

**SWANA Winter Conference
Kalahari Resort and Conference Center
Wisconsin Dells, Wisconsin
January 22, 2004**

**Janesville Landfill Expansion and Landfill Gas Control System Innovations
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Abstract

The City of Janesville was faced with developing their next landfill expansion in an adjacent former sand and gravel quarry (Photo 1). The quarry presented a number of challenges to landfill development because of the manner in which mining operations had been performed. Original quarry excavations had been performed within 100 feet of adjacent property boundaries and involved excavating downward, using steep sideslopes (1.5:1), until groundwater was intercepted approximately 90 feet below surrounding grades. The City and RMT realized that substantial amounts of structural fill material would be required in order to construct typical 3:1 sideslopes and to develop the typical subbase grade separation distance to groundwater unless unique design concepts were developed. The existing City of Janesville Landfill, which was also developed in a former quarry area, has also incurred substantial expense in repairing a landfill gas extraction header resulting from differential settlement. Site-specific factors, including the City's concern with the potential settlement of landfill gas headers, were addressed in the unique design concepts subsequently developed for the proposed expansion.

Background

The 4.7 million-cubic yard (cy) expansion of the City of Janesville Landfill is located in a mined-out portion of a large sand and gravel quarry owned by the City and operated by Janesville Sand and Gravel Company (Photo 1). It is surrounded by a residential area to the southeast, a light industrial area to the east and north of the proposed 37.6-acre landfill footprint, and past and current quarry operations to the west and northwest. The Rock River is located about 4,000 feet due west of the expansion (see PO Sheet 3, Inset Figure). Quarry practices typically used at the site involve removing deposits down to, and occasionally below, the groundwater table. The sand and gravel quarry in which the landfill will be developed is located in a flat plain of glacial outwash that extends to the Illinois border. The outwash deposit is up to 300 feet thick in the area of the landfill and consists of coarse-grained sand and gravel. There is little variation in the historical groundwater table from year to year owing to the high permeability of the glacial deposits.

The City's existing 4.2 million-cubic yard landfill is located approximately 1,000 feet south of the proposed expansion. The existing landfill has been in operation since 1985 and will attain final waste closure grades in 2005. The current landfill was also developed in a mined-out portion of the quarry, and clay-bench construction techniques were used on the steep eastern and southern quarry faces to

avoid the large amounts of structural fill material that would have been required to construct more conventional 3:1 interior sideslopes. About 10 years ago, the existing landfill was upgraded to meet Subtitle D standards in the construction of the remaining two phases, as well as the final cover system. More recently, a gas header, located within the first four phases of the landfill, had to be reconstructed as a result of differential settlement.

Design Challenges

1. Setback from Property Line

Probably the biggest challenge of the project was the edge of the quarry being located within approximately 50 to 60 feet of the property line on three sides of the proposed landfill (see PO Sheet 3). Wisconsin Administrative Code (WAC) NR 504.09(2)(f) requires a minimum separation distance of 100 feet between the limits of waste and the adjacent property line. Thus, if a standard 3:1 sideslope design offset by 100 feet from the property line at surrounding grades was used in this situation, an estimated 800,000 cy or more of structural fill material would be required just to construct the subgrades for the sideslopes.

The 90-foot depth of the quarry created still another challenge. Current DNR guidance limits the vertical depth from the top of the perimeter sideslope berm to the leachate collection sump to 70 feet. Thus, if this design criterion were to be applied, upwards of 16 feet of structural fill placement would be required to develop subbase grades (in excess of 700,000 cy).

