

RISK-BASED MANAGEMENT APPROACH TO CONTAMINATED SITES – A CASE STUDY

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ABSTRACT

The Gloucester Landfill site served as a municipal waste disposal site from approximately 1957 to 1980. From 1969 to 1980, a portion of the site, the "Special Waste Compound", was used for the disposal of wastes from various government departments. Over the past 20 years, extensive monitoring and site investigations have identified on-property and off-property impacts of primarily volatile organic compounds. The initial environmental quality objectives, defined in 1987, were used until 2003, for the remedial activities and site evaluations. The initial objectives were reflective of drinking water guidelines and were considered conservative since potable use of groundwater in the area ceased in 1984/1985. In 2003, following an Area Wide Risk Assessment study, site-specific environmental quality criteria were defined and integrated into the risk management plan of the site. These new criteria are reflective of the current site conditions and environmental fate modeling, exposure pathway analysis and toxicology knowledge.

RÉSUMÉ

Le dépotoir de Gloucester a été utilisé pour l'enfouissement de déchets municipaux d'environ 1957 à 1980 et pour l'enfouissement de déchets spéciaux provenant de départements gouvernementaux de 1969 à 1980. Durant les 20 dernières années, suite à des travaux intensifs d'évaluation et de surveillance environnementale, une contamination en composés organiques volatils a été identifiée à l'intérieur et à l'extérieur des limites du dépotoir. Les premiers seuils de qualité environnementale définies en 1987 ont été appliqués aux activités de réhabilitation et d'évaluation jusqu'en 2003. Ces seuils étaient basés sur la protection des eaux potables et étaient considérés conservateurs puisque le secteur est desservi par un aqueduc depuis 1984/1985. En 2003, suite à une Étude d'évaluation des risques, des seuils spécifiques ont été développés et intégrés au plan de gestion du site. Ces nouveaux seuils sont basés sur les conditions actuelles du site et sur les connaissances des composantes du risque.

1. BACKGROUND

1.1 Waste Disposal Activities

The former Gloucester Landfill site is located on Transport Canada property, adjacent to the Ottawa International Airport in Ottawa, Canada. It served as a municipal waste disposal site from approximately 1957 to 1980. Between 1969 and 1980, a portion of the site was used for the disposal of wastes (predominately oils and solvents) from federal government departments. These wastes were placed in a Special Waste Compound (SWC) at the edge of the landfill. Disposal activities in the Special Waste Compound were carried out in accordance with acceptable waste management practices of the day and under the supervision of federal government departments.

1.2 Study Area Settings

The former Gloucester Landfill site property, as shown on Figure 1, is owned by Transport Canada. The property is undeveloped with the exception of the groundwater treatment facility building constructed in 1992. The property has been undeveloped and unoccupied since land filling activities were initiated in 1957. Prior to 1957,

the property was undeveloped farmland. The former Gloucester Landfill site abuts the Canadian Pacific Railway tracks (decommissioned and now a 'Right of Way'). Private property is located to the east of these tracks including mixed residential and commercial/industrial properties along Leirim Road; an established residential development on Quinn Road; and a commercial/industrial area on Del Zotto Avenue. A section of land owned by Transport Canada is also located between Quinn Road and Del Zotto Avenue.

The property east of Albion Road beyond Quinn Road and Del Zotto Avenue, in the direction of groundwater flow, is mostly undeveloped and owned by various public, private and institutional owners. This area consists of open grassed and forested areas with wetlands and surface water features. To the north of the former Gloucester Landfill site is a golf course. Approximately 300 m to the west of the former landfill is a gravel pit.

The surficial deposits consist of quaternary glacial, glaciofluvial, marine, and organic deposits and sediments. Based on the hydrogeological investigations completed, the target units for chemical migration and subsequent evaluations are two overburden units referred to as the

Shallow Aquifer and the Deep Aquifer. The groundwater flow is generally horizontal and to the east in both the Shallow and Deep overburden aquifer.

