Landfill Best Management Practices

Mitigating Landfill Reaction Odors

Prepared For:

CHIQUITA CANYON LANDFILL

November 6, 2023

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RE: Stipulated Order for Abatement Case No. 6177-4, Condition 12(b)(iv) Report

South Coast AQMD,

In accordance with the Stipulated Order for Abatement issued on September 6, 2023 (Stipulated Order) by the South Coast Air Quality Management District, Neal Bolton, P.E. and Blue Ridge Services Montana, Inc. have prepared this report on LANDFILL BEST MANAGEMENT PRACTICES - *Mitigating Landfill Reaction Odors.*

The Stipulated Order requests the following under Condition 12(b)(iv):

> *A study and report on landfill best management practices and alternative methods to minimize the release of fugitive surface gas and minimize odors from fugitive surface gas, including cover practices at the Reaction Area (as defined in Condition 9(a)) and working face, and how best to address related odorous emissions, such as through the use of misting systems, fans, odor neutralizer, or other means.*
>
> *By no later than November 6, 2023, Respondent shall submit a report detailing the findings of this Fugitive Landfill Gas Odor Mitigation Study and the proposals for the minimization of landfill gas release and odors.*

This report provides an overview of landfill odors and how they are produced, specifically addressing odors caused by the reaction at Chiquita Canyon Landfill. It provides specific recommendations for operational practices that can mitigate the reaction odors, including landfill gas odors and odors from the associated leachate seeps.

Respectfully,

Neal Bolton, P.E.
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PROJECT UNDERSTANDING AND APPROACH

The Chiquita Canyon Landfill (CCL) is experiencing a significant increase in odor complaints. Most odor complaints appear to be related to the sulfur compounds Hydrogen Sulfide (H_2S) and Dimethyl Sulfide (DMS) that are present in CCL's landfill gas (LFG) as a result of the reaction. Localized leachate seeps may also be producing some odors.

A portion of the CCL is experiencing a reaction also referred to as an Elevated Temperature Landfill event (ETLF). The reaction is occurring in an area defined initially in the Stipulated Order by the boundary of Cells 1/2A, 2B/3, 4 and Module 2B/3/4/P2. While most landfills generate some odors associated with uncollected (fugitive) LFG and leachate seeps, the LFG and leachate seeps affiliated with the reaction at an ETLF can produce odors that are particularly strong/offensive and possess unique character, causing them to be more detectable. The significant increase in odor complaints in the vicinity of CCL are attributable to the LFG and leachate seeps caused by this reaction.

In accordance with Condition No. 12 of the Stipulated Order, CCL has formed a committee of subject matter experts, the DMS Committee, to aid in the investigation, impact assessment, and remediation of the ongoing landfill reaction and resultant odors. The DMS Committee is conducting investigations and studies into the cause of the landfill reaction, its impact on air emissions, interim measures to limit odor transport, and corrective measures to reduce or abate the landfill reaction. The DMS Committee also reviews data each month and determines whether to revise the current boundaries of the reaction area.

Neal Bolton, P.E., President of Blue Ridge Services Montana, Inc. (BRS) is a national expert in landfill operations and is serving as a member of the DMS Committee to satisfy Condition No. 12(a)(i) of the Stipulated Order, which requires that the DMS Committee include a subject matter expert in landfill design and operational best management practices. Mr. Bolton is well-positioned to study the ETLF event at CCL and provide recommended solutions, due to his background with CCL and the solid waste landfill industry. He has provided various consulting support to CCL since 2020, including being part of the consulting team that solved the working face odor problem in 2022. Additionally, he has broad operational experience within the heavy construction and solid waste industry that spans more than 45 years. During that time, Mr. Bolton has provided operational support for more than 500 landfills throughout North America and abroad.

This report summarizes BRS's findings and recommendations pursuant to Stipulated Order Condition No. 12(b)(iv). Condition No. 12(b)(iv) requires BMPs to minimize the release of fugitive surface gas and minimize odors from fugitive surface gas, including cover practices at the reaction area and working face. We have determined from onsite reports from our staff and CCL staff, that the excess fugitive surface gas emissions, which appear to be driving the increase in odors, are the result of the landfill reaction. The fugitive surface gas emissions that are contributing to the current odor complaints are not coming from the working face. Further, regarding the generation of odor, the working face and area impacted by the reaction are unrelated – they are mutually exclusive. CCL is already employing numerous BMPs that go beyond industry best practices to mitigate fresh trash odors at the working face.

