North River Ambient Air Formaldehyde Monitoring Final Annual Report

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EXECUTIVE SUMMARY

As part of an effort to assess whether the North River Water Resource Recovery Facility (NRWRRF) was impacting formaldehyde levels in the vicinity of the Riverbank State Park, located on the roof of the NR WRRF, the New York City Department of Environmental Protection (DEP) executed an air monitoring program to evaluate ambient formaldehyde concentrations in the Riverbank State Park as approved by the New York State Department of Environmental Conservation (DEC). The program was implemented from September 25, 2015 to September 26, 2016, in accordance with the DEC issued Order on Consent, Case Nos. R2-20010713-146, R2-3669-91-05 (Consent Order) effective in 2012.

DEP undertook additional ambient air formaldehyde sampling from December 15, 2015 to September 26, 2016 at locations in Riverbank State Park and the adjacent community, as requested by DEC and the New York State Office of Parks, Recreation and Historic Preservation (OPRHP). Following that, DEP continues to support DEC's ambient formaldehyde monitoring program with a monitoring location in Riverbank State Park. These additional datasets are summarized within this report.

The report also provides program details such as monitoring locations, test methods, meteorological data, data analyses, and conclusions as to the potential impact of the NRWRRF on formaldehyde levels found in the ambient air in and around Riverbank State Park, as well as other possible contributing sources of formaldehyde.

This report finds that the air-monitoring data coupled with the atmospheric conditions (wind direction, temperature) and North River WRRF operations, demonstrate the following:

1. The data does not indicate that the contribution from North River WRRF operations are discernable from background conditions. The data indicates that emissions from the North River WRRF do not appear to have an impact on Riverbank State Park and the surrounding area.

2. The monitoring results showed levels of formaldehyde to be generally consistent with urban environments.

   In an urban environment, emissions from cars and other vehicles are a known source of formaldehyde, particularly in the summer months. This is the result of hydrocarbon emissions (what comes out of the vehicle's tailpipe) coming into contact with sunlight. Formaldehyde formation increases when ground level ozone pollution is elevated, which typically happens in the summer. To learn more about ground level ozone pollution, visit this helpful EPA Website. The study results show a strong seasonal trend (elevated formaldehyde in the summer months) which is consistent with accepted science of indirect formation of formaldehyde from vehicle emissions rather than direct emission from the plant. This finding is supported by data collected from a nearby DEC monitoring station at City College which shows elevated ground level ozone in the summer months.

3. Samples were collected during the day and night time. The results showed no meaningful difference between the day and night samples. This indicates that formaldehyde in automobile exhausts from vehicle traffic such as on the nearby NY9A-Henry Hudson Parkway does not directly contribute to the ambient formaldehyde concentrations in the Riverbank State Park and the surrounding area.

4. However, hydrocarbons in automobile exhausts from such vehicle traffic is a potential cause of indirect formaldehyde formation and may contribute to ambient formaldehyde concentrations in Riverbank State Park and the surrounding area.

5. DEP supplemented the study with additional sampling at 13 sites in and around Riverbank State Park. The additional sampling indicates that formaldehyde concentrations were similar throughout the entire area. When higher concentrations of formaldehyde were observed, the wind was blowing from the South and South-Southeast direction toward the plant. This indicates a background presence of formaldehyde rather an emission from a specific source.

SECTION 1 INTRODUCTION

1.1 Consent Order Formaldehyde Monitoring

Pursuant to Section III.D of the 2012 NRWRRF Consent Order, between DEP and DEC, DEP performed an Air Impact Analysis Report for the NRWRRF to evaluate potential offsite impacts of emissions from the WRRF. Based upon the Analysis Report and pursuant to Section III.A(iii) of the Consent Order, DEP submitted a Monitoring Plan to DEC for review and approval. The Monitoring Plan documented the protocol for collecting two 12-hr ambient air formaldehyde samples (a daytime sample from 06:00 to 18:00 and a nighttime sample from 18:15 to 06:15) every six (6) days for a one-year period at the existing North River H_2S Air Quality Monitoring Network's Station 5 (AQMS 5) in the Riverbank State Park on the roof of the WRRF. The Monitoring Plan was approved by DEC in May of 2015.

Pursuant to the DEC approved Monitoring Plan protocol, DEP conducted formaldehyde monitoring (Consent Order Formaldehyde Monitoring) from September 25, 2015 through September 26, 2016. DEP staff worked closely with DEC staff during this monitoring period and frequently shared preliminary sampling results and updates with DEC.

As required by Section III.C of the Consent Order, DEP submitted four quarterly monitoring reports to DEC in 2016 on the following dates:

- January 29, 2016
- May 4, 2016
- July 29, 2016
- October 26, 2016

1.2 Additional Formaldehyde Sampling Program

As requested by both DEC and OPRHP, DEP developed a sampling protocol to perform additional formaldehyde sampling (Additional Formaldehyde Sampling Program) in Riverbank State Park and the adjacent community. The Additional Formaldehyde Sampling Program collected two 1-hr samples twice per week. After receiving DEC and OPRHP approval of the protocol for the Additional Formaldehyde Sampling Program, DEP conducted additional formaldehyde sampling from December 15, 2015 through September 22, 2016. The Additional Formaldehyde Sampling Program was initially performed at 11 locations but later expanded to 13, per a request from the Manhattan Borough President's Office.

DEP worked closely with DEC staff during performance of the Consent Order Formaldehyde Monitoring and the Additional Formaldehyde Sampling Program, sharing preliminary sampling results and updates with DEC.

DEP continues to support DEC's efforts to monitor ambient formaldehyde levels in New York City, and has continued to maintain and operate one sampling station for formaldehyde in the Riverbank State Park.

SECTION 2 SAMPLING LOCATIONS

2.1 Consent Order Formaldehyde Monitoring Sampling Location

The Consent Order Formaldehyde Monitoring samples were collected at the existing DEC approved North River WRRF H_2S AQMS 5, located in the Riverbank State Park oval, shown as location S4 on Figure 1. Two 12-hr ambient air samples were collected once every 6 days, for two consecutive 12-hour periods.

2.2 Additional Formaldehyde Sampling Program Locations

DEP initially collected samples at 11 locations in the Riverbank State Park and adjacent community from December 15 through 30, 2015. On December 31, 2015, the number of sampling locations was increased to 13, as requested by the Manhattan Borough President's Office. Figure 1 below is a map depicting the sampling locations. Two 1-hr ambient air samples (one in the morning and one in the afternoon) were collected twice per week at each location.

