

GOVERNMENT OF THE DISTRICT OF COLUMBIA  
OFFICE OF THE ATTORNEY GENERAL



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Public Advocacy Division  
Social Justice Section

ELECTRONIC FILING

November 30, 2021

Ms. Brinda Westbrook-Sedgwick  
Public Service Commission  
Of the District of Columbia Secretary  
1325 G Street, NW, Suite # 800  
Washington, DC 20005

**Re: Formal Case No. 1154 – In the Matter of Washington Gas Light Company’s Application for Approval of a PROJECTpipes 2 Plan,  
&  
Formal Case No. 1130 – In the Matter of the Investigation into Modernizing the Energy Delivery System for Increased Sustainability.**

Dear Ms. Westbrook-Sedgwick:

On behalf of the District of Columbia Government, please find the enclosed “2021 Fugitive Methane Emission Survey of the District of Columbia” commissioned by the Department of Energy and Environment for filing in the above-captioned proceedings. If you have any questions regarding this filing, please do not hesitate to contact the undersigned.

Respectfully submitted,

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**2021 Fugitive Methane Emission Survey of the District of Columbia**

**For the District of Columbia Department of Energy and Environment**

**October 31, 2021**

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### **ATTACHMENT A**

## **Executive Summary by the Department of Energy and Environment**

The purpose of this study is to initiate the first part of an overall study by the Department of Energy and Environment (DOEE) to understand how best to reduce methane emissions associated with the use of natural gas in the District and how such reductions may occur cost-effectively. This first part is a preliminary survey of where fugitive methane emissions may be occurring, and, more importantly, to identify where such emissions may become a concern from a climate change mitigation perspective, due to their potential for high-volume emissions.

It should be emphasized that the scope of this survey does not include an evaluation of safety. Safety determinations are made by Washington Gas using their site-specific criteria for identifying safety risks, and they are outside the scope of the survey. Air methane concentration readings that were obtained in this survey, whether low or high, are not intended to serve as indicators of safety or hazardousness.

Leaks from natural gas infrastructure contribute to climate change, damage trees, create potential safety risks, degrade air quality, and waste ratepayer money. Identifying the locations of high-volume leaks can help reduce GHG emissions effectively, and understanding where leaks may be occurring can inform policy development for a strategic and manageable transition toward decarbonized heating.

The technical consultants performed a methane (CH<sub>4</sub>) emission survey of residential neighborhoods in the District of Columbia, during April - June, 2021. They used a high-precision, vehicle-mounted methane analyzer equipped with a Global Positioning System, to survey and map surface methane emissions detected across 713 centerline miles in the District. They identified 3,346 locations where the analyzer detected methane at concentration levels higher than ambient background levels. Methane can come from sources other than natural gas pipelines, including broken sewer mains, landfills, and wetlands. Therefore, this study established strong correlations of identified methane emission points to natural gas pipes: they verified a sample set of vehicle-detected air methane concentration readings with subsurface measurements of combustible gas. For this sample set, every methane emission point they verified in the subsurface was in close spatial proximity to a natural gas main, valve, or service line, indicating that the detected methane emission points are overwhelmingly caused by leaking natural gas infrastructure. These detections take into account the naturally-occurring ambient background levels of methane, which can vary by location and time of day due to wind conditions as well as proximity of methane emission points to analyzer.

Based on this survey and in its subsequent analyses, DOEE will prioritize the identification of leak locations that have the potential to produce high-volume emissions. Scientific studies on methane leaks from natural gas distribution systems suggest that a small percentage of the overall number of leaks in a given system may be responsible for a majority of the overall volume of the leaks from the system. For example, for the gas distribution system in Boston, 7% of the leaks were shown to be contributing 50% of the total methane emissions that were measured. Therefore, DOEE presumes that of the 3,346 locations of fugitive methane emissions that were detected in this survey, a relatively small percentage of those locations may be contributing a large portion of the overall fugitive emissions from the system, and DOEE will further investigate the emissions at those locations to quantify the volume of emissions. Air methane concentration levels alone are not a reliable indicator of the overall volume of fugitive emissions, which requires further analysis, and various methods for estimating the volume of emissions are described in the report. The overall numbers are equivalent to a frequency of about 4.7 methane emission points per centerline road mile, with some of the older neighborhoods showing a higher frequency.

We emphasize that while it makes good sense to prioritize and further analyze and address the high-volume locations with high air methane concentration level readings, it must be remembered that a leak extent analysis could show some leaks with low air methane concentration level readings can also produce high volumes of emissions.

**Acknowledgements:** The report authors thank [Dominic Nicholas](#) for performing algorithm development, programming, data processing and analysis, GIS mapping and data visualization; and Julian Phillips for providing vehicle navigation support and graphics support. Gas Safety, Inc., and Nathan Phillips are wholly responsible for the content and data reported herein.

## 1. Introduction

Leaks from natural gas infrastructure constitute problems across a wide spatial range. At the point of a leak, methane (CH<sub>4</sub>), the largest constituent of natural gas, can build up in confined spaces to hazardous levels. Near the point of a gas leak, gas displaces oxygen in soils, damaging vegetation including trees (Schoellart et al. 2020). At the scale of communities, gas leaks degrade air quality, promoting the formation of surface level ozone and formaldehyde, both of which are damaging to health (West et al. 2006). At the global scale, gas leaks contribute to climate change, as the largest constituent of natural gas, methane, is a powerful greenhouse gas (IPCC 2013). Finally, gas leaks represent lost ratepayer money. In 2019, the most recent reporting year, the District of Columbia had the highest percent lost gas<sup>1</sup> (6.2%) among the US states and the District of Columbia. The volume of lost gas in 2019 (19 million therms), at a nominal price of natural gas in the District of [\\$1.25/therm](#), represents a lost value of approximately \$24M.

Most gas leaks in the pipeline distribution systems in cities and towns are associated with old, leak-prone pipe, some over a century old, of which cities along the US eastern seaboard have relatively large proportions. In 2013, we published the first study of its kind, detecting and mapping 3,356 gas leaks from natural gas distribution pipeline infrastructure in Boston, MA (Phillips et al., 2013). In 2014, this same team conducted and published a study documenting 5,893 gas leaks across approximately 1,500 centerline road miles of the District of Columbia (Jackson et al., 2014). The study reported here focuses on residential sections of the District of Columbia, serviced by gas, for the D.C. Department of Energy and Environment.

## 2. Context

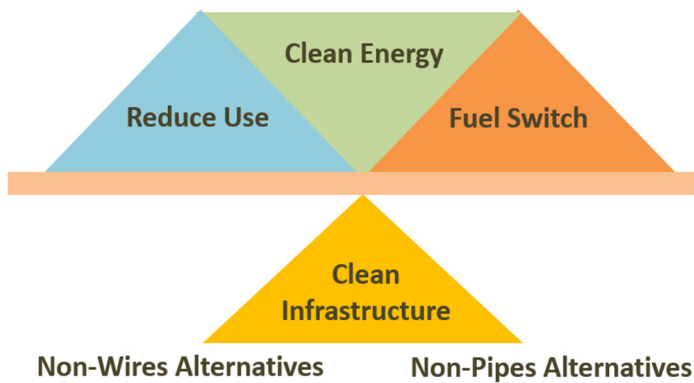
This study is conducted to help advance the District Government’s building decarbonization policy, and to inform DOEE’s ongoing intervention in Formal Cases 1154 and 1167 regarding, respectively, Washington Gas’s pipe replacement program called PROJECTpipes (currently in Phase 2)<sup>2</sup> and climate change programs. The District of Columbia is committed to doing its part to meet the challenge, as described in the 2015 Paris Climate Accord, of keeping the rise of

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<sup>1</sup> “Lost Gas” is defined by the US Energy Information Administration as “known volumes of natural gas that were the result of leaks, damage, accidents, migration, and/or blow down within the State in which these events took place.