While Condition No. 12(b)(iv) requires only consideration of BMPs to minimize the release of fugitive surface gas and minimize odors from fugitive surface gas, this report also includes BMPs to address leachate odors. This report includes leachate BMPs because the reaction is also causing an increase in

leachate production, and leachate has the potential to cause odors that require different BMPs to mitigate than would be appropriate for mitigating fugitive surface gas.

BRS's overall approach to this project – and this report – is to provide BMPs to minimize odors resulting from the landfill reaction, whether from fugitive surface gas, or leachate. The BMPs proposed to mitigate reaction odors are intended to be practical, reasonable, and cover a broad spectrum to address that specific problem.

The most challenging aspect of this project's solution, and the one that sets it apart from the BMPs that solved the working face odors, is the absolute need to reduce the quantity and concentration of odorous compounds *before* or *as* they are emitted. Under the current conditions, once the emissions reach the atmosphere, mitigation becomes impractical because of the size of the reaction area and the concentration of the constituents in the LFG. Because of this, the types of odor mitigation tools that CCL deploys at the working face (including misting systems, fans, and odor neutralizer), will not effectively mitigate the reaction odors. This report proposes the eventual deployment of a geomembrane or other synthetic cover over the entire reaction area, to be maintained for some duration while corrective measures are being implemented to slow and stop the landfill reaction. However, this cannot be accomplished until settlement normalizes. With respect to leachate, the report proposes BMPs that CCL should implement to address leachate seeps.

Because of the unique challenges of the landfill reaction, appropriate pre-emission controls are vital. For LFG, this includes expansion of the landfill gas collection system and increasing control capacity to effectively manage the increase in gas production from the reaction. For leachate, this includes a focus on dewatering wells to prevent leachate from emerging as seeps in the first place. Collectively, both of these measures will also remove heat from the reaction, which is the best method to slow down and ultimately stop the reaction. These concepts, however, are outside the scope of this report. A separate report required by Condition No. 12(b)(ii) will address solutions to slow and stop the reaction.

The Stipulated Order already requires CCL to increase its landfill gas collection and control system, add flaring capacity, and improve its dewatering capabilities. According to an update provided to South Coast AQMD on October 31, 2023, pursuant to Condition No. 15, as of October 25, forty-nine (49) vertical extraction wells had been installed to increase landfill gas collection. CCL is also operating a portable thermal oxidizer to increase flaring capacity, is adding a second thermal oxidizer, and will install a new permanent flare (Flare 3) by its November 24, 2023, deadline. Pursuant to Condition No. 17, the DMS Committee determined that there are twenty-five (25) wells in the reaction area with the worst liquid impaction issues. As stated in the DMS Committee's November 3 submission to South Coast AQMD, CCL has installed pumps at twenty-two (22) of these wells to improve dewatering capabilities. The report that will be prepared under Condition No. 12(b)(ii) will address the cause of the reaction and solutions to slow and stop the reaction, which may also address these practices and whether there is a need for continued expansion.

LANDFILL REACTION ODORS

At CCL, a reaction deep within the landfill is generating LFG, leachate, and related odors, at an accelerated rate. Figure 1 shows the area where the reaction is occurring. The area outlined in pink (approximately 30 acres) shows the boundaries of the reaction area based on the DMS Committee's review of data. For purposes of this recommendations in this report, when we refer to the "Reaction Area", we are referring to the area outlined in pink. For the purposes of the SCAQMD Order, a larger area outlined in black is defined as the reaction area to ensure that monitoring and data collecting and certain practices like ensuring prompt repair of cracks in the soil are being conducted at an area larger than that which is currently exhibiting signs of the reaction (i.e., to be sure the reaction is not spreading). We refer to this area as the "SCAQMD Reaction Area."

