the trustees related to bankruptcy proceedings. Involved quantifying all environmental liabilities and completed on an accelerated schedule working closely with the legal and accounting teams.
- **Metrus Development, Feasibility Study for Redevelopment Adjacent to Closed Landfill, Burlington, ON.** Senior Engineer for a feasibility study for a residential development adjacent to two closed landfill sites with minimal engineered facilities
- **Metrus Development, Environmental Site Assessment - Waste Disposal Assessment Area, Maple, ON.** Project manager and senior engineer for the Investigation of potential impacts from the York Disposal closed landfill within a designated Waste Disposal Assessment Zone
- **Capital Environmental Resource Inc., Waste Transfer and Recycling Facility Due Diligence Audit, Barrie, ON.** Performed an environmental due diligence audit for acquisition of a solid waste transfer and recycling facility
- **Metrus Development/York Major Holdings, Development Approvals Adjacent to Closed Landfill, Vaughan, ON:** Project manager for approvals for land redevelopment within a waste disposal assessment area adjacent to the Keele Valley landfill site
- **Waste Management Inc., Fuel Tank Remediation, North York, ON.** Project manager for underground fuel tank remediation of soils and groundwater using bioremediation techniques
- **Confidential client, Waste Transfer Station and MRF Surface and Groundwater Remediation, Toronto, ON.** Lead the investigation of contaminant migration and site remediation requirements for spills associated with a fire at a waste transfer and recycling facility
- **Waste Management Inc., Remedial Investigation for MRF Fire. Etobicoke, ON.** Project manager for the investigation and remedial design of PAH contamination of soils related to a fire at a waste materials processing facility

- **Waste Management Inc., Remedial Investigation at Former Steel Fabrication Plant, Etobicoke, ON.** Project manager and engineer for the remediation of lead and solvent soil contamination at a former steel fabricating facility
- **Waste Management Inc., Due Diligence Review For Potential Acquisition, eastern ON.** Performed a due diligence review of all environmental compliance and technical aspects for a regional waste disposal facility
- **Canadian Waste Management, Diesel Fuel Tank Remediation, Toronto, ON.** Project manager for the investigation and remediation of diesel fuel release from underground piping at a private fuelling facility; remediation included groundwater extraction and on-site pre-treatment, bioremediation of soils within a road right of way and utility corridor, and hydraulic control of groundwater on-site
- **WMX Technologies, Pfohl Bros. Superfund Landfill Site Remediation, Buffalo, NY.** Served as technical committee member for group of large industrial companies responsible for remediation a 8 ha landfill used to dispose of drums of hazardous waste over a 50-year period
- **WMX Technologies, Chem-Trol Superfund Hazardous Waste Processing Site Remediation, Tonawanda, NY.** Member of technical committee managing the remedial design, approvals and construction of a group of large industrial companies responsible for remediation former hazardous waste processing facility
- **WMX Technologies, Hazardous Waste Site Remediation - Feasibility Study, Buffalo, NY.** Managed a feasibility study for former hazardous waste processing site located adjacent to a residential subdivision, to develop a remedy for contaminant soils, PCB contaminated sediments, and DNAPL contamination in fractured bedrock
- **WMI Waste Management of Canada, MRF Redevelopment Site Assessment, Etobicoke, ON.** Project manager for Phase I and II environmental assessments for solid waste recycling facility re-development project
- **Confidential client, Underground Storage Tank Contaminant Migration Assessment, Ottawa, ON.** Technical support to legal counsel regarding potential claim from adjacent property owner in course of remediating hydrocarbon soil contamination at an industrial site.
- **WMI Waste Management of Canada, Underground Storage Tank Remediation, Toronto, ON and Bolton, ON.** Project Manager for removal of leaking underground fuel storage tanks for WMI Canada operations
- **City of Toronto, Ataratiri (West Donlands) Phases I, II and III Site Assessments, Toronto, ON.** Project manager for subsurface soil and groundwater investigations to assess the presence and extent of contaminations and preparation of valuation of environmental liabilities for expropriation proceedings for multiple land parcels covering more than 40 ha of industrial urban land; led all field operations and preparation of remediation costs estimates and preparation of reports for City and its legal team
- **General Electric, GE Silicones Scarborough Plant Site ESA, Scarborough, ON.** Project manager for Phase I and II environmental site assessment for contemplated sale and residential redevelopment of manufacturing plant site
- **City of Toronto, Toronto Refiners & Smelters Lead-Acid Battery Plant ESA, Toronto, ON.** Project manager for subsurface soil and groundwater investigations to assess the presence and extent of contaminations and preparation of valuation of environmental liabilities for expropriation proceedings; led all field operations and preparation of remediation costs estimates and preparation of reports for City and its legal team
- **Alcan, Transformer Storage Building PCB Remediation, Kingston, ON.** Lead engineer for PCB site decontamination investigation and remediation; developed innovative remedy which limited costs to shot blasting floor slab versus complete demolition and secure disposal of entire floor slab for decommissioning of aluminum production facility
- **Alcan, PCB Remediation, Bracebridge, ON.** Obtained approvals for transportation of PCB waste and registration of PCB waste interim storage facility
- **City of Toronto, Phase I, II and III Environmental Site Assessments at Toronto Refiners and Smelters Site, Toronto, ON.** Prepared evidence for legal counsel in expropriation proceedings for Toronto Refiners and Smelters lead acid battery processing facility, and preparation of environmental liability valuation for expropriation proceedings.
- **Algoma Steel (Falconbridge), Steel Mill Site Redevelopment ESA, Sault Ste. Marie, ON.** Project manager for Phase I and II environmental site assessments for Algoma Steel lands for potential sale to City of Sault Ste. Marie
- **IBM, Tank Containment System Upgrades, Poughkeepsie, NY.** Design and construction oversight for spill control systems for fuel transfer facilities and underground tank systems at major industrial campus
- **W.R. Grace, Wauconda Landfill Superfund Site Remediation, Wauconda, IL.** Contract administration for construction of interim remedial measures, including cap upgrading and installation of leachate collection and storage facilities for Superfund landfill site suspected of receiving large quantities of PCB wastes
- **Chem Dyne, Chem Dyne Site Remediation, Hamilton, OH.** Remedial construction contract administration and oversight at a Superfund hazardous waste processing facility site, including construction of geosynthetic cap and installation of aquifer extraction and treatment system
- **IBM, Wastewater Pipeline Leak Detection Retrofit, Poughkeepsie, NY.** Design and remedial construction administration for remediation and leak detection system retrofitting of double containment industrial sewer system

