LET’S INSTALL IT ONCE – CASE STUDY ON CAISSON WELLS

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ABSTRACT

Installing a Landfill Gas (LFG) Collection and Control System (GCCS) is required for a substantial number of landfills throughout the country. The major regulatory driver for this requirement is the New Source Performance Standards (NSPS) for Municipal Solid Waste Landfills. Per 40 CFR 60.752 (b)(2)(ii)(A), landfills are required to “collect gas from each area, cell, or group of cells in the landfill in which the initial solid waste has been placed for a period of 5 or more years if active; or 2 years or more if closed or at final grade” (2-Year/5-Year Rule). As a result, landfills, trying to maintain compliance with the NSPS regulations, encounter operational challenges with the installation and operation of GCCS components while continuing waste placement activities.

One of the biggest challenges that landfills face is the need for GCCS installation in active fill areas subject to the NSPS 2-Year/5-Year Rule. Installation of GCCS components in active fill areas often results in the destruction of collectors in active disposal areas, overfilling and crushing of header pipelines, and repeated replacement of extraction wells and header pipelines.

As an alternative to installing traditional extraction wells and trenched header pipelines in active fill areas, the Franklin County Sanitary Landfill (FCSL) decided to take a different approach to maintaining compliance. FCSL has dedicated a portion of the fill area for the installation of caisson wells in order to eliminate the need to re-install extraction wells as waste placement progresses vertically. Currently, there are thirty (30) caisson wells installed and operating at FCSL – ten (10) were installed in 2010 and an additional twenty (20) were installed in 2011.

FCSL will continue to evaluate the costs and operational issues involved with operating the caisson wells in the dedicated active fill area before deciding whether or not caisson wells will be installed in future phases of landfill development. This paper will present the current assessment of these costs and operation issues.

LANDFILL DESCRIPTION

FCSL, located in Grove City, Ohio, is owned and operated by the Solid Waste Authority of Central Ohio (SWACO). The facility is a licensed Municipal Solid Waste (MSW) Landfill recognized by the Ohio Environmental Protection Agency (Ohio EPA), and is subject to the operating, monitoring, and recordkeeping requirements of the NSPS.

FCSL consists of approximately 283 acres of permitted disposal area. FCSL accepts MSW, construction and demolition waste, and residual wastes as described by the Ohio Solid Waste Regulations.

FCSL began receiving refuse in 1985 and has a total design capacity of approximately 61.9 million cubic yards. Of the total capacity, approximately 40.3 million tons consist of MSW and other degradable material that will contribute to landfill gas (LFG) generation. Approximately 90% of the existing waste mass consists of MSW, with current waste intake consisting of approximately 85% MSW.
EXISTING GCCS

At the time of this paper, an active GCCS has been installed and is operating in accordance with NSPS regulations. The GCCS encompasses approximately 113 acres of the landfill footprint and consists of approximately 138 vertical extraction wells, of which 30 are caisson wells and the remaining are standard vertical extraction wells with 6-inch and 8-inch diameter well casings. These extraction wells, along with 13 horizontal collectors and 8 connections to leachate cleanout risers, collect the LFG from the refuse. The LFG is then conveyed through a series of high density polyethylene (HDPE) lateral and header pipelines to the facility’s LFG control devices.

GCCS CHALLENGES FOR NSPS COMPLIANCE

Installation of LFG extraction wells (vertical or horizontal) are required per the compliance schedule establish in the NSPS regulations. Typically, wells that are installed in areas at final fill elevations will not be extensively compromised due to waste filling activities. However, like many landfills, FCSL was required to install wells in areas that have yet to reach final waste fill elevations, and in areas of active fill operations. The installation of wells in areas that are not at final waste fill elevations often results in damage to these wells, requiring the abandonment of non-functional wells and re-drilling new wells. This was the case for FCSL.

In 2009, FCSL was required to re-drill 12 vertical extraction wells. The replacement of these wells was not expected and, therefore, was not budgeted. In 2010, FCSL was required to expand the GCCS to encompass approximately 20 acres of the active fill area. Based upon the unexpected and high cost of re-drilling wells, FCSL looked for some options.

INTERIM WELLS

Typically, interim wells are installed in areas that are not at final waste fill grades and where waste placement activities are on-going. These interim GCCS extraction components generally consist of horizontal collection trenches and vertical extraction wells.

Interim Horizontal Collection Trench

Horizontal collection trenches are commonly used throughout the landfill industry. The benefit of the horizontal collectors is the relatively low cost and ease of installation. These collectors can be installed on grade or in shallow trenches, and can typically be installed by the site operator, eliminating the need for drilling contractors. Another benefit of utilizing horizontal collectors is that above ground structures (wellheads and vacuum risers) are typically installed on outside slopes. This leaves the active fill area free of above ground structures and allows operators to conduct waste filling activities without having to maneuver around wells and riser pipes.

