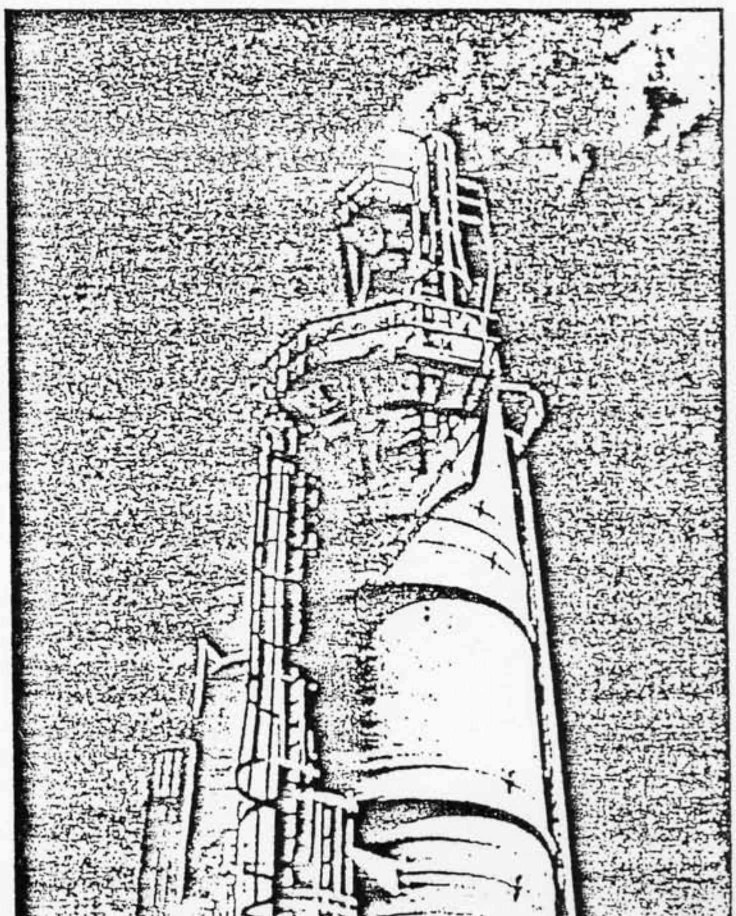
CDM Camp Dresser & McKee

Report

Camden County Municipal Utilities Authority

Air Emission and Odor Control Study

November 1998



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November 20, 1998

Mr. Andrew H. Kricun, P.E.
The Camden County Municipal Utilities Authority
1645 Ferry Avenue
Camden, New Jersey 08101-1432

RE: Air Emission and Odor Study
Final Report & Recommendations

Dear Mr. Kricun:

In accordance with the terms of our contract with the Authority, we submit our report on air emissions and odors associated with The Camden County Municipal Utilities Authority, Delaware No. 1 WPCF. This final report incorporates responses to supplemental comments received subsequent to our September report.

Briefly, sources of odors have been quantified and qualified. Solutions have been recommended and prioritized in terms of effectiveness. The first order of business is to capture and treat odors from the Preliminary Treatment Facility. Section 5 contains our detailed recommendations for reduction of odor emissions from the Facility.

We also feel strongly that CCMUA needs to work with NJDEP to revise your air permits for all five scrubber systems. The permits were drafted based on designs that were changed during construction. In some cases, the permit conditions actually preclude CCMUA from reliably meeting limits. Section 1 tabulates scrubber chemical and set point recommendations for the reworked scrubbers.

This report was prepared by the staff of Camp Dresser & McKee under the general supervision of David M. Gaddis and Robert J. Gaudes. Michael T. Lannan was the project manager and leader of the field investigations. Significant contributions were also made by project engineers Theresa A. Santoro and Daniel D. Durfee.

Very truly yours,

CAMP DRESSER & McKEE

David M. Gaddis, P.E.
Principal Engineer

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Section 1.0
Executive Summary

A number of odor studies have been performed over the last ten years in the vicinity of the Camden County Municipal Utility Authority's wastewater treatment plant (CCMUA), and at the facility itself. Findings were limited to specific daily conditions which, in many cases, distorted the recommendations. This project focused more on problem solving than source analysis and ranking.

CDM has determined that CCMUA does contribute to odors in the South Camden community. However, there are sources of odors other than CCMUA which are also impacting the community, as discussed in Section 2.0.

CDM has determined that the wastewater processes which most significantly contribute to off-site odors, and warrant mitigation, are:

- Junction Chamber
- Preliminary Treatment Facility (PTF)
- Primary Aerated Influent Channel

The long-term recommendations for these facilities is to treat their odors with packed-tower wet scrubbers. CDM recognizes that capital improvement projects take some time to plan, design and construct. In the interim, we recommend that chemical addition be initiated upstream of the Junction Chamber, perhaps to the Baldwin Run Interceptor. There are a number of chemicals which can be used for this application. This will be a temporary system, only needed until scrubbers are installed. We have reviewed a report by a national vendor and have found its conclusions to be credible. However, we cannot accurately estimate how much chemical addition CCMUA must institute on a year-round basis.

The Junction Chamber can be effectively treated with a 1,500 cubic foot per minute (cfm), skid mounted three-stage scrubber. The capital costs for the entire system, including duct work and heat tracing is estimated to be $140,000.

Odors from the PTF and the Primary Aerated Influent Channel should be treated together in a two-stage packed tower scrubbing system, sized to treat 46,500 cfm. The system would be installed on the north side of the building. The capital costs for the two-stage wet scrubbing system and associated pumps, fans, chemical storage facilities, water softening, and channel covers for the aerated primary clarifier influent channel will be approximately $2,900,000.

Solids processing facilities are designed to be exhausted to odor control systems. However, CDM found that there were fugitive odors emanating from several of the facilities due to HVAC design and operational practices, requiring that doors are opened to handle and load sludge. Since sludge processing odors are the most intense odors in the facility, fugitive emissions contribute to off-site odors. Further, we found that some of the mist chamber scrubbers were not performing well for a number of reasons. The odors they were designed to control are not those actually present but other odors are. CDM performed a series of scrubber optimization tests and recommends that CCMUA initiate the process of having their air permits changed to allow for improved chemistry as outlined in Table 1-1, New Scrubber Chemical and Set Point Recommendations.

Table 1-1
New Scrubber Chemical and Set Point Recommendations

Scrubber Location/Stage	*Chemical No. 1*	*Chemical No. 1 Set Point(s)*	*Chemical No. 2*	*Chemical No. 2 Set Point(s)*
Compost Storage-Stage 1	Sodium Hydroxide	pH - 9-10	Sodium Hypochlorite	ORP - 500 mV
Compost Storage-Stage 2	Sodium Hypochlorite	ORP - 150 mV	Sulfuric Acid (Pump Normally Off)	Only if pH exceeds 9
Sludge Storage-Single-Stage	Sodium Hydroxide	pH - 9-10	Sodium Hypochlorite	ORP - 150 -300 mV
Dewatering-Single-Stage	Sodium Hydroxide	pH - 9-10	Sodium Hypochlorite	ORP - 150 -300 mV
Composting-Stage 1	Sodium Hypochlorite	ORP - 400 - 600 mV	None	None
Composting-Stage 2	Sodium Hypochlorite	Stage 2 ORP - 150 - 300 mV Stage 3 ORP - 150 mV	Sulfuric Acid (Pump Normally Off)	Only if pH exceeds 9
Composting-Stage 3	Sodium Hydroxide	pH - 10	Hydrogen Peroxide	Residual H_2O_2 - 3 -10 ppm
Curing- Stage 1		pH - 9-10	Sodium Hypochlorite	ORP - 500 mV
Curing- Stage 2	Sodium Hypochlorite	ORP - 150 mV	Sulfuric Acid (Pump Normally Off)	Only if pH exceeds 9

We recommend that improvements be made to ventilation and odor control systems for the following residuals processing facilities:

- Sludge Storage Tanks
- Thickening and Dewatering Building

- Composting Building
- Compost Storage Building
- Curing Building

The sludge storage tanks ventilation rate should be reduced and one scrubber taken out of service. Either a new packed tower should be added as a second stage to the remaining tower, or a biofilter installed on the other side of the tracks. If a second stage of wet scrubbing is selected, modifications would cost approximately $700,000 including the tower, a new fan, packing, mist eliminator, and stack. If a biofilter is used as the "second stage" the cost will be approximately $600,000, including a new fan, in-duct heat exchanger, duct, a trestle to cross the railroad tracks, and the biofilter.

CCMUA is currently working on enclosing the truck way. Once this is complete, some of the air (19,000 cfm) currently exhausted from the belt filter press room should be directed to the truck way. The belt filter press room will still have adequate ventilation once this modification is made. The Bionomics scrubber is working satisfactorily and efficiently and can accommodate the foul air flow from both facilities. Although not directly an odor control issue, CCMUA may want to ~~consider~~ consider centrifugal dewatering to further reduce odorous emissions and reduce the mass of sludge to be either composted or disposed.

Composting Building ventilation and scrubbing should be sufficient once the chemical set points are revised as shown in Table 1-1, and water quality and pressure are upgraded.

Dewatered sludge is stored on the floor of the Compost Storage Building. We recommend this practice be terminated. From an odor generation standpoint, dewatered sludge should not be stored on site. All dewatered sludge should immediately be hauled away without transfer between vessels. However, should this building continue to be used for sludge storage, additional scrubber capacity will be necessary. An additional scrubber train and the addition of another stage to existing scrubbers would be recommended at a cost of approximately $4,000,000. Regardless of dewatered sludge storage in the composting building, we recommend that the intake louvers be removed they can be kept closed now) and replaced with intake fans to limit fugitive emissions. We estimate that the ventilation improvements will cost approximately $140,000.

Curing Building emissions should be adequately treated once the chemical set points are revised as shown in Table 1-1.

Lastly, we would be remiss in not discussing the big picture with regard to solids handling. The composting facility necessitates compost storage and curing facilities, all of which present odor problems in terms of fugitive odors and the existing inefficient odor treatment. We recommend CCMUA re-evaluate the continued use of the composting facility and related facilities, as the construction contract is completed, especially in light of the current market for low cost sludge disposal.

Table 1-2 prioritizes the odor control recommendations summarized in this section. Both Phase 1 and Phase 2 improvements should be started immediately. Phase 1 modifications can be implemented right away by CCMUA at little to no capital cost, while the Phase 2 modifications must be designed and funded. Phase 3 improvements should be implemented as soon as possible after Phase 2 is underway. While Phase 4 improvements should be considered after the other phases of work are completed.

Table 1-2
Odor Control Prioritization

Priority	Task	Additional Capital Cost
Phase 1	Stop storing dewatered sludge in the storage building Install available booster pump for composting/curing scrubbers Eliminate sulfuric acid addition to the first-stage scrubbers Close all intake louvers to the storage building Water analysis to determine softening/metal removal requirements New scraper blade in dewatering room	Less than $5,000
Phase 2	New PTF/primary influent channel odor control system New junction chamber odor control system Scrubber set point modifications and re-permit systems Install the other two garage doors in the dewatered sludge loading area Ventilation modifications to the truck loading area Ventilation modifications to the storage building Relocate scrubber chemical feed systems Install new scrubber water feed system	$3,300,000
Phase 3	Additional sludge storage tank odor control	$700,000
Phase 4	Odor control for the primary weirs and/or aeration splitter boxes	not costed

Once the new odor control system is installed at the PTF building, chemical addition to the interceptor system will no longer be needed for odor control. Therefore CDM recommends that CCMUA consider leasing the chemical addition equipment until the odor control system is installed.

Not included in Table 1-2 are the capital improvements, totaling $4,000,000, that would be needed if dewatered sludge storage is not eliminated.

2 Section Two

Section 2.0
Odorous Emissions

A number of odor studies have been performed over the last ten years in the neighborhood surrounding the Camden County Municipal Utility Authority's wastewater treatment plant (CCMUA), and at the facility itself. Most of the facility studies involved a simple walk through, and immediate recommendations. The findings were limited to specific daily conditions which, in many cases, distorted the recommendations. This study included a number of site visits to better understand the seasonal odor effect.

This project focused more on problem solving than source analysis and ranking. To problem solve it was necessary, however, to observe both the potential odors from plant sources and impacts in the neighborhood to properly identify the most odorous sources. Also, the potential was also evaluated for other industrial sources emitting odors similar in character, that at times could be misread as odorous emissions from the wastewater treatment operations.

Measurements of hydrogen sulfide (H_2S) were taken as surrogates for the total odor. Although the odors experienced both on-site and off-site are mixtures of many compounds that stimulate the odor senses, H_2S is the predominant compound at wastewater treatment plants and is a good indicator of relative odor strength. Most other compounds (not including other light sulfurous organic compounds) are less persistent. As other compounds become more dilute through dispersion, the odor strength drops quickly and below the odor threshold.

H_2S is extremely persistent and has a low odor threshold, so if it is detectable by monitoring equipment, there is a great chance that odors will be present. The human nose is a better instrument than field monitoring or laboratory analysis equipment, so at times H_2S will be present and odorous while the instrument will display nondetected. Even the most refined field and laboratory instrumentation are limited to 1 to 5 parts per billion (ppb) H_2S, while human perception can detect odors well below 1 ppb. This phenomenon generally limits field studies since the concentration is often in the ambiguous range, below instrument detection capability, yet above human detectability.

H_2S measurements can be performed immediately in the field, or by sample collection, shipment, and laboratory analysis. Hydrogen sulfide is a fairly reactive compound, so in-field measurements are more accurate. Laboratory readings tend to be lower in magnitude than field readings since H_2S will break down in the sample container, react with other compounds, and form more complicated sulfur compounds. All point and volume sources were measured directly, and all area sources were measured via Tedlar bag collection through the flux chamber and analyzed immediately. The sample bag was filled and then monitored for H_2S levels using the Jerome meter.

On-Site Hydrogen Sulfide Field Study

Engineering judgement based on source emission concentrations and previous experience were used to separate the potential plant sources into three groups: sources with high odor concentrations and large impacts, sources with high odor concentrations and low impacts, and sources with low odor concentrations. At this time, odor control is only being considered for sources with high odor concentrations and large impacts, to obtain the most benefit.

The hydrogen sulfide (H_2S) assessment of the CCMUA's liquid processes focused on the preliminary treatment facility (PTF), grit chamber effluent aerated channel, the primary aerated influent channel, primary clarification weir areas, aeration splitter chamber, aeration basin outlet vents, and secondary clarification. The PTF includes bar screens area, roof fans, and mixing chambers inside the building.

Sampling Results

Table 2-1, Hydrogen Sulfide Process Measurements, summarizes the findings from the on-site monitoring program. The "typical" values are based on field observations and expected yearly and seasonal influences. Odor control prioritization is based on the typical values and the sources' areas of influence.

Table 2-1
Hydrogen Sulfide Process Measurements

Process	H2S (ppb)		
Liquid	**High**	**Low**	**Typical**
Junction Chamber	20,000	7,500	15,000
Primary Treatment Facility	60,000	1,100	50,000
Grit Chamber Effluent Channel	21,000	420	500
Primary Aerated Influent Channel	50,000	310	20,000
Primary Weir	21,000	810	10,000
Aeration Splitter Boxes	32,000	6,500	10,000
Aeration Tanks	220	80	100
Secondary Effluent	570	15	100
Air	**High**	**Low**	**Typical**
Sludge Storage Tank Outlet	19,000	14	1,000
Dewatering Building Outlet	20	15	20
Compost Storage Building	160	2	100
Compost Process Outlet	160	13	160
Curing Process Outlet	54	11	50

Table 2-2, Potential Odor Source Grouping, sorts the potential odor sources into three categories described earlier: sources with high odor concentrations and large impacts, sources with high odor concentrations and low impacts, and sources with low odor concentrations. Not included in this table is potential fugitive emissions from the solids processing systems themselves. Fugitive emissions from the controlled sources is addressed in the scrubber section as HVAC concerns.

Table 2-2
Potential Odor Source Grouping

High/High	High/Low	Low
Junction Chamber	Aerated Grit Effluent Channel	Grit Chambers
Preliminary Treatment Facility	Primary Clarifiers	Aeration Basin Vents
Primary Aerated Influent Channel	Aeration Splitter Boxes	Secondary Clarifiers
		Chlorine Contact Tanks

Junction Chamber

The junction chamber is used to combine and stabilize the flow from two separate sewers from Camden County and Camden City. Two additional flows are added after the junction chamber in the Preliminary Treatment Facility (PTF). One is a 36-inch force main called the Baldwin Run Force Main and the other is the plant recycle line. Recently, Vulcan Technologies examined the potential benefits of adding a nitrate or peroxide to the Baldwin Run Force Main. This line was selected for analysis instead of either of the two force mains because its flow is much less and drops very low late at night, creating an odorous slug with elevated concentrations in the morning. This slug appears to have an adverse effect on the PTF building in the early morning hours, which in turn gets dispersed to the neighborhood shortly thereafter.

The Vulcan study included H_2S measurements in the two junction chamber inlet lines, after the junction chamber, the plant recycle line, the wet well, and subsequent aerated channels prior to primary clarification. It is currently not possible to sample this Baldwin Run line directly, so a mass balance was used to estimate concentrations. The results indicated a 2-4 ppm hydrogen sulfide level prediction from mass balance in the line. This is consistent with the 2 ppm of dissolved sulfides measured from the wet well during our study. Any chemical addition for odor control in the Baldwin Run force main would not improve odors in the junction chamber.

The junction chamber has both a wet well and a dry well side. At the present time, there is an activated carbon adsorption unit in place to handle the odors from the east side of the chamber. A 700 cfm fan is used to pull the odorous air from the east side of the wet well and treat it in the carbon unit. During June, the hydrogen sulfide level to the odor control unit was greater than 50,000 ppb and nearly the same coming out. At the time, it was known that the carbon had been consumed and change out had already been scheduled.

