LEAPING FORWARD TO ENERGY RECOVERY – INCREASING YOUR GCCS OUPTPUT AND REMOVING SULFUR TO BRING AN ENERGY PROJECT ONLINE

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ABSTRACT

The Apex Regional Landfill (Apex) owned by Republic Dumpco, Inc., a subsidiary of Republic Services, Inc. (RSI), located near Las Vegas, Nevada was thought to be an arid landfill in the southwestern United States. Several investigations of the site's landfilling operations identified practices (e.g., moisture addition for dust control, receipt of sewage sludge) which indicated the site may have a higher moisture content and therefore be generating more landfill gas (LFG) than the site's arid landscape would predict. Investigation of the moisture content of the waste and subsequent LFG modeling, along with a high electrical demand in the Las Vegas area, lead to interest in the site by an LFG-to-energy (LFGTE) developer.

The question then became how to move Apex toward a state of the art LFG collection and control system (GCCS) suitable to a landfill with moderate moisture content; a GCCS that would also be suitable for the LFG-to-energy project and to remove the high hydrogen sulfide levels within the LFG resulting from the disposal of large amounts of sewage sludge and construction debris from nearby Las Vegas. A design for the site had to be prepared to incorporate these design variables and to meet the compliance needs of the site as well as meet a difficult time table for implementation to bring the energy project online.

This paper focuses on the steps taken by RSI to design, permit, and construct the Apex GCCS. The paper will discuss the following:

- Completion of a Master Plan for the GCCS to ensure that the GCCS improvements can accommodate the site compliance and energy development needs for the next 20 plus years;
- Design of a new header system and LFG collectors that utilize the current GCCS system and yet provide for significant future expansion;
- Design of a 10,000 cubic feet per minute (cfm) blower skid with heat exchanger to convey gas to a sulfur treatment system, a 5,000 cfm secondary blower skid and heat exchanger to convey LFG to the energy plant, a temporary candlestick flare, and a permanent 5,000 cfm low emissions enclosed flare;
- Design and utilization of a large scale biological sulfur removal system to reduce the hydrogen sulfide content of the landfill gas from nearly 4,000 parts per million to less than 30 parts per million; and
- Construction sequencing that allowed the project to be built with little to no interruption in LFG collection and control from Apex.

The case study will highlight the steps taken, hurdles encountered, and solutions implemented to complete this large multi-faceted project under a strict and limited timeline.

BACKGROUND

Apex is an approximately 1,200-acre landfill footprint with a permitted capacity of 865 million cubic yards. Apex accepts municipal solid waste (MSW), construction and demolition (C&D) debris and wastewater treatment plant biosolids under the current solid waste facility permit. In 2009, the existing GGCS system at the site consisted of a network of vertical wells, leachate cleanout risers and horizontal wells. The horizontal wells were typically connected to the GCCS piping at one end, a header system along one side of the landfill. Certain collectors extended over 1,600 feet from the vacuum source according to existing as-built information. Spacing of vertical wells on average was more than 400-feet apart.

Despite the location of the landfill in an arid region, average rainfall in the area of the site is approximately 5 inches per year, a GCCS evaluation performed at the site in 2009 identified moisture levels at or above a typical "dry landfill". Evidence of this included 10,000 gallons per day of liquids being removed from the site leachate collection system. Operations such as the acceptance of sewer sludge and food waste from the greater Las Vegas area, watering of waste trucks for dust control at RSI's transfer stations prior to transport to the site, and the return of liquids removed from the leachate collection system to the landfill footprint for dust control are likely contributing factors for moisture in the waste. Based on this additional moisture it was hypothesized that more LFG was being generated by the landfill than would be typical of a "dry landfill" and would be suggested by the current GCCS LFG flows.

Another consideration for the collection of LFG at the site is the high hydrogen sulfide content. As noted above, the landfill accepts C&D debris and wastewater treatment biosolids as part of its waste stream. Gypsum board as part of the C&D waste stream, from numerous building renovations in nearby Las Vegas, as well as the wastewater treatment biosolids produce hydrogen sulfide as they decompose. Hydrogen sulfide gas levels in the LFG stream have been measured in the thousands (nearly 4,000) parts per million.

GCCS MASTER PLAN

In order to conceive a long term build out of the existing GCCS, a Master Plan was prepared for the site. The Master Plan was prepared with consideration of RSI standards to meet the needs of the proposed LFGTE facility. Both immediate improvements to improve collection efficiency and long term (20-year) conceptual design were prepared as part of the Master Plan. Additional considerations were given for expansion beyond 20 years as the landfill goes forward.