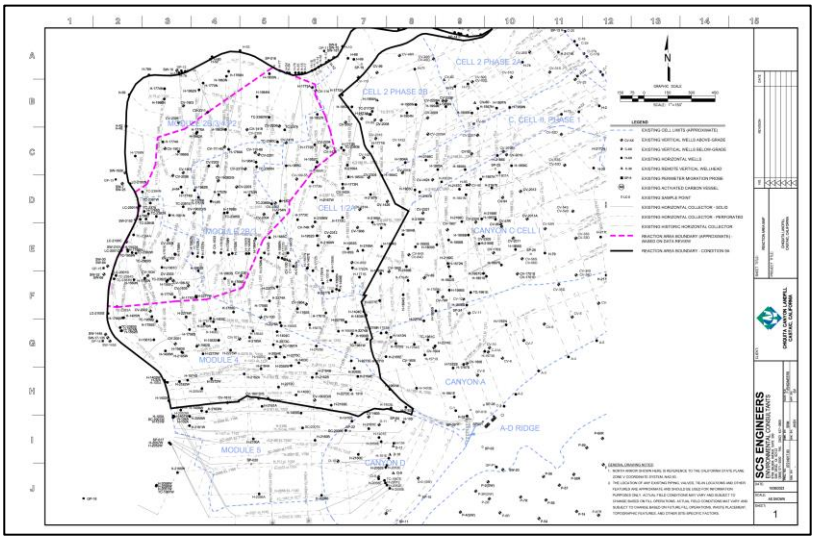

Figure 1 - Limits of Reaction Area as of 06Oct2023

A large portion of the landfill surface has settled more than 20 feet. Strong odors, particularly from DMS and H_2S, along with other characteristics of ETLF conditions – such as increased LFG and leachate temperatures and pressures, increased hydrogen concentrations and reduced methane concentrations, accelerated settlement and visible surface cracks in the cover soil in this area (which Chiquita promptly repairs as required by the Stipulated Order) – show that the reaction is continuing. Portions of the Reaction Area are currently settling at a rate of up to 3 feet per month.

The following sections provide background on typical LFG generation and discuss two different potential sources of odor resulting from this reaction: LFG and leachate.

Background on LFG Generation

LFG is released during the decomposition of organic waste. LFG generated within the waste mass of most landfills has orders of magnitude higher odor potential than any other onsite source due to the sheer volume of the waste mass and the rate of gas production. Simple estimates indicate that one ton of waste may – over its full life of decomposition – generate more than 12,000 cubic feet of LFG. There are many factors that affect if, when, and how that LFG – and the associated odors – are released. These factors include waste characterization, climate, soil type, and quantity of waste.

In a steady state system, LFG is generated gradually, increasing over time. Around the time the landfill closes, gas generation typically peaks and then follows a slow but steady decline (See Figure 2).

Under typical landfill conditions, the extraction of LFG is predictable and efficient, and LFG and the resulting LFG odors are fully controlled through a traditional LFG collection and control system.

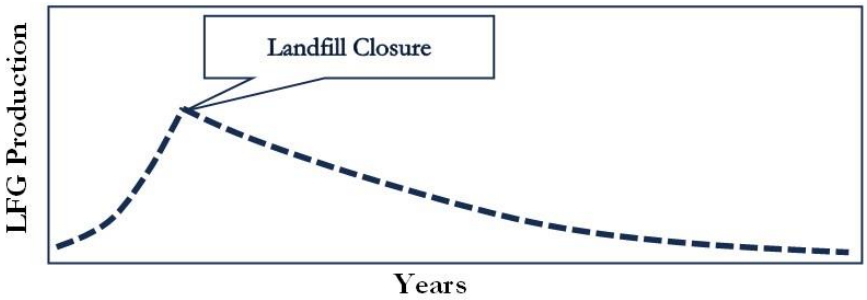

Figure 2 - Typical LFG Production Curve.

LFG Odors from Reaction

The most obvious and problematic odors are being generated because of the reaction. The reaction is producing an increase in total volume of LFG much greater than what is produced by normal decomposition within a typical landfill, which can increase odors. The spike in leachate generation has also created conditions where individual LFG collection wells impacted by the reaction are prevented from handling the current flow of LFG.