The tandem of the small carbon unit and the counteractant misting odor control systems were installed to limit odors near the parking lot and administrative buildings. While the carbon system will remove odorous compounds, the counteractant system does not significantly alter odor impacts off-site. Counteractants interfere with the human sense of smell and trick us into thinking the odor is not present or not offensive. This phenomenon is limited by contact time and dispersion effects. The air contact time is not sufficient to obtain true interaction, but there is enough contact to smell some improvement at the source. The dispersion effect however makes counteracts undesirable. Counteractants and odorous compounds disperse down wind at different rates, since they have different dispersion characteristics. Therefore down wind in the neighborhood the counteractant odor and the original odor will separate and actually more odors may be spread into the neighborhood.

Carbon adsorption should never be proceeded by a mist operation. Humid air streams will condense on the carbon surface blocking pore sites (precluding the carbon to adsorb odorous compounds into its pores) and limiting carbon life. When CDM designs a carbon system after a scrubber system which will saturate the air stream, a heating system is installed to maintain the relative humidity below 70% and limit carbon consumption. Therefore counteractant misting should be eliminated immediately.

The headspace on the west side of the junction chamber is isolated from the east side by a pipe that travels through the dry well. In the west part of the chamber, there is a large amount of turbulence and no odor control. Early in the morning, there is a "rotten egg" odor throughout the parking lot that may, in part be related to the uncontrolled west end of the junction chamber.

Preliminary Treatment Facility

Junction chamber effluent flows by gravity into the PTF building. The flow first passes through the bar screens where larger debris is removed. The debris removed is cleaned off the bar screens by mechanical rakes that scoop it and push it onto a conveyor belt that goes into a dumpster. The screenings area is somewhat odorous, but is not the primary odor concern in the building. The wastewater then flows into the wet well where it is joined by the Baldwin Run Force Main. It is here where there are the most noticeable odors. A mushroom vent directly over the wet well was emitting the strongest odors by far. There is no odor control associated with this facility.

Off-gassing of this force main as it enters may very well significantly add to odors within this building. Attempts to sample this line near the plant prior to discharge to measure dissolved sulfide (DS) was unsuccessful. Wastewater flow in the 36-inch force main travels approximately 12 to 24 hours during low flow conditions prior to discharge in the PTF. DS readings directly upstream of the 36-inch force main discharge measured approximately 1.5 parts per million (ppm). Under saturated conditions 1.5, ppm DS can lead to over two hundred ppm of H_2S in the room. The PTF is ventilated through mushroom vents on the roof. Readings of over 50 ppm were typical from all the mushroom vents on the roof.

Since there is no odor control associated with this building and the low flow vents are located directly on the building roof, inadequate dispersion is a problem. There is a door, right below a vent, that opens out above the grit chamber channels and there is a distinctive odor detected there under certain wind conditions from building downwash effects. Downwash is the influence of buildings and other structures on the dispersion of emissions from stacks or vents.

Based on the mushroom vent exhaust soot patterns on the roof near the exhaust of the vents, the predominant wind direction is from the river towards the plant parking lot and neighborhood (toward the intersection of Ferry Avenue and Broadway). In the early morning hours, when the wind is blowing off the river and towards the neighborhood, strong PTF odors are present in the parking lot and can be detected off-site.

Grit Chamber Aerated Effluent and Aerated Primary Clarifier Influent Channels

Although there is significant turbulence in the PTF, the first time wastewater is aerated mechanically is in the effluent channel from the grit chambers. Forced aeration, from the hydraulic design of the chambers, and natural aeration through turbulence, will accelerate the stripping of any H_2S in solution which will increase emissions. The effluent channel receives both from the chamber overflow and the forced air. Typical concentrations should be between 30 and 50 ppm.

The weir drop, aeration rate, and wind impacts remain fairly constant at this source, so the impact was relatively constant throughout the visits without any real variation. This source is shielded on nearly three sides (minus the few square feet per chamber with surface grating) from wind influences. While the wind shielding lessens the overall impact, so that it is grouped in the second category - high concentration/low impact, it should still be considered for odor control if odor control is applied upstream at the PTF and downstream at the influent channel. With only a small portion of open space requiring covers, odor control should be considered at the channels proximate to the PTF. The aeration rate is 3,250 cfm for the entire channel, therefore the lowest possible ventilation rate is 4,000 cfm to maintain a negative pressure.

The aerated influent channel is necessary to carry a portion of the flow to the farthest primary clarifier, well over 500 feet away. The aerated channels are aerated at approximately 3cfm/foot of channel length. The channel is located along the edge of the primary clarifiers. Its location is seriously influenced by meteorological conditions since any wind blowing in off the river will pass directly over the tanks and push the odorous emissions off-site into the neighborhood.

Primary Clarifiers

The primary clarifiers can be broken into four distinctive odor sources: the influent channel previously discussed, the quiescent settling zone, the weir area, and the effluent channel. The quiescent settling zone has little turbulence and with the exception of scum collection area almost odorless. The quiescent area is considered low impact.

Most of the odors associated with the primary clarifiers are attributed to the turbulent drop over the weirs and the splashing in the weir trough. The current weir drop is an average of 9 inches. A typical concentration from the weir trough is 15 ppm. While this source is a significantly large source, its control is not as pivotal as the control required for the PTF or the aerated influent channel. By limiting primary clarifier detention time during low flow by reducing the number of tanks in service, the emissions can be partially minimized. The possibility of installing floating baffles to limit the weir drop was considered but dismissed. The weir channels actually make a few intermediate drops that in all likelihood would end up releasing similar emissions. A weir baffle would only move the emission point.

Aeration Basin Splitter Boxes

The aeration basin splitter boxes are located on the east side of the basins. A sample was taken from the weir drop which yielded a hydrogen sulfide level of 3.5 ppm. However, two ambient samples near the top and bottom of the effluent were taken and the levels were 20 ppm and 18 ppm respectively. It seems as though air channels through the headspace in the weir troughs and up out of the four effluent boxes. While the odors here are slightly stronger than at the primary weirs because of the greater turbulence, the offsite impact will be much less, since this source is smaller in magnitude.

Remaining Liquid Processes

There are eight pure oxygen aeration basins. The basins are completely covered and the head space is vented through four goose neck vents at the end of the tanks. A grab sample was taken at the outlet of the vent which yielded a hydrogen sulfide level of 0.22 ppm, while the ambient reading from the Jerome was 0.08 ppm. This area is not an odor concern.

The secondary effluent is proximate to the chlorine contact chambers, so there is a definite chlorine smell there. Using the flux chamber, the sample was taken from the effluent channel surface. Here the hydrogen sulfide level was 0.57 ppm. Three ambient readings from the effluent surface in the channel area as well as the turbulent channels joining the channels were 75 parts per billion (ppb), 50 ppb and 15 ppb respectively. This area is not an odor concern.

Off-Site Hydrogen Sulfide Field Study

Some of the previous studies included odor receptor sampling or neighborhood surveys. One recent study, from the Monell Chemical Senses Center examined the odor sensitivity and health symptom differences between North and South Camden residents. The goal was to present findings that supported, as stated on page 1 of the Technical Report titled *Odor, Annoyance and Health Symptoms* (November 1997) "Residents claims that bad odors and health effects from the emissions are commonplace..."

Unfortunately, as stated, in reference to the health survey findings on page 7 "It is important to recognize, however, that we did not randomly sample from either the South or North Camden Residents to obtain these data. Thus, it is possible that we tested a biased sample-- in other words, that individuals who had more health problems were more likely to come to be tested." Because of potential bias and numerous other health factors encountered in everyday life, the report does not scientifically support the residents' claims on health effects.

That is not to say that the residents in South Camden do not experience odors from the wastewater plant and other surrounding industries. The off-site survey indicated that although hydrogen sulfide levels were not high offsite, four distinctive odors were noticeable in the neighborhood at the time of the survey. Three of these odors were likely emitted from the WWTF and the fourth from an industrial area along the river directly south of the CCMUA facility. The three WWTF odors are described as: "rotten egg" from the PTF and primary clarifier area of the plant, "fecal/sludgy" from the composting processes stacks; and an occasional "chlorine/chemical" from the odor control systems. The industrial odor is a mixture of "decomposing vegetation and rotten egg" and noticed downwind from the industries located near the river at the end of Jefferson Avenue.

While performing the survey of the plant each day, we examined the area around the facility. In Figure 2-1, a qualitative summary of the area of concern outlined by the NJDEP is presented graphically. Three distinctive plumes of odor are shown graphically as noticed by CDM during a hydrogen sulfide survey along Broadway. Although odor was present along Broadway from beyond Jackson Avenue to beyond Jefferson Avenue, the highest, and only significant offsite hydrogen sulfide reading, 2 ppm, was measured in the southern most odor plume at the corner of Jefferson and Broadway. The odor present was industrial in character and because of the wind out of the west, it was not from the CCMUA facility. The odor was coming from one or more of the industrial facilities on Jefferson Avenue. All other measurements taken along Broadway for H_2S were below 20 ppb and most were less than 2 ppb.

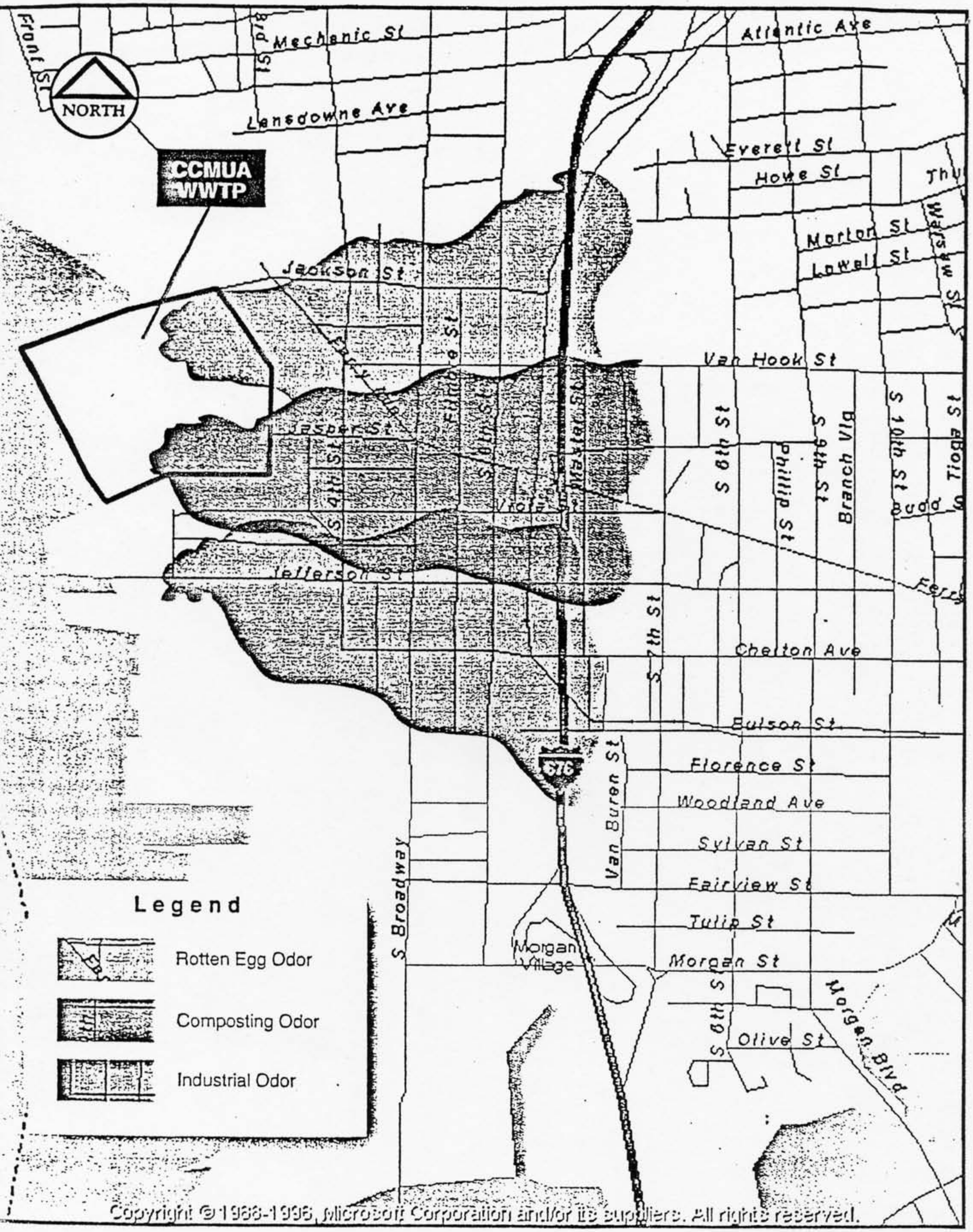
Odors from the industries along Jefferson Avenue are similar in character to odors from the CCMUA WWTF. CDM personnel, trained in odor character analysis, can distinguish the odors in the field. The odor could be confused with the treatment plant odor by a layman because of the similarities in character.

Other industrial facilities were examined for potential contributions to the neighborhood odor levels. While some had food processing odorous emissions, none were significant beyond a one block radius of each facility, and none were as offensive as the odors from the plant and the industrial facilities on Jefferson Avenue.

More observations were made during an additional neighborhood survey at the height of the odor season (mid-July) with a different wind direction. This would slightly alter the impacts to the neighborhood. Neighborhood odors were not as strong during our second visit survey as they were previously.

The wind was blowing in a northwesterly direction at the time of this additional survey. Again, the PTF building (headworks) hydrogen sulfide was detected off site. The Jerome reading here was 11 ppb. In addition to the PTF odor, there was also a composting and licorice root smell offsite. The licorice root was detected on the corner of Emerald and Broadway while the composting was apparent at both 4th Street and at the corner of Broadway and Ferry Street.

The WWTF's malodorous contribution, especially during the early morning hours, is significant and distinctive. The NJDEP has determined that composting odors in the neighborhood are the result of fugitive emissions from the buildings, but CDM noticed a significant portion of the odors emanates from the scrubber systems also.



Camden County Municipal Utilities

Figure 1
Neighborhood Odors

3 Section Three

Section 3.0
Engineering Analysis

This section discusses odor generation from both the wastewater and solids handling and composting operations. In section 2.0 the liquid treatment processes are ranked by hydrogen sulfide emissions and potential impacts to the neighborhood. In Section 4.0 the emissions from all the solids handling processes are discussed as inlet values to the odor control systems. The purpose of Section 2.0 and Section 4.0 is to rank the liquid processes based on current conditions and to optimize the removal efficiency of existing odor control systems, respectively. In both of these sections, emissions are discussed after the processes without regard to how they were formed.

Unlike most wastewater processing discussions that focus on maximizing wastewater effluent quality or creating the best compost product, this discussion focuses on operational procedures and how they can affect odor generation.

CDM had both a solids processing specialist and a wastewater specialist visit the CCMUA facility to examine the processes and how the processes affect odor generation. A discussion of the wastewater processes and the solids processes are included below. Potential changes to operational procedures that would reduce odor generation but not adversely affect effluent quality discussed in this section are summarized in Section 5.0 - Recommendations.

Wastewater Processing Operations

On August 20, 1998, Robert Gaudes, a wastewater and odor control specialist visited CCMUA. He was able to inspect and observe wastewater treatment processes and conducted an overall site tour. On that day, temperatures were in the mid-80s and there was a light breeze off the river.

Overall, wastewater treatment operations were moderately odorous. Only the Preliminary Treatment Facility (PTF) was causing off-site odors. Fugitive odors from sludge processing operations were much stronger and more prevalent. Controlling PTF emissions should be a priority action item. Other improvements to wastewater treatment processing should have less priority than addressing urgent solids processing odor control needs.

Preliminary Treatment Facility

The PTF building doors were closed and there were no fugitive emissions. The ventilation system appeared to be operating normally. Housekeeping was satisfactory. This facility handles and screens raw wastewater and is quite odorous. Air exhausted from the facility is unquestionably causing off-site odors.

Operationally, little can be done to change the nature of the emissions other than chemical addition to the raw wastewater and rerouting plant recycles directly to the oxygenation basins. CDM has found that elsewhere that it is impractical (i.e. uneconomical) to treat dissolved sulfides to less than 0.5 mg/L. In order to reduce inlet sulfides from 1.5 to 0.5 mg/L, 500 lb/day of sulfide would need to be removed.

Depending upon the chemical used, costs range from $0.20 to $1.00 per lb of sulfide removed, or between $100 and $500 per day. Chemical addition will decrease odorous emissions within the building, but not to the point where air stream treatment can be avoided. Rather, it could make a difference between furnishing a single-stage or a two-stage scrubbing system. CDM recommends that a two-stage scrubber be installed to treat PTF emissions.

Grit Chambers

All grit chambers were operational. They are not aerated. Odors were moderate. The grit chambers are partially sheltered from the wind by the adjacent PTF building and the chamber side walls. Under most meteorological and wind conditions, this sheltering will reduce the transport of odorous air off-site.

Given their limited area, moderate odors and sheltering, the grit chambers are not a strong candidate for odor control.

Aerated Influent Channels

The aerated influent channels appear to strip odors out of the wastewater at a greater rate than the aerated grit channel. Since grit has been already been removed from the wastewater, the air rate should be controlled to the point where it keeps solids in suspension. Channel air rates are generally in the range of 3 to 5 cfm per linear foot. Depending upon channel geometry, the air rate can be as low as 1 cfm per linear foot. CCMUA should experiment with channel air flow to establish the proper air minimum rate to maintain solids suspension. Additionally, it may be possible to stop air flow entirely during peak plant flow periods. However, air stream treatment will be required in any event.

Reducing the air flow rate should be considered as an interim measure only. The channels are very much exposed to wind and adjacent to the plant entrance. They cause odors in the parking lot area whenever the wind is off the water (predominant wind direction), and may also cause off-site impacts. Since the air flow rate is low (CDM estimates approximately 2,000 cfm total) and the facility is close to the PTF, we recommend that the channels be covered and their odors treated with the same scrubbers as for the PTF.

Primary Clarifiers

One of the primary clarifiers was off-line on the day of the visit. The empty tank was cleaned out and was not emitting odors. Odor levels from the quiescent zones of the operational tanks were minimal. Odors from the weir area and effluent channel were strong, but localized.

