CCE AWARDS SUBMISSION

FUGITIVE EMISSIONS RATE MEASUREMENTS, VANCOUVER LANDFILL

Golder Associates

PROJECT OUTLINE

How can the City of Vancouver effectively manage fugitive methane emissions at their landfill without a suitable method of measuring them? Golder Associates' solution to this difficult problem is the Airborne Matter Mapping (AMM) method, which allows measurement of fugitive emission rates by a unique sampling and data processing technique. The City now has the information to prioritize, according to cost-effectiveness, improvements to the existing methane collection system to reduce greenhouse gas (GHG) emissions.

Photo 1 - The Vancouver Landfill is 225 hectares.

PROJECT HIGHLIGHTS

Innovation

The City of Vancouver owns and operates the 225-hectare Vancouver Landfill in Delta, British Columbia. A landfill gas management system, consisting of gas extraction wells, piping, flares and a landfill gas utilization plant, has been installed to minimize odours and fugitive emissions of GHGs from the Landfill to the atmosphere. The methane in landfill gas is the primary GHG of concern. It is an objective of the City to operate their landfill gas management system to minimize, to the extent practicable, fugitive methane emissions. With limited funds, the City has responsibly sought to identify and prioritize construction projects that would provide the maximum benefit in terms of achieving the greatest emission reductions at the lowest cost. The potential emission reduction projects ranged from the installation of additional landfill gas extraction wells and associated piping, to the installation of enhanced cover over the waste.

GHG emissions and emission reductions, and inventories of GHG emissions, are quantified in terms of the rate of GHGs emitted or reduced. Traditional methods of quantifying fugitive emission rates have been unsatisfactory because of cost, uncertain accuracy, and/or inability to quantify emission rates from subareas of the overall Landfill. The two most popular methods of measuring emissions are surface emissions monitoring and flux chamber.

Photo 2 - Conducting surface emissions monitoring. This method measures only atmospheric concentrations of methane and does not measure methane emission rates.

Surface emissions monitoring is conducted by traversing a landfill in a pattern and obtaining frequent methane concentration measurements approximately 75 to 100 mm above a landfill surface using a flame ionization detector or similar instrument (see photo).

The problem with this method is that measured concentrations of methane are poorly correlated with actual methane emission rates. For the same emission rate, measured methane concentrations can vary with wind speed and direction, height and thickness of vegetation, and proximity to the location of the surface emission. Thus even if measured methane concentrations exceed a given threshold, the associated actual methane emission rate may be very small. Conversely, it is possible for measured methane concentrations to be below the threshold, and yet the actual methane emission rate may be relatively large.

The flux chamber method involves, for each individual measurement, placement of a small box on the landfill surface, with the bottom open to the landfill surface, and measuring the emission rate into the box (see photo). However, local variations of surface emission rates can vary tremendously – the emission rate can be on the order of tens of times greater at one location than another location just a couple of metres away. Thus, a huge number of flux chamber measurements are needed for an accurate emission rate measurement of a landfill. Conducting a huge number of measurements would be costly, to the point of being impractical, and so only a limited number of widely spaced measurements are performed at landfills, which results in large uncertainty of the emission rate measurement value obtained for a landfill using this method.

Photo 3 - Flux chamber method measurement equipment. The boxes have a very small footprint area of 0.2 sq.m. compared with the 2,250,000 sq.m. area of the Landfill.

The City had previously conducted studies using these traditional methods and concluded that they are not capable of meeting the City's objectives.

Golder Associates offered the AMM method to measure fugitive methane emission rates from areas of particular interest to the City, as well as from the entire Landfill. This method applies engineering principles to solve the problem of measuring fugitive emission rates, particularly from large area sources such as landfills or tailings ponds. The method works by measuring the concentrations of methane in the atmosphere while simultaneously recording the geographical position and altitude of each concentration measurement point, using a suitable vehicle such as a helicopter, and processing the data to obtain cross-sectional maps of concentrations through a plume upwind and downwind of the area of interest. Applying the mass balance approach to these concentration maps allows quantification of the emission rate from the area of interest. In particular, the method provides for sampling the plume near the downwind edge of the source, from the ground surface to the top of the plume. This not only allows for sampling of the entire cross-section of the plume, but the different emission rates from different areas of the landfill can be measured. The method also provides for encircling an emission source, which provides for both upwind and downwind measurements, and concentration measurements are obtained regardless of changes in the wind direction.

