DC Department of Public Works

Sustainability Assessment of Disposal Options

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Acronyms

$\mu g/m^3$	Microgram per cubic meter
ACS	American Community Survey
APEEP	Air Pollution Emission Experiments and Policy
CAPs	Criteria air pollutants
CERCLA	Comprehensive Environmental Response and Liability Act
CH_4	Methane
CO	Carbon monoxide
COBRA	Co-Benefits Risk Assessment
CTE	Central Tendency Estimate
DEQ	Department of Environmental Quality
DPW	Department of Public Works
EJ	Environmental justice
FMCSA	Federal Motor Carrier Safety Administration
GHGs	Greenhouse gases
GWPs	Global warming potentials
HAPs	Hazardous air pollutants
HHRA	Human health risk assessment
HI	Hazard Index
HQ	Hazard quotient
ICIS-AIR	Integrated Compliance Information System Air
IPCC	Intergovernmental Panel on Climate Change
IUR	Inhalation unit risk factors
IWG	Interagency Working Group
LandGEM	Landfill Gas Emissions Model
LFG	Landfill gas
MEI	Maximally exposed individuals
MHI	Median household income
MWh	Megawatt hour
Mg	Milligram
mg/m^3	Milligrams per cubic meter
MOVES3	Motor Vehicle Emission Simulator program
MSW	Municipal solid waste
$MTCO_2e$	Metric tons of carbon dioxide equivalents
NATA	National Air Toxics Assessment
NED	National Elevation Dataset
NFHL	National Flood Hazard Layer

NHTSA	National Highway Traffic Safety Administration
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NPL	National Priority List
NSPS	New Source Performance Standards
O_3	Ozone
OEHHA	Office of Environmental Health Hazard Assessment
Pb	Lead
PDO	Property-damage-only
PM2.5	Particulate matter with maximum size of 2.5 microns
PM10	Particulate matter with maximum size of 10 microns
RCRA	Resource Conservation and Recovery Act
RELs	Reference exposure levels
RfC_i	Inhalation reference concentrations
RFI	Request for information
RME	Reasonable Maximum Exposure
RSL	Regional screening level
SC-GHG	Social cost of greenhouse gases
SO_2	Sulfur dioxide
TAC	Toxic air contaminants
TPY	Tons per year
TRI	Toxic Release Inventory
TWA-PELs	Time-weighted average permissible exposure levels
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VMT	Vehicle miles traveled
VOC	Volatile organic compounds
WARM	Waste Reduction Model
WTE	Waste-to-energy

Executive Summary

In order to address concerns from the public and better inform decisions regarding waste disposal, the District of Columbia's Department of Public Works (DPW) commissioned the following study to assess, in relative terms, the impacts that waste disposal at its waste-to-energy provider, Covanta Fairfax, has as compared to two District-used landfills.

The following Life-Cycle Sustainability Assessment (LCSA) study is intended to support decision making and policy across three core lenses: Environmental, Financial, and Social. The study's methodology involves a process for identifying, measuring, and evaluating the potential impacts of waste-to-energy (also commonly referred to as "incineration" or "combustion" of waste) compared to landfilling in order to identify the best waste disposal option for the District of Columbia.

The study assessed:

- Criteria Air Pollutants (CAPs) & Hazardous Air Pollutants (HAPs)
- Social Costs & Environmental Justice Impact
- Human Health Risk Assessment (HHRA)
- Ecological Screening of Air Emissions
- Power Generation
- Hauling & Disposal Cost
- Vehicle Collisions
- Alignment with District of Columbia Sustainability Goals

This study has determined the following:

- All three facilities were shown to be well below the air quality standards established by the United States Environmental Protection Agency (USEPA) for the protection of the public and environment;
- Health risk modeling and ecological screening indicate localized air emissions from the three facilities pose minimal-to-no impact to ambient air quality and the environment;
- Cancer risks at Covanta Fairfax are lower than those at both landfills, and all facilities fall below the ten-in-one million (10 in 1,000,000) cancer risk threshold;
- The greenhouse gas (GHG) emissions resulting from disposal of refuse at either of the two landfills was shown to significantly exceed emissions released from Covanta Fairfax;
- Covanta Fairfax was found to have the lowest greenhouse gas (GHG) social costs, highest social cost for criteria air pollutants (CAPs) and hazardous air pollutants (HAPs), and the lowest overall social costs;
- Based on the information available to DPW at the time of this study, the cost of the District's use of Covanta Fairfax for the disposal of waste is lower than that of either of the two landfills due to the significantly shorter hauling distance of Covanta Fairfax;
- Vehicle collision potential is greater for both landfill scenarios, once again due to the greater distances required to travel to these landfills;