Despite the relatively low cost and ease of installation for these collectors, landfills typically will have to wait to operate these collectors until sufficient cover has been placed over them. Because the horizontal collectors are installed with minimal cover, operating them immediately will often lead to issues with air intrusion.

As waste filling operations continue, layers of horizontal collectors are typically installed to collect from the upper lifts of waste. Once the landfill has achieved final waste fill elevations, these horizontal collectors are abandoned and replaced with permanent vertical extraction wells. Figure 1 shows a typical horizontal collection trench.

FIGURE 1 – TYPICAL INTERIM HORIZONTAL COLLECTION TRENCH

Interim Vertical Extraction Well

The alternative to the use of horizontal collectors is the installation of a traditional vertical extraction well. Traditional vertical extraction wells are constructed with a section of perforated or slotted pipe at the bottom portion of the well and a section of solid pipe at the top portion of the well. Gravel is backfilled around the perforated or slotted pipe section, which serves as the
extraction zone of the well. A geotextile ring, bentonite, and soil are installed around the solid pipe section, which serves to minimize air intrusion. Figure 2 shows a typical vertical extraction well.

**FIGURE 2 – TRADITIONAL VERTICAL WELL**

Landfills operate the vertical extraction wells in one of two ways – having extraction controls (wellheads) at a remote location or at the well casing.

**Remote Wells**

Remote wells, like horizontal collectors, will typically be operated with wellheads on outside slopes, allowing operators to place waste without having to avoid wells. However, because of the remote configuration, there is no access to the well casing. In the event that liquid levels in the wells prohibit gas extraction, they will need to be replaced, as liquid extraction pumps cannot be installed.

As waste is placed above the remote well, LFG from the upper lifts of waste cannot be extracted. As a result, supplemental wells or horizontals will need to be installed, or the well will be abandoned and replaced completely. Figure 3 shows a typical remote well (i.e., lateral pipe slopes back to the vertical extraction well).

**FIGURE 3 – TYPICAL REMOTE WELL**

**Standard Wells**

Standard wells that have the wellheads at the well casing allow the landfill access to the well casings to extract liquids as needed, or to conduct camera investigations to assess well integrity. However, because of the above ground structures in the active fill area, operators are required to maneuver around the wells during waste placement activities.

When waste is filled over a standard vertical well, solid pipe is added to the well to raise the extraction point. After multiple extensions of the well, the well casing is usually at an angle other than vertical. Additionally, due to the extension of solid pipe, these wells are unable to actively collect LFG from the upper lifts of waste. When final waste fill elevations are achieved at the well location, the existing well is abandoned and replaced with a new well that has the capability extract LFG through the entire waste column.

With the installation of these interim GCCS extraction components, and associated header pipelines, in active waste placement areas, FCSL will eventually encounter issues with its GCCS operations caused by damage due to waste filling equipment operating in the areas where the GCCS components were installed. Regardless of any and all precautions FCSL may take to preserve the integrity of the GCCS components, the nature of waste filling operations often results in compromising the integrity of the GCCS components. Eventually, header pipelines will be overfilled and may be crushed, horizontal collection trenches may be flooded, and vertical extraction well casings may be pinched, or sheared. As a result, FCSL will have to undertake the task of repeatedly replacing both GCCS extraction components and associated header pipelines.

Installing wells in active fill areas, and replacing them, as needed, is a common and accepted practice in the
industry. However, FCSL chose not to accept this common practice. FCSL posed a challenging proposition – let’s install it once.

**CAISSON WELLS**

FCSL wanted to install permanent wells in the active fill area. Through numerous conversations with several professionals in the industry, a possible solution was developed – caisson wells. The use of caisson wells is not a new idea, and is currently in use in some landfills across the country. They had been used more in the past, but the industry had slowly moved away from their use.

**Design**

For a typical vertical extraction well, a section of solid pipe at the top portion of the well is required to prevent air intrusion. A caisson well eliminates the need to install the top section of solid pipe, allowing the installation of perforated or slotted pipe up to the surface of the landfill.

In lieu of the section of solid pipe used in a traditional vertical extraction well, an oversized pipe, or caisson, is placed over the upper section of perforated pipe and acts as the physical barrier to prevent air intrusion. An added benefit to this design is that the oversized above-ground structure is able to better withstand lateral forces that may damage a standard well. Figure 4 shows a typical caisson well.

![FIGURE 4 – TYPICAL CAISSON WELL](image)

**Installation**

A caisson well is installed very much like a traditional vertical well. However, no solid pipe is added to the well casing itself. Perforated pipe is used for the entire length of the well casing. A PVC slip cap is temporarily placed on top of the perforated pipe to prevent foreign objects from entering the well casing. The well casing is placed and backfilled with stone. Care must be taken to not over backfill as the caisson stick-up height will be too high.