<sup>2</sup> The purpose of PROJECTpipes is not about identifying and fixing actual leaks that are occurring, and Washington Gas already has a leak repair program. Rather, the purpose is to prevent or mitigate *potential future* leaks by replacing all pipes without accounting for building electrification. Furthermore, the method of prioritizing pipes for replacement is based on an algorithmic forecast of potential future leaks, meaning that some of the pipes targeted for replacement may not be leaking at all currently and may go unused in a future of all-electric buildings.

global warming to well below 2°C from pre-industrial levels and to pursue efforts to limit the increase to 1.5 °C. Achieving this goal requires that the world reach carbon neutrality around 2050, and DOEE’s Clean Energy DC Plan noted that hitting the 2050 GHG carbon neutral target will require the District to eliminate fossil fuel use:<sup>3</sup>



The District’s decarbonization policy rests on the three pillars of energy use reduction, clean energy supply, and fuel switching, and these pillars in turn rely on the availability of clean energy delivery infrastructure.<sup>4</sup> This means, for the electricity infrastructure, a modernized grid that maximizes and promotes the

use of Distributed Energy Resources and microgrids, and, for the natural gas system, it means prudently downsizing—via strategies such as non-pipe alternatives--the pipe system to minimize the stranded costs caused by building decarbonization, and to eliminate leaks emitting high volumes of methane.

In Formal Case 1167, DOEE commented that Washington Gas’s climate business plan proposes selling natural gas for space heating and cooking well past 2050, premised on a completely replaced pipe system, which are contrary to the District’s decarbonization efforts. Similarly, in Formal Case 1154, DOEE testified that PROJECTpipes will result in very small reductions of GHG emissions despite the high cost of the program (an overall cost ranging from \$3 billion to \$4.5 billion by 2055). PROJECTpipes doubles down on an infrastructure designed to deliver fossil fuels when District policies and market trends are rapidly moving away from the use of fossil fuels in buildings.<sup>5</sup> DOEE testified that building electrification be considered as a non-pipe alternative, similar to the non-wire alternative using distributed energy resources in the electricity sector, to PROJECTpipes. DOEE recommended in its testimony that to reduce the

<sup>3</sup> Clean Energy DC, p. 156. Specifically, the Clean Energy DC plan states that achieving the District’s 2050 GHG carbon neutral target will require the District to phase out the use of natural gas in buildings. Therefore it is readily apparent that the Company’s effort to completely rebuild a natural gas delivery system by 2054 with \$3 - \$4.5 billion in ratepayer funds is directly at odds with the District’s climate goals.

<sup>4</sup> See Clean Energy DC Plan, “Transforming to a Low Carbon District”.

<sup>5</sup> See Clean Energy DC Plan, p.24, p.156:

To achieve its 2032 GHG target, the District will clearly need to shift away from fossil fuels for buildings (natural gas and fuel oil) and transportation (gasoline and diesel) while simultaneously decarbonizing its electricity supply. For buildings, this will mean shifting to non-fossil fuel sources for heat and hot water. .... Consequently, the District must transition away from equipment and technologies that currently depend on such fuels. The equipment used to heat and cool space and water in buildings is a key aspect of this transition.

future risks of pipe leaks, (1) all of the leaks in the District be mapped using high-sensitivity leak detectors, then (2) prioritize the replacement of pipes based on the map's findings, first exploring the viability of the Non-Pipe Alternative approach. This study furthers these decarbonization objectives, and it helps to identify critical issues related to human health and equity associated with the use of fossil fuel appliances.

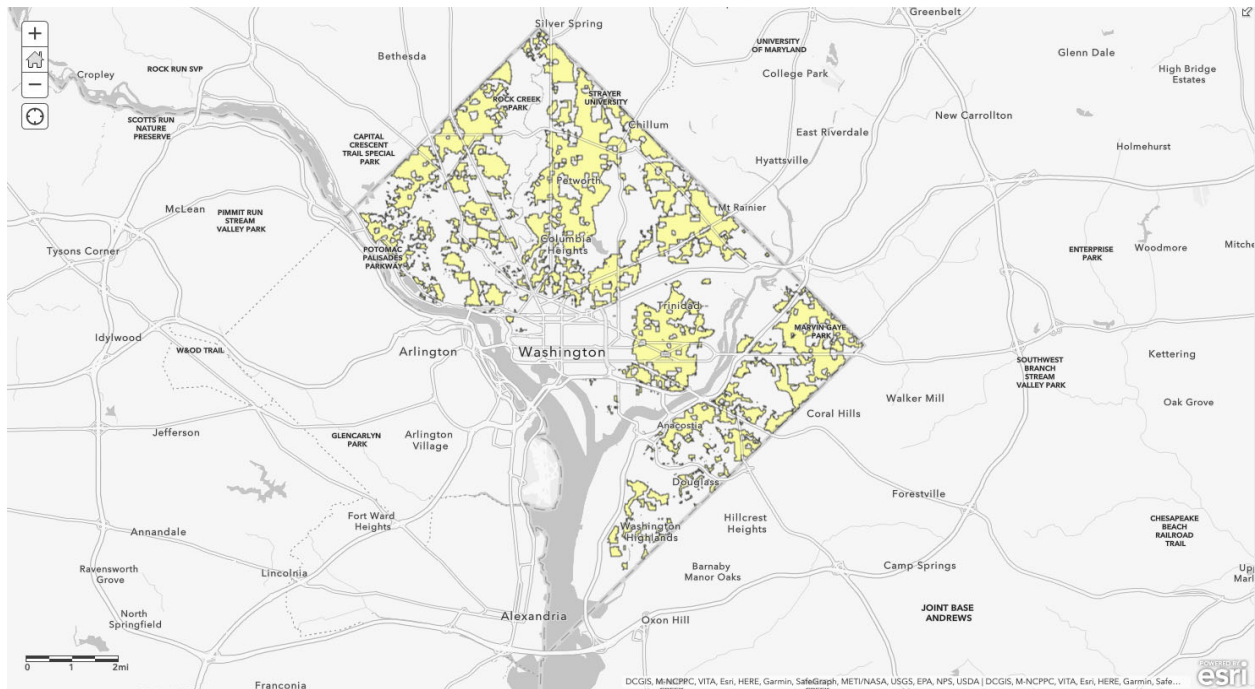
### **3. Scope of Work**

We surveyed surface methane emission points on public roads in selected residential areas of the District of Columbia as specified by the Department of Energy and Environment (Figure 1). Methane can come from sources other than natural gas pipelines, including broken sewer mains, landfills, and wetlands. Therefore, this study detected methane leaks as a broader category than natural gas leaks, and it was necessary to establish strong correlations of identified emissions points to natural gas pipes.

Our prior work in Boston and the District of Columbia showed that the vast majority of leaks detected from under streets and sidewalks bore a distinct chemical signature of natural gas methane (Jackson et al. 2014; Phillips et al. 2013). Moreover, the spatial signature of wetland and landfill leaks is distinctly different from that of pipeline leaks. Fugitive emissions from leaky pipes are recognizable as abrupt and highly localized spikes in methane concentration, whereas wetland and landfill methane emissions manifest as sloping, gradual deviations from a baseline methane concentration.

