**Airflow Modeling Study**
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## Introduction

This paper is intended to provide a constructive critique of the City of Los Angeles' Airflow Modeling Study (Modeling Study), which was conducted as part of the City's ongoing Air Treatment Facility Evaluation Study. The Modeling Study was an attempt to better understand how flowing wastewater influences the movement of the free air in the City's sewer system and better predict where odor emissions may occur. As with all models, the model created in this instance relied on major assumptions regarding the City's existing sewer system. This paper will point out the major assumptions of the Modeling Study and discuss how they could have influenced the modeled results. It is not the intention of this paper to discount the usefulness of the Modeling Study results, but rather to emphasize the fact that the results lie within a broad range of accuracy and should not be viewed as precise or as the only information that should be used to locate and size air treatment facilities (ATF) for odor control.

The movement of air above wastewater in a sewer is largely dependent on the viscous drag of the liquid on the gas. Viscous drag is the force exerted on the air by the moving water due to friction. Air movement is also influenced by the ambient air pressure and movement outside the sewer, heating or cooling of the air, and obstructions within the sewer. As moving air meets an obstruction it can be compressed, resulting in increased pressure. If the air pressure internal to the sewer is higher than that of the surrounding atmosphere, there is the potential for foul air to escape the sewer and cause nuisance odor impacts in the community.

The stated scope of the Modeling Study was to create a model that could identify odor "hot spots" under several potential wastewater flow scenarios. These hot spots are not points of actual or even modeled odor impacts, but locations in the sewer system where the model indicates airflow is likely to be restricted. According to the Modeling Study, past experience has shown that airflow restrictions are the primary cause of high air pressure in the sewer. Since we know high sewer pressure (in comparison to lower atmospheric pressure) can cause foul air to escape, being able to predict possible locations of sewer obstruction/high air pressure, is one way to predict the location of odor impacts in the community.

To estimate where these hot spots could occur, the City's engineering team used a pair of computer models to understand wastewater flow conditions and developed a third model to estimate how flowing wastewater would cause air to move within the sewer and where that movement may become restricted. It was explicitly stated that the airflow model is not intended to model air differential pressure, but only to identify hot spots as defined above.

## Airflow Modeling and Hot Spot Identification

### <u>Modeling Methodology</u>

The City used commercially available computer software to model and analyze wastewater flows under various conditions. They developed an additional computer program to estimate where the characteristics of the sewers and the flowing wastewater could result in a location where the capacity of the system to carry air would become restricted. In that case, a “hot spot” was identified.

The Modeling Study explains that the airflow model was developed assuming only that the movement of the wastewater is responsible for air movement within the sewer. The airflow model calculates the airflow capacity within a segment of the sewer based on the wastewater velocity, the depth of wastewater, and the geometry of the pipe. Based on that information, the airflow velocity is estimated as a fraction of the wastewater velocity.[1]

Modeling Assumptions and Accuracy

The City’s model is based on the assumption that flowing wastewater is the only influence causing air to move within the sewer. This phenomenon is well documented and could provide a reasonable first estimate of airflow. However, while the drag of flowing wastewater has a significant influence on sewer airflow, air pressure up and downstream of the sewer segment modeled can also have a profound effect on air movement as can the effects of air buoyancy and friction between the moving air and the sewer wall. A stated limitation of the model is that it does not account for back pressure effects from siphons, drop structures, diameter reductions, slope reductions or junction structures. The effect of ATFs on airflow is also ignored by the model.

All models predict reality with some degree of error and the absolute accuracy of the City’s model is difficult to gage. Field data was collected in an attempt to determine if the model was predicting those areas where pressurization of the sewer air was occurring. Air pressure was monitored at six locations where hot spots were predicted by the model. Data from one of the locations was discounted due to the strong effect of the air treatment facility at the Hyperion wastewater treatment plant. Data from the remaining five locations did show good correlation between the modeled and real-world conditions. However, only locations identified by the model to have a build-up of pressure were sampled. It would have been helpful if locations that the modeled airflows indicated lower or neutral pressure were monitored, also. This would have provided additional insight to the model’s accuracy.

Model Analysis and Hot Spot Identification

Analysis to identify hot spots and estimate the airflow within certain sewer sections was performed using three different wastewater flow scenarios. These represented the current and possible future sewer configurations that would divert flows from the North Outfall Relief Sewer (NORS) to the North Outfall Sewer (NOS) and from the NOS to the Central Outfall Sewer (COS). For each of these three scenarios, the airflow model was used to identify hot spots based on a 48-hour period using typical weekday and weekend wastewater flows.

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[1] That fraction varies with depth of the wastewater and the diameter of the sewer. The volumetric airflow is calculated by multiplying the air velocity by the cross section of the free air space. The airflow is similarly calculated for the next downstream sewer segment. If the first segment’s airflow is greater than the second segment’s, it is assumed that the potential for compression of the air exists. If the difference in airflows in the two segments is greater than 2,000 cubic feet per minute (cfm) a hot spot is identified.

The Modeling Study states that the airflow rate within the sewer is one of the design criteria for any future ATF. This is a reasonable statement. Knowledge of the sewer airflow is necessary to determine the rate of air extraction by an ATF to lower the pressure in the sewer to prevent odor emissions. Current airflow rates were estimated at several locations that appear to be associated with known odor problems. Airflows at the upstream ends of the North Central Outfall sewer (NCOS) and NORS siphons near the I-405 freeway and five drop structures were modeled. The Modeling Study states that actual airflow rates can differ from the model-estimated rates due to the disregard of ATF ventilation and airline effects. The Study reports the modeled airflows for eleven locations near the NCOS, NORS, and the drop structures for each of the three wastewater flow scenarios.

Hot spots were also identified by the model. Some of the model-identified hot spots were dismissed due to known actual conditions. Those locations were affected by ATFs to the degree that they were known or assumed to not be sources of odor problems. Under the current wastewater conveyance system configuration, nine hot spot locations identified by the model were considered valid. Six of these hot spots were located on the East Central Interceptor Sewer (ECIS), one was on the NORS/ECIS Junction, and the remaining two were on the NCOS and NORS siphons at I-405. When modeling the two potential future sewer configurations, three additional hot spots were identified on the ECIS, one at the NOS siphon and one immediately downstream of the North Outfall Treatment Facility (NOTF) on the NOS.

**General Remarks and Conclusions**

The City's engineering team has produced a model to estimate airflows and hot spot sites of potentially high pressure within the sewer system. The model estimates the airflow based on the assumption that air movement is only due to the viscous drag on the air by moving wastewater and ignores several other significant parameters. However, given the state of the art of sewer airflow modeling, it is not an unreasonable way to gain insight into the potential for air pressure increases, potential locations of odorous emissions, and to understand the magnitude of the air volumes moving within the sewer. The estimate of the volumetric airflow is important to quantify so that ATFs can be sized to neutralize the potential for high air pressure at the model-identified hot spots.

Given the current state of the art of modeling airflow within sewers, it is important to corroborate modeled information with real world data and observations. The City's team has conducted some field data collection that indicates that their model is capable of identifying points of air pressurization within the sewer. These locations should also be compared with those known to have a history of odor emissions to further verify the validity of the model.

From the information in the Modeling Study, one can conclude that, as a first estimate, the airflow model provides a reasonable estimate within a broad range of accuracy. The model could be used with field data and observations as an aid to locating and sizing ATFs for the control of odors.