- Location S1: Riverside Drive and W 139th St. (next to AQM6)
- Location S2: Riverside Drive and W 142nd St.
- Location S3: Riverside Drive and W 144th St.
- Location S4: AQM 5 (Consent Order Monitoring location)
- Location S5: Entrance of Administration Building
- Location S6: Eastside of park's tracking field at 50 yards line by the water fountain
- Location S7: South end of park between baseball field and tennis courts
- Location S8: Westside the park, southwest corner of the swimming pool
- Location S9: Westside the park, southeast corner of playground
- Location S10: Westside of park, south end of picnic area, direct west of stacks
- Location S11: Entrance of the restaurant
- Location S12: Northeast corner of the park, near the elevator
- Location S13: In the middle of baseball field

2.3 Continued Ambient Formaldehyde Monitoring Sampling Location

DEP continues to maintain and operate one sampling station for formaldehyde in the Riverbank State Park, at the location of the original sampling unit used for the Consent Order Formaldehyde Monitoring (S4: North River WRRF H_2S AQMS 5). One 24-hr ambient air sample is collected every 6 days.

Figure 1 Additional Formaldehyde Sampling Program Locations

SECTION 3 TEST METHODS

3.1 Consent Order and Ongoing Formaldehyde Monitoring Test Method

The Consent Order Formaldehyde Monitoring used analysis method EPA Method TO-11A to determine the formaldehyde in the ambient air. EPA Method TO-11A utilizes a coated-solid adsorbent followed by high performance liquid chromatographic detection and has the sensitivity needed to reach health-based detection limits (10^{-6} risk level). The sampling times were in 12-hr durations at a rate of about 1 liter per minute (lpm) with a Reporting Limit of about 0.07 µg/m^3 for formaldehyde. Eurofins Air Toxics, Inc. laboratory (EAT), located in Folsom, California analyzed the 12-hr samples for the Consent Order Formaldehyde Monitoring. The EAT accreditation was provided to DEC with the quarterly reports attached here as Appendix A. This same TO-11A method is being currently utilized for the continued sampling being conducted by DEP.

3.2 Additional Formaldehyde Sampling Program Test Method

The Additional Formaldehyde Sampling Program used a modified National Institute for Occupational Safety and Health (NIOSH) Method 2016. The sampling times were in 1-hr durations at a rate of 0.3 to 0.5 lpm with a Reporting Limit of approximately 3 µg/m^3 for Formaldehyde. EMSL Analytical, Inc. laboratory (EMSL), located in Cinnaminson, New Jersey analyzed the 1-hr samples for the Additional Formaldehyde Sampling Program. EMSL is accredited by the American Industrial Hygiene Association (AIHA) and the New York State Department of Health (NYSDOH) Environmental Laboratory Program (ELAP). EMSL's certifications and reports are provided in Appendix B.

3.3 Meteorology Data

Wind direction and wind speed data collected at the DEC approved North River WRRF H_2S Air Quality Monitoring Network's Meteorological Tower was used for both the Consent Order Formaldehyde Monitoring and the Additional Formaldehyde Sampling Program.

SECTION 4 RESULTS AND ANALYSIS

4.1 Consent Order Formaldehyde Monitoring

4.1.1 Consent Order Formaldehyde Monitoring Results

The Consent Order Formaldehyde Monitoring, conducted from September 25, 2015 through September 25, 2016, collected 184 samples, including 62 field blanks. The results and the associated meteorology data were previously submitted to DEC in the quarterly reports and these quarterly reports are attached here as Appendix A.

On one sampling date in early November 2015, the Consent Order Formaldehyde Monitoring program revealed unexpectedly high formaldehyde concentrations. DEP consulted with DEC and DEC subsequently performed simultaneous and independent monitoring at the same location from November 18 through 25, 2015 for quality assurance. The simultaneous monitoring results obtained by both DEP and DEC were analogous.

4.1.2 Consent Order Formaldehyde Monitoring Results Analyses

Data and outliers

The Consent Order Formaldehyde Monitoring results ranged from 3.9 µg/M3 to 84 µg/M^3.

The two highest concentrations, 82 µg/M^3 for a daytime sample and 84 µg/M^3 for a nighttime sample, were both collected on November 6, 2015. Both of these sample concentrations are far greater than and distant from the other measured concentrations; therefore these concentrations are considered outliers for the evaluation of ambient air formaldehyde concentrations.

Excluding these two outlier data points, the measured concentrations were from 3.9 to 47 µg/M^3.