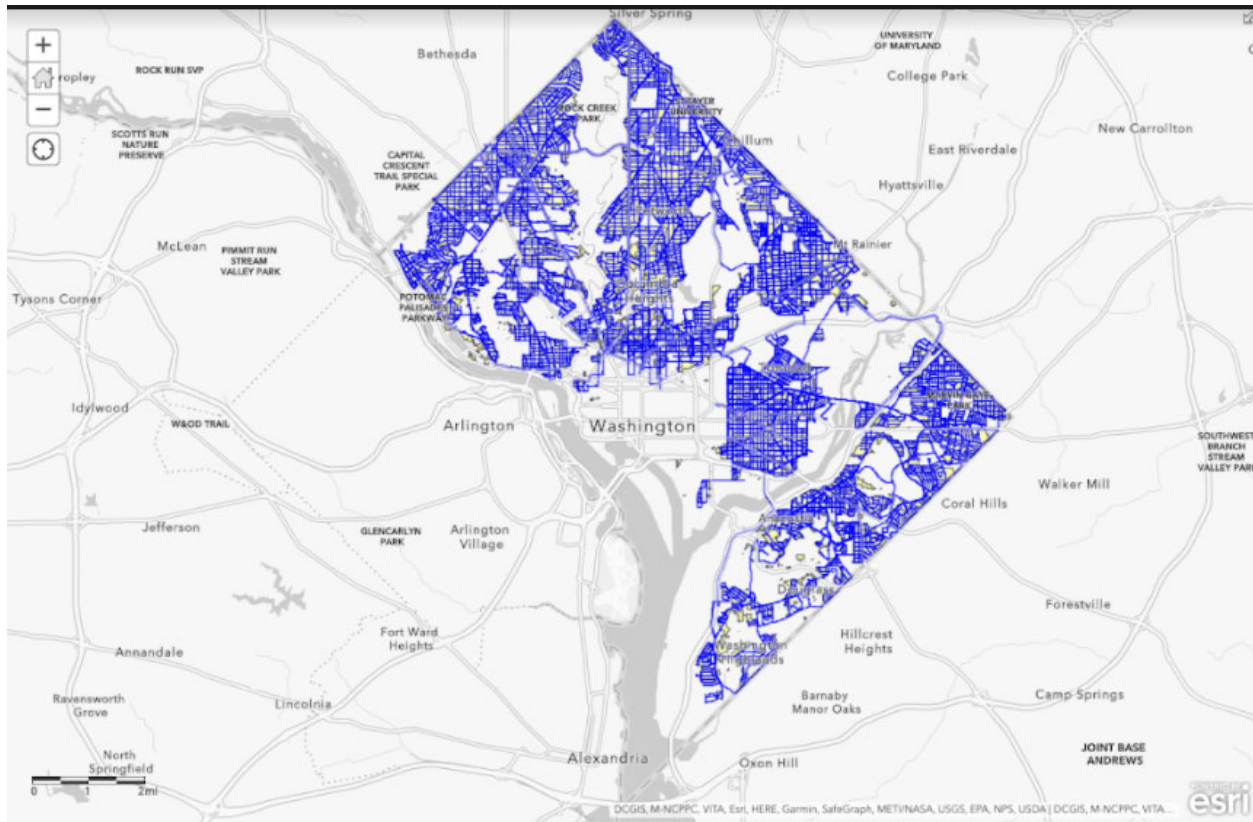
To ensure that the identified fugitive methane emissions emanated from natural gas pipes, we verified the source of emissions detected in our mobile survey, by investigating a subsample of detected fugitive emissions from the mobile survey using a hand-held combustible gas indicator with subsurface probe, walking the vicinity of detected locations in air to verify whether they were spatially associated with subsurface gas near natural gas pipeline infrastructure. Secondly, we verified whether methane emissions were from gas pipelines by detecting the odor of the mercaptan odorant added to pipeline gas.





**Figure 1.** Areas (in yellow) of the District of Columbia specified by DOEE to be surveyed for methane leaks along public roads.

Our road methane emission survey covered approximately 99% of the public roads in the specified areas of the District (Figure 2), covering 713 centerline road miles, in accordance with DOEE’s need to address the climate change and health impacts of methane leaks in residential neighborhoods. Reasons for not surveying 100% of public roads in residential neighborhoods included protracted road work, and recent pedestrianization of some streets.



**Figure 2.** Roads Driven and surveyed for methane leaks between April and June 2021, overlain on the specified areas depicted in yellow and Figure 1.

It is important to recognize that peak concentration data typically, but do not automatically nor reliably lead to the rate of methane volume emitted from each leak. This is due to a combined effect of variable proximity of each leak to the analyzer inlet as it is driven past, and to vagaries of wind that could blow a leak plume in any direction while the analyzer is being driven past it. For this reason, we traveled every road in the specified areas of interest at least twice. Although the combination of leak proximity to analyzer and wind conditions do not often create “all things being equal” conditions, it is the case that when all conditions *are* equal or at least similar, a higher peak concentration in a plume indicates a larger leak, so the higher peak concentration leaks do provide useful information as an initial indication of potentially large leaks, which, however, necessitate follow-up on-the-ground measurements to confirm.

For an estimate of the volume flux of methane emitted from each leak, a future, second phase of this research will be needed. There are several potential approaches to quantifying the volume of or categorizing the size of individual gas leaks. These approaches fall into three general categories: 1) ground-based measurements of gas emanating from the surface (e.g., Hendrick et al. 2016); 2) meteorological measurement and modeling of the size and movement of gas plumes using wind speed and direction measurements (e.g., Jackson et al. 2014; von

Fischer et al. 2017); and 3) plume spectroscopic methods that measure the absorption of radiation by methane plumes (described in Magavi 2018).

Each of the leak quantification methods has pros and cons. Ground-based measurements using chambers, as in Hendrick et al. (2016), provide direct, relatively accurate quantification of leaks using simple measurements, but is a laborious and time-consuming process, which can take many hours per leak. “Plume mapper” approaches similar to those described in Jackson et al. (2014) and von Fischer et al. (2017) are efficient methods to bin leaks into categorical sizes, but they rely on statistical models of leak size that are developed on a separate test set of leaks that may not represent the same geometric complexity of streetscapes or spatially complex leak loss points. The spectroscopic method described in Magavi (2018) is in principle the easiest and most reliably integrative of the entirety of a leak in space, as it simply uses and measures focused light passing through an entire plume, but this method is still in the research and development phase.

A variant on the ground-based method called the “leak extent method”, described in Magavi (2018) and Magavi et al. (2019), consists of making simple estimates of leak size based on the leak square footage. This is an operationally efficient surrogate method to determine leak size category (small, medium, large) based on simple subsurface measurements determining the areal extent of the presence of subsurface gas associated with a leak.

Our research team is equipped for and skilled in making any or a combination of the techniques described above (except for the plume spectroscopic method), in a second phase of this study.