The caisson is constructed of 24-inch SDR 17 HDPE pipe with a flange adapter welded to the top of the pipe. The caisson is lowered in place by the drill rig and stone is backfilled in the caisson. Figure 5 shows the installation of the caisson assembly over the perforated pipe, and into the bore hole.

![FIGURE 5 – CAISSON ASSEMBLY INSTALLATION](image)

With the caisson assembly in place, a series of bentonite plugs and soil backfill are installed outside of the caisson to create a proper seal.

Once the caisson is properly placed and properly backfilled with stone, the PVC slip cap is removed and the caisson top is placed over the perforated pipe. Figure 6 shows the installation of the caisson top.
With the caisson top in place and bolted down, a flexible PVC coupling and wellhead is then placed on the top of the caisson for LFG extraction. Figure 7 shows the completed caisson well.

**FIGURE 6 – CAISSON TOP FLANGE INSTALLATION**

**FIGURE 7 – CAISSON WELL INSTALLED**

**Maintenance**

A caisson well does require a little more attention than a traditional well. Due to the materials used, the weight of the caisson may cause settlement at the well location. Within the first few weeks of installation, it is not uncommon to have to add cover soils due to settlement. If significant settlement is encountered, the perforated well casing may come into contact with the caisson top. In this situation, the caisson top is removed and the well casing is shortened.

Because the perforations in the well casing extend to the landfill surface, additional monitoring of the quantity and quality of the extracted LFG is necessary in order to ensure that the well seals are intact, and that no short circuiting is occurring.

**Raising**

As with traditional vertical extraction wells, caisson wells will need to be raised in conjunction with waste filling operations. For a traditional well, solid piping is extended to a sufficient height to accommodate the additional lifts of waste. Caisson wells need to be raised for the same reason, and is generally extended in the same way as a traditional well. The only difference is that the caisson wells are extended with perforated pipe, instead of solid pipe, and the caisson assemblies will need to be raised also.

In order to begin the raising process, the well is disconnected from GCCS, and the vacuum lateral riser is properly capped and sealed. Then, the caisson top is unbolted to expose the interior perforated well casing. With the perforated well casing exposed, additional perforated pipe is fused onto the existing casing.

Once the perforated pipe is extended, a properly rated strap is secured around the caisson assembly, and the caisson assembly is gently pulled up out of the ground surface using an excavator, or other appropriate heavy equipment. There is normally a fair amount of tension, due to lateral loads, before the caisson assembly “breaks free”. Once the caisson assembly starts to come out of the ground, it is raised with little effort. Figure 8 shows the caisson assembly being raised with perforated pipe already extended.
Once the caisson assembly is raised, stone is added into the caisson. The caisson is then raised to the desired elevation, and more stone is added. Figure 9 shows stone being added into the caisson.

In order to provide vacuum to the well, the vacuum lateral riser is also raised to a sufficient height to accommodate LFG extraction. The extension of the vacuum lateral riser is raised in the same manner as for a riser pipe for a traditional well. Figure 10 shows the extension of the vacuum lateral riser.

After the vacuum source and caisson have been raised, the top of the well is re-established, and the well is back online. Figure 11 shows the completed extension of the caisson assembly and lateral vacuum riser.
The procedures for raising the caisson assemblies is a little more involved compared to the procedures for raising a standard well. There is a good deal of coordination required between landfill operators, field personnel, and engineers. For FCSL, the coordination was streamlined because of the fact that the facility employs its own wellfield technicians, landfill operators, and landfill engineers.

For facilities that outsource their wellfield technicians, the caisson raising will require more planning. Typically, facilities with standard wells will notify the third party wellfield technicians to perform the extensions for well and lateral riser. Raising standard wells does not require heavy equipment, and can be performed relatively easily. Should these facilities decide to install and operate caisson wells, they would be required to provide assistance with heavy equipment for the raising.

LESSONS LEARNED

The first set of caisson wells were installed in 2010. The initial design of the caisson assemblies consisted of the following:

- 20-foot overall length of 24-inch diameter caisson;
- Extrusion welded top; and
- Lifting lugs.

With the benefit of having operated the caisson wells for one year, FCSL wanted to alter the design. The majority of these wells would have to be raised 50 feet or more before achieving final fill elevations. Although the caisson assemblies were able to withstand the raising events, FCSL wanted a more durable caisson assembly.

FCSL places waste in 20-foot lifts. Initially, the 20-foot caisson was planned to be raised in increments of no greater than 10 feet, requiring two raising events per lift of waste placement. Because half of the caisson assembly was exposed out of the ground, stabilization with soil was required. After the two 10-foot raising events, some settlement (about two feet) was noted around the caisson assembly due to its weight. As a result, the caisson was needed to be raised a third time, making the total raising length to be 22 feet.