- All three facilities have similar impacts on disadvantaged communities, with Covanta Fairfax having the lowest environmental justice and social equity impacts compared to the two landfills; and
- Neither landfilling nor waste-to-energy are supportive of the District's zero waste, climate, or decarbonization goals.

Based on the results of this study, a decision to dispose of refuse at either of the two landfills instead of Covanta Fairfax would result in: (1) increased GHG emissions; (2) higher financial costs for the District; (3) higher overall social costs, with an increase in GHG social costs more than offsetting a reduction in CAP and HAP social costs; (4) an increased cancer risk for communities adjacent to the landfills relative to communities located near Covanta Fairfax; and (5) greater vehicle collision potential.

Even though this study demonstrates that both disposal options – (a) combustion of refuse at waste-to-energy facilities; and (b) burying of waste at landfills – have negative environmental and social impacts, the study supports the conclusion that Covanta Fairfax is still the best waste disposal option currently available to the District. Nonetheless, the District should continue to pursue identifying sustainable alternatives in order to achieve its zero waste goal of 80% waste diversion.

The full results of all the varied technical analyses are described in detail in the following study, and all data and calculations are provided in the attached Appendices for reference.

Section 1

Introduction

DPW provides municipal solid waste (MSW) collection services to approximately 105,000 single-family homes and small, multi-family residential buildings. DPW sends approximately 100,000 tons per year (TPY) of MSW to disposal facilities. Throughout this report, analysis and assumptions are based on DPW-provided data from the year 2018. This study compares the environmental, social, and economic impacts of three disposal options: (1) the Covanta Fairfax Waste-to-Energy (WTE) Facility; (2) the King & Queen Landfill; and (3) the King George Landfill. The results of the study will assist DPW in making informed decisions towards meeting the District's sustainability and climate goals as outlined in the *Sustainable DC 2.0 Plan* and *Clean Energy DC Plan*.

1.1 Disposal Scenarios

Residential MSW collected by DPW for disposal is taken to one of two facilities owned and operated by the District of Columbia: the Fort Totten Solid Waste Transfer Station and the Benning Road Solid Waste Transfer Station. MSW is offloaded from the curbside solid waste collection vehicles at the solid waste transfer stations and loaded into large capacity solid waste transfer trucks for delivery to disposal facilities. Waste collection was not included in the study since it is the same for all three scenarios. The following three disposal scenarios were selected to study the impacts of air emissions, power generation and, in the case of Covanta Fairfax, metals recovery:

> **Scenario 1 (current practice)**: MSW is hauled 30 miles to the Covanta Fairfax WTE Facility (Covanta Fairfax), located at 9898 Furnace Road, Lorton, Virginia, 22079. Scenario 1 is depicted in **Figure** 1-1.