The LFG from the reaction also has atypical properties that increase odors. Of the odorous compounds released from that area, the most significant are H_2S, an inorganic sulfur compound, and other Total Reduced Sulfur (TRS) Compounds including DMS. DMS is not typically present in LFG at the concentrations at which it is seen in the reaction LFG. From an odor standpoint, mitigation is challenging due to the high concentration of DMS because this is not a constituent that typically needs to be addressed in LFG control systems. The emitted LFG also contains a high percentage (83%) of Carbon Dioxide (CO_2), making the overall density of the LFG more than 1.6 times denser than ambient air. (Note that these percentages are from a flux chamber study and only represent emitted gas; they are not indicative of the as generated raw LFG.)

These conditions produce a dense mass of LFG, with high concentrations of TRS. The report being prepared under Condition No. 26 will show modeling of how this LFG may move offsite.

Leachate Odors from Reaction

In the normal process of decomposition, moisture is released, along with the typical constituents of LFG, methane (CH_4) and CO_2. Under normal conditions, that moisture creates an environment within the waste mass that is humid. In the same way that LFG is generated in a steady and predictable way, moisture generated in a typical landfill is also predictable and manageable. Liquid moisture (i.e., leachate) slowly moves downward toward the bottom of the landfill where it is collected by the leachate collection and recovery system (LCRS). Water in its gaseous state (i.e., within the LFG) is extracted along with other constituents by the LFG collection system. Much of that liquid drops out as condensate when LFG flows though the collection pipes (where it cools). Remaining moisture may be removed at the LFG plant prior to the LFG being flared or used as an energy source.

However, because of the reaction, the leachate generation rate, like that of the LFG, is much higher than normal. Liquid leachate is impacting some of the LFG collection wells, and some is also emerging as leachate seeps along the west and north slopes of the SCAQMD Reaction Area. When that leachate emerges on the surface of the landfill, it can be noticeably odorous and may contribute to the odors already being generated by the reaction LFG.

MITIGATION OF REACTION LFG ODORS

This section evaluates BMPs and alternative methods for minimizing odors caused by the reaction, from an operations perspective.

BRS recommends installing some form of geomembrane or other synthetic cap over the Reaction Area (see Figure 1, pink line) to contain excess emissions. This cap design will need to include a method for collecting and treating the LFG that is contained under the cap.

BRS has evaluated several other options, but determined they are either not feasible or will not mitigate the odors, including:

- Additional thickness of cover soil (as suggested in CalRecycle's October 16, 2023, letter to Ms. Karen Gork),
- Other Odor Control Systems,
- Biofilter system to treat emissions as they are released, and
- Various forms of alternative daily cover (ADC).

As previously noted, mitigation measures to occur before the sources of odor (LFG and/or leachate) reach the surface of the Landfill are outside the scope of this report. However, considering the many factors affecting the reaction, BRS suggests that mitigating odors must include expansion of the LFG collection system and increasing LFG flaring/control capacity and improved liquids removal.

Geomembrane or Other Synthetic Cap

BRS recommends installing a contiguous layer of geomembrane or scrim-reinforced synthetic material over the Reaction Area (see Figure 1, pink line) and the western and northern sloped areas adjacent to the Reaction Area. The material will be maintained for some duration while corrective measures are being implemented to slow and stop the reaction. Such a project will require detailed design work, including for the underlying piping that will convey collected LFG. This design work is outside the scope of this report.

The pros and cons associated with placement of any geomembrane in these areas must be carefully considered and there are unique operational challenges to placing such material that vary between the sloped portions and the plateau area of the Reaction Area. The cap must also be paired with an appropriate LFG collection and control system because the geomembrane alone does not solve the problem, it just contains and redirects the LFG.

The benefits of this type of cap include:

1. A cap would provide an absolute barrier to LFG emissions. Such a layer would restrict and re-direct surface emissions to one or more points where the LFG can be collected and treated.
2. Placement of a geomembrane or other synthetic material would also help to control stormwater, primarily to keep infiltration (e.g., from rain) from adding liquid to the reaction.

Potential downsides include:

1. Placement of a geomembrane on any portion of the Reaction Area or adjacent slopes will force LFG emissions to the next path of least resistance. This could increase the potential for lateral gas migration, increasing emissions along the edge of the geomembrane.
2. Placement of geomembrane could also direct more gas toward the bottom of the Landfill where it could potentially change the chemistry of leachate.