1.3 Environmental Monitoring Activities

During the past 20 years, the former Gloucester Landfill Site has received intense technical scrutiny, which would likely not be encountered at a similar site today. Prominent research scientists and engineers in North America have completed studies and published numerous peer-reviewed studies. Since 1978, it is estimated that thousands of soil and groundwater samples were collected and analyzed for a variety of priority pollutants including polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, solvents, metals and isotopes.

To date, more than 10,000 groundwater samples have been collected from groundwater monitoring sites distributed throughout the western portion of the Study Area. Surface water samples from ditches located along Del Zotto Avenue, Quinn Road, Leitrim Road, Albion Road and/or Leitrim Wetland have been collected since 1992. To date, more than 100 surface water samples have been analyzed for volatile organic compounds and over 350 soil samples have been analyzed. Soil chemical analysis programs have been completed within the Special Waste Compound, within the Municipal Waste Landfill and within the vicinity of the Gloucester Landfill Site. Soil quality analyses were essentially performed between 1984 and 1990 and in 2002.

The soil and groundwater analyses revealed that contaminants were transported in the subsurface from the Special Waste Compound past the landfill's eastern boundary. More recent work identified groundwater impacts near the intersection of Leitrim Road and the former railways tracks as well as outside Transport Canada lands located east of the railway line corridor.

2. DESCRIPTION OF INITIAL ENVIRONMENTAL QUALITY OBJECTIVES AND RELATED IMPACT, REMEDIATION AND MONITORING ACTIVITIES

2.1 Initial Environmental Quality Objectives

Environmental quality criteria have been used throughout the years to evaluate the potential environmental and human health impacts associated with the former Gloucester Landfill and to assess the remediation requirements/efficiency.

Prior to the former Gloucester Landfill remediation activities, which were conducted in the late 1980s, air and water quality criteria were proposed and accepted, based on the latest toxicological data. The quality criteria were reflective of drinking water guidelines, although local groundwater supply wells were taken out of service and municipal water service (from the Ottawa River) and municipal water were provided to the Leitrim Road, Albion

Road and Del Zotto Avenue houses of the area in 1984-1985. As a result, these quality criteria were considered conservative.

The environmental quality objectives defined in 1987, were used for the remedial activities and site evaluations. These criteria, presented in Table 1, became formalized as part of the Gloucester Treatment Objectives, the "Gloucester List", for the on-site pump-and-treat remediation and monitoring program. Objectives were defined for the compounds that were most frequently detected, most mobile and that had been detected at concentrations that warranted continued investigation. These compounds were also the substances that represented a relatively large proportion of the wastes that were disposed of in the SWC.

2.2 Initial Understanding of Environmental Impacts

During the course of the previous subsurface investigations and chemical analysis programs, it became clear that the primary chemicals of concern were the volatile organic compounds (VOCs). The chemicals in this group are generally mobile in groundwater and have been found off-property within the developed areas.

Soil in exceedance of initial quality criteria was found in the SWC. A groundwater plume was found emanating from the SWC, and migrating east in the deep aquifer. An additional plume was identified, originating from the municipal waste site and migrating east within the shallow aquifer. It was concluded that remediation activities were required to decrease the risk associated with the impacted soil and groundwater.

2.3 Remediation and Monitoring Activities

In 1984 and 1985, local groundwater supply wells were taken out of service and municipal water service (from the Ottawa River) was provided to the Leitrim Road, Albion Road and Del Zotto Avenue houses of the area, to ensure a safe water supply for homes and businesses.

From 1987 to 1989, impacted soil and waste materials were removed from the Special Waste Compound and disposed of off-property at a licensed waste treatment facility in Ontario. Following the removal of wastes, additional studies were completed to determine the extent of solvent impacts present in the groundwater. Various groundwater remedial options were evaluated. The preferred option was a pump-and-treat system to contain and remediate impacted groundwater.

A groundwater treatment facility was constructed in 1991-1992 and treatment began in April 1992 and is ongoing. Impacted groundwater is pumped from a number of shallow and deep groundwater extraction wells. This water is pumped to a groundwater treatment facility. The treated groundwater is then re-injected into the subsurface to aid in groundwater plume control.