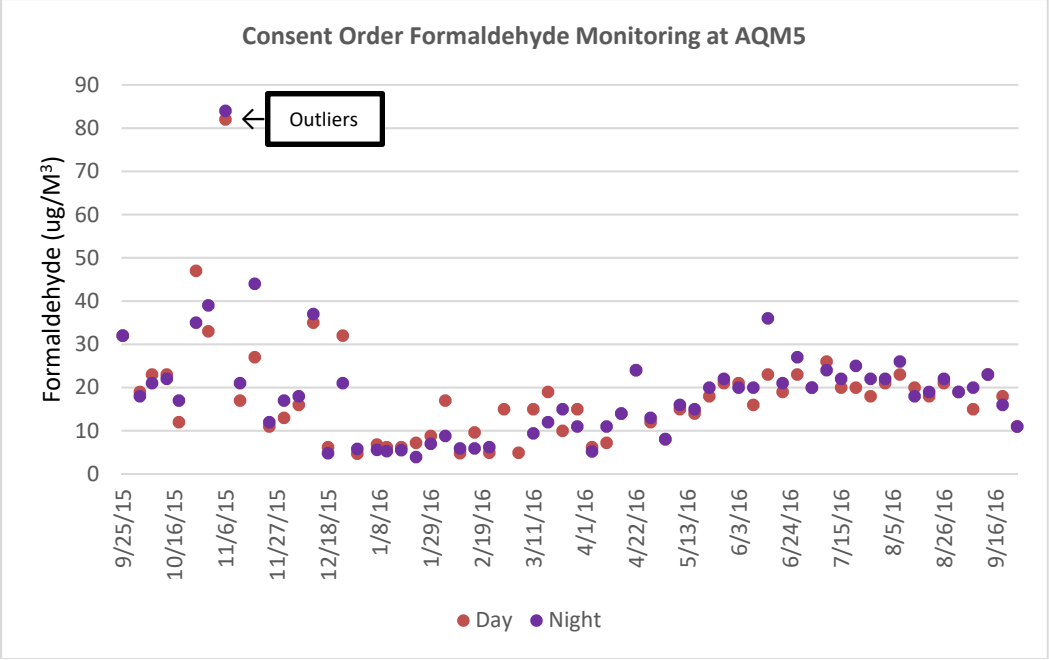

Figure 2 Consent Order Formaldehyde Monitoring Results

Very limited difference between concentrations for day and night time

The Consent Order Formaldehyde Monitoring collected two 12-hr samples (a day sample from 06:00 to 18:00 and a night sample from 18:15 to 06:15) on scheduled days in order to evaluate if there was a diurnal variation caused by generally heavier traffic on the NY 9A Henry Hudson Parkway and other daytime activities in the area. The averaged concentrations were 18.3 µg/m^3 with a Standard Deviation of 11.76 µg/m^3 (64.3% of the averaged concentration) for samples collected in the morning, during the first 12 hours (06:00-18:00 daytime) and 18.9 µg/m^3 with a Standard Deviation of 12.55 µg/m^3 (66.4% of the averaged concentration) for the samples collected for the next 12 hours (18:15-06:15 nighttime). Considering that the difference between the averaged concentrations was only 3.3%, and both sampling periods had similar high variations, no statistically meaningful diurnal variation could be identified.

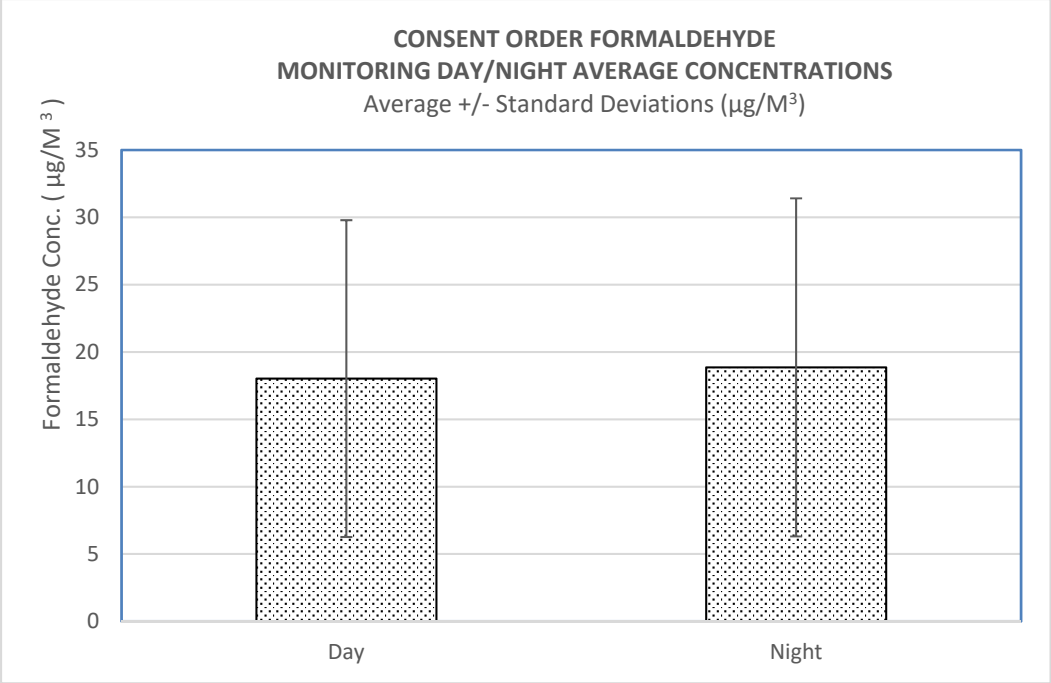

Figure 3 Consent Order Formaldehyde Monitoring Day/Night Average Concentrations

There is a strong correlation between formaldehyde concentrations, temperature and ozone concentrations.

While the data does not indicate any significant day and night variations, there is an apparent correlation between the formaldehyde concentrations and ambient temperatures. As seen below in Figure 4, apart from certain relatively large variations during the initial monitoring period, the data shows a noticeable correlation with temperatures. Figure 5 shows a similar correlation of the data with DEC's ambient ozone monitoring concentrations at the nearby City College of New York, as ambient ozone concentrations are known to correlate with temperature, with higher ozone levels observed during the warmer months. The underlying driver for both, elevated ground level ozone and formaldehyde concentrations is the increased UV index in the summer months, as both pollutants are produced from their precursors by photochemical reactions driven by sunlight intensity.