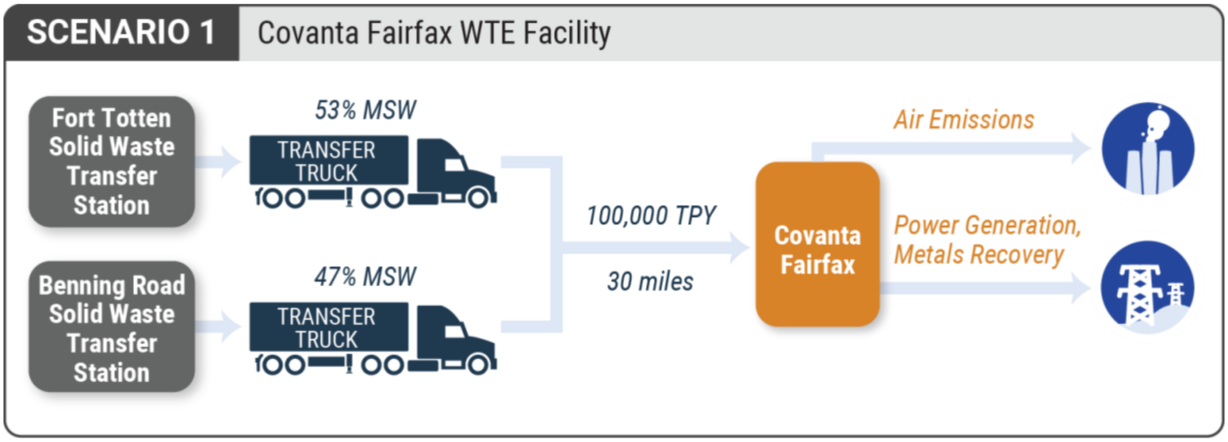


Figure 1-1. Scenario 1 – Covanta Fairfax Waste-To-Energy Facility

- **Scenario 2**: As depicted in **Figure** 1-2, MSW is hauled 72 miles to the King George Landfill, located at 10376 Bullock Dr, King George, Virginia, 22485.

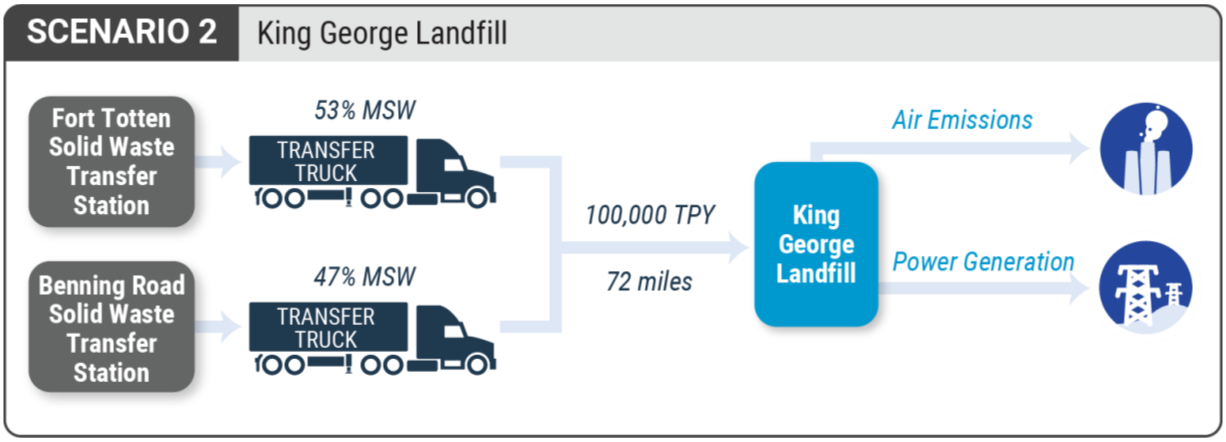


Figure 1-2. Scenario 2 – King George Landfill

- **Scenario 3**: As depicted in **Figure** 1-3, MSW is hauled 160 miles to the King & Queen Landfill, located at 4443 Iris Road, Little Plymouth, Virginia, 23091.