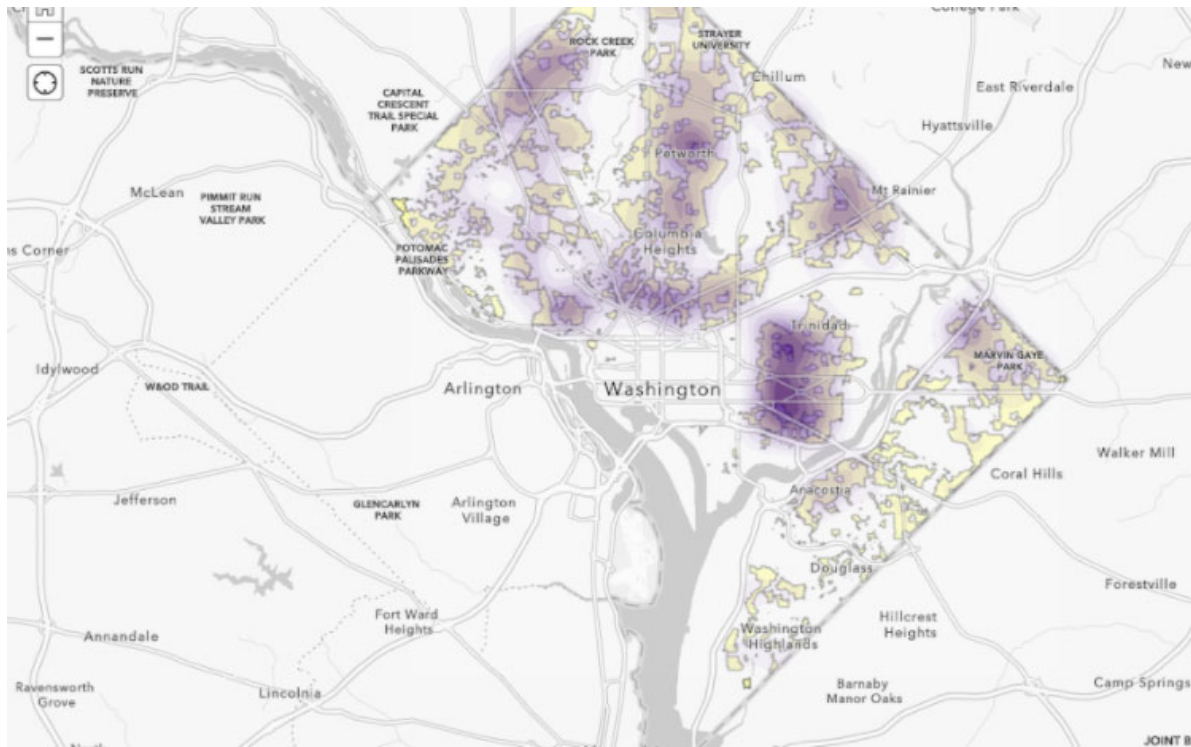
#### 4. Results and Discussion

We detected methane in 3,346 surface locations that exceeded background levels of methane in air across the residential areas of the District of Columbia. The table below shows the overall number of detections by District Wards. Using a statistical sample, we subsequently verified that most of these emissions were coming from the natural gas delivery system.

Ward	# of surface methane emission points above background levels
1	218
2	288
3	595
4	691
5	523
6	554
7	309
8	160

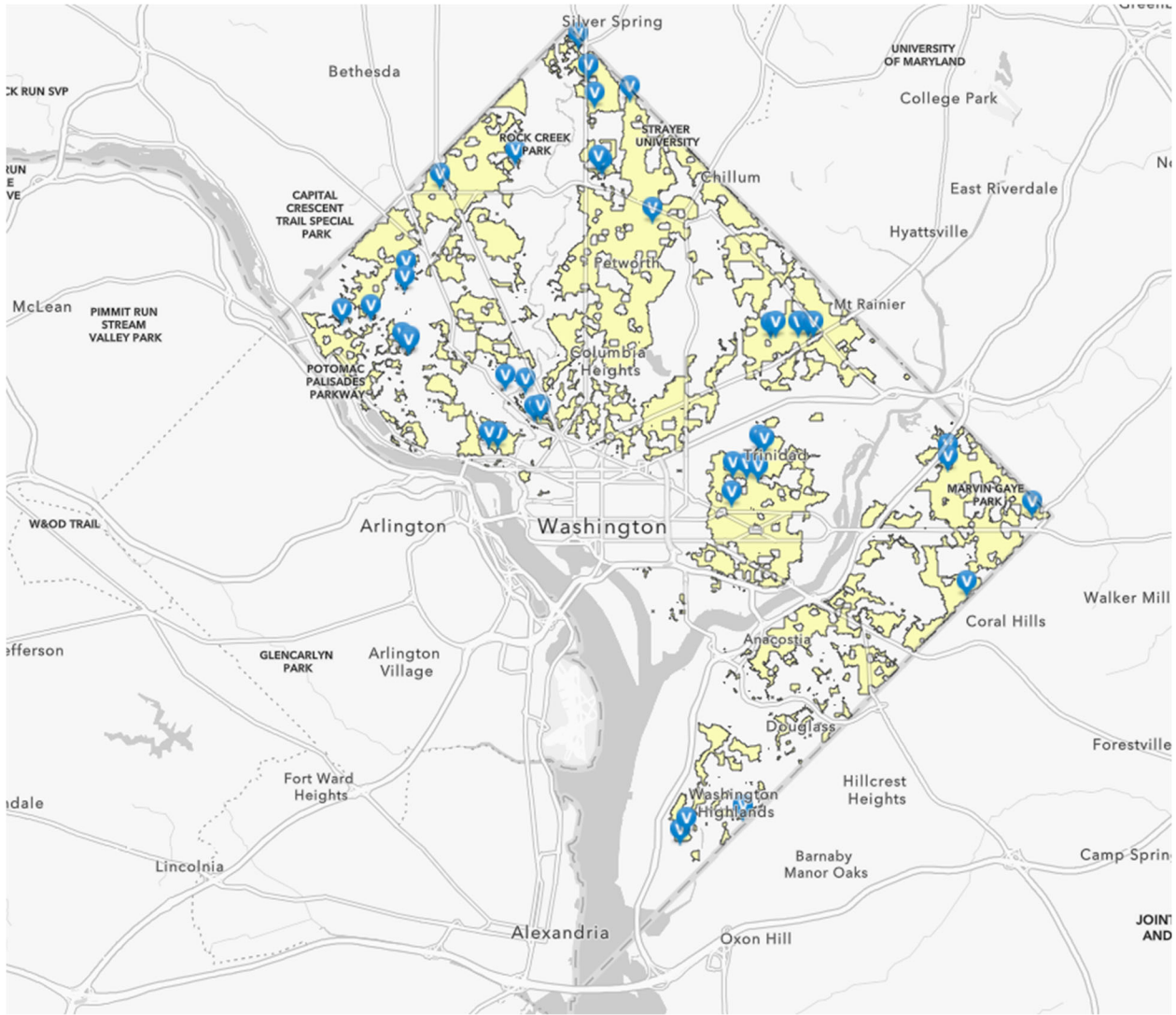
The report includes an Attachment A of the identified methane emission locations and the associated concentration levels that are indicated in quintiles. DOEE can provide the numerical values associated with each location upon specific locational request. The spatial density of methane emission points appeared to be relatively evenly distributed across the study areas. In addition to the point locations,

leak density variation, which may be useful in policy decisions on addressing leaks at the street or neighborhood scale, are shown in Figure 3.



**Figure 3.** Density of methane emission point distributions.

For verification, forty emission points were selected based on preliminary observations of point [CH<sub>4</sub>] elevations, distributed across the District and representing small, medium and large observed methane concentrations (Figure 4). The verification method is explained in Appendix 1. We identified elevated subsurface methane in 39 of the 40 locations, and in every one of the locations in which elevated subsurface methane was found, it was closely spatially associated with a gas main, valve, or service line. Individual reports for each of the 40 verifications are available upon request. These results indicate that analyzer sensitivity to natural gas leaks is high, even for small ones or those that may originate on service lines under sidewalks and yards, or from building meters.



**Figure 4.** Location of forty leak verifications. A combustible gas indicator with subsurface probe was used to find subsurface leak origins associated with leaks detected by the mobile survey.

Future improvements on this study would include obtaining the complete pipeline inventory and map, and a map of the operating pressures of the pipes in the District of Columbia, from Washington Gas. These data would help explain why certain roadways in the District had a higher spatial density of leaks than others, and it would allow for an estimate of the likely rankings of leak rates from particular lengths of pipeline. Among the low-pressure distribution pipelines, operating pressures can vary substantially, from 0.5 psi to 90 psi or more. Generally, all things being equal, a leak in a pipe will leak at a rate that is proportional to the pipeline operating pressure, so leaks we found in zones of higher operating pressure will be expected to leak at higher rates.