Sloped Portions Adjacent to the Reaction Area

Condition No. 26 already requires the installation of a geosynthetic cover (geomembrane) over western portions of Module 2B/3/4 Phase 2, Module 2B/3, and Module 4 (western slope). BRS also understands that CCL is planning to install a geosynthetic cover over the northern slope that is adjacent to the Reaction Area. These sloped areas adjacent to the Reaction Area are places where CCL has seen leachate seeps emerge, as well as excess surface emissions. A geomembrane placed along the western and/or northern slope, especially where leachate seeps have emerged, could provide the important benefit of keeping stormwater from infiltrating and potentially adding to the subsurface flow of liquid within the waste mass where the leachate seeps are originating. In this way, adding the cover could help reduce/prevent leachate seeps.

On the other hand, if leachate emerges along the slope under the geomembrane, it could be difficult to detect until it emerges at the bottom of the slope. By that time, a significant portion of the slope could be affected. This could also create some level of slope instability. CCL should frequently inspect that area to allow for early detection of any potential problem.

Similarly, the placement of a geomembrane on the slope will focus all stormwater runoff to the toe of the slope. Thus, additional stormwater controls may be required at the toe of the slope to handle the increased runoff and prevent erosion. CCL should install stormwater controls at the toe of the slope (i.e., the bottom of the geomembrane).

Plateau Portion of the Reaction Area

Covering the entire Reaction Area with a geomembrane or other synthetic cover could be challenging because of the rapid settlement this area is experiencing. Even with the flexibility of high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE), or other similar synthetic material, it could be difficult maintaining the integrity of a single contiguous geomembrane cap. In other words, a single contiguous geomembrane panel could potentially rip or be displaced due to settlement in the Reaction Area. This must be addressed during the design of any geomembrane placement.

Because of this, BRS recommends extending this cap over the plateau portion of the Reaction Area only once the settlement normalizes. Criteria for considering when the geomembrane cap could be removed would need to include the prevalence of odors emanating as a result of the reaction.

Means of Managing LFG Contained under Any Geomembrane

As noted above, placement of a geomembrane or other synthetic cover over the Reaction Area and adjacent slopes must be paired with a way of collecting and managing the LFG that will be captured by the cap.

BRS considered the following LFG management options that could be paired with the geomembrane to create an effective hybrid system:

1. Routing the collected LFG to the existing LFG collection and control system (i.e., flares.).

2. Routing the collected LFG to a portable thermal oxidizer such as the one currently used at CCL, or a larger unit sized to accommodate the flow of LFG from under the geomembrane.

BRS believes that either or a combination of both options would be suitable to pair with the geomembrane cap. An expert in LFG collection and control systems will need to design proper piping and determine the optimal solution to treat the LFG contained under the geomembrane or other synthetic cap.

Additional Cover Soil

BRS has reviewed the recommendation in CalRecycle's October 16, 2023, letter to Ms. Karen Gork, to place an additional 24 inches of soil on top of the "Reaction Settlement Area" (see Figure 3).

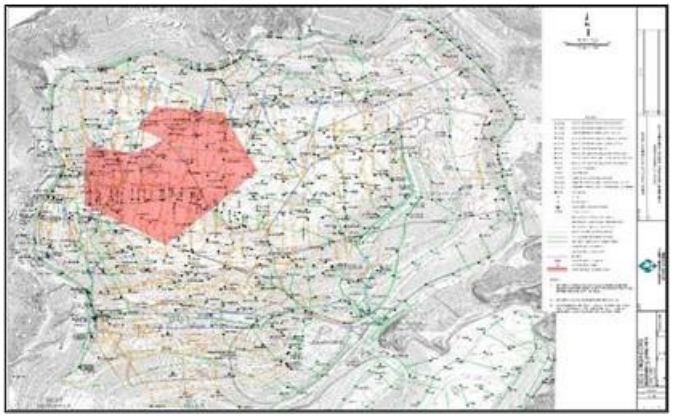

Figure 3 - Reaction Settlement Area map per CalRecycle Report.

Cover soil provides some odor mitigation benefits. It should be noted that a minimal degree of stripping of methane, other Volatile Organic Compounds (VOCs), and Volatile Organic Sulfur Compounds (VOSCs) occurs as LFG emissions pass through daily and /or intermediate cover soil. This occurs when the bacteria on soil particles contacts and oxidizes various types of organic compounds.