The effluent end has finger weirs which lead to launders. There are hydraulic drops across the weirs and at the junctions of the launders into the effluent trough. The turbulence induced by each of the hydraulic drops accelerates mass transfer and odor emissions. One way of reducing these emissions is to create a backwater such that there is a moderate drop (several inches) across the weirs and the downstream drops are submerged. The existing gate arrangement does not permit the creation of a controlled backwater.

In order to control the backwater, gate openings must be modulated as a function of influent flow. Since flow rates vary diurnally, frequent adjustments of gate openings would be necessary. Electrically driven operators would wear out with frequent movement. Therefore, hydraulically operated gates would need to be installed. The openings in the gate would be dictated by water level in the launder. The control system would need to be "tuned" to prevent hunting and creating a wave action. Given the existing basin geometry, installation of a hydraulically operated gate system would require some careful engineering to design. Considering the localized odors from the weirs, additional investigations are probably not warranted.

Aeration Splitter Boxes

Odors from the aeration splitter boxes were stronger than those from the primary effluent launders, probably because the boxes are even more turbulent and the wastewater characteristics are essentially the same. Fortunately, the area is even smaller and the odors were more localized. No means of controlling the hydraulic drops by inducing head loss were apparent. Introducing the air to the oxygenation basin would be impractical as the foul air may contain volatile organic compounds (VOCs). In an enriched oxygen atmosphere, the explosive potential of VOCs is greatly enhanced.

CCMUA could consider covering both the aeration basin splitter boxes and the primary effluent weirs and launders and providing odor control for these area. However, as previously noted, it is our opinion that the odors are localized and do not warrant such an expenditure. Further, siting of a scrubbing facility will be difficult because of the roadway between the tankage.

There are no significant odors from any wastewater process downstream of the aeration splitter boxes.

Solids Processing Operations

On July 21, 1998 a solids processing site visit was conducted by Daniel Durfee, a CDM specialist in composting and solids processing. He met with both the composting facility staff and the Chief Operator to discuss the solids processing and composting facility history. He toured the composting operations, and the dewatering and compost storage buildings, and collected solids handling, composting and curing facility operations data. For the dewatering, the composting, and the compost/dewatered sludge storage operations, operational data analysis is discussed.

The solids processing train consists of separate primary and secondary sludge storage, secondary sludge thickening, mixed primary and secondary sludge dewatering, dewatered sludge loading, sludge composting and curing, and dewatered sludge and compost storage.

The composting facility processed 4,418 wet tons (1,060 dry tons) of sludge from April to June 1998. The composting facility received sludge 50 out of the 70 days the wastewater treatment plant ran the dewatering facility. During this time an average of 88 wtpd (21.2 dtpd) was processed. This represents only 29 percent of the total sludge dewatered by the treatment plant and only 42 percent of the composting facility design loading rate. The remainder of the sludge was stockpiled in the compost storage building (1 to 3 days) and then hauled to offsite disposal or reuse facilities.

The following discussion addresses the problems which were observed with the systems which are currently installed. We recognize that CCMUA has made substantial investments in these facilities and desires to continue to operate them as designed. However, we feel that it necessary to point out that means of controlling odors effectively from these processes, in particular from the sludge composting building, will be quite costly. CCMUA should carefully weigh the merits of continuing to operate this unit process, once the composting contract is fulfilled, as the future costs to operate and control odors will increase markedly.

Sludge Storage Tank Operations

In secondary treatment, and to a lesser extent in primary treatment, both aerobic and anaerobic microorganisms are present. Aerobic growth emits primarily carbon dioxide and water, while anaerobic growth emits methane and odorous hydrogen sulfide. By adding oxygen in the aeration basins, aerobic growth is favored.

In sludge storage, over time biological activity will shift towards anaerobic activity, as the dissolved oxygen is consumed and not replaced. It is very important to limit the time sludge is stored to limit the shift to odorous decomposition.

The life cycle of the biological species that decompose wastewater in secondary treatment fluctuates based on food source. Secondary treatment systems cycle mixed liquor from aeration basin to secondary clarification and back again (with a fraction wasted as sludge). Throughout the cycle, the growth rate of the organisms rise and fall based on available food. During the higher growth periods, more emissions are generated. If wasted secondary sludge is mixed with primary sludge, starved biological activity will have a new food source and emissions will be generated. Historically, two of the four 70 ft. diameter sludge storage tanks contain primary sludge, as well as a smaller amount of thickened secondary sludge, one of the four tanks contained unthickened secondary sludge, and the 4th tank is kept empty. Separate sludge storage is important to minimize odor generation.

Unfortunately even after minimizing hold time and maintaining separate storage, odorous emissions will be generated, even if there is available dissolved oxygen. Pockets of anaerobic activity are inevitable in the sludge storage tanks and, therefore, covers and odor control systems are important. Ventilation and odor control for the storage tanks are discussed in Section 4.0.

Although the building surrounding the sludge storage tanks is typically nonodorous, since all equipment and sludge in the building are contained, there are times during operational upsets and routine maintenance when sludge can be exposed to the atmosphere if the doors remain open. Throughout the morning of the solids site visit, the garage door to the sludge storage area was left open as well as the access door on the opposite side of the building. A wind tunnel effect was occurring through this area and a significant amount of concentrated odors were being released through the garage door opening. The odors were associated with a ruptured pump in the basement that was spilling sludge on the floor. The odors were present in the basement near the pump and on the first floor where the sump pump was discharging to a sewer drain.

Thickening and Dewatering Operations

Currently secondary sludge is thickened by centrifuge (from 1-2 percent solids to 3-4 percent solids) and mixed primary and secondary sludge is dewatered via belt filter presses. The dewatering facility is operated 24 hours per day, each weekday and on approximately two Saturdays per month. Up to seven belt presses dewater combined primary and secondary sludge which is fed to the presses at an average of 2.9 percent solids. The presses average 92 percent solids capture. Over a 3- month operating period (April - June 1998), CCMUA dewatered 15,286 wet tons of sludge to an average of 24 percent solids. The dewatering facility has averaged 218 wtpd or 52.6 dtpd based on the number of days the presses are operated.

Belt filter presses are open processes with odors emitted from the movement along the belts, the pressing process, and from the liquid filtrate splashing down through the presses. The splashing creates a fine odorous mist and a very humid environment. It is possible, and CDM has recommended in certain situations, enclosing existing belt filter presses to fully capture fugitive emissions and to minimize the headspace requiring odor control treatment. The volume of air for treatment still remains quite large because of the size of a belt filter press and the space around the press that is needed to allow proper operation and maintenance.

Sludge from the transfer conveyor which brings sludge from the dewatering area and transfers it on to a short belt conveyor before emptying into the sludge storage bin has been dropping sludge onto the side wall and floor for an extended period of time. Odors in this area are excessive. Operators reported that a new scraper blade is required on the belt to prevent this condition from continuing.

Composting Operations

The 20 tunnel (50 dtpd) Simon Waste Solutions (formerly Ashbrook) composting facility began operation in February 1995. The composting system is considered an in-vessel composting technology which utilizes a horizontal plug-flow reactor also known as a "tunnel". The reactor is driven by a pneumatically operated steel ram at one end and an outfeed conveyor at the other. During loading, the ram is pulled back away from the compost and fresh mix is placed between it and the face of the compost bed. The ram is then closed, which compresses the mix and "pushes" the whole compost plug longitudinally along the reactor. Based on 14 days of retention in the tunnel, 4 to 5 "pushes" are performed each day. At the outlet end of the reactor, finished compost falls off the end of the tunnel onto an outfeed conveyor. Compost material remains in the tunnel for approximately 14 days then is either recycled or conveyed to an enclosed aerated curing area for approximately 30 days. Following curing the material is hauled to an enclosed on site storage area for approximately 90 days.

At the time of construction, the Camden facility was 250 percent larger than any other Simon Waste Solutions facility in the Country. Today the facility remains one of the two largest in-vessel biosolids composting facilities designed in the country. As with other Simon Waste Solution facilities operating in the United States, the facility has continuously experienced significant mechanical and odor control problems. These problems can be partially attributed to the scale-up of this facility. However, Camden has also been faced with technical support being extremely limited. Simon Waste Solutions went out of business shortly after start-up. Mechanical failures have limited process availability to the point where the facility is now only able to operate 6 of 20 tunnels (Tunnel Groups 3 & 5) and process slightly over 40 percent of the design loading rate. CCMUA is in the process of replacing one of six outfeed conveyors (chain & flight) with a new screw conveyor. This is expected to increase the available tunnel processing capacity from 6 to 10. As CCMUA increases production, odors in each of the processing areas will also increase. Appropriate modifications should be made to the odor control system during this change of operations. Odor Control is discussed in Section 4.0.

The compost mix loaded into each tunnel varies throughout the day. This could potentially cause a fluctuation in odors from tunnel to tunnel throughout the day. Based on experiences at other facilities, it is difficult to provide proper chemical feed to the odor control system when the inlet odor concentration fluctuates. Mechanical modifications are recommended to insure a uniform feed to each tunnel is achieved throughout the day. CCMUA has begun a project to upgrade the recycle bins with the intention of improving the operators' ability to deliver uniform feed rates.

Based on a review of 3 months of operating data (April - June 1998), the tunnel composting system does not appear to be operating as efficiently as it could. The initial mix is loaded into the tunnel at an average solids content of 40 percent and discharged from the tunnel with an average solids content of 43 percent. Typically compost solids content increases to between 55 to 65 percent in tunnel composting. The less-than-typical increase is an indication of incomplete composting. This could be caused by a combination of several factors including: improper mix ratio; lack of an adequate bulking agent; improper positive and negative aeration sequencing; and/or an inherent design flaw in the tunnel technology itself caused by the continuous compaction of material with no agitation. A further evaluation of this condition would be necessary before any further recommendations could be made.

To properly evaluate and modify the mix ratio, a mix ratio study utilizing various amendments should be completed to ensure the composting process in the tunnels is being optimized (and excess odors are not being generated). Initial observations indicate that the sawdust amendment being used may not be providing adequate porosity in the mix. Without proper porosity the compost becomes compressed through the tunnel into a "brick" which leads to air flow short circuiting and anaerobic pockets. Anaerobic pockets will result in excessive odors once the material exits the tunnels. Compound concentration and odor control are discussed in Section 4.0.

Curing Operations

Based on a review of the curing facility operating data (January 11, 1998 to July 13, 1998) the material entered the curing area at 45 percent solids and left at 59 percent solids. As discussed in composting subsection, the data indicates that the material's solids content is coming in well below what is typically expected from an "in-vessel" composting process. There also appears to be a very inconsistent increase in solids content during curing. Some piles have only gone up approximately 1 or 2 percent while others achieve over a 20 percent increase. We would expect an average increase in solids content of 10 percent during a typical 30-day curing process. This discrepancy could be caused by either an improper operational practice or inadequate aeration. It also indicates that the quality of the uncured compost is highly variable.

The blower area on one side of the curing building is a source of highly concentrated odors. At the time of the site visit only one side of the curing building was being utilized and all piles were being aerated in the positive mode. The blower corridor was dry and emissions were minimal. However, the opposite side of the curing building had recently been aerated in the negative mode and leachate had ponded on the corridor floor and in the collection troughs. The outside access door to this room was also open and highly concentrated fugitive odors were being released to the atmosphere untreated. Typically CDM recommends negative aeration to minimize the volume of odorous air to be treated. In this case, however, the facilities are already sized for either positive or negative aeration. Positive aeration is recommended at CCMUA because it would reduce leachate and maintenance issues.

The compost material across one full curing bunker was observed to be either partially built or partially taken down. In either case, aeration piping was exposed. Proper aeration air will follow the path of least resistance, so if a portion of the aeration pipe is exposed there will be no additional static pressure over that section of the pipe. The process air will short circuit through the exposed pipe and little to none of the material in the bunker will be aerated. To prevent short circuiting, each pile should be built and taken down before another is started. This would insure that aeration is provided to each pile during the entire curing period. Aeration will minimize anaerobic pockets which cause increased odors within the curing and storage buildings.

Dewatering and Compost Storage Operations

Currently unstabilized dewatered sludge is stored on the "short side" of the storage building and compost is stored on the other side. Dewatered sludge is stored on the floor of the compost storage building from 1 to 4 days, so that the best market value can be obtained for sludge hauling and disposal. During the site visit, leachate was observed draining out of the front left access door of the storage building. This leachate was coming from sludge stored in that corner of the building.

CDM highly recommends that no sludge be stored in the compost storage building for a variety of reasons. The first, as mentioned above, concerns dewatered sludge drainage. Although it is called dewatered sludge, it is still approximately 75% water. Leachate can either drain outside or into the finished compost product and thereby contaminate it. Additionally, the dewatered sludge is unstabilized. Unstabilized sludge breaks down anaerobically if stored and not aerated. The anaerobic decomposition rapidly increases odor loading to the odor control scrubbers. Reduced sulfur compounds that are moderately soluble and more difficult to treat in scrubbers (e.g. dimethyl sulfide and dimethyl disulfide) are readily formed in sludge under these conditions. Also, the sludge itself emits odors at a higher rate when it is finally reloaded for disposal and hauled off-site. Trucks hauling unstabilized sludge that has aged for an additional one to four days will be more odorous as they pass through the neighborhood. And finally, the double loading of sludge tracks sludge throughout the plant, creating fugitive odors. There really is no practical way to eliminate the tracking of sludge into the building without either eliminating the practice or creating a separate feed system. The truck tires pick up sludge in the storage building and deposit sludge from the truck loading bay to the building and down the main driveway. The practice of dewatered sludge storage in this building should be discontinued as soon as possible. Dewatered sludge cake not processed in the composting facility should be either hauled off-site immediately, or stored in a separate storage bin (similar to that located in the composting facility).

Although compost is stabilized, its storage time should also be minimized, since it will continue to breakdown anaerobically if it is allowed to sit. Compost turning is limited if the building becomes too full. This has a multiple effect on odor increase.

4

Section Four

Section 4.0
Ventilation and Odor Control Analysis

This section discusses ventilation for each covered process and existing odor control performance. An optimization study was performed on existing odor control scrubbers to determine whether the systems can be modified to operate effectively through setpoint modifications only, or if major capital improvements must be undertaken to satisfy odor control requirements.

Ventilation Introduction

In this section, organized by process, each ventilation system is discussed as a prelude, then the odor control system analysis is presented for that system. The junction chamber, preliminary treatment facility (PTF), primary clarifier aerated influent channel, four circular sludge storage tanks, dewatering facility, composting and curing operations, and compost storage building are all covered and ventilated. All but the PTF are ventilated to odor control systems and all the odor control systems except for the carbon adsorber on the junction chamber are wet scrubbing systems.

Ventilation in the compost storage building and the sludge storage tanks does not include an intake system. In the sludge storage tanks, air is drawn into the tank via the negative pressure applied to the headspace and then positively pushed through the odor control system. In the compost storage building, air is also pulled into the building from louvers located on three walls and then pushed through the odor control system. In both these systems the intake velocity (air flow divided by cross sectional area) through intake vents and louvers and any cover seams or building openings is important. If the velocity is less than about 200 feet per minute, for small openings, there is a potential for a localized positive pressure scenario caused by a strong breeze near the intake or opening which would result in fugitive emissions. Larger openings require even higher face velocities for adequate capture. Based on the difference between exhaust air flow and air intake rate for the sources with intake air supplies, a similar analysis can be performed. A velocity analysis was performed for each system.

An air exchange rate analysis was also incorporated to determine the number of times each hour the air within odorous headspaces is replaced. New Jersey regulations require that occupied wastewater treatment headspaces be evacuated either at one air change per hour (AC/hr) when they are unoccupied and 60 AC/hr when someone enters the headspace, or at 12 AC/hr continuously. It is impractical to size odor control systems for intermittent use, so continuous ventilation is utilized in this analysis. Sludge storage tanks, the primary influent channels, and the junction chambers which are unoccupied areas can be ventilated at rates lower than 12 AC/hr. However, the higher the odor concentration within headspace, the greater the corrosion potential. Also electrical equipment will have to be designed to a different standard. Each air exchange rate is discussed, by process.

Scrubber Introduction

Optimization of the scrubber systems involves determining the current system setpoints, evaluating the emissions at the current setpoints, offering alternative setpoints, and piloting these alternate setpoints.

Currently, scrubbers are used to control odors from five processing areas. These areas include liquid sludge storage, sludge loading, composting and dewatered sludge storage/loading area, curing area, and composting tunnels. Each of these areas employ different scrubber systems for odor control. A brief description of wet scrubbing and important opening parameters is included prior to discussions of the individual systems at CCMUA.

Odorous gases can be removed from an air stream by absorption into a liquid medium. Once the gas is captured, it may be eliminated either by chemical oxidation or disposal of the adsorption/ absorption medium. The two most common types of liquid-absorption odor scrubbers are:

- Packed-tower Scrubbers
- Mist Chamber Scrubbers

If given sufficient time, the vapor-phase and liquid-phase concentrations of a specific gas will equalize in a closed system. The distribution of a gas between the air and a liquid with which it is in contact follows Henry's Law in most cases of odor control. Henry's Law expresses the absorption limits of a gas in terms of equilibrium in dilute systems. The greater the departure from equilibrium conditions between the air and contacting liquid, the greater the driving force for absorbing the gas. Oxidants further increase the driving force and absorption rate for hydrogen sulfide by oxidizing the dissolved sulfides to sulfur and, if enough oxidant is present, to sulfate.

Acid compounds require an absorption medium with a high pH. Basic compounds require an absorption medium with a low pH. In instances where multiple acidic and basic odor-causing compounds are present, a multi-stage scrubber system using both high- and low-pH solutions may be required.

A brief description of both packed towers and mist scrubbers is offered below. Although only mist chambers were installed at CCMUA, packed towers were specified in some cases and the draft air permits were filed accordingly. An understanding of packed-tower scrubbers will offer insight into necessary permit modifications.