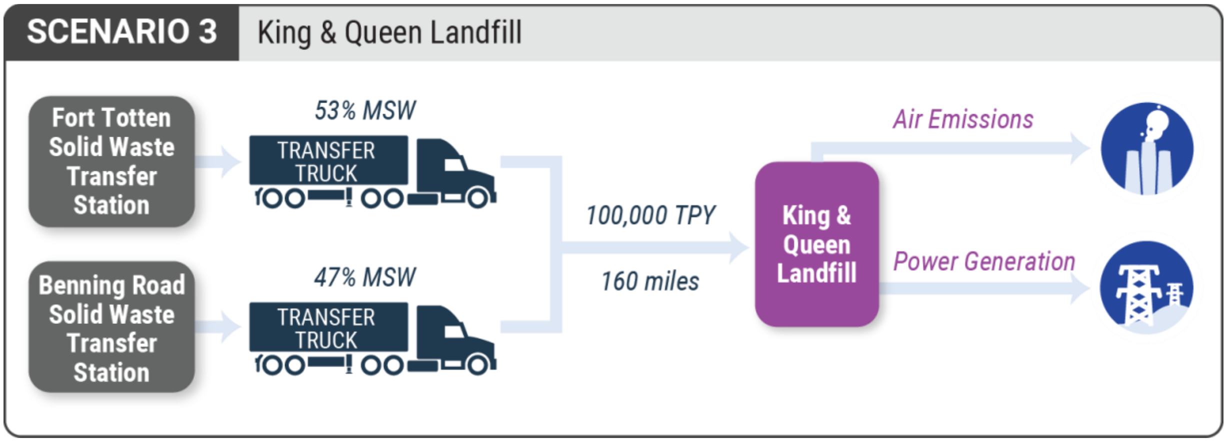


Figure 1-3. Scenario 3 – King & Queen Landfill

The hauling routes for the three scenarios are provided in **Figure** 1-4.

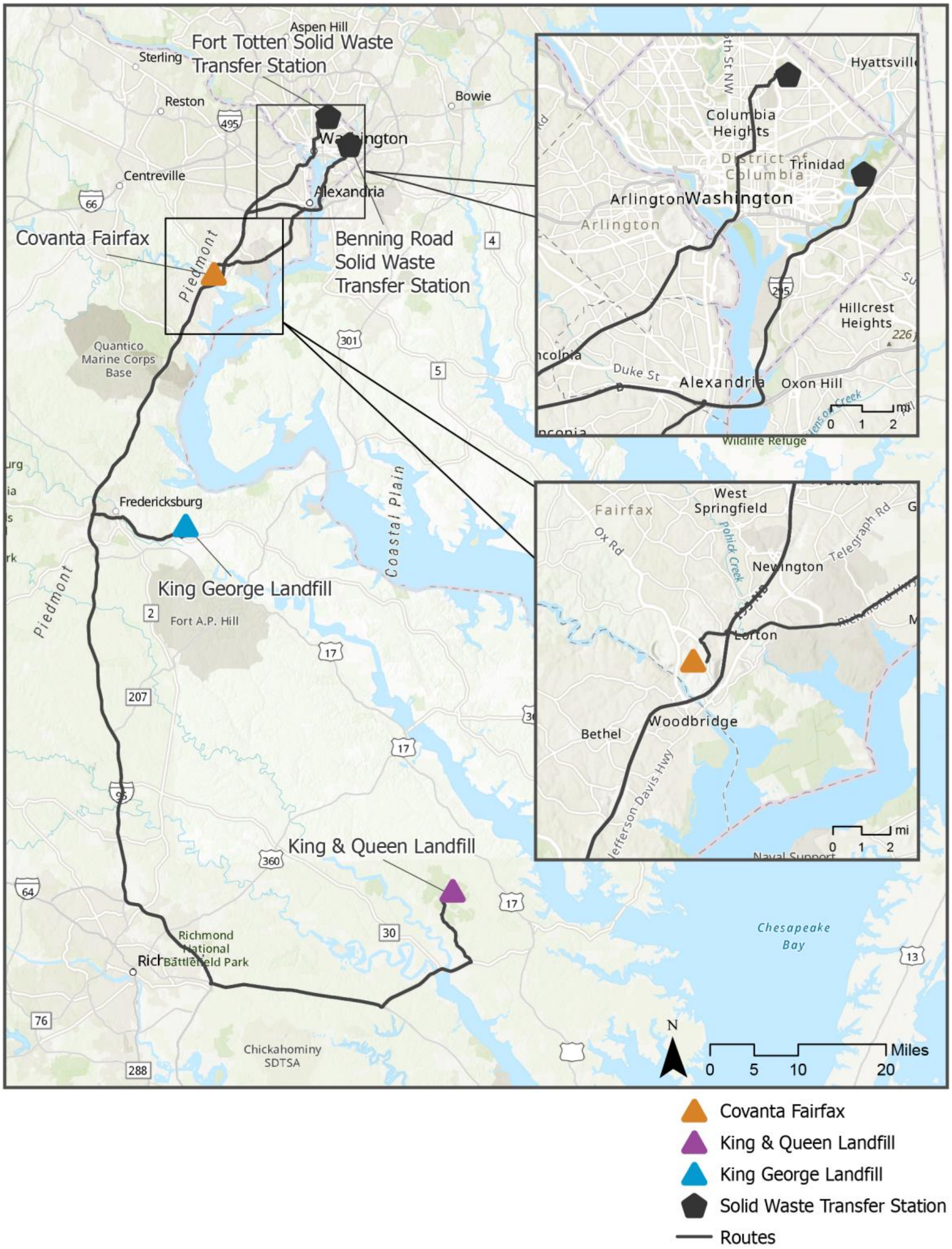


Figure 1-4. Hauling Routes

1.2 Criteria

The criteria selected for the study include:

- United States Environmental Protection Agency (USEPA) Criteria Air Pollutants (CAPs)
- Hazardous Air Pollutants (HAPs)
- Greenhouse Gases (GHGs)
- Social Costs of Air Emissions
- Health Risk of Air Emissions
- Ecological Screening of Air Emissions
- Vehicle Collisions
- Hauling and Disposal Costs
- Environmental Justice (EJ)
- Power Generation

1.2.1 Environmental Protection Agency Criteria Air Pollutants

The USEPA designated six major air pollutants as CAPs since they are known to be hazardous to human health. The list includes carbon monoxide (CO), lead (Pb), particulate matter (PM10 and PM2.5), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and ozone (O_3). CAPs are the only air pollutants with national air quality standards that define the allowable concentrations of these substances in ambient air. *See* USEPA 2021a.

Ozone is not directly emitted by sources, rather it is formed in the atmosphere through a series of reactions that include nitrogen oxides (NO_x) and volatile organic compounds (VOC). Therefore, the study will compare NO_x and VOC emissions for the three scenarios. NO_2 emissions are included in the NO_x emission estimates.

1.2.1.1 Carbon Monoxide

CO is an odorless, colorless gas that is formed by the incomplete combustion of fuels. The health effects associated with CO are related to its interaction with hemoglobin once it enters the bloodstream. At high concentrations, CO reduces the amount of oxygen in the blood, causing heart difficulties in people with chronic diseases, reduced lung capacity, and impaired mental abilities. *See* USEPA 2021b.

1.2.1.2 Lead

Lead can adversely affect the nervous system, the immune system, the reproductive system, the cardiovascular system, and kidney function. Infants and young children are especially sensitive to lead exposure, which can contribute to behavioral problems, learning deficits, and a lowered IQ.

1.2.1.3 Particulate Matter

Particulate matter consists of solid and liquid particles of dust, soot, aerosols, and other matter that are small enough to remain suspended in the air for long periods of time. PM10 and PM2.5 refer to particulate matter that have diameters less than or equal to 10 micrometers and

2.5 micrometers, respectively. PM10 and PM2.5 can aggravate existing respiratory conditions, increase respiratory symptoms and disease, decrease long-term lung function, and potentially cause premature death. The segments of the population that are most sensitive to particulate matter are the elderly, individuals with cardiopulmonary disease, and children. Aside from adverse health effects, particulate matter causes a reduction of visibility and damage to paints and building materials. *See* USEPA 2021c.

1.2.1.4 Sulfur Dioxide

Sulfur dioxide is formed when fuel containing sulfur is combusted. The adverse health effects of sulfur dioxide include breathing impairment, respiratory illness, and the aggravation of existing cardiovascular diseases. Children and the elderly are most susceptible to the negative effects of exposure to sulfur dioxide. *See* USEPA 2021d.

1.2.1.5 Nitrogen Dioxide

Nitrogen dioxide is emitted from the burning of fuel. Common sources are vehicles and power plants. Nitrogen dioxide can irritate airways in the human respiratory system and can aggravate respiratory diseases. People with asthma, as well as children and the elderly, are generally at greater risk to negative health effects from nitrogen dioxide. Nitrogen dioxide, along with other nitrogen oxides, reacts with other chemicals to form particulate matter and ozone.

1.2.1.6 Ozone Precursors (Volatile Organic Compounds and Nitrogen Oxides)

Ozone causes health effects such as chest discomfort, coughing, nausea, respiratory tract and eye irritation, and decreased pulmonary functions. Ozone is formed when VOCs and NO_x react in the presence of sunlight. For this reason, VOCs and NO_x are termed “ozone precursors” and, as such, their emissions are regulated to control the formation of O_3. *See* USEPA 2021e.