However, there are many risks in placing additional cover soil on the Reaction Settlement Area. Because of these risks, BRS does not agree with this approach and suggests that CCL avoid placing additional weight on top of the Reaction Settlement Area. Additional soil cover could exacerbate the problem by:

1. Adding more weight, which could increase the rate and amount of settlement,
2. Insulating the Reaction Settlement Area, which could prevent release of internal heat,
3. Increasing settlement, which could potentially increase ponding and infiltration, and
4. Adding moisture to the Reaction Settlement Area, which could further accelerate the decomposition process.

Even though soil can provide some biofiltration, the potential benefit is not worth the risk. Further, the loading rate from gas emissions at most landfills generally exceeds the soil's treatment capacity. Loading rates from the Reaction Settlement Area certainly exceed the capacity of the existing soil, even with an additional 24 inches. Thus, any reduction in odorous compounds is likely to be minimal.

Other Odor Mitigation Systems

In accordance with Condition No. 12(b)(iv), BRS has considered the BMPs that were successful at controlling working face odors, including the use of misting systems, fans, and odor neutralizer, but has rejected them as potential mitigation measures to address the reaction odors. The working face odor mitigation measures will not be effective in controlling odors from the reaction due to a variety of factors, including:

1. The effectiveness of fans, even the very large orchard fans, will be minimal because of the characteristics of the LFG emissions at the Reaction Area. Moreover, placing fans within the Reaction Area could pose safety risks in terms of fan stability (i.e., fans becoming unstable or even tipping over), simply because of the rapid vertical and differential settlement occurring in that area.
2. The density of the emitted gas from the reaction is more than 1.6 times denser than ambient air due primarily to the higher concentration of CO_2 (approximately 83%). This makes mixing the air with fans, thermal air movement, and normal wind flow patterns more difficult because the odorous gas tends to settle in low areas, while ambient air flows over and around that dense mass of LFG. For a visual image, consider that vinegar is approximately 1.12 times denser than oil. Getting it to mix with oil requires lots of shaking (turbulence). Working face odors have nearly the same density as ambient air, making the mixing process much easier; fans were very effective at controlling working face odors.
3. The volume and concentration of odor-causing chemicals, namely DMS and H_2S, are much higher than that of the odorous compounds that were released at the working face. This makes dilution and oxidation – by fans and air turbulence – critical, but much more difficult.
4. The odor neutralizer is inadequate to successfully treat the flow of gas from the reaction. This is not a limitation of the odor neutralizer itself but is instead a result of the quantity and concentration of the emitted gas (DMS), its density, and the difficulty mixing the neutralizer with the gas. Again, think oil and vinegar.

Because of the challenges in treating the higher quantity, flow rate, density, and concentration of gas emitted from the reaction, these odor mitigation tools will be unable to provide effective control.

Biofilter Treatment System

BRS also considered a biofilter treatment system. There is much ongoing research about the ability of organic media biofilters to remove methane and other constituents from LFG emissions. The biofilter process has been shown to be effective, and biofilters are used to mitigate odors at various types of industrial facilities, including wastewater treatment plants, anaerobic digesters, and of course, landfills.

In many cases, biofilters are used at landfills to reduce methane emissions because methane is a powerful greenhouse gas. But in the process, biofilters can also significantly reduce VOCs and VOSCs.

Biofilters are typically constructed with a layer of organic media, such as wood chips, compost, shredded wood/bark, or a combination of those materials (See Figure 4).

When maintained within a certain moisture content, the organic particles in the biofilter become coated with a layer of biofilm. As air passes through the biofilter, many chemicals, including DMS and H_2S, may be attenuated and oxidized by the bacteria present within the layer of biofilm.

Most biofilters are constructed to a depth of 2-6 feet, depending on the type of media, design (gas) flow rate, concentration of target constituents, and other factors.

BRS considered whether it would be effective at CCL to strategically place a layer of organic material (i.e., compost, wood chips, shredded bark, or other similar material) as a biofilter on portions of the Reaction Area and along the edge of any geomembrane placed over the Reaction Area.

Figure 4 - Jefferson County Landfill, WA. from EPA's Landfill Methane Outreach Program.