Packed-tower Scrubbers

Packed-tower scrubbers have achieved high levels of hydrogen sulfide and ammonia removal over a wide range of air flow rates in wastewater process off-gas treatment, but have had limited success in removing VOCs. Typical hydrogen sulfide removal efficiencies range from 50 to 99 percent. System configurations for packed-tower scrubbers range from multi-stage systems that use both absorption and oxidation to remove air contaminants to single-stage systems or systems that do not use oxidants.

Packed-tower scrubbers have been used extensively for odor control at wastewater treatment plants lift stations and pump stations. Packed towers can handle high air flow rates and high influent-odor concentrations. As much as 99.9 percent of the hydrogen sulfide can be removed with properly designed packed-tower systems. Costs for packed-tower scrubber systems vary depending on the number of stages and the concentration of odors to be treated. Additional costs may be incurred if the equipment and storage tanks must be housed inside, if heat tracing is required, or if noise-control measures are included in the design.

General Description. Packing provides large interfacial contact between the air and absorbing solution, which enhances the transfer of constituents from the air to the liquid stream. The absorbing solution enters at the top of the tower, cascades down through the packing, and falls into a sump at the bottom of the tower. The absorbing solution then is pumped back to the top of the tower. A make-up stream replaces liquid lost due to evaporation and removal of spent absorbing solution (blowdown).

The blowdown stream removes absorbed constituents to minimize the build up of dissolved solids, sulfides, and other contaminants removed from the air stream. Continuous blowdown is recommended to maintain fresh scrubbing solutions and lessen scale formation.

Packed-tower scrubber systems have been used in a variety of configurations. The number of scrubber stages required and the type of scrubbant used depends on the concentration and type of contaminants in the odorous air stream that will be treated. Caustic scrubbers provide excellent hydrogen sulfide removal and treat a number of other species which are acidic in solution. Acid scrubbers provide excellent ammonia removal, but may strip off hydrogen sulfide odors. Oxidants provide treatment to the widest range of compounds.

Headworks facilities, which typically produce primarily sulfide odors, usually require caustic scrubbers that also use an oxidant. A two-stage system may be used for high hydrogen sulfide concentrations: the first stage typically uses high-pH absorption and the second stage uses neutral to high-pH absorption and oxidation. Solids-handling facilities frequently produce both ammonia and sulfide odors. In this situation, a first-stage acid scrubber may be used to remove ammonia before the second-stage high-pH absorption and oxidation scrubber removes the sulfides. In many cases, however, a neutral first stage (water only) will provide enough ammonia removal to eliminate the need or an acid first stage and neutralization of any acid carryover into the second stage. Acid carryover into a high pH stage consumes chemicals for neutralization.

Operating at an excessively high pH should be avoided. At a pH greater than 10, a caustic absorption scrubber will begin to form carbonate scale from atmospheric carbon dioxide. Increasing pH above 10 markedly increases caustic consumption.

Design Considerations. Successful designs for packed-tower scrubbers require that the following goals be met:

- a scrubber environment that enhances mass transfer of odors from the foul air to the scrubbant by optimizing blowdown
- contact time for the scrubbant and gas so odor removal goals can be met
- good liquid distribution onto and through the packing
- account for air pressure loss through the scrubber when sizing fans
- appropriate scrubbant chemicals
- release of odors from blowdown

- adequate scrubbant feed controls

Continuous blowdown is recommended to reduce scale formation on the packing and thus maximize the efficiency and minimize the chance of structural failure of the media. Because high blowdown rates will waste chemicals and water, blowdown rates must be optimized. Regular cleaning of the packing and provision to add an acidic cleaner is recommended.

Mist Chamber Scrubbers

Mist scrubbers use a very fine mist or fog to increase the available surface area for transferring odorous constituents from the gas stream to the scrubbant solution. Mist particles in the range of 5 to 20 microns are typically the most effective for mass transfer of air contaminants to the scrubbants. Odorous air is introduced into the top and exits out the bottom of the mist chamber (or vice versa). Contact time range is 5 to 30 seconds. Typical hydrogen sulfide removal rates are 90 to 95 percent at a 10-second detention time.

Scrubbant solution is introduced into the chamber by specially designed proprietary atomizing nozzles. The Calvert atomizing nozzle requires a high air flow with a moderate pressure demand. The Quad nozzle requires a much lower air flow with a much higher pressure demand (50-70 psi). Actual air pressures at CCMUA fluctuate because of demand but average about 50 psi. Therefore, at times the air pressure is not enough to create adequate mist. The liquid passage of the Quad nozzle is quite small and more susceptible to plugging than the Calvert nozzle. Cleaning plugged nozzles includes either feeding acid through the nozzles or removing the nozzles and soaking them in a mild acid solution. If air pressure demands can not be met, CCMUA may consider replacing the nozzles with a more generic nozzle such as the Bete nozzles used in the Bionomics system. Bete manufacturers many different nozzles that operate at different pressures, flow rates and pressures.

For sulfide odors, the scrubbant solution typically consists of caustic soda and sodium hypochlorite. Chemicals are typically added to the scrubbant solution water at a dilution panel located upstream of the atomizing nozzle. Scrubbant solution water is typically softened to reduce calcium carbonate scaling of the atomizing nozzle. The liquid flow for both the Calvert and Quad systems is 0.75 gpm per nozzle. If the air stream is particularly dry, evaporation will be excessive and multiple nozzles may be required to supersaturate the air stream. For example, at 10,000 cfm, 70° F, and 40 percent relative humidity, 0.75 gpm of liquid flow through one nozzle would raise the relative humidity to approximately 90 percent and an additional nozzle would be necessary.

Mist scrubbers can be arranged in single- or multi-stage configurations. Multi-stage configurations typically are used when a single scrubbant liquid cannot remove all odor constituents simultaneously. For example, when both ammonia and sulfides are present, a first-stage acid scrubbant is used for ammonia removal and a second-stage caustic/oxidizing scrubbant is used for sulfide removal. In general, the number of scrubber stages and the type of scrubbant selected for each stage are determined in the same manner for both packed-tower and mist scrubbers. However, when staging mist scrubbers, a mist eliminator is necessary between stages to reduce chemical carry-over. A mist scrubber system typically includes the following components:

- Scrubber tower
- Atomizing nozzle
- Mist eliminator
- Scrubber fan
- Chemical-feed system
- Air compressor/Positive Displacement Blower
- Water supply system
  - City water
  - Water softener
- Control panel

Design Considerations

There is no technique for sizing atomized-mist systems in the public domain. The manufacturers are not willing to disclose their procedures for sizing the system. The required chamber contact time is a function of influent odor concentration. Required contact time increases dramatically with greater hydrogen sulfide concentration.

Because of the uncertainty about mist-system sizing, it is advisable to have the manufacturer commit to a contact time and a removal efficiency during design. The contact time should be specified as a minimum contact time to prevent the manufacturer from under sizing the system in order to submit a lower bid. Other factors to be considered with mist scrubbers are:

- Short circuiting: The scrubber design must ensure that air-flow patterns allow full use of available contact volume. Short-circuited air flow in the contact chamber will reduce the efficiency of the scrubber. Short circuiting can be prevented by proper sizing of the vessels and placement of nozzles.

- Odor-concentration parameters: The maximum odor concentration must be properly determined and specified. No excess chemical is available for treating unusual peaks in odor concentration.

- Scrubber-control system: Because the mist system tries to match chemical feed exactly to system demand, the controls must be accurate and carefully designed. Typically, the control system is provided by the manufacturer and is based on pH. The mist scrubber is less capable of handling fluctuating odor concentrations than the packed-tower scrubber, unless the scrubber is oversized and is routinely operated with excess chemical feed.

- Mist-elimination system: Because the droplets are very small, they are difficult to remove with conventional mist-elimination systems. If not adequately demisted, the supersaturated exhaust can form "rain" during some meteorological conditions. Mist-elimination systems include mesh demisters and exhaust heaters.

Chemical Reaction Background

An understanding of chemical reactions that work to reduce odorous compounds is important to better interpret the different optimization alternatives. Many chemical reactions occur in chemical absorbers (commonly called wet scrubbers). In odor control we are most concerned with reactions for lightweight sulfur and ammonia compounds. The reactions of concern are designed to decompose the contaminants into aromatically inert byproducts in an aqueous solution, so that the concentration of the contaminant does not accumulate in the liquid stream and prevent air/liquid transfer. Transfer rate will slow down as the contaminant concentration approaches the saturation limits.

Understanding treatment alternatives is key to designing an effective strategy for odor control. Contaminant reactions addressed include in order of importance: Hydrogen Sulfide; Mercaptans; Dimethyl Sulfide(s); Ammonia reacting with Sodium Hypochlorite; Caustic (Sodium Hydroxide); and Hydrogen Peroxide. Possible side reactions of importance are also discussed.

Hydrogen sulfide is highly reactive, and so is fairly easy to remove in scrubbing applications. If the concentration is greater than from 5 to 10 ppm in the inlet stream, more than one stage of treatment may be necessary. Hydrogen sulfide is acidic in nature and therefore easily removed in a basic chemical environment by a neutralization reaction such as with a strong base, such as sodium hydroxide. The sodium and sulfur ions are highly soluble in water and are not rate limiting.

Reaction of H_2S with Caustic (Sodium Hydroxide - NaOH):

$$2NaOH + H_2S \text{ ------> } Na_2S + 2H_2O$$

Oxidation of H_2S to sulfur dioxide which bubbles off as sulfate is another alternative. Sulfate is also highly soluble in water and not rate limiting. With Sodium Hypochlorite (NaOCl) a number of reactions occur simultaneously:

$$NaOCl + H_2S \text{ ------> } S^0 + NaCl + H_2O$$

$$3NaOCl + H_2S \text{ ------> } SO_2 + 3\,NaCl + H_2O$$

$$4NaOCl + H_2S \text{ ------> } 4NaCl + H_2SO_4$$

$$NaOCl + H_2O \text{ <------> } Na^+OH^- + HOCl$$
$$8Na^+ + 8OH^- + 8HOCl^- + H_2S \text{ -----> } 8NaCl + 6H_2O + SO_4^{2-} + 6OH^-$$

$$3\,NaOCl + HS^- + H_2O \text{ ------> } H^+ + SO_4^{2-} + 3NaCl$$

$$H_2S + H_2O \text{ <-------> } HS^- + H^+ + H_2O$$
$$HS^- + 4NaOCl \text{ -----> } SO_4^{2-} + 8HCl + H^+$$

Sodium hypochlorite has a strong influence on pH when dissolved in water, while hydrogen peroxide, a nonpolar compound, does not. Also, unlike sodium hypochlorite, residual hydrogen peroxide, since it is a nonpolar compound, can not be measured with oxidation reduction potential. With Hydrogen Peroxide (H_2O_2) there are different reaction mechanisms depending on the pH. In basic environments the mechanisms are:

$$Na_2S + 4H_2O_2 \text{ ------> } Na_2SO_4 + 6\ H_2O$$

$$H_2S + 4H_2O_2 \text{ ------> } 4H_2O + H_2SO_4$$

In neutral environments the reaction is:

$$HS^- + H_2O_2 + H^+ \text{ -----> } 1/8\ S^0 + 2H_2O$$

And in acidic environments (not usually used in scrubbers because of its long detention time)

$$H_2S \text{ <------> } H^+ + HS^-$$
$$H_2O_2 + H_2S \text{ ------> } S + 2H_2O$$

In most scrubbers, once ammonia has been reduced, the primary goal is to reduce hydrogen sulfide, so a basic environment is employed by adding caustic and hypochlorite. If hydrogen peroxide is added to this situation, side reactions will consume both hypochlorite and peroxide.

$$NaOCl + H_2O \text{ ------> } HOCl + NaOH$$
$$H_2O_2 + HOCl \text{ ------> } HCl + H_2O + O_2$$

Hydrogen sulfide will also react with any oxygen that is available in the waste stream. A percentage of the liquid stream is always wasted to remove salts and also to add water that has some dissolved oxygen in it. Hydrogen peroxide will also add oxygen to a system. Oxygen will oxidize hydrogen sulfide as follows:

$$H_2S + 2O_2 \text{ ------> } SO_4^{2-}$$

The other sulfur compounds of concern are mercaptans and the dimethyl sulfide(s). They are not as heavily influenced by a high pH. In fact, they are more soluble in water in neutral pH, so basic environments closer to neutral pHs are preferred. Care must be taken to not operate at acid environments, since sulfur compounds will change form and create more complex compounds. For example, mercaptan will form dimethyl disulfide in an acid environment with peroxide present, as follows:

$$2\ RSH + H_2O_2 \text{ ------> } RSSR(\text{Dimethyl Disulfide}) + 2H_2O$$

However in basic environments Mercaptan (RSH) will react as follows:

$$RSH + 3H_2O_2 \text{ -----> } RSO_3H + 3H_2O$$

$$RSH + 3H_2O_2 + OH^- \longrightarrow RSO_3^- + 4H_2O$$

Dimethyl Disulfide (DMDS - CH_3SSCH_3) will also react with peroxide or available hydroxide in an basic environment to form less odorous compounds as follows:

$$CH_3SSCH_3 + 5H_2O_2 + 2OH^- \longrightarrow 2CH_3SO_3^- + 6H_2O$$

$$CH_3SSCH_3 + OH^- \longleftrightarrow CH_3SOH + CH_3S^-$$
$$CH_3SOH + OH^- \longleftrightarrow CH_3SO^- + H_2O$$
$$3CH_3SO^- \longrightarrow CH_3SO_3^- + CH_3CH_2S^-$$

Many treatment alternatives are optimized in radically different environments. (i.e. Acidic vs. basic) Certain alternatives, particularly those involving sodium hypochlorite, are capable of fostering side reactions which can produce undesirable compounds in the effluent. Other reactions yield products which are capable of changing the environment of the reaction (from basic to acidic, for example). Changes in the theoretical dosages can impact the products obtained. For example, adding 1 equivalent of peroxide per equivalent of H_2S removed yields elemental sulfur and water. Increasing peroxide dosage to 4 equivalents yields water and Sulfuric Acid. These effects must be taken into consideration when determining field dosing rates for H_2S.

Possible side reactions can also impact the actual dosage rates for chemical additives. Peroxide and hypochlorite are both capable of oxidizing a variety of compounds. It is also plausible that during the course of some of these reactions, chlorine could be freed and released as a gas. Chlorine also reacts with the organisms in the waste stream. Caustic may react with acid or any acidic byproducts (like HCl or H_2SO_4).

Ventilation and Odor Control Systems

Existing ventilation and odor control for the junction chamber, preliminary treatment facilities (PTF), sludge storage tanks, dewatering and thickening operations, composting and curing operations, and compost storing operations are discussed in this subsection. All systems were first set to the current permit setpoints establish baseline operating effectiveness. Systems were then temporarily adjusted to optimize performance. These modifications, if effective, should form the basis for requesting to permit modifications from DEP. The current odor control configuration is shown in Figure 4-1.

The Junction Chamber

The junction chamber is sectioned into three areas: a west side wet well, a dry well and an east side wet well. The two influent sewers enter in the east side. An enclosed pipe carries the flow to the west side. From the west side enclosed pipes carry the flow to the PTF building. At the present time, there is an activated carbon adsorption unit in place to handle the odors from the east side of the chamber. The maximum headspace in east side is approximately 5,400 cubic feet. A 700 cfm fan is used to pull the odorous air from the east side of the wet well and treat it in the carbon unit. Based on the volume and 700 cfm being drawn, there are approximately 8 air changes per hour in that side of the wet well.

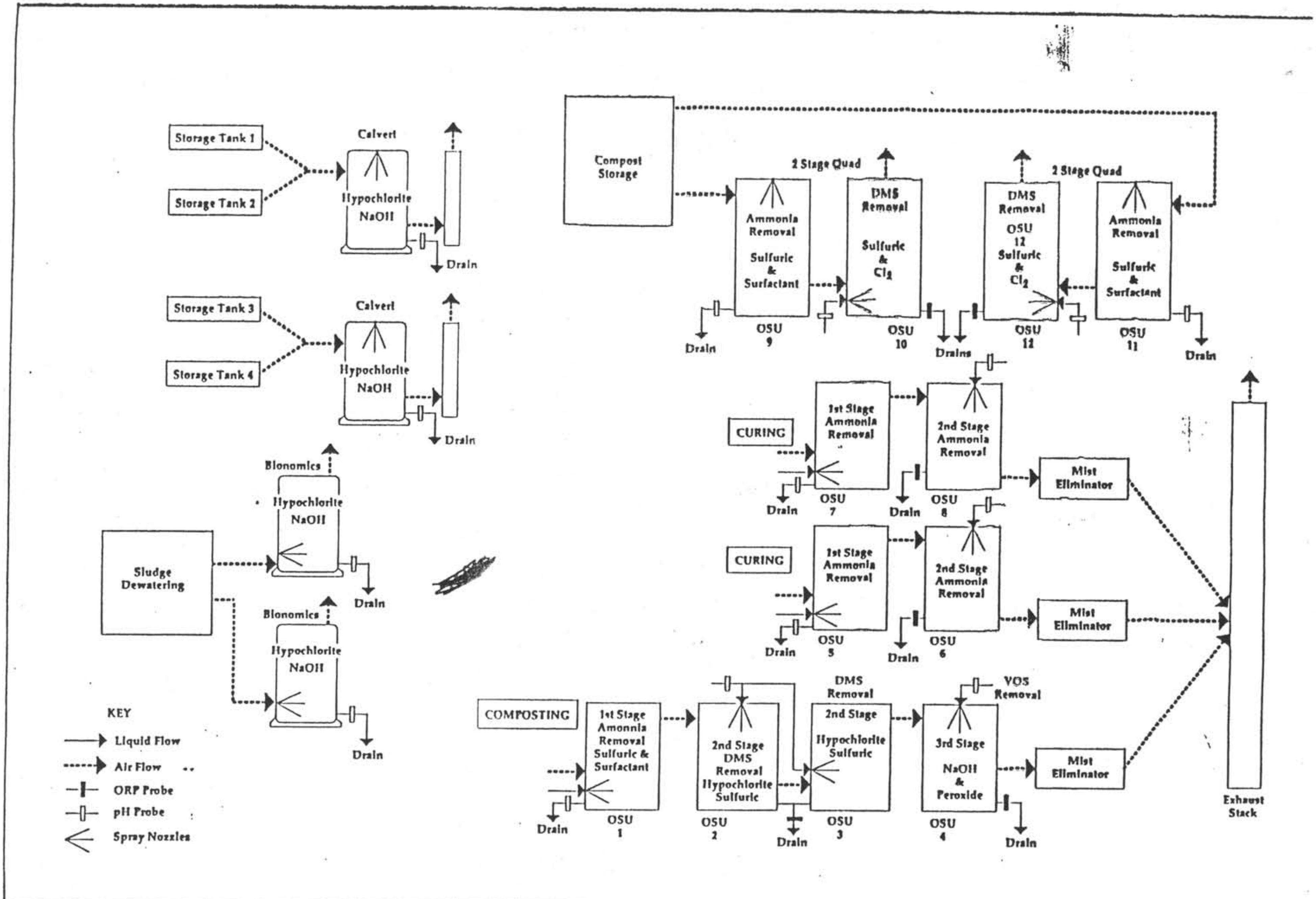


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Figure 4
Existing Odor Control Systen

Early in the morning, on many occasions, there was a "rotten egg" odor throughout the parking lot. There is a strong downwash effect from the PTF building, so it is impossible to assess the true impact of the west side wet well on the parking lot odors, but since there is a large amount of turbulence and no odor control, it is highly likely that this area adds detectable odor to the area. The headspace in the west side is approximately 2,100 cubic feet and would require 210 cfm of ventilation at approximately 6 AC/hr. Alternately, the odors in this area may be from the PTF. This should be further addressed during the design phase of the PTF improvements.