Although peak methane concentrations observed from the mobile survey offer a rough indication of leak size, it is itself not a reliable indicator of leak sizes because of the vagaries of wind speed and direction that make the peak concentrations vary from second to second, and from one drive-by to another. Moreover, a mobile survey is unable to determine the actual distance of the leak from the air inlet collection point, as a large, distant leak could potentially appear similar, under certain wind conditions, to a small, near leak. Therefore, a leak sizing study, using one of the enumerated methods described earlier in this document, should be performed, using the one that is best suited for furthering the objectives concerning the District's climate change and health policies.

We emphasize that while it makes good sense to prioritize and further analyze and address the locations with very high air methane concentration level readings, it must be remembered that a leak extent analysis could show that some leaks with low air methane concentration level readings produce high volumes of emissions.



## Appendix 1: Materials and Methods

We used a mobile Picarro G2301 Cavity Ring-Down Spectrometer (Picarro, Inc., Santa Clara, CA; <http://www.picarro.com/>) in all surveys, installed in a vehicle equipped with a geographic positioning system (GPS), and driven on the specified roads. A filtered inlet tube was placed outside the passenger side of the vehicle. The analyzer was periodically tested with <0.01 ppmv, 2.0 ppmv, and 10 ppmv [CH<sub>4</sub>] test gas (Scott Marrin, Inc. Riverside, CA). Further detail is provided below and Figure 8 shows analyzer test results.

To determine the lag time between when air was drawn into the filtered inlet and detected by the analyzer, we used a 50 ppm concentration tank of methane to impart a known methane signal at a specified location, driving at a range of speeds typical of actual survey speeds. We determined a lag time of 4.4 seconds (or, 4 records in the data files) best spatially aligned the detected methane signal with its known location.

As roadways in the town being surveyed are driven, the system records parts per billion (ppb) CH<sub>4</sub> concentration each 1.1 seconds, along with latitude-longitude GPS coordinates. Per the lag test described above, in each data file we shifted the apparent GPS location four rows to correct for the 4.4 second time lag between surface methane emission location and analyzer detection.

We started and stopped recording data into individual files representing survey micro-areas likely to have similar ambient conditions, and therefore the DC survey resulted in many individual files of [CH<sub>4</sub>] readings by geo-position. The DC survey produced 282 data files over 23 days between April 5 and June 26, 2021. Of these 282 files, 176 were used in this analysis, the remainder being extraneous (e.g., files started and ended in a stopped location).

To distinguish discrete leaks from the spatially continuous raw methane concentration data, a modified Tau approach (Keyes et al. 2020; Olewuezi et al., 2015) was used to perform outlier detection on the raw spatial methane concentration data. This method is a statistical approach to support deciding whether to keep or discard suspected outliers in a population sample, in this case an individual [CH<sub>4</sub>] measurement. A threshold methane level that meets the outlier category, indicating a leak, is calculated by the data file's CH<sub>4</sub> sample size, sample average, sample standard deviation, and desired confidence level.

To avoid double-counting methane emission points that were driven past multiple times, a procedure was used to eliminate multiple outliers within a spatial window of 30 m radius from the highest peak methane concentration in the vicinity. Since vehicle lane widths are generally

approximately 10 m or less, the 30-meter window is large enough to prevent double-counting but small enough to avoid incorrectly combining separate observed leaks into one.

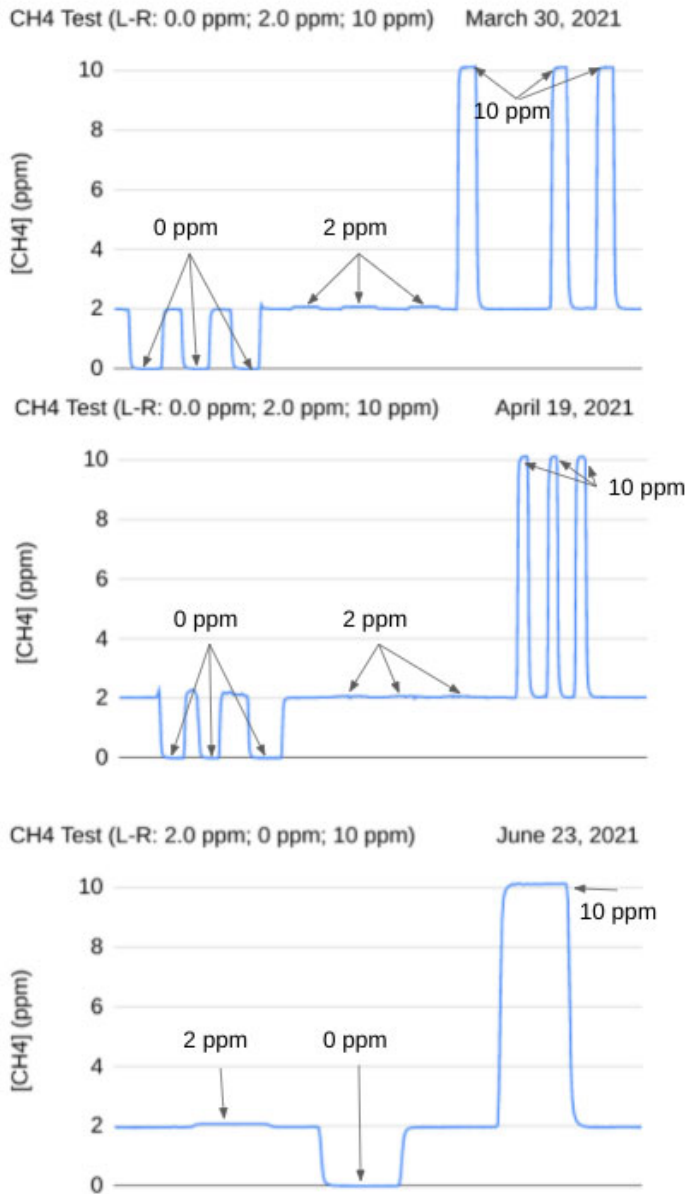
To test the accuracy of our leak detection, we verified gas in the subsurface, using a handheld Combustible Gas Indicator and probe, from a selection of methane emission points representing small, medium, and large peak concentrations observed across the District. To determine the number of methane emission points to test, we determined to accept a nominal error rate of less than or equal to 5% - that is, that we would accept a “false positive” (assigning a leak where there was none) in less than or equal to 5% of leaks we detected. Practically speaking, this required us to assess at least 20 putatively-detected methane emission points to find if at least one of those emission points did not actually exist as proven by detection of subsurface gas using a hand held probe. In our first 20 emission points, we verified 100% of the detected emissions corresponded to the presence of gas in the subsurface within 30 meters of where our car-based analyzer detected the elevated methane concentrations. We decided to continue to verify detected emission points until we found our first “false positive”, so that we could identify our first non-zero false positive rate. Our 40th reading was a false positive, producing a first false positive rate of 2.5%, at which point we concluded this test as having a satisfactory outcome.