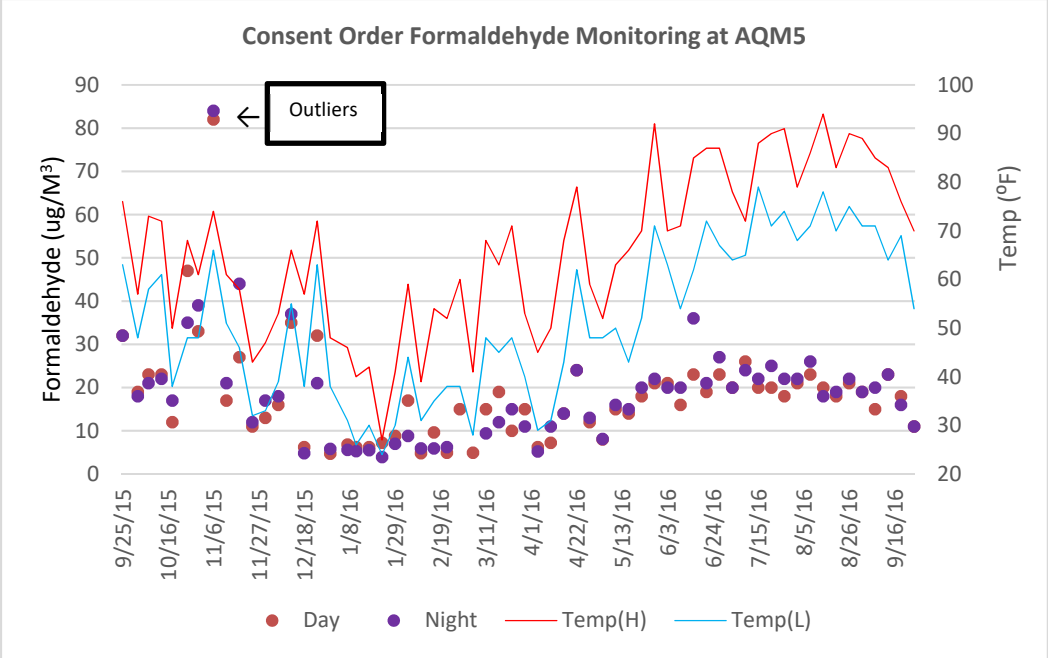

Figure 4 Consent Order Formaldehyde Monitoring Concentrations vs. Temperatures

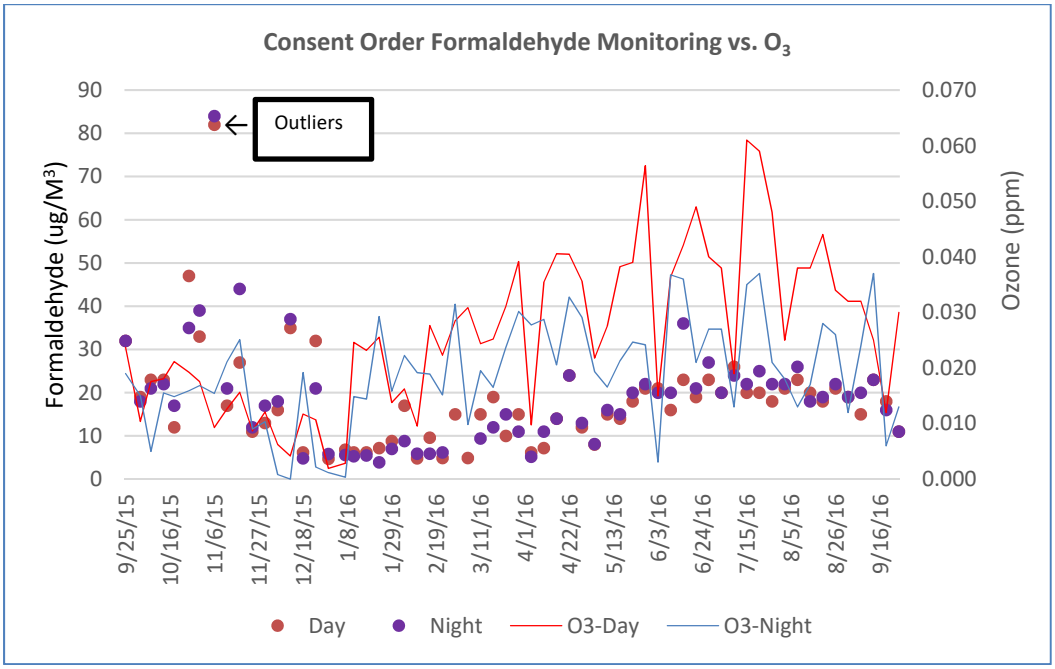

Figure 5 Consent Order Formaldehyde Monitoring Concentrations vs. DEC O_3 Monitoring Concentrations at CCNY

After fulfilling the Order's formaldehyde monitoring requirement in September 2016, at the request of the DEC, DEP continued performing 24 hr formaldehyde sampling every 6 days using sampling materials provided by DEC and following DEC's ambient monitoring schedule. As seen in the Figure 6, these additional formaldehyde monitoring results confirmed the seasonal ambient formaldehyde concentrations variation and the strong correlation with ambient temperatures observed during the initial 2015/2016 formaldehyde monitoring.

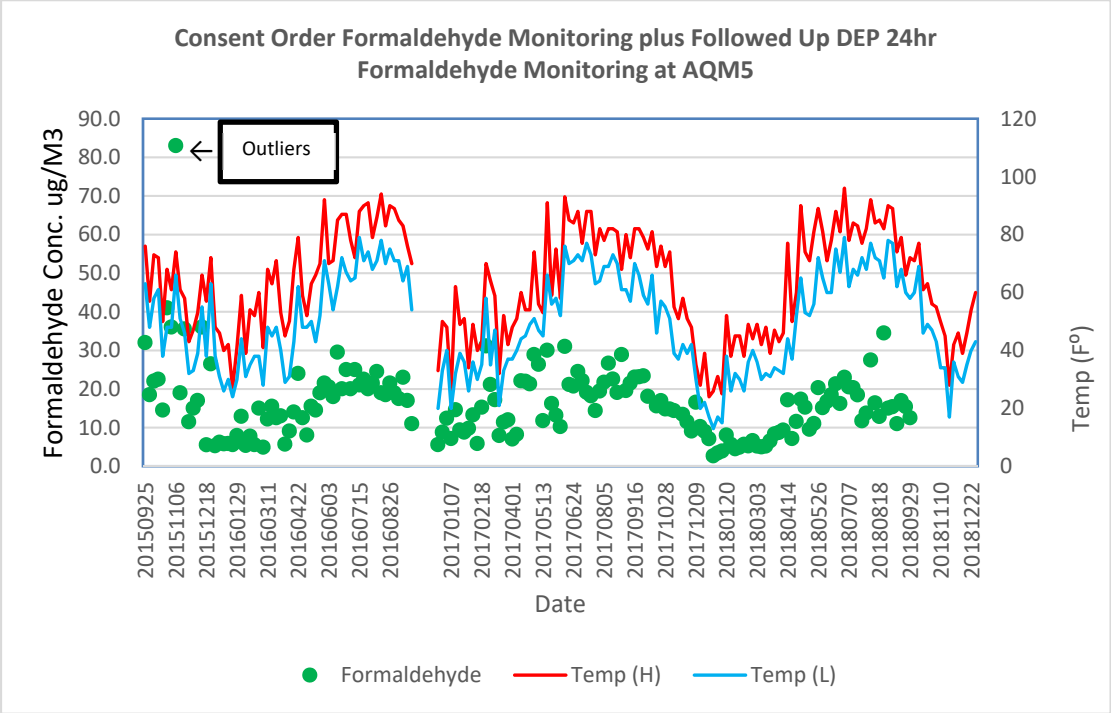

Figure 6 Consent Order And Followed Up Formaldehyde Monitoring Concentrations vs. Temperatures

There is no indication of correlation between the formaldehyde concentrations and the plant's flared digester gas volume

An analysis was conducted to assess if there is correlation between ambient formaldehyde concentrations and the North River WRRF flared digester gas volume. As seen in Figure 7, there is no suggestion of correlation between the formaldehyde concentrations and the flared digester gas volume.