Photo 4 - AMM method concentration measurements obtained using a helicopter

The project is unique because it was the first time that a method for measuring fugitive methane emission rates – that has peer-reviewed evidence of accuracy and precision – has been applied for the determination of the cost-effectiveness of emission reduction options at a large area source of fugitive emissions. The objectives of the City would simply not have been achieved without the AMM method.

Complexity

The quantification of fugitive emission rates from large area sources has long been a challenge, as evidenced by the large body of research on this subject. The difficulty arises from the naturally high variability of surface emissions across an area source. Existing methods of fugitive emission rate measurement are stymied by this non-uniformity, especially if the source area is large. While measurement values can be obtained using conventional methods, the accuracy of the results is unknown because such conventional methods lack peer-reviewed evidence of accuracy for measurement of emission rates from large area sources. This lack of peer-reviewed evidence of the accuracy of conventional methods of fugitive emission rate measurements is due to the complexity of the problem. The flux chamber method could address the high variability through closely spaced sampling, but the costs to do so are prohibitive.

Photo 5 - The Vancouver Landfill, looking west with Phase 3 enclosed by the black line.

The AMM method provides a cost-effective solution to this difficult problem. The naturally high variability of surface emissions is addressed by obtaining many concentration measurements rapidly across the height and width of the emission plume using a suitable vehicle. Mapping these concentrations in cross-section provides a “snapshot” of the plume concentrations, which are then processed with information on the wind velocity to obtain the emission rate. Subareas of the source can be measured by measurement paths that target these subareas. A helicopter is a preferred vehicle for carrying the concentration measurement instrumentation, and if the helicopter is flown at an air speed greater than about 55 km/hr, the downwash of the rotors will not affect the measurements.

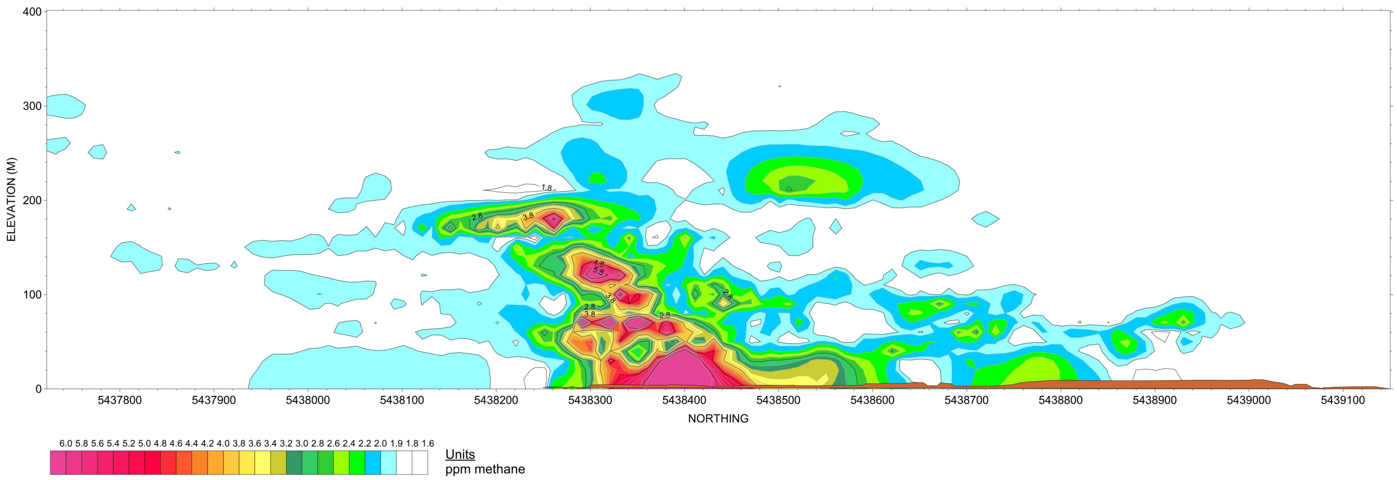

Photo 6 - Contour map of methane concentrations (parts per million) in cross-section through the emission plume downwind (east) of Phase 3 of the Landfill.