1.2.2 Hazardous Air Pollutants

HAPs are those known to cause cancer and other serious health impacts such as birth defects and reproductive effects. In addition to exposure from breathing air, some HAPs such as mercury and dioxin deposit onto soils or surface waters where they are taken up by plants and then ingested by animals and humans. Deposition pathways are outside the scope of this study.

1.2.3 Greenhouse Gases

GHGs, such as carbon dioxide and methane, absorb infrared radiation and trap heat in the atmosphere, contributing to climate change. In the study scenarios, GHGs are emitted by waste hauling vehicles, combustion of waste, fugitive emissions of landfill gas from the decomposition of landfilled waste, and combustion of landfill gas in flares and landfill gas-to-energy generators located at the landfills.

1.2.4 Social Costs and Environmental Justice Impacts

Societal sustainability metrics were evaluated to determine the impact of the disposal scenarios on the local community and on society. A cost-benefit analysis was used to estimate the social costs of air emissions from waste hauling and disposal facilities. A qualitative assessment of the disposal scenarios was performed to evaluate environmental justice and social equity considerations for the communities near the disposal facilities.

1.2.5 Health Risk

Operational activities at the facilities release HAPs to the air from combustion activities, motor vehicles, processing equipment, and other sources. Inhalation of HAPs from these releases could have human health impacts on people living in the vicinity of the facilities. Potential human health impacts were assessed by estimating cancer risks, chronic (long-term) non-cancer health hazards, and acute (short-term) non-cancer health hazards from inhalation of HAPs releases from the disposal scenarios.

1.2.6 Ecological Screening of Air Emissions

Criteria pollutant emissions from facility activities such as combustion of waste, landfill gas generated from the decomposition of landfilled waste, and combustion of landfill gas in flares and landfill gas-to-energy facilities can cause adverse effects on soil, water, crops, animals and wildlife, and vegetation. Dispersion modeling of criteria pollutants from the facilities was used for the ecological screening assessment.

1.2.7 Power Generation

Landfills generate landfill gas from the anaerobic decomposition of organic wastes that is used in generators to produce electricity. Covanta Fairfax is a waste combustion facility that produces steam to operate turbine generators. GHG emission offsets are credited to each scenario based on the amount of power generated.

1.2.8 Hauling and Disposal Costs

Hauling costs were estimated for waste hauling from the solid waste transfer stations to the disposal facilities. The cost of collection from households and delivery to the solid waste transfer stations was not included as it is the same for all scenarios. Disposal costs were estimated as described in Section 2.8.

1.2.9 Vehicle Collisions

Federal highway data were used to estimate statistical vehicular collisions attributed to hauling waste to the three facilities. Collisions were classified into categories ranging from property damage to loss of human life.

Section 2

Methodology

This section provides a summary of the study methodology. Refer to **Appendix A** for the complete methodology plan.

2.1 Data Compilation

DPW provided requested data sets from their operation records. Data not available from DPW were obtained from state and federal agencies, or from research literature. The source of each data set is noted in the corresponding methodology section. Calculations, assumptions, and modeling inputs and outputs are all provided as appendices to this report.

2.2 USEPA Criteria Air Pollutants and Hazardous Air Pollutants Emissions

2.2.1 Criteria Air Pollutants and Hazardous Air Pollutants Selection

The following list of criteria air pollutants (CAPs) were evaluated:

- Carbon monoxide (CO)
- Lead (Pb)
- Particulate matter (PM10 and PM2.5)
- Sulfur dioxide (SO_2)
- Volatile organic compounds (VOC)
- Nitrogen oxides (NO_x)

The Covanta Fairfax WTE Facility list of HAPs was derived from Covanta's 2020 Annual Emissions Statement and the 2020 Covanta Fairfax Stack Test report. The HAPs list for the landfill scenarios was developed using the USEPA Landfill Gas Emissions Model (LandGEM) version 3.03. The lists of HAPs for the three scenarios are presented in **Appendix B**.

CAPs and HAPs emissions associated with transport of MSW were estimated using vehicle miles traveled and vehicle emission factors provided in the USEPA Motor Vehicle Emission Simulator program (MOVES3).