The City of Janesville and RMT realized that a landfill design requiring up to 1.5 million cy of fill material would make this site unacceptable. Thus, some additional alternative designs were developed in an effort to minimize the amount of fill material required and still satisfy the property line offset. Of the alternatives developed, one stood out immediately as the logical choice. The unique alternative design involved terminating the top of the landfill perimeter berm on the side with the collection sumps to approximately 20 feet below the edge of the quarry to take advantage of the natural existing slope of the quarry in that area (see PO Sheet 15, Section 2805+00N). This design not only substantially reduced the amount of fill material required to develop sideslope grades, but also eliminated substantial amounts of fill material required at base grades in order to satisfy the maximum allowable sideslope depth of 70 feet in the leachate sump area. Although this design substantially reduced the amount of fill material required on one side of the landfill, it did not provide the typical minimum offset distance of 100 feet from the property line to the limits of waste placement boundary at the top of the perimeter berm on two other sides of the landfill. To satisfy the 100-foot offset, we proposed deliberately placing a general fill berm above the waste near the top of the perimeter berm to provide an offset buffer against which solid waste can be placed (see PO Sheet 18, Detail 2).

During their review of the feasibility report, the Department expressed concern with regard to the stability of the proposed sideslope design. Appropriate geotechnical calculations were presented in

the Plan of Operation confirming the stability as well as the constructibility of the berm using standard construction techniques.

2. Separation Distance to Groundwater

Another challenge of locating a landfill expansion in a former quarry operation was the removal of the sand and gravel deposits down to the groundwater table. Since Wisconsin Administrative Code NR 504.06(2)(b) requires a minimum separation distance of 10 feet between the seasonal high groundwater and the bottom of the clay liner, the City of Janesville was faced with the potential costs of having to haul in an additional 10 feet of fill material over the 37.6-acre footprint (in excess of 600,000 cy). Thus, a decision was made to evaluate site-specific hydrogeologic data to determine if an alternative design was available that would reduce the large amount of required fill.

As indicated earlier, the quarry in which the landfill expansion will be developed is located in a flat plain of glacial outwash consisting of coarse-grained sand and gravel up to 300 feet thick. During the subsurface drilling investigation, we observed horizontal hydraulic conductivity values that ranged from approximately 1×10^{-2} cm/s to 1×10^0 cm/s. During the hydrogeologic investigation, we also found that the historical groundwater elevations in the area did not vary much (typically not more than 1 or 2 feet over decades of data). In consideration of a number of factors, including the high permeability of the sand and gravel aquifer, the southwesterly flow of groundwater and the Rock River (a major groundwater discharge feature) being about $\frac{2}{3}$ mile to the west of the landfill, a decision was made to design a gradient control (or underdrain) system for the landfill expansion to minimize the potential for groundwater rising up and coming into contact with the clay liner system. This design would also reduce the minimum separation distance requirement between the landfill liner and seasonally high groundwater from 10 feet to 2 feet, thus eliminating the placement of approximately 8 feet of fill material over the 37.6-acre landfill footprint (or about 500,000 cy of fill material). See PO Sheet 15, Section 2799+00N; and FR Sheet 15.

Because of the expansive and prolific nature of the aquifer material, it was fairly straightforward to develop a qualitative and quantitative analysis supporting a reduced separation distance between the bottom liner and groundwater. The technical analysis was also supported by the historical data indicating very limited fluctuation in the seasonal water table surface. The fluctuation is limited because the underlying sand aquifer has a high transmissivity, which dampens the water table response to unusually high infiltration events. Furthermore, the site is relatively close to the Rock River, a major discharge feature, which will have the effect of maintaining consistent groundwater elevations within the area. However, to be conservative, the Gradient Control System was designed with a series of perforated pipes to assist in collecting and removing groundwater in the unlikely event that it rises to the elevation of the bottom of the landfill liner system. The 6-inch-diameter underdrain pipes are embedded in a minimum 1-foot-thick select granular fill material obtained from the on-site quarry operation. The underdrain pipes are located beneath the leachate collection trenches and are sloped to convey any collected groundwater to a collection pipe located beneath the sideslope liner along the southern side of the landfill, which in turn is conveyed to the southwestern corner of the landfill (see PO Sheet 4). From the southwestern corner, collected groundwater will be

transported by a pipe from the landfill to an infiltration basin located about 1,200 feet south of the landfill (see PO Sheet 3).