The North River WRRF's flare operation was optimized by a manufacturer's technician on March 24, 2016. The flare's February 15, 2017 stack testing results indicated the flare is not a significant source of formaldehyde. As seen in Figure 6, there is no indication of significant changes in the ambient formaldehyde concentrations before and after the March 24, 2016 flare operation optimization. Therefore, it is unlikely that the unusually high flared digester gas volumes at the beginning of the Consent Order monitoring period, affected ambient formaldehyde concentrations. The strongest correlation observed is driven by the seasonal variation, indicative of a diffuse, background presence of formaldehyde rather than a point source such as the digester gas flare.

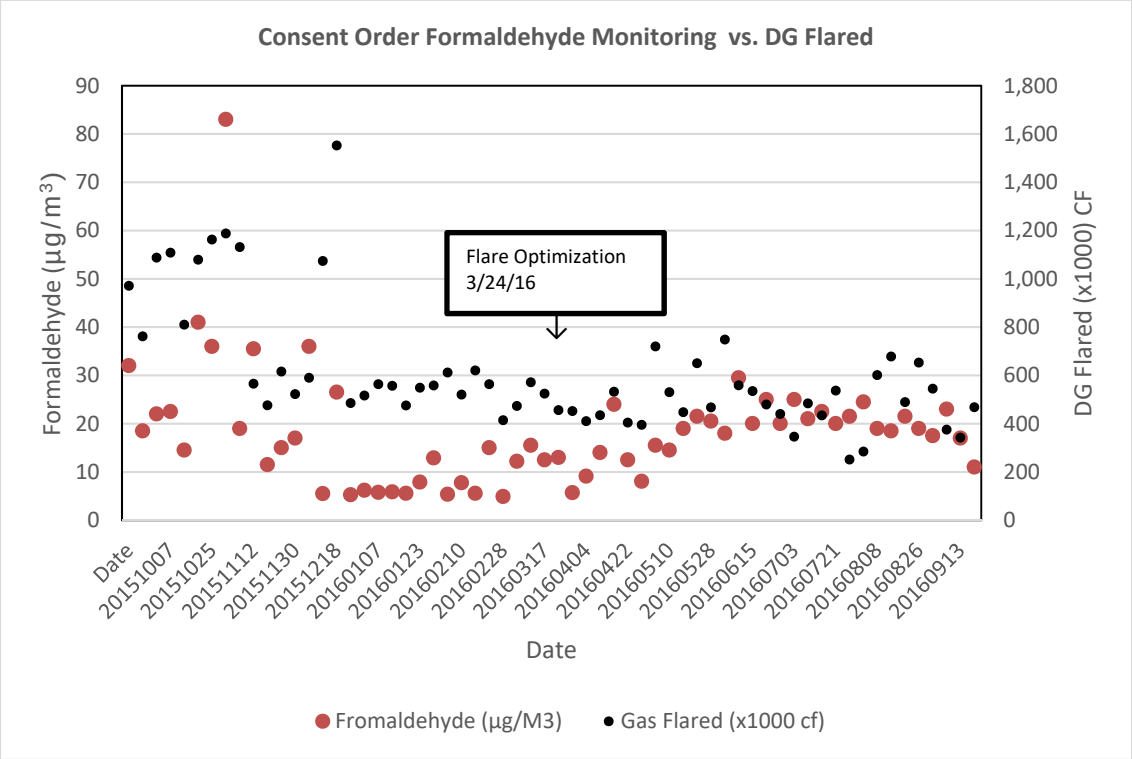

Figure 7 Consent Order Formaldehyde Monitoring Concentrations vs. Plant Flared Digester Gas

4.2 Additional Formaldehyde Sampling Program

4.2.1 Additional Formaldehyde Sampling Program Results

DEP's Additional Formaldehyde Sampling Program conducted from December 15, 2015 through September 22, 2016, collected two 1-hr samples (one AM sample in the morning and one PM sample in the afternoon) twice per week, providing 1369 samples, including 368 field blanks. The laboratory results, Chain-of-Custody documentation, and the associated meteorology data were previously submitted to DEC and are attached here as Appendix B.

4.2.2 Additional Formaldehyde Sampling Program Data Analyses

Data and outliers

The Additional Formaldehyde Sampling Program results ranged from 2.5 to 200 µg/M^3. A single 200 µg/M^3 concentration was registered for an AM sample at location S1 on July 28, 2016 and was far greater than and clearly distant from other measurement concentrations. The sampling field notes from that sampling event indicated that a vehicle was idling nearby for almost the entire sampling period. This sample data point is thus considered an outlier.

Excluding this outlier data point, the measured daily average concentrations ranged from 2.65 to 19.40 µg/M^3 as shown in Figure 8.