2.2.2 Criteria Air Pollutants and Hazardous Air Pollutants Emission Estimates

In developing emission estimates, it is important to recognize that air emissions from landfills are released over many years as the waste slowly decomposes, whereas air emissions from a WTE facility are released immediately upon combustion. The dramatic difference in emission rates between these two disposal methods must be carefully considered since health impacts are directly related to pollutant concentration levels.

Emissions steadily increase in active landfills until waste is no longer received. For a 20-year study period, emissions in Year 1 are the lowest and emissions in Year 20 are the highest. The most equitable choice for comparing landfill emissions to WTE emissions was determined to be the 20-year annual average emissions (sum emissions over 20 years and divide by 20).

2.3 Greenhouse Gas Emission Estimates

2.3.1 Greenhouse Gas Emissions from Disposal Facilities

The USEPA Waste Reduction Model (WARM) Version 15 was used to estimate GHG emissions from the disposal facilities. This section describes key assumptions for each management strategy based on WARM Version 15 documentation.

Landfilling waste results in anaerobic decomposition, producing landfill gas that primarily consists of methane and carbon dioxide. *See* ICF 2020a. Landfill gas collection and control systems (GCCS) are installed to collect and treat the gas. The landfills selected for the study use landfill gas to power electrical generators. Excess landfill gas is flared. GCCS are installed in phases causing collection efficiency to vary over the life of an active landfill (*i.e.*, collection efficiency is lowest in the first year of operation and highest when the entire GCCS are installed and the landfill is capped with an impermeable geomembrane).

WARM estimates emissions and offsets as summarized below:

- Greenhouse Gas Emissions for Waste-to-Energy
    - WARM excludes GHG emissions from the combustion of biogenic carbon sources (organic materials) as they are part of the natural carbon cycle. However, for this study it was decided that biogenic carbon from tree products (paper, cardboard, fiberboard, and wood) would not be excluded due to the extended duration of the tree carbon cycle. Given the urgency of the climate change crisis, it was deemed prudent to acknowledge that carbon released from the combustion or decomposition of tree products will not be reabsorbed by replacement trees for decades.
    - Biogenic carbon from food waste and yard waste is excluded in accordance with WARM protocol as their carbon cycles are short (within 1 to 2 years).
- Greenhouse Gas Emission Offsets for Waste-to-Energy
    - GHG emission offsets (deductions) for WTE are based on the amount of power uploaded to the utility grid. The offset reflects the carbon intensity of the non-baseload power sources for the utility grid.
    - WTE is credited with GHG emission offsets for recovery of steel. The credit is based on the avoided carbon emissions of manufacturing steel from virgin resources.
- Greenhouse Gas Emissions for landfilling
    - Methane emissions from the anaerobic decomposition of organic material is accounted for in WARM since it is a direct result of landfilling (under natural conditions organic materials predominately decompose aerobically and do not produce methane).

  - WARM excludes carbon dioxide from landfills because it is a part of the natural carbon cycle. However, carbon dioxide emissions from tree products that are currently excluded by the model, are included in this study for the reasons stated above.
  - Carbon dioxide emissions from landfill operations equipment are included.

- Greenhouse Gas Emission Offsets for landfilling
  - Landfills are credited with GHG emission offsets based on the amount of power uploaded to the utility grid. The credit reflects the carbon intensity of the non-baseload power sources for the utility grid.
  - Landfills are credited with GHG emission offsets for the sequestering of biogenic carbon in the landfill. (a portion of the organic wastes disposed of in landfills remains undecomposed due to dry entombment conditions).

Additionally, the global warming potential (GWP) used in WARM was revised to use the 20-year GWP rather than 100-year GWP to more closely reflect the urgent time frame for addressing climate change. Methane and nitrous oxide have a 100-year GWP of 25 and 298, respectively, whereas their 20-year GWP are 86 and 268, respectively.

Methane is partially oxidized to carbon dioxide as it passes through the landfill cover soils. WARM assumes an average methane oxidation rate of 20 percent over the life of a landfill. *See* ICF 2020b.