The Preliminary Treatment Facility

The PTF houses screenings removal equipment screenings and grit storage, a wet well and channels that feed the grit chambers in the odorous side of the building. Intake air is heated in the nonodorous side of the building. The odorous side of the building contains approximately 220,000 cubic feet of headspace and is ventilated at up to 61,500 cfm from building roof vents. The maximum air exchange rate is 17 air changes per hour (AC/hr). All fans on the roof do not operate at all times, however.

Odors from a preliminary treatment facility are primarily hydrogen sulfide emissions, since any reduced sulfides that have been generated in the collection system are first exposed to the atmosphere (inside the building). Other sulfur-containing compounds such as mercaptan and dimethyl sulfides are typically created in sludge streams where the organic concentration is greater, therefore their concentrations at preliminary treatment facilities are not a major concern.

Typically, wastewater plants located in residential areas or plants with neighbors as close as in Camden, are designed today with odor control on the liquid side of the plant from the influent chambers/pump stations through grit removal and sometimes through primary treatment. In some rare cases, odor control includes the aeration basins, and even less frequently, the entire plant includes odor control. Odor control is necessary for the PTF area based on comparisons to other facilities but more importantly, because the hydrogen sulfide level measured through the roof vents exceed 50 to 100 ppm. At concentrations of 100 ppm hydrogen sulfide more than 100,000 units of fresh air are needed to dilute the sample to less than detectable in the neighborhood. It is impossible to achieve this dilution rate at the distance of less than two blocks to the first set of houses. Odor control is required and should be designed around a continuous airflow of 12 AC/hr or 43,000 cfm.

Primary Clarifiers Aerated Influent Channel

Assuming that the channel is aerated at approximately 5 cfm per foot to maintain suspension. There are two channels, one approximately 234 feet long and the other 416 feet long. The total aeration rate is approximately 2,000 cfm. The covered channel should be ventilated at approximately 3,500 cfm to maintain a negative pressure in the channel. With the channels each six and a half feet wide approximately 4,200 square feet of metal or fiberglass cover will be needed to enclose the channel. The actual coverage will be slightly less. The aerated channel should be grouped with the PTF building for odor control, since it is fairly close and there will be no duct interferences. The exhaust duct will be run along the surface of the tank and up to join the PTF exhaust emissions on the roof wherein both will be sent to odor control.

The Sludge Storage Tanks

Each of the four covered sludge storage tanks contains 110,000 cubic feet of headspace when empty and 34,000 cubic feet of headspace when full. Each is ventilated at up to 8,000 cfm from building roof vents. The air exchange rate is 14 AC/hr when full and 4 AC/hr when empty.

There are over 700 feet of cover seams on the recently replaced covers that account for over 7 square feet of area based on an average width of 1/8 inch, and over 31 square feet of surface area for all five intake vents. The average leakage velocity is therefore 1,000 feet per min (ft/min) with the vents closed airtight or 210 ft/min with the vents entirely open. CDM recommends between 200 and 400 ft/min to overcome external wind influences and maintain effective odor containment. The lower velocity (200 ft/min) will maintain odor capture at small openings such as tank cracks and closed dampers, while the larger velocity (400 ft/min) is necessary for larger openings such as doors and louvers. Since the velocity for the full open scenario is approximately one half the desired velocity, proper air balancing should be performed and the intake vents should be only partially open.

The odor control system for the sludge storage tanks consists of two single-stage Calvert mist systems ("Calvert-1" for tanks 1 & 2, and "Calvert-2" for Tanks 3 & 4). Only Calvert-2 was sampled, since Calvert-1 was not operating normally. Tank 1 was drained for cover replacement during both sampling events. The cover systems are being replaced because the previous covers were too shallow and their support structure failed. The new covers will be deeper. This will create a larger headspace. This larger headspace and the same ventilation rate will result in a lower air change rate per time. The lower air exchange rate will not be of concern however, since the new air change rate will be above 14 AC/hr with the new covers. Since the air exchange rate is so high, it could be possible to reduce the flow rate and still receive adequate capture through the tank cover seams with proper intake vent balancing. Air flow should not be reduced however, without consideration for the increase in concentration, the potential for corrosion, and impact to the odor control systems.

The odor control systems use caustic and hypochlorite addition, but because of the permit setpoint requirement of 8 pH and the pH of a hypochlorite solution between 8 and 9.5 pH, caustic is almost never added. If it were added, the pH would rise and there would be no room for hypochlorite without exceeding setpoint requirements. Single stages are most effective for overall wastewater odor removal with a pH setpoint of greater than 10.

The scrubbers were examined and sampled on two separate occasions. From interviews with operations staff the sludge was "older" and "stronger" than typical during the first round of sampling. Odors from sludge that is both older and stronger will generally be higher than average. The sludge was older than usual because of sludge processing equipment repair shutdowns. The stronger odors were also related, in part, to a select group of industrial dischargers that were temporarily exceeding their discharge permit limits. The sludge age and stronger odorous precursors in the sludge led to higher sludge concentrations, and therefore higher than typical odor emissions.

The second sampling event in July was also during the Delta Fiberglass replacement cover installation. Odors were considered typical by Operations staff during the second sampling event. Table 4-1 lists the

Table 4-1
Sludge Storage Tank Scrubber
Sulfur Compound Removal

Odorant	Location	Units	Permit Scenario	Modified Scenario	
			Calvert-2 Liquid Sludge Storage (tank 4) 18-Jun	Calvert-2 Liquid Sludge Storage (tank 3) 22-Jul	Calvert-2 Liquid Sludge Storage (tank 4) 22-Jul
Hydrogen Sulfide (H2S)	Inlet	(ppb)	43000	1600	1700
	Outlet	(ppb)	19000	14	14
	Removal	(%)	56%	>99%	>99%
Carbonyl Sulfide (COS)	Inlet	(ppb)	ND(16)	17	14
	Outlet	(ppb)	ND(17)	7	7
	Removal	(%)	NA	59%	50%
Methyl Mercaptan (CH3SH)	Inlet	(ppb)	490	17	31
	Outlet	(ppb)	68	9.8	9.8
	Removal	(%)	86%	42%	68%
Dimethyl Sulfide (DMS)	Inlet	(ppb)	160	ND(8)	ND(8)
	Outlet	(ppb)	ND(17)	ND(4)	ND(4)
	Removal	(%)	>89%	NA	NA
Carbon Disulfide (CS2)	Inlet	(ppb)	78	22	24
	Outlet	(ppb)	ND(17)	ND(4)	ND(4)
	Removal	(%)	>78%	>83%	>13%
Dimethyl Disulfide (DMDS)	Inlet	(ppb)	ND(16)	ND(8)	ND(8)
	Outlet	(ppb)	ND(17)	ND(4)	ND(4)
	Removal	(%)	NA	NA	NA

NA = Not Applicable

sulfur compound results for the two sampling scenarios. The first scenario was operated within the current permit limitations while the second scenario was operated with modified setpoints. The setpoints are listed in Table 4-2. The inlet pH was raised from approximately 8 to 10 in the scrubber blowdown (liquid effluent) stream while the ORP was lowered from approximately 800 to 700. Ideally the ORP would be lower (400-500 in a single stage) to prevent chlorinated odors from entering the neighborhood, but in this case, the scrubber is required to operate at a highly efficient rate to satisfy the odor control needs.

Samples from the Calvert system were taken at both the inlet and outlet of the scrubber. During the first sampling event only one half of the scrubber inlet was measured (after the fan for Tank 4). During the second event, samples were taken from both the inlet stream from Tank 3 and Tank 4.

Hydrogen sulfide was measured with portable Jerome meters while the other sulfur compounds, also shown in Table 4-1, were sampled and analyzed at a laboratory. There is no cost effective portable meter that can detect the sulfurous organic compounds of concern in the field. While it is possible to sample and analyze for hydrogen sulfide in the laboratory, it is a highly reactive compound that is more accurately measured immediately in the field. The other sulfur compounds are more stable and can accurately be measured within 48 hours of sampling. The Jerome readings yielded peak readings of over 50 ppm of hydrogen sulfide entering the scrubbers during the "greater than average" first sampling event (and a bag sample result of 43 ppm), and only 1.7 ppm during the average readings, because of the large discrepancy in readings, only general conclusions can be drawn from the comparison. What is clear, however is that even with the lower loading mercaptan and dimethyl sulfide in the typical scenario, outlet concentrations were greater than the odor detection thresholds. Methyl mercaptan outlet concentrations, ranging from 9.8 to 68 ppb, were much greater than the detection threshold which is less than 1 ppb.

Initially, the inlet sample had a Tedlar bag hydrogen sulfide concentration of 43 ppm, while the outlet bag sample had a 19-ppm concentration. The percent removal was then about 40 percent. Normal H_2S removal will exceed 90 percent in a single-stage scrubber with other compounds present, so it appears when the level is that high, the system is overloaded. Additional removal at the high concentration may have been gained by increasing the pH setpoint.

During the second scenario, the inlet concentration was 1.7 ppm, which was much less than before. At this inlet concentration and with the setpoint modifications, the system operated well with respect to hydrogen sulfide removal.

With only one tower, there can only be one set of operational parameters. As was demonstrated in the reactions section, the reaction mechanisms change at different pH. Unfortunately, hydrogen sulfide removal is optimized at a high pH, while dimethyl sulfide and mercaptans are more soluble and therefore easily removed at a neutral pH. Hydrogen sulfide is by far the most prevalent and odorous compound in odor control. It must be removed first, or odor control will never be considered successful. Only after removed, can the focus be adjusted to other compounds. Therefore, the removal rate for other sulfur compounds is typically less than optimal for a single-stage tower.

Table 4-2
Sludge Storage Tank Scrubber Setpoints
(Field Measurements and In-Line Probe Measurements)

			Permit Scenario	Modified Scenario
			Calvert Sludge Storage Single Stage 18-Jun	Calvert Sludge Storage Single Stage 22-Jul
Inlet pH	Measured	(unitless)	11.1	13.2
	Probe	(unitless)	no probe	no probe
Outlet pH	Measured	(unitless)	8.2	10.2
	Probe	(unitless)	8.2	10
Inlet ORP	Measured	(mV)	563	460
	Probe	(mV)	no probe	no probe
Outlet ORP	Measured	(mV)	816	692
	Probe	(mV)	no probe	no probe

Methyl mercaptan was detected in the outlet stream during the first and second scenarios. It has an extremely low odor detection level and smells like rotten cabbage. There have been many studies done to determine the actual odor threshold of methyl mercaptan with varying results. Of the four tests that were considered superior, the most conservative result suggests that methyl mercaptan can be detected by the human nose down to 2 parts per trillion (ppt), while the least conservative suggests a 41 ppb (41,000 ppt) limit. This is an extremely large range. From actual field experience, CDM believes that the value is closer to the lower limit. Previously, CDM personnel have identified mercaptans in ambient air downwind of an odorous sources, taken samples and had them analyzed and found that the values were less than the 4 ppb analysis limit. Assuming the lower detention threshold, even at the lowest outlet concentration of 7 ppb, the outlet concentration must be diluted over 1,000 times before it is not detectable offsite. At the higher outlet concentration measured at 68 ppb, it is detectable through the full range of limits and would need to be diluted 10,000 times before it could not be detected offsite.

In addition to removal concerns in the scrubber, there are stack dispersion issues. The stack on the Calvert system is not tall enough to eliminate the downward wind forces from air traveling over the tanks (commonly called downwash). Downwash causes the stack plume to prematurely touch down relatively close to the stack. The dispersion is also inhibited by low exit velocity and therefore low buoyancy. Dispersion could be enhanced by reducing the exit diameter with a cone, but the stack height would still be low when compared with the surrounding buildings, tanks, and other odor control systems.

Tower mist emissions are also a concern from both Calvert units. Mist currently exits the towers and is clearly visible throughout the day. In the early morning hours, it was possible to actually see a plume of mist travel from Calvert-2 offsite. The mist creates numerous problems. First of all it is odorous. Depending on the percentage of free chlorine it can exhibit odors ranging from chemicals from a swimming pool to rotten chemical discharge. It is a distinctive odor that most residents without knowing anything about it would describe instinctively as harmful because of its odor character. Another problem is corrosion from the mist, since chlorine is present. And the final problem is that without capturing the mist, full removal is not obtained. Odor trapped in the emitted mist evaporates, causing odorous impacts off-site.

Thickening/Dewatering Operations

Thickening, dewatering and dewatered sludge loading are performed in the same building. Secondary sludge is thickened via centrifuges and then stored in the sludge storage tanks. The centrifuge area is ventilated directly to the atmosphere through roof vents, since the centrifuge is not odorous.

Mixed primary and secondary sludge are dewatered via belt filter presses in a room that contains 145,700 cubic feet and is ventilated at 48,800 cfm (or 20 AC/hr). The room is supplied with 48,800 cfm of intake air, therefore there is no negative pressure in the building and any open windows or doors will release odors. During the site visits, the roof top hatch was open continuously and was a source of fugitive emissions.

The sludge is dewatered and then passes either into the composting storage bins or is directly loaded into trucks in one of two truck bays. Currently there are doors on one side (north) of the truck bays and trucks are moved in and out of the other (south) side of the bay. There is no odor control associated with this area. Ambient hydrogen sulfide measurements of greater than 100 ppm were measured in the doorway near the trucks during loading. This area is in dire need of odor control, especially after the other two (proposed) doors are installed, since the area will then have to be ventilated. Ventilation for the dewatering room could be partially redirected to the truck loading bay if centrifuges were installed to replace the belt filter presses.

The Bionomics system for the dewatering building is operating effectively at the current flow rate. The operating permits require that the pH levels be between 7.5 and 9 with no specification for ORP. When the system samples were taken, the pH was recorded at 9.11 for the outlet of the #2 Bionomics tower which corresponds to the inside reading of 9, as the permit requires. The sample results are shown in Table 4-3 and the operating parameters are shown in Table 4-4.

The inlet results were much higher than the norm, but consistent with the levels measured in the sludge storage tanks. Even at the higher than typical loading, the towers were extremely effective at removing hydrogen sulfide. No additional odor control is needed for the dewatering building, but the potential to redirect some of the air for the truck bays will be discussed in Section 5.0.

Composting and Curing Operations

For the composting operations, intake air is heated in the nonodorous side of the building and used to ventilate non-process areas and the composting tunnels. The twenty odorous tunnels contain 248,400 cubic feet and are ventilated at up to 42,000 cfm to the odor control system. An additional 6,000 cfm is pulled from other areas of the building to make up the total 48,000 cfm in the "Heavy Plenum" that is sent to a four-tower odor control system. There is little to no ventilation from the basement area where the chemical feed pumps are located.

Unlike the composting building, where the building is sectioned into many areas were air is reused for ventilation, the curing building is essentially one large room. The odorous room contains 306,000 cubic feet and is ventilated from 34,300 cfm up to 68,500 cfm to the odor control system. Of the exhaust rate, 7,000 cfm is blower air to aerate the piles. The remainder comes from a variety of sources. The exhaust air and a separate conveyor, that is ventilated at 6,400 cfm, are sent to the "Medium Plenum" with an additional 22,900 cfm from a number of composting building conveyors. The conveyor systems were designed for 21 cfm/ft of covered conveyor. The remaining air (up to a total of 96,000 cfm) is pulled from the composting basement. (Note that if the curing area fan is operating at high flow, the air flow exceeds the 96,000 cfm that is being drawn through the two two-stage scrubbers and the building will become positive and no air will be withdrawn from the basement.) At the highest exhaust rate, the curing area air exchange rate is 13 air changes per hour (AC/hr).

The odor control system for the composting and curing areas were designed for removal of over 200 ppm of ammonia from 20 tunnels. The operating permit conditions and setpoints are based on high levels. Since less than 50 percent of the tunnels are active, the permit conditions do not optimize removal of the compounds present.