The materials and methods used in this study were similar to those we used in our previous study of methane leaks in the District of Columbia (Jackson et al. 2014), including that both studies used a GPS-equipped Cavity Ringdown Spectrometer mounted in a car. There were two small but important differences in the methods used in the 2014 study and this one. First, the combination of pump speed differences and lengths of the sample tubing from the analyzer to the inlet outside the vehicle differed from that used in a different vehicle and analyzer air pump of the 2014 study, so that the measured, repeatable, and time shift-adjusted lag between injection of a known methane source and detection by the analyzer was 4.4 seconds in this study as compared to ~1 second in Jackson et al. (2014). Secondly, while the 2014 study used an air inlet point ~ 0.5 m above the road surface, this study placed the inlet at ~ 1.0 m above the road surface. This was an intentional decision to provide us with the ability to detect methane leaks from a wider spatial extent than in the 2014 study, as sampling from a greater vertical distance above ground is akin to having a wider scope of view. This decision follows from our improved sensitivity in leak detection we have published subsequent to the 2014 study (Keyes et al., 2020). The expected and observed effect of this methodological change was that the plumes from the methane leaks we detected from 1.0 m above the road surface were characterized by lower peak concentrations than the plumes from leaks observed at ~ 0.5 m above the road surface in the 2014 study.



***Instrument calibration checks:***

We tested the analyzer prior to the beginning of the survey (March 30, 2021); during a midpoint of the survey (April 19, 2021), and near the conclusion of the survey (June 23, 2021), against nominal 0.0 ppm; 2.0 ppm and 10 ppm test gases in ultrapure air. The test gas tanks were certified to contain < 0.01 ppm; 2.072 ppm; and 10.32 ppm, respectively (+/- 1% NIST). The test results are shown in Figure 8. These results demonstrate that our analyzer was working properly and with adequate precision for the study.



**Figure 6.** Analyzer calibration checks prior to (top), during (middle) and toward the end (bottom) of the methane leak survey. Triple checks at each of three standards were made in the first two dates and a single check at each of three concentrations was made in the final check.

## **Appendix 2: Gas Leak Classification**

Gas leaks upon detection have traditionally been classified into three categories with each category requiring different repair requirements and timelines. For Washington Gas's leak classification and reporting, please refer to D.C. Municipal Regulations, Title 15, Chapter 37, [Reporting and Repairing Requirements for Gas Leaks and Odor Complaints](#)

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# **ATTACHMENT A**

WARD GPS\_ABS\_GPS\_ABS\_origCH4

1 38.92575 -77.0297 5th Quintile

1 38.92207 -77.0413 5th Quintile

1 38.93072 -77.0296 5th Quintile

1 38.9141 -77.0317 5th Quintile

1 38.93202 -77.0241 5th Quintile

1 38.92484 -77.0392 5th Quintile

1 38.91793 -77.0239 5th Quintile

1 38.9352 -77.0309 5th Quintile

1 38.93236 -77.0268 5th Quintile

1 38.9328 -77.0352 5th Quintile

1 38.91669 -77.0219 5th Quintile

1 38.92429 -77.0256 5th Quintile

1 38.93358 -77.024 5th Quintile

1 38.91783 -77.047 5th Quintile

1 38.93102 -77.024 5th Quintile

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1 38.9345 -77.0309 5th Quintile

1 38.93499 -77.0436 5th Quintile

1 38.93326 -77.0364 5th Quintile

1 38.9307 -77.029 5th Quintile

1 38.92157 -77.048 5th Quintile

1 38.92139 -77.0483 5th Quintile

1 38.93236 -77.0297 5th Quintile

1 38.93193 -77.0194 5th Quintile

1 38.93138 -77.0201 5th Quintile

1 38.9335 -77.0298 5th Quintile

1 38.92612 -77.0232 5th Quintile

1 38.9141 -77.0231 5th Quintile

1 38.92698 -77.0356 5th Quintile

1 38.91911 -77.0239 5th Quintile

1 38.93094 -77.0249 4th Quintile

1 38.92524 -77.0379 4th Quintile

1 38.93532 -77.0234 4th Quintile

1 38.92308 -77.0415 4th Quintile

1 38.92753 -77.0273 4th Quintile

1 38.91814 -77.0459 4th Quintile

Ward	Total Leaks
1	218
2	288
3	595
4	691
5	523
6	554
7	309
8	160

1 38.93191 -77.0237 4th Quintile  
1 38.92477 -77.0292 4th Quintile  
1 38.91784 -77.0442 4th Quintile  
1 38.92576 -77.0311 4th Quintile  
1 38.93595 -77.0315 4th Quintile  
1 38.92575 -77.0286 4th Quintile  
1 38.92676 -77.0295 4th Quintile  
1 38.92582 -77.0264 4th Quintile  
1 38.92416 -77.0226 4th Quintile  
1 38.9324 -77.0405 4th Quintile  
1 38.92247 -77.0413 4th Quintile  
1 38.93068 -77.0228 4th Quintile  
1 38.93176 -77.0284 4th Quintile  
1 38.93064 -77.0234 4th Quintile  
1 38.92786 -77.0373 4th Quintile  
1 38.91411 -77.0234 4th Quintile  
1 38.93325 -77.0388 4th Quintile  
1 38.93331 -77.0427 4th Quintile  
1 38.9141 -77.0225 4th Quintile  
1 38.92577 -77.0277 4th Quintile  
1 38.92379 -77.041 4th Quintile  
1 38.91965 -77.0443 4th Quintile  
1 38.93294 -77.0249 4th Quintile  
1 38.92315 -77.0398 4th Quintile  
1 38.92288 -77.0366 4th Quintile  
1 38.92322 -77.0433 4th Quintile  
1 38.93418 -77.0425 4th Quintile  
1 38.92638 -77.0365 4th Quintile  
1 38.92719 -77.0368 3rd Quintile  
1 38.92758 -77.0235 3rd Quintile  
1 38.93071 -77.0277 3rd Quintile  
1 38.93657 -77.0309 3rd Quintile  
1 38.93289 -77.0254 3rd Quintile  
1 38.92578 -77.027 3rd Quintile  
1 38.91983 -77.0319 3rd Quintile  
1 38.92058 -77.0469 3rd Quintile  
1 38.91411 -77.0291 3rd Quintile  
1 38.92522 -77.0388 3rd Quintile  
1 38.92477 -77.0306 3rd Quintile  
1 38.9141 -77.0248 3rd Quintile  
1 38.91783 -77.0439 3rd Quintile  
1 38.9141 -77.0283 3rd Quintile  
1 38.92485 -77.0261 3rd Quintile  
1 38.92082 -77.024 3rd Quintile  
1 38.91598 -77.026 3rd Quintile  
1 38.93246 -77.0401 3rd Quintile  
1 38.93527 -77.0238 3rd Quintile



1 38.92074 -77.0482 3rd Quintile  
1 38.92167 -77.0253 3rd Quintile  
1 38.92377 -77.0297 3rd Quintile  
1 38.92062 -77.0319 3rd Quintile  
1 38.93195 -77.0246 3rd Quintile  
1 38.93458 -77.0316 3rd Quintile  
1 38.92477 -77.0309 3rd Quintile  
1 38.92163 -77.0413 3rd Quintile  
1 38.92957 -77.0297 3rd Quintile  
1 38.92856 -77.0297 3rd Quintile  
1 38.93031 -77.0297 3rd Quintile  
1 38.93626 -77.0297 3rd Quintile  
1 38.91641 -77.0436 3rd Quintile  
1 38.92233 -77.0451 3rd Quintile  
1 38.92622 -77.0297 3rd Quintile  
1 38.92576 -77.0293 3rd Quintile  
1 38.92745 -77.0297 3rd Quintile  
1 38.93275 -77.0388 3rd Quintile  
1 38.93212 -77.0334 3rd Quintile  
1 38.92209 -77.0253 3rd Quintile  
1 38.93258 -77.0346 3rd Quintile  
1 38.92971 -77.0413 3rd Quintile  
1 38.9241 -77.0406 3rd Quintile  
1 38.93597 -77.0212 3rd Quintile  
1 38.91806 -77.0463 3rd Quintile  
1 38.91875 -77.0246 3rd Quintile  
1 38.92506 -77.0297 3rd Quintile  
1 38.92789 -77.0377 2nd Quintile  
1 38.92802 -77.041 2nd Quintile  
1 38.91432 -77.0165 2nd Quintile  
1 38.92333 -77.0418 2nd Quintile  
1 38.93422 -77.0241 2nd Quintile  
1 38.92632 -77.0357 2nd Quintile  
1 38.93457 -77.0375 2nd Quintile  
1 38.93133 -77.0214 2nd Quintile  
1 38.91649 -77.0423 2nd Quintile  
1 38.93458 -77.0302 2nd Quintile  
1 38.92837 -77.0372 2nd Quintile  
1 38.91719 -77.0159 2nd Quintile  
1 38.92038 -77.0441 2nd Quintile  
1 38.93465 -77.0226 2nd Quintile  
1 38.92705 -77.0271 2nd Quintile  
1 38.91716 -77.0219 2nd Quintile  
1 38.93611 -77.0321 2nd Quintile  
1 38.93371 -77.0364 2nd Quintile  
1 38.93531 -77.0312 2nd Quintile  
1 38.93644 -77.0205 2nd Quintile