Phasing Plan Approach

A phasing plan approach was developed as part of the Master Plan in order to address current, near-term and long-term needs.

Immediate needs were addressed through the development of Year 1 and a planned Year 2 improvements designs. The Year 1 improvements were designed based on the dry nature of the landfill, while assessment of the landfill and potential higher moisture content continued. Year 2 was to be designed based on additional site evaluation and the real-time assessment of the LFG recovery operations on the completed installation of Year 1 improvements. The results of the assessment would dictate the extent of Year 2 improvements necessary to address remaining issues.

Beyond the immediate detailed design to address the existing needs, Cornerstone produced base line drawings showing all existing GCCS structures at the facility as of 2009 and developed the phasing of the facility's GCCS from this point forward for 2010 through 2029. The GCCS Development Plans 2010-2029 primarily focused on installation of the GCCS components and infrastructure based on and/or in conjunction with the fill sequencing plans for the landfill, the estimated LFG flow, and the installation schedule set forth by the New Source Performance Standards (NSPS) regulations.

20-Year Conceptual Plan: A 20-year conceptual site plan was prepared based on the fill sequencing plans and the estimated LFG potential generation for 20 years into the future. The expansion included:

- Multiple 5,000 cfm enclosed flares and hydrogen sulfide removal systems installed in parallel;
- An LFGTE plant is also planned for construction at the Landfill and will be operated under a separate permit by a third party;
- A new 24-inch header along the majority of the southern, eastern and northern boundaries of the fill area;
- Utilizing an existing 22-inch diameter header along the western and southwestern perimeters;
- A new 12-inch diameter header located in the eastern portion of the landfill connecting the northern and southern new 24-inch header which is moved east as new units are completed;
- A new 36-inch diameter header connecting the GCCS to the flare station;
- A new 36-inch manifold at the flare station for adding new flares and hydrogen sulfide removal systems;
- New vertical LFG collection wells; and
- Associated 4-, 8-, and 12-inch lateral collection piping.

Kentucky Gas (KY Gas) modeling version 1.1 was used in combination with as-built pipe details to assist in determining flow through the proposed system. The modeling results were used to confirm the system is sized appropriately for the predicted LFG flow for the estimated 20-year LFG generation flow.

Year 1 Conceptual Plan: The Year 1 conceptual plan associated with the Master Plan incorporated existing

GCCS components as well as elements from the 20-year conceptual plan. Improvements included the following:

- Installation of a temporary 1,400 cfm open flare. A year's worth of meteorological data is required to permit a new 5,000 cfm enclosed flare. A 1,400 cfm open flare was designed to handle the additional flow from the expanded wellfield until the 5,000 cfm enclosed flare can be installed;

- Installation of 10,000 cfm blower skid (blowers designed to accommodate flow to the LFGTE project and 5,000 cfm flare simultaneously);

- Installation of a hydrogen sulfide treatment system. The Cameron THIOPAQ® bio-desulfurization process was identified for application at the site;

- Installation of 37 new vertical extraction wells across the landfill;

- Installation of new 4-, 8- and 12-inch lateral collection piping;

- Relocation of a portion of the existing 22-inch diameter header;

- Installation of a new 24-inch header through the southern portion of the landfill to connect to the relocated 22-inch header;

- Installation of a new 24-inch diameter header along the northern edge of the cells;

- Installation of a 12-inch diameter header along the eastern portion of the cells to connect the northern and southern 24-inch headers;

- Conversion of standard wellheads to remote wellheads along the southeast slope and use of manifolds to simplify monitoring of remote wellheads in order to allow a new cell be built;

- Routing condensate to existing drains (horizontal collectors) and leachate collection system (LCRS) risers;

- Installation of an 18-inch pipeline from the blower skid to the planned LFGTE facility; and

- Installation of a new 36-inch header to the new flare station with a 36-inch manifold for tying in the new and future flare(s) and hydrogen sulfide treatment systems.

DESIGN COORDINATION

In order to move the conceptual Year 1 design toward construction level detail, coordination was sought with the different parties involved with the various aspects of the overall project. Parties included:

- RSI as the owner and operator of the landfill and GCCS;

- Cornerstone as the GCCS design firm;

- The manufacturer of the flare and associated equipment;

- The designer/manufacturer of the bio-desulfurization treatment system;

- The electrical contractor;

- The general contractor

- The piping contractor; and

- LFGTE developer.

Tools used to coordinate the parties included regularly scheduled meetings, design checklists and a process hazard analysis.