3. Gas Header Pipe

As indicated earlier, the City of Janesville incurred considerable expense in repairing a gas extraction header at their existing landfill owing to settlement. Thus they were adamant that the gas header in the landfill expansion be located outside the limits of waste to the maximum extent possible. Typically, landfill gas headers are required to be located beneath the final cover, within the limits of waste, so that if there is a leak in the header, the condensate would be contained by the bottom liner and leachate collection system. Thus, some regulatory aspects would also need to be addressed to the satisfaction of the Department of Natural Resources (DNR) in order to proceed. In developing the data on which a final design would be based, we gathered input from a number of sources that included DNR staff; Terra Construction, Inc., in Madison, who are known for their extensive landfill gas system experience; as well as RMT staff, who have experience in landfill gas system designs.

A number of factors seemed to support the location of the gas header outside the limits of waste. These factors included stability, recent precedent, and the performance history of the materials of construction. Because of the unique quarry location of the landfill, the header, when offset from the gas extraction wells in order to obtain typical pipe slopes, was found to be located near the limits of the landfill. Thus, it made sense to consider locating the header just outside the limits of waste within a structural berm, which would eliminate future settlement concerns for the header pipe. This approach would allow almost 70 percent of the header around the perimeter of the landfill to be located out of the less stable solid waste mass. The remaining header located within the landfill was placed as close as possible to the limits of waste to minimize the underlying depth of waste and the amount of future settlement.

Recent precedent also seemed to support the location of the header outside the limits of waste. It came to our attention a couple of years ago that a gas header had been located above the landfill final cover as part of a project to repair a settled header. Terra was the contractor on this project, so we proceeded to contact the engineers at Terra Construction for their input, as well as DNR staff associated with the project. Although the project was for the replacement of a gas header at an existing landfill, we came away with an understanding that there were no perceived fatal flaws in the logic of proposing a gas header outside the limits of waste for a landfill expansion design. Part of this understanding also had to do with the current degree of comfort that regulatory personnel now have with the materials of construction based on their preponderance of use in landfill applications over the last 15+ years.

The final design for the Janesville Western Landfill Expansion resulted in approximately 70 percent of the perimeter gas collection header being located outside the limits of waste (see PO Sheet 14). However, the Department did request that the condensate knock-out for this portion of the header be

located within the limits of waste in the event that the knock-out apparatus were to leak. Thus, the knock-out was relocated within the waste mass (see PO Sheet 14).

Another feature of the gas collection system includes the connection of the leachate line cleanouts to the gas extraction header. This will allow for the collection of landfill gas during the early stages of waste placement as well as odor control, which is of concern because of the adjacent business and residential areas (see PO Sheet 3, Inset Figure). The gas collected within the leachate line cleanouts will be routed to the electrical generation facility located near the existing landfill. The 1.5-megawatt facility is expected to come on-line this summer. RMT is also working with the City toward the installation of up to Eight Capstone micro-turbines at the closed Janesville Disposal Facility. This would add at least another 240 kW of electrical generation derived from landfill gas.

Project Benefits

The biggest project challenge was attempting to minimize the amount of fill material required to develop a viable project within a deep former sand and gravel quarry. Utilizing site-specific hydrogeologic factors, RMT was able to successfully develop a design that reduced the groundwater separation distance typically required from 10 feet to 2 feet, yet satisfied environmental concerns. We also developed a modification that allowed the sideslope liner to be constructed up to 20 feet below existing grades, which would satisfy the minimum offset to adjacent property. The reduced groundwater separation distance and the modified sideslope design reduced the fill material required for the project by an estimated 750,000 cy. Typically for structural fill, a placement cost of \$2/cy would result in an overall project savings of \$1.5 million.

RMT also listened to the City's request with regard to locating the gas header outside the limits of waste and above the geomembrane in the final cover. I believe we satisfied their request to the greatest extent practicable, given the unique features of the project.