1 38.93239 -77.0341 2nd Quintile  
1 38.9186 -77.0239 2nd Quintile  
1 38.92316 -77.0473 2nd Quintile  
1 38.9315 -77.0267 2nd Quintile  
1 38.91665 -77.042 2nd Quintile  
1 38.92058 -77.0326 2nd Quintile  
1 38.91692 -77.0463 2nd Quintile  
1 38.92678 -77.0266 2nd Quintile  
1 38.9141 -77.0307 2nd Quintile  
1 38.93388 -77.0239 2nd Quintile  
1 38.93419 -77.042 2nd Quintile  
1 38.92767 -77.0291 2nd Quintile  
1 38.92313 -77.0403 2nd Quintile  
1 38.93109 -77.0212 2nd Quintile  
1 38.92925 -77.039 2nd Quintile  
1 38.92991 -77.0297 2nd Quintile  
1 38.93206 -77.0386 2nd Quintile  
1 38.93334 -77.0413 2nd Quintile  
1 38.92087 -77.0235 2nd Quintile  
1 38.92823 -77.023 2nd Quintile  
1 38.93477 -77.021 2nd Quintile  
1 38.92664 -77.027 2nd Quintile  
1 38.9356 -77.0213 2nd Quintile  
1 38.93438 -77.0363 2nd Quintile  
1 38.928 -77.0243 2nd Quintile  
1 38.92629 -77.027 2nd Quintile  
1 38.92481 -77.0265 2nd Quintile  
1 38.92432 -77.0391 2nd Quintile  
1 38.91643 -77.027 2nd Quintile  
1 38.93206 -77.0267 2nd Quintile  
1 38.93148 -77.0453 2nd Quintile  
1 38.93072 -77.0222 2nd Quintile  
1 38.92695 -77.0212 1st Quintile  
1 38.93034 -77.0198 1st Quintile  
1 38.91783 -77.0429 1st Quintile  
1 38.92768 -77.0287 1st Quintile  
1 38.9235 -77.0437 1st Quintile  
1 38.92774 -77.0297 1st Quintile  
1 38.93275 -77.0454 1st Quintile  
1 38.9141 -77.0311 1st Quintile  
1 38.92973 -77.0433 1st Quintile  
1 38.91592 -77.0145 1st Quintile  
1 38.92309 -77.0412 1st Quintile  
1 38.93069 -77.0371 1st Quintile  
1 38.91558 -77.0301 1st Quintile  
1 38.91917 -77.0447 1st Quintile  
1 38.92902 -77.0228 1st Quintile

1 38.91863 -77.0446 1st Quintile  
1 38.92641 -77.0255 1st Quintile  
1 38.93347 -77.0259 1st Quintile  
1 38.93617 -77.0221 1st Quintile  
1 38.93415 -77.0272 1st Quintile  
1 38.93122 -77.044 1st Quintile  
1 38.92538 -77.027 1st Quintile  
1 38.93391 -77.0231 1st Quintile  
1 38.93565 -77.0309 1st Quintile  
1 38.93131 -77.0198 1st Quintile  
1 38.9346 -77.0369 1st Quintile  
1 38.93255 -77.0237 1st Quintile  
1 38.92259 -77.0271 1st Quintile  
1 38.92064 -77.0401 1st Quintile  
1 38.92392 -77.0256 1st Quintile  
1 38.91783 -77.0423 1st Quintile  
1 38.93531 -77.0326 1st Quintile  
1 38.93003 -77.0217 1st Quintile  
1 38.9346 -77.0221 1st Quintile  
1 38.93097 -77.0383 1st Quintile  
1 38.91833 -77.0239 1st Quintile  
1 38.92235 -77.0459 1st Quintile  
1 38.93695 -77.0218 1st Quintile  
1 38.92 -77.0322 1st Quintile  
1 38.9339 -77.0309 1st Quintile  
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1 38.93324 -77.0275 1st Quintile  
1 38.91811 -77.0354 1st Quintile  
1 38.91715 -77.0366 1st Quintile  
2 38.90575 -77.026 5th Quintile  
2 38.90685 -77.0597 5th Quintile  
2 38.90926 -77.0582 5th Quintile  
2 38.91539 -77.0729 5th Quintile  
2 38.91262 -77.0287 5th Quintile  
2 38.91034 -77.0416 5th Quintile  
2 38.91356 -77.0735 5th Quintile  
2 38.91456 -77.0693 5th Quintile  
2 38.90781 -77.026 5th Quintile  
2 38.91484 -77.0415 5th Quintile  
2 38.91453 -77.045 5th Quintile  
2 38.90565 -77.027 5th Quintile  
2 38.91227 -77.0582 5th Quintile  
2 38.90651 -77.0661 5th Quintile  
2 38.90276 -77.027 5th Quintile  
2 38.90449 -77.0612 5th Quintile

2 38.90162 -77.0537 5th Quintile  
2 38.91113 -77.0298 5th Quintile  
2 38.91416 -77.0693 5th Quintile  
2 38.91263 -77.0281 5th Quintile  
2 38.91108 -77.0271 5th Quintile  
2 38.91388 -77.0449 5th Quintile  
2 38.90686 -77.0661 5th Quintile  
2 38.91628 -77.0508 5th Quintile  
2 38.90812 -77.026 5th Quintile  
2 38.91038 -77.0341 5th Quintile  
2 38.91558 -77.0386 5th Quintile  
2 38.91187 -77.0365 5th Quintile  
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2 38.91113 -77.0362 5th Quintile  
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2 38.91263 -77.0297 5th Quintile  
2 38.90981 -77.0309 5th Quintile  
2 38.9136 -77.0727 5th Quintile  
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2 38.91045 -77.0271 5th Quintile  
2 38.90843 -77.0613 5th Quintile  
2 38.91419 -77.0416 5th Quintile  
2 38.91112 -77.028 5th Quintile  
2 38.90686 -77.0581 5th Quintile  
2 38.90699 -77.0592 5th Quintile  
2 38.90107 -77.0515 4th Quintile  
2 38.91882 -77.053 4th Quintile  
2 38.91009 -77.0309 4th Quintile  
2 38.91558 -77.0416 4th Quintile  
2 38.91411 -77.0503 4th Quintile  
2 38.90756 -77.0612 4th Quintile  
2 38.91187 -77.0307 4th Quintile  
2 38.90847 -77.0618 4th Quintile  
2 38.9134 -77.0488 4th Quintile  
2 38.9096 -77.0288 4th Quintile  
2 38.90076 -77.0547 4th Quintile  
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2 38.91536 -77.0746 4th Quintile  
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2 38.91657 -77.0506 4th Quintile  
2 38.90845 -77.063 4th Quintile  
2 38.90054 -77.0514 4th Quintile  
2 38.91335 -77.0502 4th Quintile