However, placing a biofilter to address a LFG issue of this scale comes with challenges – and some potential negative impacts. Effective biofilters require a specific moisture content – around 50%. Due to the weather conditions at CCL, to obtain the optimal moisture content, CCL would need to constantly add water to the biofilter. Since water infiltration could exacerbate leachate production, this is not recommended at this time. Even the logistics of maintaining a uniform 50% moisture content would be operationally difficult. Further, biofilters, which are made up of organic materials, may have their own odor issues, particularly when deployed at such a large scale. Adding a potential source of odors is not recommended.

For the time being, we have rejected the idea of utilizing a biofilter to pre-treat emissions at the Reaction Area.

MITIGATION OF REACTION LEACHATE ODORS

At landfills, most leachate is generated when stormwater seeps through waste, in the same way coffee is formed when water drips through a coffee maker. The bacterial and/or chemical processes of decomposition may also produce or release moisture.

Some waste materials, such as food waste, sludge, or agricultural waste may begin with a relatively high moisture content, thus increasing the potential for leachate creation. Consider how a plastic bag of residential trash containing food or green waste might sweat after a few days sitting in a warm garage or trash bin. The decomposition process is producing water. That same phenomenon occurs in a landfill at a scale many orders of magnitude greater.

At CCL, the reaction is producing a significant quantity of liquid (i.e., leachate) in addition to the excess production of LFG due to the reaction itself creating water as a by-product.

Generation of Landfill Odors from Leachate Seeps

When there is an excess amount of liquid in a landfill, leachate can emerge from the perimeter landfill slopes in the form of a leachate seep. Leachate seeps are typically more common at landfills that receive significant rainfall and have fine-grained soils such as clay or silt. CCL does not receive significant rainfall and has limited fine-grained soil.

Leachate seeps are very similar to a natural spring one might find while hiking. Leachate seeps occur when liquid within the landfill moves downward, encounters a layer of low permeability material, then flows along the top of that layer, often emerging on a perimeter landfill slope.

Several leachate seeps have recently emerged at CCL – mostly along the slopes immediately west and north of the Reaction Area. This is driven by the increased moisture being generated by the reaction.

Because of its potential to contain bacteria, VOCs, VOSCs, and other chemicals, leachate from the reaction is odorous and may be adding to offsite odor complaints. In that regard, and from a regulatory perspective, control of those leachate seeps is important.

BMPs to Mitigate Odors from Leachate Seeps

Leachate odors may be reduced or eliminated by treating the leachate biologically or chemically. In some cases, odors from surface impoundments of leachate have been reduced by treatment with hydrogen peroxide, chlorine bleach, or potassium permanganate. BRS does not recommend any biological or chemical treatment of leachate seeps at CCL, because of the difficulty in applying, managing, and monitoring an appropriate concentration. Leachate seeps are typically inconsistent in flowrates, can vary in chemical composition, can relocate to different positions over time, and the application of biological or chemical treatment may require the leachate to remain standing at the seep location, which is counterproductive to odor abatement. These treatments typically work well in a leachate pond where the volume of leachate – and applied chemical – can be controlled. Chemical application is not practical in this situation and so we have rejected it as a treatment option.

Instead, BRS recommends implementing measures to eliminate the seeps. This is a practical approach because the most effective way to reduce leachate odors from the leachate seeps is to eliminate the seeps. Leachate within the Landfill's waste mass poses virtually no potential to cause odors.

In some cases, minor seeps may be corrected by simply placing additional soil on that portion of the slope, like a patch on a leaky tire. If the patch doesn't work, it may be necessary to excavate into the slope at, or just above, the seep. The seeps occurring at CCL are large enough that patching will not be an effective long-term solution. BRS recommends that CCL undertake a more significant and permanent fix to reroute the leachate and prevent it from becoming exposed to air, which is, in fact, the process that CCL is currently undertaking.

Figure 5 - Leachate Seep Remediation – north edge of reaction area.

To eliminate the seeps near the Reaction Area, CCL is excavating a trench along the contour of the western slope and slightly above the level of the emerging leachate (See Figure 5). The trench excavation extends below (i.e., through) the low-permeability layer that is acting as a quasi-liner.

The trench is then backfilled with drain rock (creating a French drain) and capped with cover soil to match the adjacent slope(s). Because of the apparent high flow rate of the leachate seeps, the trenches are at least 2 feet wide, to help prevent sediment from plugging the drain rock in the French drain. This method allows leachate to flow downward within the Landfill where it can be captured by the liner and leachate collection system.

