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Case study of landfill reclamation at a Florida landfill site

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ABSTRACT

A landfill reclamation project was considered to recover landfill airspace and soil, reduce future groundwater impacts by removing the waste buried in the unlined area, and optimize airspace use at the site. A phased approach was utilized to evaluate the technical and economic feasibility of the reclamation project; based on the results of these evaluations, approximately 6.8 ha of the unlined cells were reclaimed. Approximately 371,000 in-place cubic meters of waste was mined from 6.8 ha in this project. Approximately 230,600 cubic meters of net airspace was recovered due to beneficial use of the recovered final cover soil and reclaimed soil as intermediate and daily cover soil, respectively, for the current landfill operations. This paper presents the researchers' landfill reclamation project experience, including a summary of activities pertaining to reclamation operations, an estimation of reclamation rates achieved during the project, project costs and benefits, and estimated composition of the reclaimed materials.

1. Introduction

Municipal solid waste (MSW) landfill reclamation (also frequently referred to as *landfill mining* biomining) refers to the process of excavating previously disposed of materials from a landfill to recover metal, glass, plastic and other combustibles, soil and fine materials (referred to herein as *reclaimed soil*), and the landfill volume itself (Morelli, 1990). Landfill reclamation has been practiced to a limited extent at number of landfill sites throughout the US (Murphy and Stessel, 1991; NYSERDA, 1992; US EPA, 1997; Serpa, 2008) and is of growing interest worldwide (Jones et al., 2012). The primary factors that have motivated operators to consider and implement landfill reclamation at their sites are: (1) to address groundwater contamination problems posed by wastes in old, unlined landfills by removing the source of pollution; (2) to create new capacity for future landfilling activities; and (3) to reduce closure costs by reducing the footprint area of a landfill. A side benefit to landfill reclamation reported in some cases is the recovery of recyclables, particularly metals, for resale. When used as part of an integrated strategy for sustainable landfilling, reclamation may also serve as a means of recovering stabilized solid waste in a bioreactor landfill operation (Nelson, 1994; Reinhart and Townsend, 1997).

The economic viability of the reclamation needs to be evaluated before making a decision to implement the project. A number of factors such as composition (specifically soil content) of the excavated waste, end-use of the recovered materials and reclaimed soil, amount and value of the airspace recovered, and cost of excavating and processing waste have a significant impact on the project cost. Some data on the composition of the excavated waste and the quality of reclaimed soil have been published (Flyhammar et al., 1998; Zornberg et al., 1999; Earle et al., 1999; Kilmer and Tustin, 1999; Das et al., 2002; Jain et al., 2005; Hull et al., 2005). The primary factors impacting the unit reclamation cost ($/m^3) are waste excavation and processing rates achievable with a given set of equipment, and environmental controls that need to be implemented to address issues such as odor, dust, and litter. The authors conducted a search of the peer-reviewed literature to find these data, which dictate the economic viability of full-scale reclamation projects, as a part of a reclamation feasibility evaluation project in 2006 and realized that these data and inputs were lacking. Potential reasons for such data gaps are that landfill reclamation projects are not as prevalent as other landfill construction activities (e.g., landfill liner construction) and that the limited number of landfill reclamation projects that have been conducted in the past did not target detailed data collection and information dissemination.

This paper presents results from a recently completed full-scale reclamation project at a MSW landfill in Florida. Specifically, this paper reports an investigation to assess the viability of the project and the associated results, a summary of activities pertaining to reclamation operations, operational issues encountered during the project, and waste excavation and screening rates achieved

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during the project. Given the paucity of published information on similar projects, the information presented here provides valuable inputs to landfill owners and engineers who are evaluating the technical and economic feasibility of a reclamation project at their site.

2. Site description

Escambia County Department of Solid Waste Management (DSWM) owns and operates the Perdido Landfill, which contains both unlined and lined MSW disposal areas and other waste management facilities such as a whole tire stockpile area and a household hazardous waste management center. Fig. 1 presents the layout of the site. From 1981 to part of 1990, municipal solid waste from residential and commercial sources and non-hazardous waste from industrial waste was disposed of into approximately 45 acres of unlined landfill cells using a trench-and-fill disposal method. C&D debris was later disposed of in some portions of the lined area. The unlined cells were closed with a soil cap in the early 1990s. Several lined cells (Sections 1, 2A, 2B, 3A, 3B, and 3C) were constructed contiguous to the unlined cells. Waste is currently deposited in Section 4. The unlined cells were identified as a cause of groundwater impacts at the site; elevated levels of benzene and vinyl chloride have been encountered outside the property boundary. A pump-and-treat system is operational to address the groundwater contamination issue. More details pertaining to the site can be found elsewhere (Jennings, 2008; IWCS, 2009).