Table 4-3
Dewatering Building Scrubber
Sulfur Compound Removal

Odorant	Location	Units	Bionomics-2 Dewatering Building
Hydrogen Sulfide (H2S)	Inlet	(ppb)	>50000
	Outlet	(ppb)	20
	Removal	(%)	>99.96%
Carbonyl Sulfide (COS)	Inlet	(ppb)	ND(4)
	Outlet	(ppb)	5.4
	Removal	(%)	<-35%
Methyl Mercaptan (CH3SH)	Inlet	(ppb)	260
	Outlet	(ppb)	ND(9)
	Removal	(%)	>97%
Dimethyl Sulfide (DMS)	Inlet	(ppb)	84
	Outlet	(ppb)	ND(4.0)
	Removal	(%)	>95%
Carbon Disulfide (CS2)	Inlet	(ppb)	150
	Outlet	(ppb)	7.5
	Removal	(%)	95%
Dimethyl Disulfide (DMDS)	Inlet	(ppb)	ND(20)
	Outlet	(ppb)	ND(4)
	Removal	(%)	NA

Table 4-4
Dewatering Building Scrubber Setpoints
(Field Measurements and In-Line Probe Measurements)

			Permit Scenario
			Bionomics-2 Dewatering Building
Inlet pH	Measured	(unitless)	11.6
	Probe	(unitless)	no probe
Outlet pH	Measured	(unitless)	9.11
	Probe	(unitless)	9
Inlet ORP	Measured	(mV)	580
	Probe	(mV)	no probe
Outlet ORP	Measured	(mV)	802
	Probe	(mV)	no probe

Also because of pH probe locations and the lack of demisters between stages, the sulfuric acid added to maintain the permit setpoints is exaggerating the effect of the inaccurate setpoints. The pH probe in all but the first stage of each tower is in the inlet to the tower and not the blowdown. Inlet pH is not nearly as important as outlet pH. Outlet pH is an indication of whether additional reactants are needed. All pH and ORP probes should be located in each scrubber liquid outlet.

Because there are no demisters between stages, unreacted mist carried between stages will affect the equilibrium of the downstream tower. Therefore any unreacted sulfuric acid mist will carry over with the airstream into the next stage. Since the pH of the next stage is being measured prior to the scrubber, the effect of carryover is not monitored. This phenomenon is increased as the pollutant concentration decreases. Because of the tower design where the spray nozzles and flow alternate for upflow and downflow and the tight tower spacing, neither internal nor external demister installation is practical.

Other physical scrubber modifications for the composting and curing scrubbers, such as converting them to packed towers and replacing the nozzles were considered but dismissed. The nozzles create a fine mist that can not be replicated by a typical nozzle. While CDM does not recommend a switch to a different type nozzle, switching to the original Quad nozzle should increase performance.

The scrubbers could be converted to packed towers by adding packing, new nozzles, and a recycle pump, but since the towers were not structurally designed to handle flooding, it is not advisable. Instead, scrubber operational modifications including setpoint changes are recommended to improve removal. Operational recommendations are included in Section 5.

Table 4-5 lists the results of the permitted scenario for both the composting train and the curing train of scrubbers. Table 4-6 lists the permitted setpoints that were measured and recorded during the analysis. During this sampling event, by afternoon the water pressure dropped to a level where no more than two-thirds of the desired 1.5 gallons per minute of water flow to the nozzles could be maintained. Because of the water pressure problems, the modified scenario was not examined, since optimal operations could not be achieved with the current configuration. We examined the water distribution system and found adequate flow for the towers but insufficient pressure. Recommendations to improve water pressure are also presented in Section 5.

The Composting Storage Building

The odorous areas of the building contains 907,000 cubic feet and is ventilated at up to 96,000 cfm to the odor control system. The air exchange rate in the building is 6 air changes per hour (AC/hr). The intake velocity based on 16 louvers at 32 square feet each corresponds to a velocity of 180 ft/min, when all louvers are open and 360 ft/min when half the louvers are open. Currently one half of the louvers are closed but it is unclear how tightly they are sealed. It does not appear that they are tightly sealed. This means that during more turbulent wind conditions outside, it is possible that some fugitive emissions are released.

The doors on this building are quite large. There are mechanisms installed that will only allow one door, approximately 14 by 22 foot, to operate at a time to help maintain odor capture. Unfortunately, when

Table 4-5
Compostind and Curing Scrubbers
Sulfur Compound Removal

			Permit Scenario			
Odorant	Location	Units	Quad-OSU1 Composting 21-Jul	Quad-OSU4 Composting 21-Jul	Quad-OSU5 Curing 21-Jul	Quad-OSU6 Curing 21-Jul
Hydrogen Sulfide (H2S)	Inlet	(ppb)	140	120	28	73
	Outlet	(ppb)	130	160	73	54
	Removal	(%)	38%	NA	NA	26%
Carbonyl Sulfide (COS)	Inlet	(ppb)	30	28	9.2	8.9
	Outlet	(ppb)	32	30	8.9	12
	Removal	(%)	NA	NA	3%	
Methyl Mercaptan (CH3SH)	Inlet	(ppb)	15	13	ND(4)	ND(4)
	Outlet	(ppb)	16	14	ND(4)	ND(4)
	Removal	(%)	NA	NA	NA	NA
Dimethyl Sulfide (DMS)	Inlet	(ppb)	35	26	ND(4)	ND(4)
	Outlet	(ppb)	34	28	ND(4)	ND(4)
	Removal	(%)	NA	NA	NA	NA
Carbon Disulfide (CS2)	Inlet	(ppb)	19	18	ND(4)	5.6
	Outlet	(ppb)	20	19	5.6	7.8
	Removal	(%)	NA	NA	NA	NA
Dimethyl Disulfide (DMDS)	Inlet	(ppb)	75	64	12	8.3
	Outlet	(ppb)	82	68	8.3	11
	Removal	(%)	NA	NA	31%	NA

NA = Not Applicable

Table 4-6
Composting and Curing Scrubber Setpoints
(Field Measurements and In-Line Probe Measurements)

			Permit Scenario				
			Quad-OSU1 Composting 21-Jul	Quad-OSU4 Composting 21-Jul	Quad-OSU4 Composting 21-Jul	Quad-OSU5 Curing 21-Jul	Quad-OSU6 Curing 21-Jul
Inlet pH	Measured	(unitless)	1.5	1.9	12.5*, 8.3**	8.1	6.7
	Probe	(unitless)	no probe	2	no probe	no probe	6.3
Outlet pH	Measured	(unitless)	1.8	1.9	9.8	8.1	7.7
	Probe	(unitless)	2.1	no probe	9.7	11.75	no probe
Inlet ORP	Measured	(mV)	804	750	90*, 292**	390	510
	Probe	(mV)	no probe	no probe	no probe	no probe	no probe
Outlet ORP	Measured	(mV)	625	423	160	340	405
	Probe	(mV)	no probe	630	200	no probe	77

* Separate Caustic feed line reading or measurement

**Separate H_2O_2 feed line reading or measurement the door is open the louvers are also still open. The inlet velocity in the louvers (and the door) drops to 170 ft/min, which would be overcome by the slightest wind (between one and two miles per hour).

To properly control the inlet air, all louvers should be blocked and four inlet fans should be installed to provide intake air that can not be influenced by outside wind conditions. The intake fans should be installed in the four corners of the building where the louvers are located. The fans, each approximately 20,000 cfm should be installed with a system that shuts them all off temporarily as the doors are open. Even with no intake air, the velocity through the door is only 310 ft/min. Since the fan uptake is located near the doors and only one door will be open at a time, leakage will be minimized.

There is a manual override that will allow both doors at one time. Having both doors open at any time is an odor control nightmare that should be avoided at all costs. Even with no louvers, the velocity through two doors would be 155 ft/min, which again is too low. Virtually any wind speed greater than 2 miles per hour will create a wind tunnel through the building that will push volumes of odorous air into the neighborhood. This phenomenon is even more severe today in the current configuration with the louvers unblocked.

Samples were taken from the first stage inlet stream, between the stages, and at the outlet of the second stage. The scrubber system includes two two-stage Quad mist chambers. Hydrogen sulfide and ammonia inlet concentrations are not very high in this system. The first stage is set up to remove ammonia at a very low pH. However, with little ammonia (<2 ppm) and no mist elimination between stages, the sulfuric acid is carrying over from the first stage into the second stage. Table 4-7 lists the results of the permitted scenario and modified scenario for the compost storage building scrubbers.

Although this lessens the demand for sulfuric acid in the second stage, there is little removal of sulfur-based compounds, which are generally the most persistent odors from WWTFs. This phenomenon was confirmed in the field by pH monitoring. Although the hydrogen sulfide and other sulfur-based compounds concentrations are very low, the inlet pH of 8.4 drops to 3.8 in the outlet liquid stream. The drop can only be associated with sulfuric acid carryover, since the main chemical added to the second stage, sodium hypochlorite, has a natural pH of approximately 8.5. The result of both stages operating at low pH is little change is odor character. During the permit conditions, the outlet still smells like compost and sulfur organic compounds were actually created in the first stage.

The modified scenario was adopted to eliminate the ammonia removal phase and concentrate purely on sulfur compound removal. The modified scenario had higher inlet concentration but better removal in the first stage. The second stage removal was not optimal because even the smallest amount of sulfuric acid added (less than one gallon per day) depressed the inlet pH to 2.6, although the probe was reading 3.4. The pH depression resulted in no additional hydrogen sulfide removal and more sulfur organic formation. Therefore no sulfuric acid should be added to the second stage (hypochlorite only) unless the outlet pH exceeds 9 to 10. Table 4-8 lists the permitted setpoints that were measured and recorded during the analysis.

Table 4-7
Compost Storage Scrubbers
Sulfur Compound Removal

Odorant	Location	Units	Permit Scenario		Modified Scenario	
			Quad-OSU11 Composting Storage (stage 1) 18-Jun	Quad-OSU12 Composting Storage (stage 2) 18-Jun	Quad-OSU11 Composting Storage (stage 1) 22-Jul	Quad-OSU12 Composting Storage (stage 2) 22-Jul
Hydrogen Sulfide (H2S)	Inlet	(ppb)	47	29	610	160
	Outlet	(ppb)	29	2	160	160
	Removal	(%)	38%	93%	74%	0%
Carbonyl Sulfide (COS)	Inlet	(ppb)	ND(7.2)	ND(7.2)	13	6.3
	Outlet	(ppb)	ND(7.2)	ND(7.0)	6.3	8.5
	Removal	(%)	NA	NA	52%	NA
Methyl Mercaptan (CH3SH)	Inlet	(ppb)	38	99	360	30
	Outlet	(ppb)	99	ND(16)	30	13
	Removal	(%)	NA	>83%	92%	57%
Dimethyl Sulfide (DMS)	Inlet	(ppb)	24	30	100	30
	Outlet	(ppb)	30	14	30	9.5
	Removal	(%)	NA	0.533	70%	68%
Carbon Disulfide (CS2)	Inlet	(ppb)	ND(7.2)	ND(7.2)	7	ND(4)
	Outlet	(ppb)	ND(7.2)	ND(7.0)	ND(4)	4.6
	Removal	(%)	NA	NA	43%	NA
Dimethyl Disulfide (DMDS)	Inlet	(ppb)	ND(7.2)	8.1	32	5.9
	Outlet	(ppb)	8.1	ND(7.0)	5.9	19
	Removal	(%)	NA	>14%	82%	NA

NA = Not Applicable

Table 4-8
Compost Storage Scrubber Setpoints
(Field Measurements and In-Line Probe Measurements)

			Permit Scenario		Modified Scenario	
			Quad-OSU11 Compost Storage 18-Jun	Quad-OSU12 Compost Storage 18-Jun	Quad-OSU11 Compost Storage 21-Jul	Quad-OSU12 Compost Storage 22-Jul
Inlet pH	Measured	(unitless)	1.8	8.4	11.9	2.5
	Probe	(unitless)	no probe	8.24	no probe	3.4
Outlet pH	Measured	(unitless)	6.1	3.8	9.9	7.8
	Probe	(unitless)	no probe	no probe	no probe	no probe
Inlet ORP	Measured	(mV)	822	590	461	1130
	Probe	(mV)	no probe	no probe	no probe	no probe
Outlet ORP	Measured	(mV)	624	695	685	531
	Probe	(mV)	no probe	373	no probe	343

5 Section Five

Section 5.0
Recommendations

This section discusses recommendations for the processing and odor control operations within the plant. Both current scrubber operating performance and potential changes to operational procedures that would reduce odor generation discussed in Section 2, but not adversely alter effluent quality are summarized here. The costs presented here are preliminary estimates of construction cost, unless otherwise stated, within an expected range of -15 percent to +30 percent of expected actual cost for budgeting. All costs should be refined during preliminary design.

Preliminary Treatment Facility Building and Aerated Channel

The primary treatment facility (PTF) building emits high levels of "rotten egg"odors. Odors are generated throughout the building which are then vented through the roof, untreated. CDM considers this building the first priority for additional treatment. Odors from this building have to be captured and treated. As discussed previously, chemical addition in the collection system would only have limited effectiveness because of the turbulence in the PTF building.

Currently there are many separate odor control systems onsite that are extremely labor intensive. With that in mind a biofilter was considered first for this additional odor control system. A biofilter is extremely easy to maintain and upkeep. Unfortunately, given the size of the PTF building and the 45,000 cfm air flow rate, 80,000 square feet of space would be required. Given the land requirements for the biofilter, it is not possible to fit it in anywhere around this building. Thus, this option was not considered further.

Activated carbon has been widely used for the control of both VOCs and odor-causing compounds in exhaust air streams. Activated carbon options included virgin carbon for high VOC sources, carbon impregnated with caustic for medium strength hydrogen sulfide streams, and catalytic carbon that is water washable for medium strength hydrogen sulfide streams. All carbon options have a limited life and must be replaced once the carbon sites have been consumed. The carbon life is driven by pollutant concentration. In this case with periodic concentrations above 50 ppm, the life of even the impregnated or catalytic carbons will only be one to two months. Replacing carbon every month or every other month is cost prohibitive, so this option was not considered further.

Wet scrubbing is used throughout the facility for sludge odor control. Wet scrubbing is more geared toward a hydrogen sulfide laden airstream like the one from the PTF building than one from sludge operations where sulfur organics are also present in appreciable amounts. Given the space constraints, measured pollutant concentrations, and air flow required for treatment, CDM recommends packed-tower wet scrubbers for the PTF. Packed-towers are preferred over mist towers primarily because they can handle a fluctuation in influent loadings better than a mist tower. The wastewater concentration will fluctuate diurnally causing fluctuations in scrubber loading.

A packed-tower scrubber can be installed on the north side of the building away from any doors and driveways that are in use. Since the pollutant is mainly H_2S, wet scrubbing will work well at the PTF building.

The volume of air for the PTF building is approximately 218,000 cubic feet. Currently the capacity of the HVAC system is over 60,000 cfm. The air flow rate at 12 air changes per hour (AC/hr) is 43,500 cfm. Assuming that 3,000 cfm is included from the aerated primary clarifier influent channels, 46,500 cfm will be sent to the scrubbing system. At that flow rate, only one single scrubber train is required. Because of the projected inlet H_2S loading, two stages of treatment will be needed for effective treatment. Scrubber duct supply design must necessarily capture concentrated sources, and the overall ventilation design must preclude worker exposure to unacceptable levels of contaminants.

The capital costs for the two-stage wet scrubbing system, associated pumps, fans, chemical storage facilities, water softening, duct (including from the primary influent channel), and diamond plate channel covers for the aerated primary clarifier influent channel will be $2,900,000.

Junction Chamber

The junction chamber has two wet well sections and one dry well section. The dry well section connects the two wet well sides together with a pipe. While one side of the junction chamber wet well is covered and ventilated to a carbon unit, the other side is covered but not ventilated to any particular odor control. This contributes to the "rotten egg" smell that emanates throughout the parking lot and drifts off-site.

We examined the possibility of including the junction chamber air flow in the PTF building system. Unfortunately from the plans it is clear that running an underground duct on-site is impossible without major disruption to existing utilities. The other duct option would be to keep the duct above ground and go over the entrance to the plant or above ground everywhere except at the driveways where it would go under. Given the long distance and the many obstacles the duct must overcome, duct costs will exceed the cost of new packaged odor control system.

For the same reasons stated for the PTF building, wet scrubbing is preferred here also. A number of companies have recently developed "skid mounted" three stage scrubbers that include everything but chemical storage and heat tracing. CDM recommends one of these systems for this source.

Assuming a 12 AC/hr ventilation rate, the airflow for the wet sides of the junction chamber is approximately 1,500 cfm. The capital costs for the entire system including new duct for the other area and heat tracing will be $140,000 installed.

Sludge Storage Tanks

The four sludge storage tanks are currently ventilated to two single-stage Calvert systems. This system works relatively well under average conditions when the set points are changed from the permit conditions to the modified scenario of caustic addition based on 9-10 pH in the outlet and hypochlorite addition based on an ORP set point of 500 mV. Chemical odor is a concern when the system is pushed with such high set points. The system is not adequate for odor control at greater than typical conditions. Mercaptan outlet concentrations were significant during the first scenario which had a higher than typical loading. Therefore to capture and treat odors continuously, additional control is needed.

Instead of recommending an entirely new, more costly odor control system, the current equipment will be utilized as much as possible. Since the air exchange rate is so high (14 AC/hr in a full tank), even with new higher covers installed, the exhaust rate from each tank can be halved. One scrubber can be taken out of service and a new packed tower added as a second stage to the remaining tower, or a biofilter installed on the other side of the tracks.

To continue to properly load the wet scrubber, the flow to the scrubber will remain constant at 16,000 cfm. We recommend that the scrubber by the compost storage scrubber (Calvert-2) be used in the future and Calvert-1 shut down. The air flow from each tank should be halved from 8,000 cfm to 4,000 cfm. New duct will be needed to connect the two existing fans for Tanks 1 and 2 to the inlet duct for Tanks 3 and 4.

If a second stage of wet scrubbing is selected, the new packed tower should be added with the air inlet in the bottom (countercurrent flow), up through the packing a mist eliminator, and out through a new stack. The mist eliminator would be built into the packed tower, so that air flow can exit the tower and enter the stack at the top of the tower. This modification is estimated to cost $700,000 which includes the tower, a new fan, packing, mist eliminator, and stack.

If a biofilter is used as the "second stage", the chemical feed to the first scrubber would be reduced to caustic only based on a 7-8 pH outlet. The biofilter would require the same roof modifications described for the wet scrubber option, new underground duct from the new fan to the train tracks, a trestle over the tracks, and duct to the biofilter. The biofilter would be approximately 100 feet by 100 feet and be sectioned into four cells. Three of the four cells are required for operation. The fourth cell is added to satisfy the redundancy required during bed changeout. The cost, $600,000, includes a new fan, in-duct heat exchanger, duct, a trestle, and the biofilter.