3. DEVELOPMENT OF SITE-SPECIFIC ENVIRONMENTAL QUALITY CRITERIA

3.1 Overview of Area Wide Risk Assessment Study

A risk assessment study was conducted to evaluate the likelihood of undesired effects on human and ecological health resulting from exposure to a contaminant source. The study focused on an "Area Wide" approach and encompassed not only the former Gloucester Landfill itself, but also the area downgradient from the landfill. The general boundaries of the Study Area were the former Gloucester Landfill to the west, Bank Street to the east, Leitrim Road to the north, and Transport Canada property to the south (approximately 500 m south of Del Zotto Avenue).

The large VOC groundwater data set provided representative data to use in the human health and ecological risk assessments. In order to complete the risk assessment, chemical concentrations that are representative of the soil, soil vapour (air), groundwater and surface water found within the Study Area were selected. The risk assessment was conducted on a zone basis to reflect the variations in environmental conditions observed throughout the Study Area. Although potential impacts to ecological receptors within the entire Study Area were considered, the primary focus of this assessment was the Leitrim Wetlands.

The main pathway of concern for human exposure was vapour transport from groundwater into indoor air. The 95% Upper Confidence Limit (UCL) was derived from the groundwater concentrations data set and used for calculation of health risks. The potential impacts to ecological receptors were evaluated based on the maximum chemical concentration detected in surface water or on the MDL if the substance had not been detected.

The representative environmental concentrations were first screened against generic quality criteria (i.e., Ontario Ministry of Environment (MOE, 1996a) Table B, MOE Provincial Water Quality Objectives (PWQO; MOE, 1995) and Canadian Council of Ministers of the Environment (CCME, 1999) Aquatic Life Freshwater). Since these criteria are designed to be broadly protective of human and ecosystem health, any substance present at a concentration less than the appropriate criterion is not expected to represent a risk and therefore, was considered further in the assessment. Substances detected at concentrations greater than the appropriate screening criteria, or for which no generic criteria were available, required further evaluation to determine their significance to human and ecosystem health. To evaluate the potential for adverse effects associated with exposure to these substances, health-based toxicity reference values and/or toxicity profiles were used and incorporated into the risk estimates.

The AWRA concluded that the environmental conditions within the entire Study Area examined do not represent a

health risk to current and future residents, or commercial/industrial building occupants/workers. It was concluded, based on the most recent surface water quality data, water quality guidelines and aquatic toxicity data used as benchmarks in this evaluation, that there is no potential risk of adverse effects to aquatic receptors within the Study Area.

3.2 Selection of Site-Specific Environmental Quality Criteria

Site-Specific Environmental Quality Criteria (SSQC) were established to formalize the performance objectives and reporting requirements as part of the Risk Management Plan for the site. SSQCs represent baseline values to which the results of the monitoring program can be compared. The SSQC have been generated from the AWRA study and from the most up to date toxicological information. The SSQC are presented in Table 1.

Table 1. Environmental Quality Criteria – "Gloucester List" Compounds

Chemicals of Potential Concern	Initial Ground-water Quality Criteria (ug/L)	AWRA SSQC Ground-water (ug/L)	AWRA Surface Water (ug/L)
Vinyl Chloride	1	2	600
Diethyl Ether	300	50,000	165
1,1 Dichloroethane	10	9,000	200
Tetrahydrofuran	8100	30,000	5,930
Benzene	10	1,900	100
1,4 Dioxane	66.5	50,000	20
Toluene	1000	5,900	0.8
Chlorobenzene	NS	500	1.3
m,p-Xylene	NS	5,600	2
o-Xylene	NS	5,600	40
Trichlorofluoromethane	NS	Removed from List	
1,1,2	NS	Removed from List	
Trichlorotrifluoroethane			
1,1 Dichloroethene	7	7	40
cis 1,2 Dichloroethene	NS	70	200
Chloroform	350	430	1.8
1,1,1 Trichloroethane	200	200	10
1,2 Dichloroethane	10	17	100
Trichloroethene	30	50	20
1,1,2 Trichloroethane	6	16,000	800
Tetrachloroethene	10	5	50