FCSL wanted to reduce the number of raising events in order to preserve the structural integrity of the caisson assembly. In order to further preserve the integrity of the caissons, FCSL wanted a stronger weld on the caisson top. The revised design of the caisson assemblies consisted of the following:

- 30-foot overall length of 24-inch diameter caisson;
- Butt welded flange adaptor for the top; and
- No lifting lugs.

The revised caisson assemblies were installed in 2011. The benefits of the re-designed caissons enabled FCSL to raise the caisson in 12-foot increments to accommodate settlement, while maintaining stability without the need for soil. This allowed FCSL to reduce the number of raising events to two per lift of waste placement.

FCSL also modified the sequence for raising the caissons. Initially, stone was added to the caisson before waste was placed around it. By doing so, the stability of the caissons was compromised due to the additional weight of stone above ground surface. This procedure also made it difficult to place the stone due to the height at which the stone was placed. Any stone that would spill over was wasted. FCSL modified this procedure to add stone after the waste surrounding the caisson reached grade (after the first or second raising event). This procedure modification had three main benefits:

1. It increased stability of the raised caisson;
2. Stone was much easier to load; and
3. In the event the caisson was lightly impacted during the filling process, the interior void space decreased the likelihood that the interior well casing would be impacted.
COSTS

The incremental cost difference between installing a caisson well and standard well is manageable. The additional items needed for the caisson wells are the caisson assemblies, perforated pipe (instead of solid pipe) extended to the surface, and stone to fill the caisson assembly. The additional costs per well to install the 20-foot-long caisson well are summarized in Table 1.

TABLE 1 – COST DIFFERENCE TO INSTALL 20-FOOT-LONG CAISSON WELL

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-foot caisson assembly</td>
<td>$1,645</td>
</tr>
<tr>
<td>Perforated pipe instead of solid pipe to ground surface (difference of approx. $2 per linear foot at 20 feet)</td>
<td>$40</td>
</tr>
<tr>
<td>Additional stone placed inside caisson assembly (approx. 0.4 tons per linear foot at $20 per ton at 20 feet).</td>
<td>$160</td>
</tr>
<tr>
<td>Total additional cost per well</td>
<td>$1,845</td>
</tr>
</tbody>
</table>

The 20-foot-long caissons were installed in 2010, and the costs reflect pricing in 2010.

The additional costs per well to install the 30-foot-long caisson well are summarized in Table 2.

TABLE 2 – COST DIFFERENCE TO INSTALL 30-FOOT-LONG CAISSON WELL

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
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<tr>
<td>30-foot caisson assembly</td>
<td>$1,700</td>
</tr>
<tr>
<td>Perforated pipe instead of solid pipe to ground surface (difference of approx. $2 per linear foot at 20 feet)</td>
<td>$40</td>
</tr>
<tr>
<td>Additional stone placed inside caisson assembly (approx. 0.4 tons per linear foot at $20 per ton at 20 feet).</td>
<td>$160</td>
</tr>
<tr>
<td>Total additional cost per well</td>
<td>$1,900</td>
</tr>
</tbody>
</table>

The 30-foot-long caissons were installed in 2011, and the costs reflect pricing in 2011. For both 2010 and 2011 installation events, there were no additional charges from the drilling contractor to install the caisson assemblies.

Beside the incremental cost difference for installation, there are additional costs associated with the raising of the caisson wells. Raising the caisson wells require perforated pipe (instead of solid pipe), stone to fill the caisson, and heavy equipment to raise the caisson assembly.

In addition to the material costs, extra time and coordination is required for raising the caissons. On average, it took FCSL an additional hour to raise the caisson wells, compared to the time required to raise a standard well. Again, FCSL employs all the parties necessary to facilitate the raising. For a facility that has third party contractors to perform well raising, costs and time required will vary.

SUMMARY

Landfills that are subject to the NSPS regulations are required to collect LFG in accordance with the NSPS 2-Year/5-Year Rule. This has led to difficult challenges in maintaining a properly operating GCCS. The dilemma of installing costly wells with the expectation that the landfill will have to repeatedly replace them may be difficult to resolve.

FCSL chose to install and operate caisson wells in an effort to minimize the costs associated with re-drilling wells. Given the relatively small incremental costs associated with this approach, it was an easy decision to make. FCSL now has the ability to extend wells with perforated piping to allow LFG collection from new lifts of waste placed after the initial installation of the well. Additionally, the oversized above ground portion of the caisson assembly also provides a mechanism to prevent extensive damage to the wells during waste filling activities.

Caisson wells may not be the solution for all landfills. A good deal of coordination and extra effort are required to properly maintain and operate these wells. Because FCSL employs all the necessary parties for maintaining and operating these wells, the coordination efforts are relatively easy to manage.