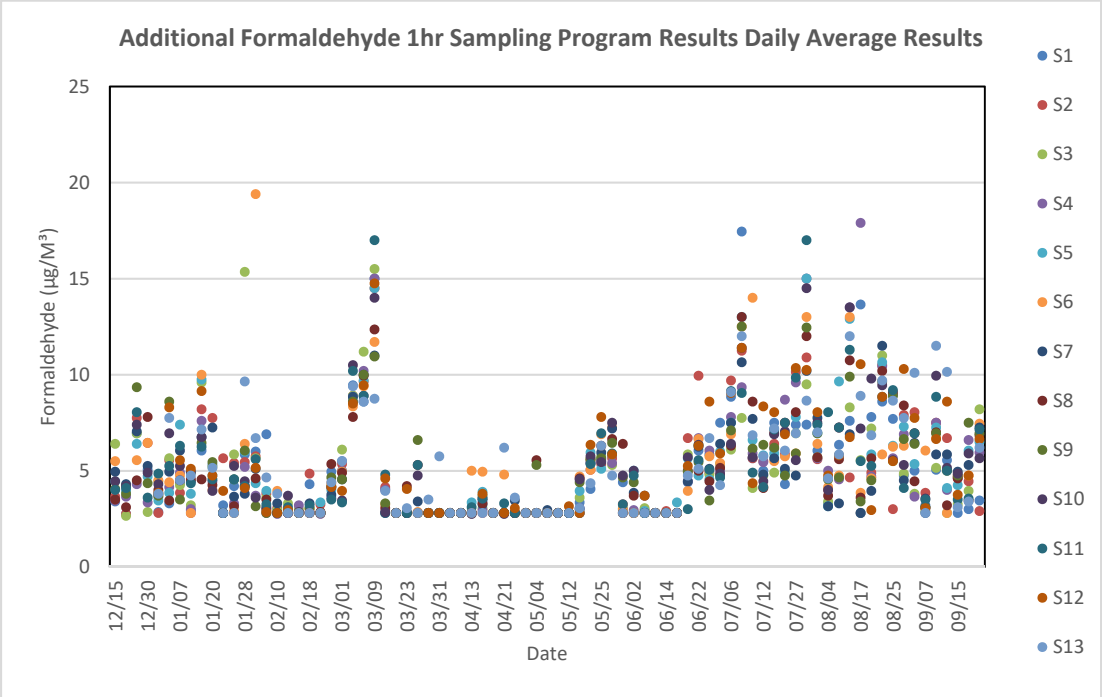

Figure 8 Additional Formaldehyde Sampling Program Results

Variations in the Additional Formaldehyde Sampling Program concentrations can be attributed to temperature.

Excluding the outlier, the Additional Formaldehyde Sampling Program results show certain variations that may be affected by temperature, as illustrated below in Figure 9.

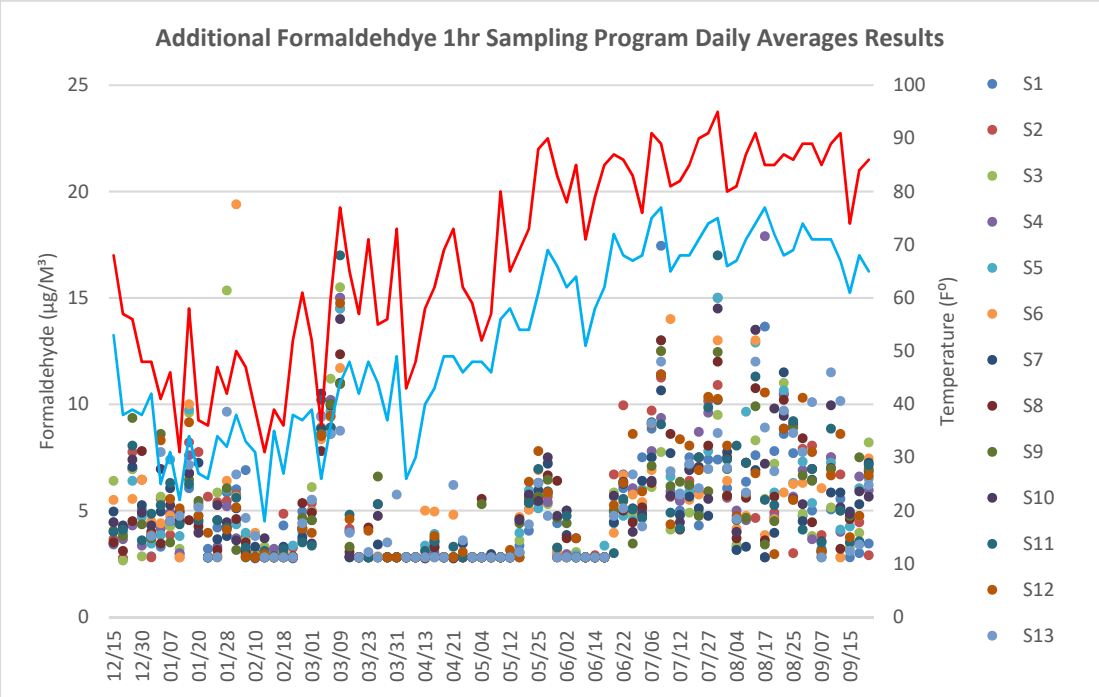

Figure 9 Additional Formaldehyde Sampling Program Daily Averages vs. Temperature

There was no significant difference of averaged concentrations at different locations.

These Additional Formaldehyde Sampling Program results average +/- 2 Standard Deviations for each of the 13 sampling locations, and are illustrated below in Figure 10. Although there were noticeable differences between the Standard Deviations at the various locations, the averaged concentrations at all 13 locations exhibited limited variation.

A more detailed spatial variation analysis, focusing on the data collected inside Riverbank State Park, will be discussed in Section 5.

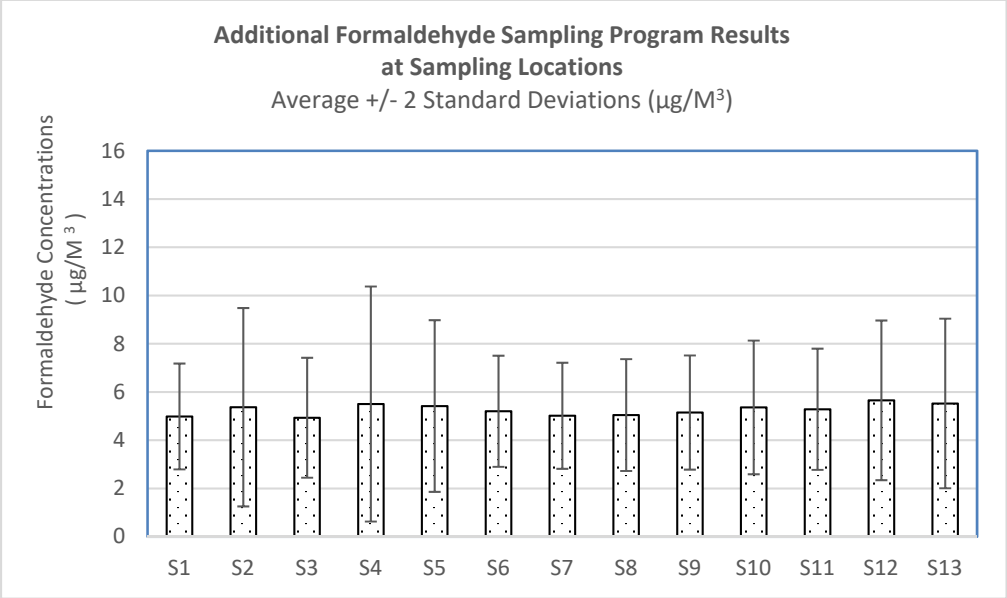

Figure 10 Additional Formaldehyde Sampling Program Location Averages

Wind direction specific average formaldehyde concentrations at each sampling location show similar distributions

As seen below, in Figure 11, the Additional Formaldehyde Sampling Program wind direction specific average concentrations show similar distributions at the sampling locations, exhibiting higher average concentrations when wind was blowing from the South and South-Southeast directions.