The biofilter will cost less to install, but it will cost approximately $10,000 more per year to operate because of greater fuel and electrical costs. The costs should be recovered from operations, however. If the second stage of scrubbing were installed, the wet scrubber system will include another set of feed pumps, nozzles, etc. to maintain. If the biofilter is installed, the mist scrubber becomes essentially a humidification chamber with a buffer, which does not require nearly as much attention to function as needed. Since the scrubber will further burden staff while the biofilter will lessen the burden, the biofilter option is preferred.

Thickening & Dewatering Building

CCMUA currently thickens sludge via centrifuge and dewaters via belt filter press. The thickening area is down to a single centrifuge and based on the limited data presented to CDM, the solids capture and overall operation does not appear to be cost-effective. However, additional evaluation would be necessary before any firm recommendations could be made.

The belt press dewatering area appears to be operating within typical design parameters (92 percent solids capture and 24% solids output). However, CDM has recently performed two different dewatering evaluations at large-scale facilities that determined by replacing existing belt filter presses (which generate 23-25% solids) with new centrifuge units (which generate around 30% solids) results in a substantial savings in composting operational costs (amendment and power) and a significant hauling and disposal cost savings. These savings justify the capital expense with a very short pay back period (2 to 5 years). The transition to centrifuge dewatering also makes a significant reduction in the generation of building odors and actual odor control costs. Both facilities referenced above have accepted CDM's recommendations and built these new dewatering facilities and are very pleased with the results. CDM recommends that CCMUA consider this same evaluation so that they may further reduce their overall solids handling and disposal costs.

The dewatering building has a Bionomics scrubbing system. Based on sampling results and field readings, these scrubbers are operating effectively. In order to handle a higher H_2S loading, the pH should be raised so that it is between 9 and 10.

The truck loading area is odorous and requires containment and odor control. There is no ventilation applied to the truck bay. Currently, CCMUA is working on a design to enclose the truck loading area. Once all four doors are in place, a confined space will be created inside the truck bay. The new confined space will require constant ventilation with at least 12 AC/hr and preferably more to limit fugitive emissions as the garage doors are opened and closed to allow truck access. The truck bay will require at least 10,000 cfm, based on 12 AC/hr.

The belt filter press room is currently ventilated at 48,800 cfm or 20 AC/hr. Therefore 19,000 cfm could be redirected from the room and used to treat the truck bay. With this change, the belt press room would still have greater than 12 AC/hr.

To fully maintain a negative pressure in the truck bay when the garage door is open, the air flow rate should be approximate 60,000 cfm. Therefore, assuming the hydrogen sulfide concentration does not increase dramatically because of the reduced air flow rate in the belt filter press room, as much air as possible (19,000 cfm) should be redirected to the scrubber through the truck bay.

Even more air could be redirected, if dewatering was changed from belt filter presses to centrifuges. The centrifuges could improve dewatering from current levels to 30 percent solids and nearly all of the 48,800 cfm could be redirected through the truck bay.

A source of fugitive emissions in the dewatering building was the roof access hatch, which was open during the walk through. It was not clear how long nor why this hatch was open. However, this should remain closed at all times.

Composting Building

Due to the significant mechanical problems CCMUA has experienced with the process building, only 6 of 20 tunnels are currently operational (Tunnel Groups 3 & 5). CCMUA is in the process of replacing one of six outfeed conveyors (chain & flight) with a new screw conveyor. This is expected to increase the available tunnel processing capacity from 6 to 10. If CCMUA decides to increase production, the odors in each of the processing areas will also increase. Appropriate modifications should be made to the odor control system during this change of operations.

The compost mix loaded into each tunnel varies throughout the day. This could potentially cause a fluctuation in odors from tunnel to tunnel throughout the day. Based on experiences at other facilities, it is difficult to provide proper chemical feed to the odor control system when the inlet odor concentration fluctuates. Mechanical modifications are recommended to insure a uniform feed to each tunnel is achieved throughout the day.

Based on a review of 3 months of operating data (April - June 1998), the tunnel composting system does not appear to be operating properly. The initial mix is loaded into the tunnel at an average solids content of 40 percent. The data shows that the compost discharged from the tunnel has had an average solids content of 43 percent. Since very little moisture is being driven off, this indicates that the composting process is not being optimized within the tunnel. This could be caused by a combination of several factors including; improper mix ratio, lack of an adequate bulking agent, improper positive and negative aeration sequencing, an inherent design flaw in the tunnel technology itself caused by the continuous compaction of material with no agitation. A further evaluation of this condition would be necessary before any further recommendations could be made.

Although beyond the scope of this evaluation, a compost mix ratio study utilizing various amendments would be a good idea to insure the composting process in the tunnels is being optimized (and excess odors are not being generated). Initial observations indicate that the sawdust amendment being used may not be providing adequate porosity in the mix as it gets compressed through the tunnel. Anaerobic pockets could be generated in the compacted material which results in excessive odors once the material exits the tunnels.

The composting scrubber system is a three-stage, four-tower system. Hydrogen sulfide and ammonia inlet concentrations are not very high in this system. The first stage is set up to remove ammonia at a low pH. However, with little ammonia, and no mist elimination until the end of the system, there is sulfuric acid carryover from the first stage into the second. Mist eliminators added between stages could reduce the carryover and increase the efficiency of the system, but their installation is not possible without great difficulty.

Based on the results of the sampling, there is no removal of sulfurous compounds and in some cases there is generation of sulfurous compounds. The current permit conditions operating parameters should no longer be used and new ones should be implemented. The first stage should be operated as a neutral stage with hypochlorite addition and an ORP setpoint of 500 mV to oxidize any compounds that are absorbed.

The second stage should be set for dimethyl sulfide and mercaptan removal by adding a small amount of sulfuric acid to maintain the pH below 8. A new sulfuric acid pump should be installed that operates at a maximum of less than 5 gallons per day (gpd). The lowest capacity pump currently available for sulfuric acid at the facility is 14.4 gpd. Even at the lower stroke and speed settings the sulfuric acid would overdose.

The third stage would operate as the hydrogen sulfide removal with the current chemicals at a high pH of 10 and an ORP of less than 150 mV. The ORP measurement is actually measuring hypochlorite carryover from the stage before, therefore if the level is above 150 mV, the second stage hypochlorite feed levels would require adjustment.

A major concern associated with this system is the chemical metering pumps area. This area is located in the basement of the composting building. It is designed with little to no ventilation. With sulfuric acid and hypochlorite present there is a potential for chlorine gas evolution if concentrated streams of each were to meet. This scenario is highly likely since currently there is one common drain and sump system for all six scrubber towers (both composting and curing scrubbers). There is a high risk of inhalation of the chemicals in case of any spills or during any routine pH or ORP calibration. This area should be ventilated immediately, or preferably redesigned - relocated closer to the scrubbers in an area with ventilation.

Due to the lack of water pressure there is insufficient water flow to stages 2 and 3 of this system. In order to ensure that there is always enough water for this system, booster pumps, and possibly a storage tank, should be added to supply proper volumes of water to the scrubbers at the proper pressure.

Curing Building

Based on a review of the curing facility operating data (January 11, 1998 to July 13, 1998) the material entering the curing area averaged 45 percent solids and left at 59 percent solids. The data indicates that the material's solids content is coming in well below what is typically expected from an "in-vessel" composting process. There also appears to be a very inconsistent increase (ranging from 1% to 23%) in solids content during curing. Some piles have only gone up approximately 1 or 2 percent while others achieve over a 20 percent increase. We would expect an average increase in solids content of 10 percent during a typical 30 day curing process. This discrepancy could be caused by either an operational issue or improper aeration. Additional investigation is necessary before any recommendations can be made.

The blower area on one side of the curing building is a source of highly concentrated odors. During the site visit, only one side of the curing building was being utilized and all piles were being aerated in the positive mode. The blower corridor was dry and emissions were minimal. However, the opposite side of the curing building had recently been aerated in the negative mode and leachate had ponded on the corridor floor and in the collection troughs. The outside access door to this room was also open and highly concentrated fugitive odors were being released to the atmosphere untreated. CDM's recommendation regarding this area would be to clean up the leachate on the floor and in the collection trough and switch all blowers to the positive mode to avoid this odor and maintenance issue in the future.

During the site walk-through of the curing area, the curing piles across one full bunker were observed to be either partially built or partially taken down. In each case the aeration piping was exposed and all the process air was short-circuiting through the exposed pipe so none of the material in the bunker was being aerated. Whether or not this is standard practice is not known. However, if aeration to the individual piles can be controlled (valved on/off), CDM recommends that each pile be built and taken down before another is started. This would ensure that aeration is provided to each pile during the entire curing period and no anaerobic pockets develop, which could cause increased odors within the curing and storage buildings.

According to the operators, the curing area has been undersized and can not handle design loadings. The very small increase in solids content being achieved during active composting in the tunnels would lead to an increased volume of material being delivered to the curing area above and beyond what was originally anticipated when the facility was first designed. Whether this is the reason for the inadequate space or there is a discrepancy in the original design criteria is unclear at this time. If the Authority has not prepared one yet, a mass balance based on recent operating data should be developed to quantify exactly what this deficiency amounts to. As described by one of the operators, a potential curing expansion could include the use of some or all of the inactive tunnels. Depending on the mechanical requirements and material movement for this alternative, odor control system impacts should also be considered.

Based on the investigation of the airflow associated with the curing building, the loading into the Quad, 2-stage scrubbing system designated to remove odors has excess capacity. After examining the airflow rates through the building and the scrubbers on the drawings, both curing scrubbers should have equal air flow. However, based on the investigations of the air flow associated with this scrubber while on site, there is a negative air flow through the system. This means that the fans after the scrubbing system designed to push exhaust air from the scrubber and put it through the common exhaust stack for all three scrubbers is actually pulling air through the scrubbers. This could be a result of a two things. Either the manual FRP butterfly damper upstream of the towers is partially closed or the downstream demister is clogged. Before any major optimizations on this system are underway, the airflow variations should be examined more thoroughly to determine the cause of the problem.

In order to maximize the efficiency of the curing area scrubbers, they should be operated the same way as the compost storage building scrubbers. The set points should be changed to the values discussed in the next subsection.

Compost Storage Building

Currently, unstabilized dewatered sludge is stored on the floor of the compost storage building from 1 to 4 days. This practice should be discontinued as soon as possible. Neither the building (leachate drainage issues), nor its odor control system were designed for sludge storage. The purpose of dewatered sludge storage is to obtain the best hauling price available, but the practice is causing fugitive odors and tracking of sludge throughout the site. The practice also increases the design load on the odor control system, and can very easily contaminate the finished compost product stored nearby. We recommend CCMUA establish a contract for a reasonable fixed price with a hauling company.

Language can be added to the contract that demands that the sludge haulers leave site immediately after fills and use specially enclosed trucks to minimize fugitive odors as the truck leaves the site.

As discussed above, leachate is a concern in and around the storage building. During the site visit, leachate was observed draining out of the front left access door of the storage building. This appeared to be coming from sludge stored in that corner of the building. This is not only an odor issue but an environmental concern.

Fugitive emissions are a problem from this building. The intake louvers should be blocked and four intake vents should be installed each rated at 22,000 cfm, to blow a total of 88,000 cfm into the building. The current louvers emit fugitive emissions, especially when the garage doors are open. The fans should be set up so that as soon as a garage door is opened, they shut down and the fans drawing air from the building to the scrubbers remain operating, thereby creating a negative airflow so that no fugitive emissions are able to escape. The cost, $140,000, includes four fans and a contact system for door activation.

The set points for these scrubbers were changed during the second sampling event with mixed results. There was a significant reduction in outlet concentrations from stage one, but not stage two. The final recommendations herein will correct the deficiencies in the second stage related to excess sulfuric acid addition. The final recommendations follow: caustic and hypochlorite should be added in the first stage at a pH of 9-10 and an ORP of 500 to 600 mV measured in the outlet stream. Only hypochlorite should be added in the second stage, the pH should be allowed to float and the ORP setpoint should be 150 mV, measured at the outlet. All probes should be moved to the outlet streams and installed where they can be easily accessed and calibrated one to three times per week. There were significant calibration concerns throughout the sample program. Some probes had drifted from their calibration set points, but more importantly some were just calibrated wrong. The probes that were incorrectly calibrated were set to read in the permit range, yet the actual values were much different.

Also, in order to have the changed set points work appropriately, the nozzles must not continually clog. Changing the nozzle is not the answer. All nozzles will clog with the quality of the current water used. Better treatment of the water prior to use is the proper solution. To determine the best type of filtration and/or softening system needed for the scrubber supply water, a small scale sampling program is needed. A few grab samples can be taken and sent to a laboratory to be analyzed for make up metals, alkalinity, hardness, etc. for a few hundred dollars. This would determine what type of softening and/or filtration system is needed. A softening and filtration system will help to reduce the scaling of the nozzles thereby reducing the amount of time required for maintenance.

The chemical metering pumps should be moved closer to the scrubbers, so the scrubbers respond faster to feed pump adjustments, and the pumps are located in an area that is ventilated to NFPA standards for worker safety. It may be possible to install a heater and ventilation system in the CEM building adjacent to the towers and use that building as the chemical feed building. If that option is not available, other options should be explored.

The final scrubber modification recommendation is to add mist elimination to the scrubber outlet. The first option would be to install a mist eliminator inside the last stage near the top of the tower. The second option would be to bring the scrubber outlet down to the ground, through a mist eliminator and then sent up a stack. This would help with dispersion of the exiting plume, but cost significantly more ($300,000).

Based on discussions with the Chief Operator, several contracts for compost product have been acquired recently. Bulk sales/contracts should be increased to make use of private offsite storage/ handling/ processing facilities. This will minimize the odors generated from the compost storage facility and reduce the loading to the odor control system for this building.

If dewatered sludge storage continues, additional odor control must be installed. The air flow in the building should be increased, which would require an additional scrubber train and another stage of scrubbing on the existing trains for a total of five additional towers at an estimated cost of $4,000,000. Elimination of the sludge storage, intake vent installation and scrubber set point modifications will eliminate the need for this upgrade.

Conclusions

Odor control capital improvements are recommended (and costed) at the junction chamber ($140,000), the PTF building ($2,900,000), the primary aerated influent channel (included in PTF), the storage tanks ($600,000), and ventilation improvements at the dewatering building ($80,000) and the compost storage building ($140,000 for ventilation only option) for a total of $3,860,000. Additional operational recommendations are included but have not been not costed since a majority of the labor and parts are expected to be absorbed through plant operations staff and budgets.

By not including the grit chamber aerated effluent channel, primary weir areas, and the aeration basin splitter boxes, we are not saying that these sources are not odor concerns because they are. Although these sources at times will be odorous, the other sources are more urgent and therefore more cost-effective at this juncture.

We recognize that CCMUA has made substantial investments in the composting facilities and desires to continue to operate them as designed. However, we feel that it necessary to point out that means of controlling odors effectively from these processes, in particular from the sludge composting building, will be quite costly.. Once the composting contract work is completed, CCMUA should carefully weigh the merits of continuing to operate this unit process, as its future costs to operate and control its odors will increase markedly.

Appendix A

@AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9806259

Work Order Summary

CLIENT: Mr. Mike Lannan
Camp, Dresser & McKee, Inc.
10 Cambridge Center
Cambridge, MA 02142

BILL TO: Same

PHONE: 617-252-8000
FAX: 617-621-2565
DATE RECEIVED: 6/19/98
DATE COMPLETED: 6/30/98

P.O. # NR
PROJECT # Camden County

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	Calvert Inlet-Sludge Storage #4	ASTM D-5504	5.5 "Hg
02A	Calvert Outlet	ASTM D-5504	20.5 "Hg
03A	Storage Bldg.-Outlet Quad	ASTM D-5504	7.0 "Hg
04A	Storage Bldg.-Inlet Quad	ASTM D-5504	7.5 "Hg
05A	Sludge Storage-Quad Middle	ASTM D-5504	7.5 "Hg
06A	Lab Blank	ASTM D-5504	NA

LAB NARRATIVE:
Tedlar bag samples were transferred into 6L Silco Canisters to extend hold time.
A change in instrument sensitivity resulted on a slightly elevated reporting limit for Methyl Mercaptan.

CERTIFIED BY: [signature]
Laboratory Director

DATE: 7/7/98

Certification numbers: CA ELAP - 1149, NY ELAP - 11291, UT ELAP - E-217

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA 95630
(916) 985-1000 • (800) 985-5955 • FAX (916) 985-1020

AIR TOXICS LTD.

SAMPLE NAME : Calvert Inlet-Sludge Storage #4

ID#: 9806259-01A

Sulfur Gases by ASTM D-5504 GC/SCD

ile Name:	b062020	Date of Collection: 6/18/98
il. Factor:	4.10	Date of Analysis: 6/20/98

ompound	Rpt. Limit (ppbv)	Amount (ppbv)
arbonyl Sulfide	16	Not Detected
lethyl Mercaptan	37	490
imethyl Sulfide	16	160
arbon Disulfide	16	78
imethyl Disulfide	16	Not Detected

ontainer Type: 6 Liter Silco Canister

AIR TOXICS LTD.

SAMPLE NAME : Calvert Outlet

ID#: 9806259-02A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b062016	Date of Collection: 6/18/98
Dil. Factor:	4.23	Date of Analysis: 6/20/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	17	Not Detected
Methyl Mercaptan	38	68
Dimethyl Sulfide	17	Not Detected
Carbon Disulfide	17	Not Detected
Dimethyl Disulfide	17	Not Detected

Container Type: 6 Liter Silco Canister

AIR TOXICS LTD.

SAMPLE NAME : Storage Bldg-Outlet Quad

ID#: 9806259-03A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name: b062017	**Date of Collection:** 6/18/98
Dil. Factor: 1.75	**Date of Analysis:** 6/20/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	7.0	Not Detected
Methyl Mercaptan	16	Not Detected
Dimethyl Sulfide	7.0	14
Carbon Disulfide	7.0	Not Detected
Dimethyl Disulfide	7.0	Not Detected

Container Type: 6 Liter Silco Canister

AIR TOXICS LTD.