The method is patented and is a significant improvement over existing methods of measuring fugitive emission rates. Unlike any other method, evidence of the accuracy and precision of the AMM method has been published in a peer-reviewed journal (Journal of the Air & Waste Management Association, Vol. 63, No. 11, November 2013, pp 1324-1334).

Social and/or Economic Benefits

The project identified the most cost-effective emission reduction actions for the Landfill and shows how GHG fugitive emissions can be minimized when funds are limited. While the project alone will not result in a measurable reduction to global temperatures, it is part of the global collective action that is necessary to tackle global warming. Without these individual contributions, the social consequences of global warming will remain unchecked. These social consequences include the greater risks of more frequent and severe extreme weather events affecting the population, health problems associated with rising temperatures, and an increased risk to people living in Canada’s northern communities.

The project demonstrated the value of fugitive emission rate measurements. Society will derive an economic benefit from such measurements because they allow prioritization of emission reduction measures according to cost-effectiveness. Prior to the project, the City was considering implementation of various fugitive emission reduction measures, such as placement of additional landfill cover or installation of additional vertical landfill gas extraction wells, with a capital cost totalling more than $1 million. After the AMM method measurements, it was determined that placement of additional landfill cover would not be cost effective, allowing the City to focus on additional vertical gas extraction wells instead and to investigate the potential for increasing landfill gas collection from the active waste placement area in addition to the measures that were already installed and are the common practice.

Environmental Benefits

The importance of greenhouse gases to our environment and the sustainability of our future is well known. Climate change has been attributed by many scientists to be the result of human activity, specifically as a result of the increase of GHG emissions. Methane, a greenhouse gas, has been identified as a significant contributor to global warming. It has a global warming potential that is about 25 times greater than that of carbon dioxide over a 100-year period. The Vancouver Landfill is the largest single GHG emission source of the City of Vancouver's municipal operations. The City recognizes that the quantification and control of landfill gas emissions is an important aspect to meeting the City's objectives for GHG emissions reductions. By collecting methane that would otherwise be emitted to the atmosphere and converting it to carbon dioxide through combustion, GHG emissions can be reduced. Moreover, increasing the amount of methane collected also increases the potential that the Landfill's methane utilization capacity could be increased, with the added benefit of a corresponding offset of fossil fuel use.

Photo 7 - A typical vertical landfill gas extraction well installation at the Vancouver Landfill. (photo by City of Vancouver).

Photo 8 - A portion of the landfill gas that the City collects is utilized to generate electricity and heat at this greenhouse facility. Potentially more landfill gas could be utilized if cost-effective measures for reducing methane emissions and increasing collection are implemented.

The project provides the City with key information to achieve the greatest reduction of GHG emissions (methane) at the lowest cost. Without this information and subsequent control actions, methane emissions from the Landfill would be greater than without the project. The project also serves as a demonstration of what is possible, for fugitive emission rate measurements, at other large fugitive emission sites such as tailings ponds, mines and natural gas production areas, and other landfills.

Photo 9 - AMM method measurements can be used to identify the most cost effective method for reducing GHG emissions, thereby maximizing the landfill gas that is utilized, or combusted in these flares.

Meeting Client's Needs

The City of Vancouver's goal is to become the greenest city in the world. The client has adopted the Greenest City 2020 Action Plan to achieve this objective. A significant generator of GHGs is the Vancouver Landfill. Increased collection and combustion or utilization of the generated methane is a key element of the City's plan to meet its GHG emission reduction targets and contribute to its climate leadership goals. Fundamental to meeting these goals is the ability to measure the rate of methane emitted into the atmosphere. Since the Landfill is large and funding is limited, the City sought to prioritize its capital improvements to reduce methane emissions and improve collection efficiency in the most cost-effective manner.

The completion of several rounds of AMM method measurements resulted in the identification and quantification of methane emission rates from the entire Landfill, as well as from subareas of interest. Cost estimates for implementing measures to enhance landfill gas collection were then developed for each subarea of interest. The result was an estimate of the cost per cubic metre per hour of methane emissions that could be avoided by implementing an emission reduction project, for each subarea of interest. This met the City's goal of identifying and prioritizing cost-effective emission reduction projects. As a result, the City can proceed with planning and implementing the environmental improvements, knowing that its limited capital will be well spent. Additional measurement rounds have been ordered for 2016, affirming the value of the AMM method measurements to the City.

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