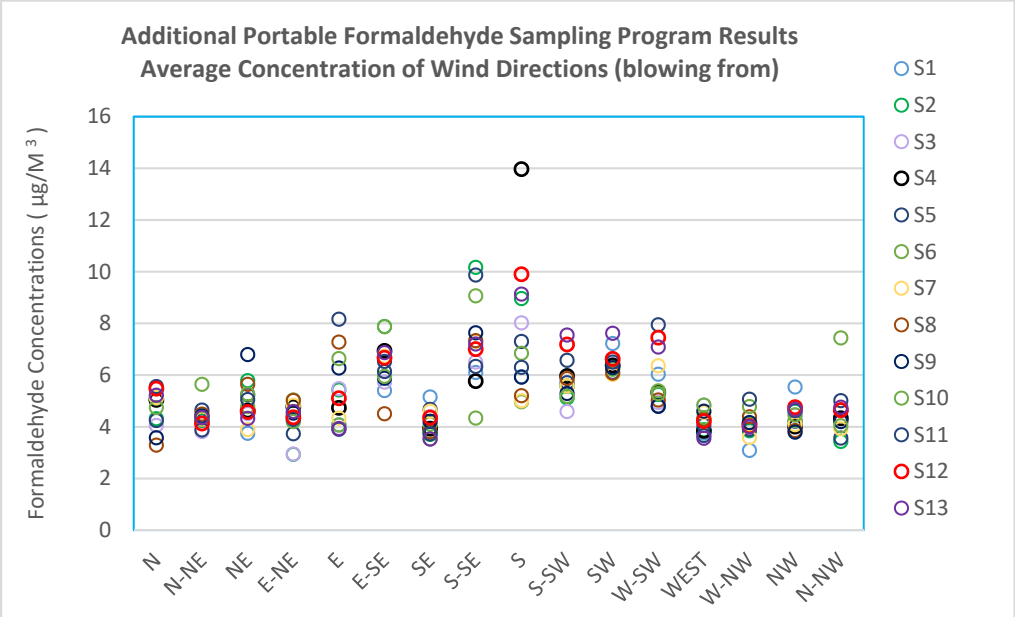

Figure 11 Additional Formaldehyde Sampling Program Average Concentrations of Wind Directions

All sampling locations registered their highest wind specific average Formaldehyde concentrations when the wind was blowing from southerly directions.

As seen below, in Figure 12, further review of the Additional Formaldehyde Sampling Program results revealed the highest wind direction specific average concentrations at all sampling locations were registered when wind was blowing from directions south of the sampling locations. Specifically, 10 of the 13 sampling locations registered their highest wind direction specific concentration when wind was blowing from the South and South Southeast directions.

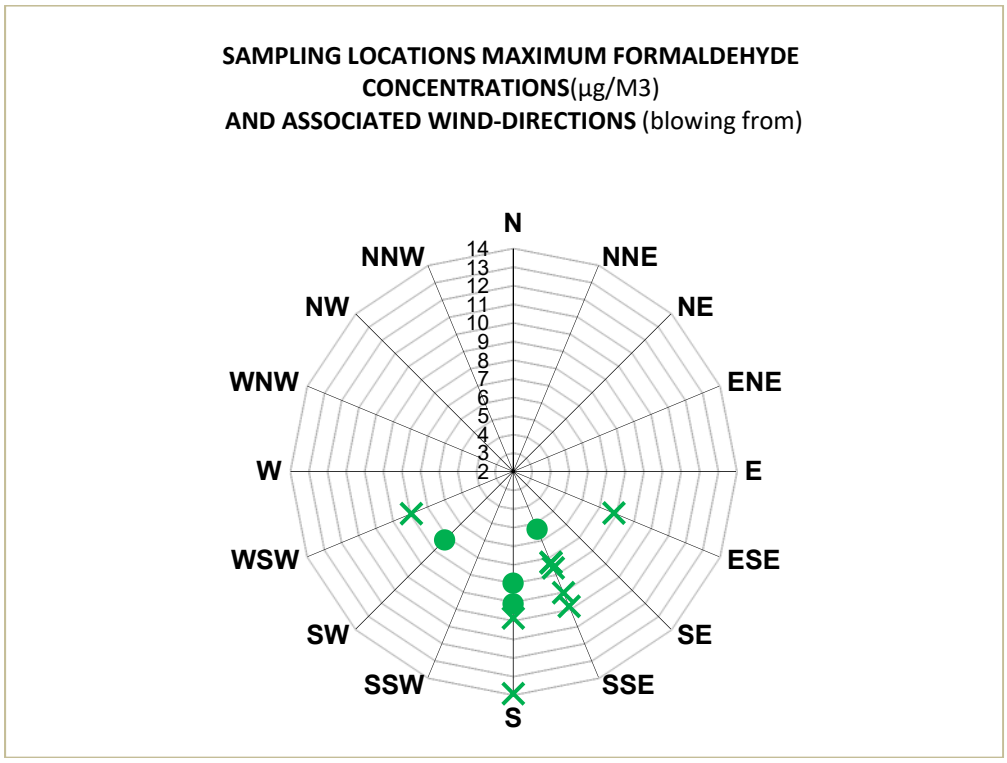

Figure 12 Additional Formaldehyde Sampling Program Locations Maximum Wind Direction Average Concentrations and the Associated Wind Directions

There was no indication of significant impact from specific single point source(s) and most of the sampling locations had higher average concentrations when the wind was blowing from various southern directions.

Pollution Roses of the sampling results from December 15, 2015 through September 22, 2016 at each of the 13 sampling locations are presented below in Figure 13. These pollution roses suggest no significant impact from the North River WRRF exhaust stacks or other particular emission point source(s) within the WRRF but confirm that most of the locations had similar high average concentrations when the wind was blowing from various southern directions.