- **Ontario Ministry of the Environment, Pottersberg Creek PCB Remediation, London, ON.** Design and construction management for removal of PCB contaminated sediments and construction of secure hazardous waste landfill facility, London, Ontario
- **Ford Motor Company, Bullitt County Disposal Site Remediation, Bullitt County, KY.** Containment system design former hazardous waste drum disposal site.

## ENVIRONMENTAL PERMITTING AND APPROVALS

- **Confidential client, Environmental Compliance Approval of a Vertical Landfill Expansion, Lambton County, ON.** Following Ontario Environmental Assessment Act approval of the 4 million m<sup>3</sup> landfill expansion, led the preparation and submission to MOECC of an ECA application that included an application for an OWRA ECA for an expanded and upgraded stormwater management. Approval was obtained within three months of approval of the EAA approval.
- **City of Winnipeg, Brady Road Landfill, Winnipeg, ON.** Obtain Conservation and Water Stewardship approval for two alternative landfill cell liner designs to accommodate cold weather construction of a new cell required to address imminent depletion of available airspace at the City's sole waste disposal site.
- **Invista (formerly Dupont), Waste Management Permit Amendment, Maitland, ON.** Review engineer for a permit amendment application for process changes impacting waste quantities generated at an industrial facility.
- **Sandhill Disposal, Greenfield Waste Transfer Station Approvals and Permitting, Caledon, ON.** Project manager for conceptual design and preparation of application for MOE approvals for new waste transfer station.
- **Waste Management Inc., Air Emissions Approval for Landfill Gas Control System, Stouffville, ON.** Project manager for approvals for passive gas venting barrier system for 40 ha landfill site.
- **Chemical Waste Management Inc., Hazardous Waste Processing Site Remediation Permitting & Approvals, Buffalo, NY.** Obtained various waste management system permits and permit amendments to certificates of approval to for hazardous waste processing facility with residual groundwater, surface water sediment, and soils contamination.
- **WMI Waste Management of Canada, Sewer Discharge Permitting, Stoney Creek, ON.** Obtained discharge agreement from Region of Hamilton-Wentworth for sewer discharges from waste container and vehicle washing facility exceeding sewer use guideline criteria
- **WMI Waste Management of Canada, Environmental Approvals, various sites, ON.** Prepared applications and hearings before municipal committees of adjustment and Ontario Municipal Board for changes in use for waste transportation system facilities and recycling operations for three Ontario operating units
- **WMI Waste Management of Canada, Waste Management Site Approvals and Permitting, various sites, ON.** Obtained waste site approvals for five solid non-hazardous waste transfer/processing facilities
- **WMI Waste Management of Canada, Landfill Gas System Air Permitting, Aurora, ON.** Project manager for air emissions permit for landfill gas flaring facility for gas collection system at closed landfill facility.