Design Checklist

As a first step to coordinating these parties, a checklist was prepared to collect information regarding a variety of design elements associated with each system. To conceptualize layout of the overall system, the physical layout, size and required offsets for equipment and/or structures and road access requirements were collected. The size, location and elevation of the LFG inlet and outlet from each structure and/or piece of equipment were required in order to lay out LFG header pipe through the flare station. Information was collected regarding utility requirements including size, location and elevation of process water inlet, volume and/or flow rate of water required, locations for electrical connections, electrical requirements, phone and Ethernet connection points and installation requirements.

Process streams for each party were also evaluated. LFG inlet temperature, pressure, flow rate and quality requirements as well as LFG outlet temperature, pressure loss range, flow rate, and quality information were collected. The location, size and elevation of process water lines as well as the flow rate, water quality, pressure and temperature were also collected.

The checklist and subsequent checklist review meetings with all of the involved parties brought to light design conflicts and opportunities for coordinated design to streamline the overall system. An example of a potential conflict was the location of the 5,000 cfm enclosed flare stack with respect to the bio-desulfurization plant contactor tower. The contactor tower was projected to be approximately 95-feet tall, and the operational requirements of the enclosed flare did not allow for a structure of that height to be within two stack heights, or 100 feet, of the flare stack. The location for the bio-desulfurization plant was revised based on this information.

Several iterations of the checklist were prepared as design elements changed and were adjusted based on new information. As design elements were modified, other design criteria were checked to identify potential modifications. One example was the identification of the requirement of an LFG inlet pressure of two (2) pounds per square inch gauge (psig) at the LFGTE plant. This requirement resulted in the upsizing of the secondary blower at the flare station (i.e. the blower would provide five (5) psig at the blower outlet in order to meet the two (2) psig criteria for the LFGTE plant inlet over a mile and a half away).

Once the new secondary blower equipment was identified, the design criteria from the checklist for that piece of equipment were reviewed again. This new review showed that the secondary blower outlet temperature would be too high for the high density polyethylene (HDPE) piping and LFGTE plant LFG temperature inlet requirements. As a result, an evaporative closed circuit cooler was added to lower the temperature at the booster blower outlet. This new piece of equipment added its own set of design variables including physical dimensions, electrical requirements, water requirements and effluent.

Routine Communication

Throughout the design process, weekly calls were held to update all parties on design progress for the various systems, identify questions or design input from one party to another and establish new deadlines for various design milestones. Meeting minutes were recorded and distributed for review after each call. Multiple site meetings were also held.

Process Hazard Analysis

A Process Hazard Analysis (PHA) was held at the site for all parties during the design process. This analysis reviewed the overall system and examined how the parts operate and interact. Potential deviations from operational standards were posed for the various parts of the system and the causes and effects of these potential deviations were discussed. The health and safety concerns associated with the high levels of hydrogen sulfide present in the LFG were a driving force behind choosing to conduct a PHA for the site.

The PHA was a useful tool for coordinating design in several ways. It highlighted how the various processes in the system interacted and identified interactions that had not been previously recognized. Based on this information opportunities were identified to update system design to improve these interactions or to collect additional system information in order to better monitor process interaction. It also highlighted safeguards already integrated into the system and ones that may be beneficial to add. Performing this analysis later in the design process provided redundancy and identified changes to individual processes that may have been missed.

PHA recommendations included health and safety measures such as providing communications between the bio-desulfurization plant and the landfill facility and design additions such as the installation of pressure and temperature gauges on the HDPE header line downstream of the bio-desulfurization plant.

CONSTRUCTION LEVEL DESIGN

Based on the design coordination the following major design components were part of the final construction level design for the GCCS improvements:

- 37 new vertical wells and approximately one mile of new six-inch pipe laterals;
- Approximately two miles of 24-inch HDPE header pipe around the wellfield;
- Approximately one half mile of 36-inch HDPE header pipe from the wellfield to the flare station;
- Approximately one and a half miles of 18-inch HDPE header pipe from the flare station to the LFGTE plant;
- Flare station including two sets of blower skids (a 10,000 cfm skid and a 5,000 cfm booster skid) and heat exchangers, a temporary 1,400 cfm candlestick flare and a permanent 5,000 cfm enclosed flare and piping connections to and from the bio-desulfurization plant;
- A Cameron THIOPAQ® biodesulfurization plant; and
- A condensate tank farm with capacity of approximately 45,000 gallons for process water both from the flare station and the bio-desulfurization plant.

Design elements at the flare station were based not only on immediate operational needs but on future equipment installation as well. For example, an HDPE tee-fitting with a blind flange was installed downstream of the bio-desulfurization plant for connection to a future second 5,000 scfm enclosed flare.