2 38.91047 -77.0582 4th Quintile  
2 38.91334 -77.0507 4th Quintile  
2 38.90928 -77.0633 4th Quintile  
2 38.91407 -77.0435 4th Quintile  
2 38.91167 -77.0679 4th Quintile  
2 38.90941 -77.0305 4th Quintile  
2 38.91562 -77.0506 4th Quintile  
2 38.91636 -77.0417 4th Quintile  
2 38.91096 -77.0593 4th Quintile  
2 38.91039 -77.0323 4th Quintile  
2 38.90639 -77.0295 4th Quintile  
2 38.90205 -77.0504 4th Quintile  
2 38.89972 -77.0533 4th Quintile  
2 38.90595 -77.0677 4th Quintile  
2 38.90934 -77.0572 4th Quintile  
2 38.90934 -77.0599 4th Quintile  
2 38.91263 -77.0311 4th Quintile  
2 38.91483 -77.0357 4th Quintile  
2 38.91832 -77.052 4th Quintile  
2 38.9077 -77.0559 4th Quintile  
2 38.91538 -77.0739 4th Quintile  
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2 38.90737 -77.026 4th Quintile  
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2 38.90427 -77.027 4th Quintile  
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2 38.90928 -77.0557 4th Quintile  
2 38.90766 -77.0609 3rd Quintile  
2 38.91114 -77.0293 3rd Quintile  
2 38.90771 -77.0555 3rd Quintile  
2 38.91853 -77.0532 3rd Quintile  
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2 38.91631 -77.0406 3rd Quintile

2 38.91411 -77.0334 3rd Quintile  
2 38.91361 -77.0719 3rd Quintile  
2 38.90742 -77.0592 3rd Quintile  
2 38.91007 -77.0582 3rd Quintile  
2 38.90964 -77.0448 3rd Quintile  
2 38.91355 -77.074 3rd Quintile  
2 38.90546 -77.0316 3rd Quintile  
2 38.90905 -77.0592 3rd Quintile  
2 38.90766 -77.06 3rd Quintile  
2 38.91179 -77.0284 3rd Quintile  
2 38.90614 -77.0661 3rd Quintile  
2 38.91421 -77.0449 3rd Quintile  
2 38.91698 -77.0411 3rd Quintile  
2 38.90929 -77.0629 3rd Quintile  
2 38.91106 -77.0416 3rd Quintile  
2 38.9141 -77.0329 3rd Quintile  
2 38.90073 -77.0488 3rd Quintile  
2 38.90763 -77.0627 3rd Quintile  
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2 38.91334 -77.0374 3rd Quintile  
2 38.91336 -77.0497 3rd Quintile  
2 38.91112 -77.0349 3rd Quintile  
2 38.91599 -77.0702 3rd Quintile  
2 38.91184 -77.0405 3rd Quintile  
2 38.90624 -77.026 3rd Quintile  
2 38.91282 -77.0609 3rd Quintile  
2 38.90674 -77.0695 3rd Quintile  
2 38.91129 -77.0582 3rd Quintile  
2 38.90828 -77.0571 3rd Quintile  
2 38.90202 -77.0499 3rd Quintile  
2 38.91335 -77.0384 3rd Quintile  
2 38.90787 -77.0571 3rd Quintile  
2 38.91338 -77.0419 3rd Quintile  
2 38.90764 -77.0617 3rd Quintile  
2 38.9105 -77.0592 3rd Quintile  
2 38.90887 -77.0691 3rd Quintile  
2 38.91265 -77.0692 3rd Quintile  
2 38.91336 -77.0476 3rd Quintile  
2 38.90794 -77.0488 3rd Quintile  
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2 38.91257 -77.0581 3rd Quintile  
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2 38.91545 -77.0713 2nd Quintile  
2 38.90966 -77.0282 2nd Quintile  
2 38.90851 -77.027 2nd Quintile  
2 38.9091 -77.0417 2nd Quintile  
2 38.91181 -77.0609 2nd Quintile  
2 38.91111 -77.0289 2nd Quintile  
2 38.9163 -77.0387 2nd Quintile  
2 38.90516 -77.0656 2nd Quintile  
2 38.91111 -77.0422 2nd Quintile  
2 38.91448 -77.0733 2nd Quintile  
2 38.91256 -77.0588 2nd Quintile  
2 38.91251 -77.0593 2nd Quintile  
2 38.91771 -77.0474 2nd Quintile  
2 38.90865 -77.0364 2nd Quintile  
2 38.91232 -77.0374 2nd Quintile  
2 38.90817 -77.027 2nd Quintile  
2 38.91463 -77.039 2nd Quintile  
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2 38.9133 -77.063 2nd Quintile  
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2 38.9098 -77.0582 2nd Quintile  
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2 38.90939 -77.0561 2nd Quintile  
2 38.90788 -77.0581 2nd Quintile  
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2 38.90977 -77.067 1st Quintile  
2 38.91547 -77.0703 1st Quintile  
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2 38.90685 -77.0558 1st Quintile  
2 38.91114 -77.0355 1st Quintile  
2 38.91369 -77.0687 1st Quintile  
2 38.91072 -77.0417 1st Quintile  
2 38.90683 -77.0654 1st Quintile  
2 38.91071 -77.0687 1st Quintile  
2 38.91115 -77.04 1st Quintile  
2 38.91486 -77.0515 1st Quintile  
2 38.9093 -77.0604 1st Quintile  
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2 38.91343 -77.0635 1st Quintile



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2 38.9114 -77.0367 1st Quintile  
2 38.90685 -77.0586 1st Quintile  
2 38.90803 -77.0613 1st Quintile  
2 38.91054 -77.0578 1st Quintile  
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2 38.91019 -77.028 1st Quintile  
2 38.91514 -77.0385 1st Quintile  
2 38.90848 -77.0558 1st Quintile  
2 38.91305 -77.0621 1st Quintile  
2 38.90992 -77.0448 1st Quintile  
2 38.91412 -77.0515 1st Quintile  
2 38.91328 -77.0521 1st Quintile  
2 38.90676 -77.045 1st Quintile  
2 38.90749 -77.0369 1st Quintile  
2 38.91026 -77.0452 1st Quintile  
2 38.90936 -77.0466 1st Quintile  
2 38.91039 -77.0336 1st Quintile  
2 38.90733 -77.0295 1st Quintile  
2 38.91333 -77.0367 1st Quintile  
2 38.90379 -77.0268 1st Quintile  
2 38.9092 -77.0423 1st Quintile  
2 38.90725 -77.0482 1st Quintile  
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2 38.90772 -77.0242 1st Quintile  
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2 38.91113 -77.0439 1st Quintile  
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3 38.95469 -77.089 2nd Quintile

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8 38.86947 -76.971 1st Quintile  
8 38.82502 -76.9985 1st Quintile  
8 38.84224 -76.994 1st Quintile  
8 38.82519 -77.0091 1st Quintile  
8 38.84287 -76.98 1st Quintile  
8 38.84429 -76.9966 1st Quintile

8 38.827 -77.0106 1st Quintile  
8 38.84887 -76.981 1st Quintile

## CERTIFICATE OF SERVICE

I hereby certify that on this 30<sup>th</sup> day of November 2021, I caused true and correct copies of the 2021 Fugitive Methane Emission Survey of the District of Columbia, to be emailed to the following:

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*/s/ Brian Caldwell*  
Brian Caldwell