During the completion of the AWRA, a review of the groundwater data from 1992 onwards revealed that two of the "Gloucester List" compounds targeted by the monitoring and remediation programs have essentially not been detected between 1992 and 2002: trichlorofluoromethane (TCFM) and 1,1,2 trichlorotrifluoroethane (1,1,2 TCTFE). As a result, a revised "Gloucester List" was developed which excludes these two compounds.

3.2.1 Groundwater SSQC

Consistent with the MOE Guideline (MOE, 1996a), the MOE Table B non-potable groundwater criteria were selected as SSQC for most of the chemicals of potential concern (COPCs) on the revised "Gloucester List". These concentrations will be used to evaluate potential risks to human health and the environment in the entire Study Area. These criteria are appropriate because they are protective of human health for all land uses found within the Study Area. They are also protective of aquatic receptors in instances where groundwater discharges to surface water, such as within the Leitrim Wetland.

Further to the MOE Table B concentrations, SSQC were derived for the compounds with no available Table B criteria (i.e. diethyl ether, tetrahydrofuran, and 1,4-dioxane). The lowest of the two concentrations, the upper concentration limit (MOE, 1996b) and the health-based concentration from the AWRA modeling results were selected as the SSQC.

An SSQC was also derived for vinyl chloride and 1,1-dichloroethylene (1,1 DCE) in light of revised available toxicity data. For these SSQC, the process used by the MOE to set the Table B criteria was repeated with the use of the revised toxicity characteristics.

3.2.2 Surface Water SSQC

The ecological toxicity reference concentrations described in the AWRA were selected for the evaluation of surface water quality and potential risk to ecological receptors. These concentrations are protective of ecological receptors or recreational uses of surface water by humans, such as a child playing in a ditch or pond within the current and proposed residential areas or the Leitrim Wetland itself.

The SSQC for surface water quality evaluation are largely MOE PWQOs, but some have been derived by the CCME. When both PWQO and CCME criteria were available, the lower of the two was selected as the SSQC for the Risk Management Plan. SSQC were derived for the compounds with no available MOE or CCME surface water quality criteria (diethyl ether and tetrahydrofuran). The SSQC are based on the most sensitive endpoint for *Daphnia magna* (aquatic receptor) using a 1000x species sensitivity correction factor.

3.3 Current Understanding of Contaminant Impacts

Most chemicals associated with the Gloucester Landfill have not been detected in soil, groundwater or surface water off-property within the entire Study Area. The groundwater and surface water concentrations detected off-property between 1998 and 2002 are below the SSQC, as indicated by the results of the risk assessment, which identified no likelihood of adverse effects to human and ecological receptors present within the Study Area.

4. CONCLUSION

Environmental quality criteria have been used throughout the years to evaluate the potential environmental and human health impacts associated with the former Gloucester Landfill and to assess the remediation requirements/efficiency. The initial objectives established in the 1980s were reflective of drinking water guidelines and were considered conservative since potable use of groundwater in the area ceased in 1984/1985. Based on observed environmental conditions and initial environmental quality objectives, it was concluded that remediation activities were required to decrease the risk associated with the impacted soil and groundwater. Measures that were implemented include: servicing of municipal water in 1984-1985, excavation of impacted soil in 1987-1989 and commissioning of a groundwater pump-and-treat system in 1992 (on-going).

In 2003, following an AWRA study, SSQC were defined and integrated to the risk management plan of the site. These new criteria are reflective of the current site conditions and environmental fate modeling, exposure pathway analysis and toxicology knowledge. The current environmental conditions and SSQC indicate no likelihood of adverse effects to human and ecological receptors present within the Study Area.