CONSTRUCTION COORDINATION

Construction for the GCCS improvements was coordinated between the general contractor, the piping contractor, and the electrical contractor along with the design and manufacturer firms for the equipment being installed. Weekly calls were conducted during the construction process in order to identify project milestones and adjust project schedules for the various parties based on progress. Although the LFGTE plant construction operated independently of the flare station construction, the construction schedule and startup of the LFGTE plant was relevant to the GCCS improvements construction as the LFGTE plant start date for receiving LFG served as a milestone date for the flare station operation.

The construction of the bio-desulfurization plant and the flare station was performed by different contractors, and coordination was critical to identifying critical path items and ensuring all parts of the system were installed per the design. Identifying which parties were providing which components associated with the system and which parties were then responsible for installation was an important component for ensuring all connections were made between the GCCS piping in the wellfield, piping at the flare station, the flare station equipment, the bio-desulfurization plant and the LFGTE facility.

In addition to meeting the timeline for gas delivery to the LFGTE plant, and coordinating intersecting construction events, construction was conducted to meet compliance requirements. Understanding what environmental and building permitting was required for this work was one element of compliance that could affect construction timelines. Construction also included sequencing that allowed the entire project to be built with little to no interruption in LFG collection and control from Apex.

The majority of the construction for the GCCS improvements took place between March and November 2011. Initial construction included piping improvements in the wellfield. These improvements, as outlined above, included the installation of new 24-inch and 36-inch header pipe, smaller lateral piping to future vertical extraction well locations, and relocation and tie-ins of existing header pipe. Tie-ins were performed to limit the downtime for the existing flare and were coordinated with site operations and compliance personnel.

FIGURE 1
INSTALLATION OF 24-INCH WELLFIELD HEADER

Inlet and outlet header tie-ins to the new flare station were coordinated for later in the construction schedule to allow for site grading to be completed and the majority of the equipment to be installed so connections to the new headers could be made simultaneously to their installation.

FIGURE 2
INSTALLATION OF NEW 36-INCH FLARE STATION INLET HEADER

Drilling activities were scheduled towards the end of the construction. Without new header and lateral piping in place, or flare station equipment installed, the installation of new vertical extraction wells at the site would have led to wells in place with no connection to a control device which could lead to compliance issues such as surface emissions hits near the new well locations. By leaving the well drilling towards the end of the project, the piping network and control device equipment were in-place and wells could be hooked up as they were drilled if operations warranted.

FIGURE 3
VERTICAL GAS EXTRACTION WELL DRILLING

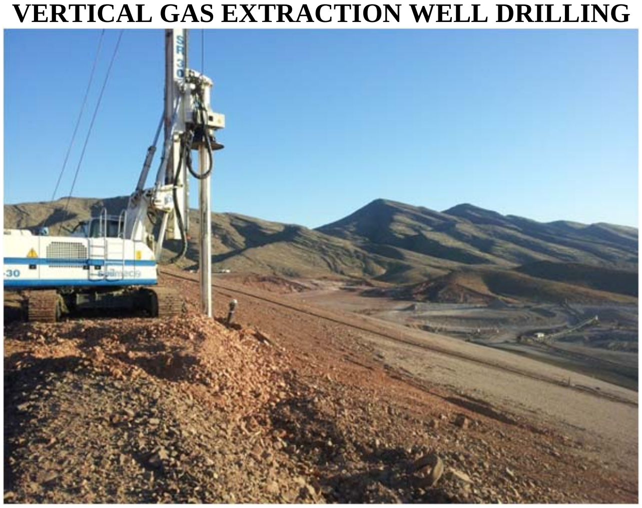

FIGURE 4
VIEW OF THE NEW FLARE STATION AND BIO-DESULFURIZATION PLANT

PROJECT SUMMARY AND FUTURE OPERATION

A Master Plan for the GCCS which incorporated an evaluation of the existing GCCS, modeling for LFG generation for the facility, and phasing development for the GCCS utilizing sequencing fill plans for the facility was the first step in creating a baseline and identifying major components for the design of a GCCS to meet the demands of an LFGTE facility and maintain site compliance.

With a project of this size and complexity it was critical to have constant communication between the various parties involved. Design firms, equipment manufacturers and contractors were involved with the project from the early stages of the project during the design phase. The design was an iterative process in which each change in design for any part of the system had to be communicated and examined for how it might affect other parts of the system. This required routine meetings and exchange of design information. Construction also had to be coordinated between the various parties in order to meet project deadlines and maintain compliance for the GCCS.

The lessons learned during the design and construction phases of this project may be applied to other large and/or multifaceted projects. They may also be applied to operation of this project as the lessons of communication and phasing may still be applicable.