SAMPLE NAME : Storage Bldg-Inlet Quad

ID#: 9806259-04A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b062019	Date of Collection:	6/18/98
Dil. Factor:	1.79	Date of Analysis:	6/20/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	7.2	Not Detected
Methyl Mercaptan	16	38
Dimethyl Sulfide	7.2	24
Carbon Disulfide	7.2	Not Detected
Dimethyl Disulfide	7.2	Not Detected

Container Type: 6 Liter Silco Canister

AIR TOXICS LTD.

SAMPLE NAME : Sludge Storage-Quad Middle

ID#: 9806259-05A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	**b062018**	**Date of Collection: 6/18/98**
Dil. Factor:	**1.79**	**Date of Analysis: 6/20/98**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	7.2	Not Detected
Methyl Mercaptan	16	99
Dimethyl Sulfide	7.2	30
Carbon Disulfide	7.2	Not Detected
Dimethyl Disulfide	7.2	8.1

Container Type: 6 Liter Silco Canister

AIR TOXICS LTD.

SAMPLE NAME : Lab Blank

ID#: 9806259-06A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b0620002	**Date of Collection: NA**
Dil. Factor:	1.00	**Date of Analysis: 6/20/98**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	Not Detected
Methyl Mercaptan	9.0	Not Detected
Dimethyl Sulfide	4.0	Not Detected
Carbon Disulfide	4.0	Not Detected
Dimethyl Disulfide	4.0	Not Detected

Container Type: NA

AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-10

CHAIN-OF-CUSTODY RECORD

№ 015267

Page 1 of

Contact Person Mike Lannan
Company Camp Dresser & McKee
Address 10 Cambridge Ctr City Cambridge State MA Zip 02142
Phone 617-252-8000 FAX ~~617-25~~ 617-621-2565
Collected By: Signature Therese A. Santoro

Project Info:
P.O. #:
Project #
Project Name Camden County

Turn Around Time:
☑ Normal
☐ Rush ______ Specify

Lab I.D.	Analyses Requested ~~Field Sample I.D.~~	Date & Time	Field Sample ID ~~Analyses Requested~~	Canister Pressure / Vacuum Initial	Final	Rec'd
01A	ASTM D-5504	6/18/98 8:50	Calvert Inlet - Sludge Storage #4			
02A	for 5	" 9:25	Calvert Outlet	Tedlar		
03A	compounds	" 11:15	Storage Bldg. - Outlet Quad			
04A	from each sample	" 11:30	Storage Bldg. - Inlet Quad	Bags		
05A	The five compounds	" 11:45	Sludge Storage - Quad Middle			
	are: carbonyl sulfide					
	carbon disulfide					
	methyl mercaptan					
	Dimethyl Sulfide					
	Dimethyl DiSulfide					

Relinquished By: (Signature) Date/Time: Therese A. Santoro 6/18/98 3:15 — Print Name: Therese Santoro
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time: Therese Shnepeke AR 6/19/98 930

Notes:

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
	Fed-X	8019141041991	TJ	6/19/98 930	Ambient	Good	Yes No (None) N/A	98062

Form 1293

@AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9806301

Work Order Summary

CLIENT: Mr. Mike Lannan
Camp, Dresser & McKee, Inc.
10 Cambridge Center
Cambridge, MA 02142

BILL TO: Same

PHONE: 617-252-8000
FAX: 617-621-2565
DATE RECEIVED: 6/22/98
DATE COMPLETED: 7/6/98

P.O. # NR
PROJECT # Camden County

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	Junction Chamber Scrubber Inlet	ASTM D-5504	Tedlar Bags
02A	Bionomics Outlet	ASTM D-5504	Tedlar Bags
03A	Bionomics Inlet	ASTM D-5504	Tedlar Bags
04A	Lab Blank	ASTM D-5504	NA

LAB NARRATIVE:
Analyzed out of hold time per client's request.

CERTIFIED BY: Linda T. Freeman
Laboratory Director

DATE: 7/7/98

Certification numbers: CA ELAP - 1149, NY ELAP - 11291, UT ELAP - E-217

AIR TOXICS LTD.

SAMPLE NAME : Junction Chamber Scrubber Inlet

ID#: 9806301-01A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	**b062214**	**Date of Collection: 6/19/98**
Dil. Factor:	**5.00**	**Date of Analysis: 6/22/98**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	20	120
Methyl Mercaptan	45	470
Dimethyl Sulfide	20	Not Detected
Carbon Disulfide	20	120
Dimethyl Disulfide	20	Not Detected

Container Type: *Tedlar Bag*

AIR TOXICS LTD.

SAMPLE NAME : Bionomics Outlet

ID#: 9806301-02A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b062215	**Date of Collection: 6/19/98**
Dil. Factor:	1.00	**Date of Analysis: 6/22/98**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	5.4
Methyl Mercaptan	9.0	Not Detected
Dimethyl Sulfide	4.0	Not Detected
Carbon Disulfide	4.0	7.5
Dimethyl Disulfide	4.0	Not Detected

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : Bionomics Inlet

ID#: 9806301-03A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b062216	**Date of Collection:**	6/19/98
Dil. Factor:	5.00	**Date of Analysis:**	6/22/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	20	Not Detected
Methyl Mercaptan	45	260
Dimethyl Sulfide	20	84
Carbon Disulfide	20	150
Dimethyl Disulfide	20	Not Detected

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : Lab Blank

ID#: 9806301-04A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b062203	Date of Collection: NA	
Dil. Factor:	1.00	Date of Analysis: 6/22/98	

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	Not Detected
Methyl Mercaptan	9.0	Not Detected
Dimethyl Sulfide	4.0	Not Detected
Carbon Disulfide	4.0	Not Detected
Dimethyl Disulfide	4.0	Not Detected

Container Type: NA

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180 BLUE RAVINE ROAD, SUITE B
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(916) 985-1000 FAX: (916) 985-1020

CHAIN-OF-CUSTODY RECORD

№ 015266

Page ___ of

Contact Person Mike Lannan
Company CDM
Address 10 Cambridge Ctr. City Cambridge State MA Zip 02142
Phone 617-252-8000 FAX 617-621-2565

Collected By: Signature ______

Project Info:
P.O. # ______
Project # Camden
Project Name County

Turn Around Time:
☑ Normal
☐ Rush ______ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
01A	Junction chamber Scrubber Inlet	6/19/98 8:00	ASTM D-5504 for 5 compounds	Tedlar		
02A	Bionomics Outlet	↓ 9:45	from each sample. The five	Bag		
03A	Bionomics Inlet	↓ 10:00	compounds are: Carbonyl disulfide			
			Carbon disulfide			
			methyl mercaptan			
			dimethyl Sulfide			
			dimethyl disulfide			

Relinquished By: (Signature) Date/Time: Therese A. Santoro 6/19/98 10:30 Print Name: Therese Santoro
Received By: (Signature) Date/Time: [signature] 6/22/98 10:11
Relinquished By: (Signature) Date/Time
Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time

Notes:

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
	Fed EX	8019141041188	6/22/98 10:44	[signature]	Amber	Good	Yes No None N/A	9806301

@AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9807283

Work Order Summary

CLIENT: Mr. Mike Lannan
Camp, Dresser & McKee. Inc.
10 Cambridge Center
Cambridge. MA 02142

BILL TO: Same

PHONE: 617-252-8000
FAX: 617-621-2565
DATE RECEIVED: 7/22/98
DATE COMPLETED: 8/3/98

P.O. # NR
PROJECT # Camden County

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	OSU1-Inlet Composting	ASTM D-5504	Tedlar Bag
02A	OSU1-Outlet Composting	ASTM D-5504	Tedlar Bag
03A	OSU5-Outlet Curing	ASTM D-5504	Tedlar Bag
04A	OSU4-Inlet Composting	ASTM D-5504	Tedlar Bag
04AA	OSU4-Inlet Composting Duplicate	ASTM D-5504	Tedlar Bag
05A	OSU4-Outlet Composting	ASTM D-5504	Tedlar Bag
06A	OSU5-Inlet Curing	ASTM D-5504	Tedlar Bag
07A	OSU6-Outlet Curing	ASTM D-5504	Tedlar Bag
08A	Method Spike	ASTM D-5504	NA
09A	Lab Blank	ASTM D-5504	NA

CERTIFIED BY: Linda L. Freeman
Laboratory Director

DATE: 8/3/98

Certification numbers: CA ELAP - 1149. NY ELAP - 11291, UT ELAP - E-217

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA 95630
(916) 985-1000 • (800) 985-5955 • FAX (916) 985-1020

AIR TOXICS LTD.

SAMPLE NAME : OSU1-Inlet Composting

ID#: 9807283-01A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072211	Date of Collection: 7/21/98
Dil. Factor:	1.00	Date of Analysis: 7/22/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	30
Methyl Mercaptan	4.0	15
Dimethyl Sulfide	4.0	35
Carbon Disulfide	4.0	19
Dimethyl Disulfide	4.0	75

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : OSU5-Outlet Curing

ID#: 9807283-03A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072207	**Date of Collection:** 7/21/98
Dil. Factor:	1.00	**Date of Analysis:** 7/22/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	8.9
Methyl Mercaptan	4.0	Not Detected
Dimethyl Sulfide	4.0	Not Detected
Carbon Disulfide	4.0	5.6
Dimethyl Disulfide	4.0	8.3

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : OSU4-Inlet Composting

ID#: 9807283-04A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	**b072212**	**Date of Collection:**	**7/21/98**
Dil. Factor:	**1.00**	**Date of Analysis:**	**7/22/98**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	28
Methyl Mercaptan	4.0	13
Dimethyl Sulfide	4.0	26
Carbon Disulfide	4.0	18
Dimethyl Disulfide	4.0	64

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : OSU4-Inlet Composting Duplicate

ID#: 9807283-04AA

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072213	Date of Collection: 7/21/98
Dil. Factor:	1.00	Date of Analysis: 7/22/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	26
Methyl Mercaptan	4.0	13
Dimethyl Sulfide	4.0	25
Carbon Disulfide	4.0	16
Dimethyl Disulfide	4.0	64

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : OSU4-Outlet Composting

ID#: 9807283-05A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072208	**Date of Collection: 7/21/98**
Dil. Factor:	1.00	**Date of Analysis: 7/22/98**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	30
Methyl Mercaptan	4.0	14
Dimethyl Sulfide	4.0	28
Carbon Disulfide	4.0	19
Dimethyl Disulfide	4.0	68

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : OSUS-Inlet Curing

ID#: 9807283-06A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072210	**Date of Collection: 7/21/98**
Dil. Factor:	1.00	**Date of Analysis: 7/22/98**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	9.2
Methyl Mercaptan	4.0	Not Detected
Dimethyl Sulfide	4.0	Not Detected
Carbon Disulfide	4.0	Not Detected
Dimethyl Disulfide	4.0	12

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : Lab Blank

ID#: 9807314-08A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072302	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 7/23/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	Not Detected
Methyl Mercaptan	4.0	Not Detected
Dimethyl Sulfide	4.0	Not Detected
Carbon Disulfide	4.0	Not Detected
Dimethyl Disulfide	4.0	Not Detected

Container Type: NA

AIR TOXICS LTD.

SAMPLE NAME : Lab Blank

ID#: 9807283-09A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072202	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 7/22/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	Not Detected
Methyl Mercaptan	4.0	Not Detected
Dimethyl Sulfide	4.0	Not Detected
Carbon Disulfide	4.0	Not Detected
Dimethyl Disulfide	4.0	Not Detected

Container Type: NA

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180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

N 001??? Page __ of __

CHAIN-OF-CUSTODY RECORD

Contact Person [illegible]
Company [illegible]
Address [illegible] City [illegible] State [illegible] Zip [illegible]
Phone [illegible] FAX [illegible]
Collected By: Signature [illegible]

Project Info:
P.O. # ____
Project # ____
Project Name [illegible] County

Turn Around Time:
☐ Normal
☐ Rush ____ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
01A	[illegible]	[illegible]	[illegible]			
02A	[illegible]	15:15	Carbonyl sulfide			
03A	[illegible]	15:30	Methyl Mercaptan			
04A	[illegible]	15:45	dimethyl sulfide			
05A	[illegible]	16:00	Dimethyl disulfide			
06A	[illegible]	16:10	Carbon disulfide			
07A	[illegible]	16:20				

Relinquished By: (Signature) Date/Time [illegible] Print Name [illegible]
Relinquished By: (Signature) Date/Time Received By: (Signature) Date/Time
Relinquished By: (Signature) Date/Time Received By: (Signature) Date/Time [illegible]

Notes:

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact? Yes No None N/A	Work Order #
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		9807283

@AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9807314

Work Order Summary

CLIENT: Mr. Mike Lannan
Camp. Dresser & McKee. Inc.
10 Cambridge Center
Cambridge. MA 02142

BILL TO: Same

PHONE: 617-252-8000
FAX: 617-621-2565
DATE RECEIVED: 7/23/98
DATE COMPLETED: 8/3/98

P.O. # NR
PROJECT # Camden County

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	Compost Storage Inlet	ASTM D-5504	Tedlar Bag
02A	OSU 12 Inlet - Compost Storage	ASTM D-5504	Tedlar Bag
03A	Calvert Outlet	ASTM D-5504	Tedlar Bag
04A	OSU 12 Outlet	ASTM D-5504	Tedlar Bag
05A	Calvert Inlet Tank #4	ASTM D-5504	Tedlar Bag
06A	Calvert Inlet Tank #3	ASTM D-5504	Tedlar Bag
07A	OSU1 - Inlet Composting	ASTM D-5504	Tedlar Bag
08A	Lab Blank	ASTM D-5504	NA

CERTIFIED BY: [signature]
Laboratory Director

DATE: 8/4/98

Certification numbers. CA ELAP - 1149, NY ELAP - 11291, UT ELAP - E-217

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA 95630
(916) 985-1000 · (800) 985-5955 · FAX (916) 985-1020

AIR TOXICS LTD.

SAMPLE NAME : Compost Storage Inlet

ID#: 9807314-01A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072310	Date of Collection: 7/22/98
Dil. Factor:	1.00	Date of Analysis: 7/23/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	13
Methyl Mercaptan	4.0	360
Dimethyl Sulfide	4.0	100
Carbon Disulfide	4.0	7.0
Dimethyl Disulfide	4.0	32

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : OSU 12 Inlet - Compost Storage

ID#: 9807314-02A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072311	Date of Collection: 7/22/98
Dil. Factor:	1.00	Date of Analysis: 7/23/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	6.3
Methyl Mercaptan	4.0	30
Dimethyl Sulfide	4.0	30
Carbon Disulfide	4.0	Not Detected
Dimethyl Disulfide	4.0	5.9

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : Calvert Outlet

ID#: 9807314-03A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072312	Date of Collection: 7/22/98
Dil. Factor:	1.00	Date of Analysis: 7/23/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	7.0
Methyl Mercaptan	4.0	9.8
Dimethyl Sulfide	4.0	Not Detected
Carbon Disulfide	4.0	Not Detected
Dimethyl Disulfide	4.0	Not Detected

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : OSU 12 Outlet

ID#: 9807314-04A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072313	Date of Collection: 7/22/98
Dil. Factor:	1.00	Date of Analysis: 7/23/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	5.5
Methyl Mercaptan	4.0	13
Dimethyl Sulfide	4.0	9.5
Carbon Disulfide	4.0	4.6
Dimethyl Disulfide	4.0	19

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : Calvert Inlet Tank #4

ID#: 9807314-05A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072316	Date of Collection: 7/22/98
Dil. Factor:	2.00	Date of Analysis: 7/23/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	8.0	14
Methyl Mercaptan	8.0	31
Dimethyl Sulfide	8.0	Not Detected
Carbon Disulfide	8.0	24
Dimethyl Disulfide	8.0	Not Detected

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : Calvert Inlet Tank #3

ID#: 9807314-06A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name: b072315		Date of Collection: 7/22/98
Dil. Factor: 2.00		Date of Analysis: 7/23/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	8.0	17
Methyl Mercaptan	8.0	17
Dimethyl Sulfide	8.0	Not Detected
Carbon Disulfide	8.0	22
Dimethyl Disulfide	8.0	Not Detected

Container Type: Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME : OSU1 -Inlet Composting

ID#: 9807314-07A

Sulfur Gases by ASTM D-5504 GC/SCD

File Name:	b072317	Date of Collection: 7/22/98
Dil. Factor:	1.00	Date of Analysis: 7/23/98

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Carbonyl Sulfide	4.0	47
Methyl Mercaptan	4.0	84
Dimethyl Sulfide	4.0	80
Carbon Disulfide	4.0	19
Dimethyl Disulfide	4.0	86

Container Type: Tedlar Bag

[illegible]
FOLSOM, CA [illegible]
(916) 985-1000 FAX: (916) [illegible]

AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

CHAIN-OF-CUSTODY RECORD

Nº 015126

Contact Person [illegible]
Company [illegible]
Address [illegible] City [illegible] State [illegible] Zip [illegible]
Phone [illegible] FAX [illegible]
Collected By: Signature [illegible]

Project Info:
P.O. # ____
Project # ____
Project Name [illegible]

Turn Around Time:
☐ Normal
☐ Rush ____ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
01A	[illegible]	7/1/98 8:30	ASTM D-5504 for	[illegible]		
02A	[illegible]	[illegible]	Carbonyl Sulfide	[illegible]		
03A	[illegible]		Methyl mercaptan	[illegible]	[illegible]	
04A			Dimethyl Sulfide	[illegible]	[illegible]	
05A	[illegible]		Dimethyl Disulfide			
06A	[illegible]		Carbon disulfide			
07A	[illegible]	12:30				

Relinquished By: (Signature) Date/Time [illegible] 7/2/98 Print Name [illegible]

Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time

Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time [illegible] 7/03/98 9:10

Notes:

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
	Fed-X	[illegible]	[illegible]	7/3/98 [illegible]	Ambient	Good	Yes No None N/A	9807314