Figure 13 Additional Formaldehyde Sampling Program Location Pollution Roses

Average formaldehyde concentrations at sampling locations inside the Riverbank State Park in general appear to increase going from the south towards the north, and at sampling locations along the east side of park are slightly higher than those locations on the west side of the park.

As seen in Figure 14 below, the lowest sampling location average formaldehyde concentration 5.01 ug/m^3 was at sampling location 7, which is located at the southern edge of the park, and the highest sampling location average formaldehyde concentration 5.65 ug/ m^3 was at sampling location 12, which is located at the northern edge of the park, and the average concentrations in general appear to increase going from the south towards the north within the park.

Figure 14 Additional Formaldehyde Sampling Program Riverbank State Park Locations Average Formaldehyde Concentrations

SECTION 5 CONCLUSIONS

Based upon the data and analysis presented in Section 4 Results and Analysis, that includes three different data sets, it is concluded that:

1. Formaldehyde is both a direct and an indirect product of incomplete combustion. Typical sources of airborne formaldehyde in an urban environment include direct formaldehyde emissions from incomplete combustion (oxidation) products, from motor vehicle exhaust byproducts, or indirectly from formation of formaldehyde in the ambient air from photo-oxidation of hydrocarbon precursors, also emitted from motor vehicle exhaust and other combustion sources.

   Very limited difference was found between formaldehyde concentrations for day and night time sampling events. This analysis was conducted in an attempt to assess if traffic density variability in the vicinity of the NRWRRF impacted formaldehyde readings. No meaningful diurnal (single-day) variation could be identified, indicating minimal direct formaldehyde emissions from vehicular traffic in the immediate vicinity of the NRWRRF and the Riverbank State Park.

2. As shown in Figure 13, the average formaldehyde concentrations at locations along the east side of Riverbank State Park, which are adjacent to the NY 9A Henry Hudson Parkway and Manhattan, are marginally higher than those on the west side of the park by the Hudson River. This may reflect the minimal impact of direct formaldehyde emissions from traffic on the NY 9A Henry Hudson Parkway and other activities in Manhattan. However, since automobiles are known sources of hydrocarbon emissions, the impact of their hydrocarbon emissions which can be later converted to ambient formaldehyde by photo-oxidation, particularly during the summer months, cannot be ruled out. Vehicular traffic on the nearby NY9A-Henry Hudson Parkway is a potential cause of photo-oxidation derived formaldehyde formation and a likely contributor to ambient formaldehyde concentrations in Riverbank State Park and the surrounding area.

3. As shown in Figures 4 and 6, the Consent Order Formaldehyde Monitoring data shows a strong correlation between measured formaldehyde concentrations, ambient temperatures and ozone concentrations. The formaldehyde concentrations and temperatures correlations were further verified by the ongoing 24 hr sampling results, now spanning three years. Direct formaldehyde emissions would not be expected to show seasonality, whereas indirect emissions would be expected to show an increase in ambient formaldehyde levels in the summer months when temperatures and solar intensity are at the highest. The seasonality of the data suggests the ambient air formaldehyde concentration is more likely attributed to formaldehyde formation by photo-oxidation of hydrocarbons in the ambient air rather than emission from a specific point source.

The long term formaldehyde monitoring data collected at the Riverbank State Park exhibits a consistent seasonal trend in ambient formaldehyde concentrations indicative of a photo-catalytically driven background presence with no correlation to the operations associated with the North River WRRF.

4. There was no significant difference in the average formaldehyde concentrations of the Additional Formaldehyde Sampling Program locations when compared to each other. Figures 10 through 12, all show higher formaldehyde concentrations at each location being registered when the wind was blowing from southerly directions. This suggests that the main contributor of the ambient air formaldehyde concentrations in the area is from south of the area studied. The sampling results do not suggest impact from any single specific point source, North River WRRF or other. The Pollution Roses in Figure 13 don't show concentration contours or concentration profiles toward a specific point source.

   Overall, spatially there was no significant difference of averaged concentrations at different locations with the averaged concentrations at all 13 locations exhibiting limited variation. Results suggest there is no significant impact from the North River WRRF exhaust stacks or other emission point source(s) within the WRRF. The Additional Formaldehyde Sampling Program did confirm that most of the locations exhibited higher average concentrations when wind was blowing from the South and South-Southeast directions toward the North River WRRF. This may be indicative of the area's background formaldehyde concentration.

5. As seen from Figures 10 through 12, all Additional Formaldehyde Sampling Program's locations registered the highest formaldehyde concentrations and had higher average formaldehyde concentrations when the wind was blowing from southern directions. Pollution Rose analyses of the Additional Formaldehyde Sampling Program data show no noticeable indication of a significant impact from the North River WRRF exhaust stacks or any specific point source(s).

   Even if one assumes that the increase of the highest location average concentration of 5.65 ug/ m^3 at sampling location S12 from the lowest location average concentration of 5.01 ug/ m^3 at sampling location S7 was solely due to the North River WRRF exhaust stacks, the impact would be 0.64 $\mu g/m^3$. This limited impact of 0.64 ug/m^3 is materially lower than DEC's Short-term Guidance Concentration limit of 30 ug/m^3, for a 1 hour average concentration in order "to protect the general population from adverse acute one-hour exposure" for formaldehyde.

   As seen in Figure 7, there is no correlation between the ambient formaldehyde concentrations and the flared digester gas volumes. The flare's February 15, 2017 stack testing results indicated the flare is currently not a significant source of formaldehyde. As seen in Figure 7, the ambient formaldehyde concentrations were at the same level, with no

indication of significant change before and after the March 24, 2016 flare operation optimization. Long term monitoring indicates that there was no indication of correlation between the formaldehyde concentrations in Riverbank State Park and the North River WRRF's flared digester gas volumes.

Emissions from the North River WRRF do not appear to have an impact on Riverbank State Park and the surrounding area.

Ambient air formaldehyde concentrations in the area appear to be originating primarily from directions south of the North River Wastewater Resource Recovery Facility and may be an indication of the area's background formaldehyde concentrations.

Appendix A

Consent Order Formaldehyde Monitoring Quarterly Reports

Appendix B

Additional Formaldehyde Sampling Program Laboratory Reports