In the event leachate must be transported from a leachate seep to a tank or other collection or treatment location, it should be transported with a vacuum truck or via pipes, rather than in a ditch. Leachate that is exposed on the surface of the Landfill may produce a significant quantity of odor. This is particularly concerning due to the high odor potential of gas and liquid (i.e., leachate) generated by the reaction. There is additional risk that leachate may contact stormwater as the wet season approaches, so there should be control measures in place to ensure any such leachate is contained and removed via vacuum truck.

Until the leachate seeps are fully mitigated, CCL should continue utilizing vacuum trucks to extract leachate from active seeps to several "Baker" tanks. These tanks provide secure temporary storage for leachate until it can be transported to an offsite treatment facility (See Figure 6).

CCL is and should continue following a strict set of BMPs. The entire leachate mitigation process has multiple important BMPs:

Figure 6 - Baker Tanks for temporary leachate storage.

1. Develop written Standard Operating Procedures to ensure consistency between works and shifts.
2. Regular inspections of the slopes west and north of the Reaction Area:
    a. Look for wet spots or horizontal bands of wet soil.
    b. Look for bands of vegetation that are green or lusher.
3. Immediately contain any seep using dirt / soil berms or dams, or by digging a hole.
4. Immediately contact Site Management to report seep location.
5. If required, contact appropriate agency if seep is off the landfill liner footprint.
6. To repair the seep, a variety of actions may be appropriate, depending on the specific nature and location of the seep. As needed, CCL should take a combination of the following steps to repair the seep:
    a. Cover seep with dirt and monitor to confirm that the seep stops.
    b. Dig a hole into waste to redirect seep for downward drainage.
    c. Pump any contained liquids into LCS or tanks or trucks.
    d. Install sumps (vertical or horizontal perforated pipes surrounded by drain rock).
    e. Install pumps, air supply lines, and liquid conveyance lines to & from sumps.
    f. Install horizontal perforated pipes with drain rock or manufactured textiles.
    g. Install solid pipes to convey liquids.
7. Once seep is repaired, cover the area with clean soil and compact accordingly.
8. Monitor seep periodically for any breech or issues.
9. Currently, seep liquids are contained in concrete ditches & channels, these ditches and channels should be controlled using dirt berms / dams to prevent commingling with stormwater and allow for quick removal via vacuum truck.
10. Ensure vacuum trucks are available on site daily to pump liquids from any ditch or channel and transfer liquids to the onsite storage tanks.
11. Onsite storage tanks should be consolidated in a few primary areas (as opposed to being spread across the landfill) and there should be appropriate vacuum on tank farms to prevent odors.
12. Tankers should be available to remove liquids from the onsite storage tanks and transport the liquids to an approved POTW for proper disposal.
13. CCL should ensure that there is sufficient capacity for offsite disposal and sufficient tankers for transport to align. Insufficient capacity for either may require CCL to increase the number of onsite storage tanks.

CCL should continue its efforts to address the leachate seep on the western slope by digging into the waste to redirect the leachate and prevent it from surfacing. CCL should also continue to employ the above best management practices for addressing leachate seeps and managing leachate onsite to minimize odors.

CONCLUSION

Condition 12(b)(iv) requires BMPs and alternative methods to minimize the release of fugitive surface gas and minimize odors from fugitive surface gas. As explained above, the scope of this report has been expanded to address BMPs and alternative methods to minimize odors resulting from the landfill reaction, including both fugitive surface gas and leachate.

In summary, BRS recommends CCL take the following actions:

- As required by the Stipulated Order, continue to expand the LFG collection system and flaring/control capacity, and continue to improve dewatering capabilities.
- As required by the Stipulated Order, install a geomembrane cover on the western slope of the Reaction Area.
- Install a geomembrane or other synthetic material cover on the northern slope of the Reaction Area.
- Once settlement at the Reaction Area has normalized, install a geomembrane or other synthetic material cover over the plateau portion of the Reaction Area.
- Continue reconstructing the western slope to mitigate leachate seeps in the area and prevent them from exposure to the surface.
- Continue implementing BMPs for addressing leachate seeps and managing leachate onsite.