5. REFERENCES

- Canadian Council of Ministers of the Environment (CCME), 1999. Canadian Environmental Quality Guidelines. Winnipeg, MB.
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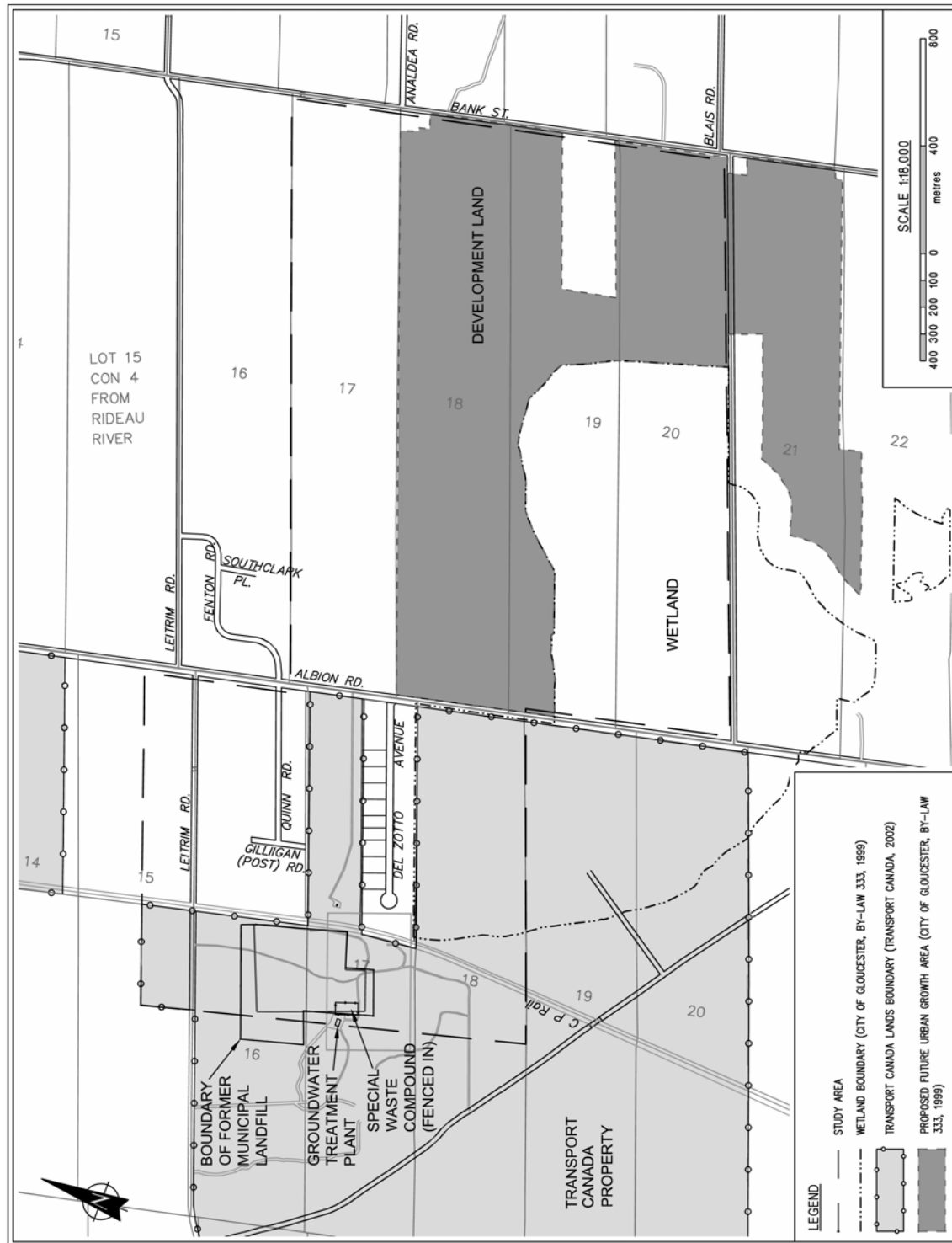


Figure 1. Site setting.