## GREENHOUSE GAS EMISSIONS REDUCTIONS

- **Natsource LLC, Greenhouse Gas Emission Reduction Clean Development Mechanism Projects, Argentina and Brazil.** Subject matter expert and project manager for the Identification of potential greenhouse gas emission reduction projects, including technical due diligence and evaluations of the approvability and economic viability of potential projects in Argentina and Brazil as Clean Development Mechanism projects under the Kyoto protocol. Projects including renewable energy generation from wood waste biomass, landfill gas flaring and/or utilization, leakage prevention for natural gas transmission systems, wind power generation, sulphur hexafluoride emission reductions from an industrial process, and nitrogen oxide reduction for a fertilizer manufacturing plant.
- **Natsource LLC, Greenhouse Gas Emission Reduction Due Diligence Reviews, Tianjin ad Fuxin, China.** Project manager for feasibility reviews of potential greenhouse gas emission reduction projects, including technical due diligence and evaluations of the approvability and economic viability of potential projects in the Tianjin Economic Development Area, People's Republic of China, including: coal mine gas recovery, wind power generation, cement production process upgrades, petrochemical refinery methane emission recovery.
- **Natsource LLC, Greenhouse Gas Emission Reduction Clean Development Mechanism Projects, Tianjin Economic Development Zone, China.** Performed evaluations of several greenhouse gas reduction projects in the Tianjin Economic Development Area for greenhouse gas reductions through flaring of landfill gas and/or utilization for power generation. Developed gas generation estimates and preliminary financial analysis of projects, as well as approvals reviews and technical due diligence evaluations.
- **Ontario Ministry of the Environment, Ontario Landfill Gas Emission Reduction Study, Toronto, ON.** Developed a model of greenhouse gas emissions from all Ontario landfill sites to determine costs and predicted GHG emissions reductions from proposed regulatory measures. Included an evaluation of various landfill capacity thresholds and associated costs and benefits in terms of emission reductions using a comprehensive Excel model that facilitated sensitivity analysis of various regulatory approaches.

## ENVIRONMENTAL MANAGEMENT SYSTEMS AND AUDITING

- **Canadian Waste Management Inc., Waste Classification System Development, ON, AB, BC, QC.** Developed waste classification tool for CWM's disposal operations to ensure compliance with provincial regulatory restrictions and identify sampling and laboratory analysis requirements to determine classification and acceptance at its disposal facilities.

- **WMI Waste Management of Canada, Environmental Audits, various locations, ON, QC.** Developed and implemented an environmental management system and waste stream audits for active industrial facilities throughout Ontario.

## RENEWABLE ENERGY

- **Confidential client, Approvals and Permitting Feasibility Review for 3 Solar PV Power Sites, ON.** Project Manager for a study to evaluate the approvability of three proposed sites for large-scale photovoltaic solar power plant projects under the Ontario Power Authority's Feed-In Tariff program. Included an evaluation of physical infrastructure, ecological sensitivity and potential impacts, zoning compliance and development approval potential, and archeological/cultural assessment of the proposed sites to assess their feasibility as potential power generation sites.

## PROFESSIONAL RECORD

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2013/Present	Tetra Tech., Senior Project Manager and Ontario Solid Waste Lead
2011/2013	Coffey Geotechnics, Business Unit Manager
2004/2011	CH2M HILL, Waste Management Market Sector Leader – Canadian Region, Sustainable Solutions Manager, Renewable Energy Business Development Lead, Greenhouse Gas Carbon Credit Team Engineer
1999/2004	AECOM (formerly Earth Tech Canada Inc.), Senior Environmental Engineer
1996/1999	Stantec, Senior Environmental Engineer, Profit Centre Manager
1990/1996	Waste Management Inc., Engineer and Project Manager, Environmental Management Department
1989/1990	AECOM (formerly Proctor & Redfern Group), Environmental Engineer
1985/1988	Conestoga-Rovers & Associates, Environmental Engineer