Site-specific constraints limited DSWM's ability to expand the landfill into adjacent areas for future landfill operations. Because of the availability of substantial airspace above the unlined cells (the final elevation of these cells was at least 30 m below the permitted elevation for the adjacent lined cells), reclamation of the unlined cells and construction of lined cells on reclaimed land was considered as an expansion option to meet the future waste disposal needs of the county. The maintenance of the unlined cells has been challenging because of leachate outbreaks (seeps) and differential settlement. The reclamation of these cells seemed to reduce maintenance issues and cost associated with the seeps and settlement of these cells. The project seemed to produce substantial benefits including the reduction in future groundwater impacts by removing the waste buried in the unlined area, and the use of reclaimed soil as daily cover. Since the nature and volume of the waste deposited in these cells and the reclamation cost were not accurately known, DSWM took a phased approach to evaluate the technical and economic feasibility of the reclamation project.

3. Project conceptualization and execution sequence

3.1. Information collection

Details of only a few landfill reclamation projects are published in peer-reviewed journals, conference proceedings, and magazine articles. Since most landfill reclamation projects are not research-oriented, they are seldom reported in the targeted literature. Therefore, in addition to a literature review, the authors contacted individual state regulatory agencies in the US to identify state-specific regulations pertaining to landfill reclamation projects and contact information of landfill owners who have conducted landfill reclamation projects in the past. Thirty-two current or previously conducted landfill reclamation projects were identified. The authors gathered details of 12 of the 32 identified projects through a literature review and interviews with select project owners (some project owners did not respond to the authors' calls for information).

Although most states have some basic reclamation-specific requirements, such as informing the appropriate state agency before waste is excavated from a closed landfill and proper management of the excavated waste, few states have elaborate regulations specific to landfill reclamation. Most of the states that were contacted did not have any past landfill reclamation projects. Ohio had 13 former and in-progress landfill reclamation projects. Wisconsin had five former and in-progress landfill reclamation projects. The most common objective of these reclamation projects was to relocate waste from an unlined landfill unit to an adjacent lined unit.

Typically, the excavated waste was directly disposed of in the lined cell and not processed to recover any other constituents (e.g., soil, metals). Only 4 of the 12 landfills for which detailed information was available processed waste to segregated soil or fine fraction from the waste materials. None of the 12 landfill reclamation project owners interviewed reported encountering any hazardous waste. Some of these sites conducted reclamation only during winter time to minimize odor issues. The reclamation cost was reported to range from \$3.9 to \$6.5 per m^3 without waste processing and \$2.9 to \$11.5 per m^3 with waste processing. More details on individual project details can be found elsewhere (IWCS, 2009).

3.2. Field tests and project feasibility evaluation

In 2006, a preliminary technical and economic feasibility assessment for reclaiming the unlined cells was conducted based on data from landfill reclamation projects conducted in the past. Data from thirty-nine (39) 12.7-cm diameter boreholes was advanced to tag the waste bottom and estimate the final cover soil depth. Eight $6.0 \times 4.5 \times 4.5$ m^3 (length $\times$ width $\times$ depth) test pits were excavated and screened using a shaker screen (Extec PS-5) equipped with 2.5-cm and 7.6-cm screens to collect site-specific waste composition data. The key lessons learned from the first two phases of the evaluation are summarized as follows; details of this investigation can be found elsewhere (Jennings, 2008; IWCS, 2009).

The borehole data indicated that the historical topographic maps available for the unlined cells were reasonably accurate representations of the landfill bottom. The waste bottom elevations estimated from boreholes were on average 2.1 m lower than those projected from the waste bottom topographic map. Based on the topographic maps available for the top and the bottom of unlined cells it was estimated that approximately 1.15 million m^3 of material in the unlined cells (final cover soil and waste) could be mined without any substantial reclamation of the construction and demolition waste that is deposited over a portion of the unlined cells.

The thickness of the final cover soil, which was measured at the 39 borehole locations, ranged from approximately 0.15 m to 4 m. The final cover soil was estimated to comprise approximately 30% of the total volume of the material present in the unlined areas. The soil/fines fraction of the bulk excavated material (which consisted of a mixture of soil and MSW) was estimated to be 24% of the volume (60% by weight) of the material excavated from the unlined cells (this excludes the final cover fraction). This volume of soil also excluded the soil contained in the berms that separated the trenches of waste in the lower portion of the unlined cells. A waste screening evaluation suggested that a screen with an opening size between 2.5 cm and 7.6 cm would result in effective segregation of soil from the excavated waste material. Sufficient contact time between the material and the screen was observed to be critical for efficient soil separation. Dust and odor were insignificant. Blowing litter was encountered on windy days.

The preliminary economic feasibility analysis was updated based on the waste compositional data collected from test pits.