The landfilled materials that are not decomposed by anaerobic bacteria are stored in the landfill. This remaining undecomposed carbon is considered an anthropogenic sink since this carbon would have normally been released as biogenic carbon dioxide from natural decomposition as it completes the photosynthesis/respiration cycle. WARM accounts for the landfill carbon storage associated with the landfilling of organic materials. *See* USEPA 2010.

Consistent with the CAPs and HAPs analysis, the GHG analysis assumed a 20-year period in which 100,000 tons of MSW is disposed of each year. Even though decomposition in landfills occurs for many decades, WARM results for landfilling do not include emissions beyond 20 years. This was done to provide a fair comparison to the WTE scenario.

The carbon intensity of power on the grid is decreasing as more low carbon energy sources such as wind and solar contribute power to the grid. To account for the increase in low carbon energy sources in the future, the study used three energy mixes for determining GHG emission offsets:

1. Energy Mix Case 1 – the current sources of non-baseload power.
2. Energy Mix Case 2 – 50% fossil fuels and 50% renewables for non-baseload power.
3. Energy Mix Case 3 – 10% fossil fuels and 90% renewables for non-baseload power.

Non-baseload power is used because this is the only type of power offset by WTE and landfills.

2.3.2 Greenhouse Gas Emissions from Transfer Trucks

GHG emissions from transfer trucks were computed using recorded and estimated vehicle miles traveled (VMT) data and applying emission factors from the USEPA MOVES3 model. It was assumed that transfer trucks use the same route for both legs of their roundtrips between the disposal facilities and the solid waste transfer stations. The MOVES3 emission factors are averaged for loaded and unloaded conditions making them the same for hauling and backhaul. The GHG emissions from the disposal facilities (WARM) and the hauling vehicles (MOVES3) were summed to compute the total GHG emissions for each of the three scenarios.

2.4 Air Pollutant Dispersion Modeling

AERMOD, the preferred dispersion model in USEPA's *Guideline on Air Quality Models* (*See* Appendix W of *40 Code of Federal Regulations 51*), was used to predict air pollutant concentrations at select downwind receptor locations from the disposal facilities. The graphical user interface AERMOD View (created by Lakes Environmental) was used to facilitate model setup and the post-processing of data. Dispersion modeling results for criteria pollutants were compared to the primary national ambient air quality standards that provide health protection within a 5-kilometer (km) radius of the facilities. The criteria modeling dispersion modeling also included a high-level screening analysis to determine the impacts the transfer trucks have on ambient air quality along the haul routes. Finally, dispersion modeling results for HAPs were used to perform the health risk assessments.

The dispersion modeling was conducted as described in **Appendix A**.

2.5 Human Health Risk Assessment

A human health risk assessment (HHRA) was conducted to estimate increased health risk associated with HAPs emissions for residents living near the facilities. The concentrations of HAPs estimated from air pollutant dispersion modeling were used to quantify cancer and non-cancer health hazards associated with inhalation exposure to the identified HAPs using standard methods developed by the USEPA. The methodology plan provided in **Appendix A** and the HHRA technical report provided in **Appendix D** detail the approach used for the HHRA.

2.6 Ecological Screening Assessment

Criteria air pollutant dispersion modeling within a 5-km radius of the disposal facilities was compared to the USEPA Secondary National Ambient Air Quality Standards to assess adverse effects on ecology including soil, water, crops, animals and wildlife, and vegetation. *See* USEPA 2021f. Note that an ecological screening assessment does not assess actual ecological impacts since doing so was determined to be cost-prohibitive for this study.

2.7 Power Generation Estimates

Power generation data from Covanta Fairfax was used to calculate the annual amount of power attributed to the 100,000 tons of MSW from the District.

Power generated at the landfills that is attributed to the waste delivered from the District was calculated using the following:

- Landfill gas estimates from the USEPA LandGEM model Version 3.03
- Landfill gas (LFG) collection efficiency from the USEPA WARM model Version 15
- Percentage of landfill gas used for power generation from landfill managers

- Power conversion efficiency for the specific generators used at the landfills as reported by manufacturers. *See* **Appendix E.**

2.8 Hauling and Disposal Costs

Costs for Covanta Fairfax reflect actual costs incurred by the District through their current contracts (January 1, 2021–December 31, 2021, extension of the Covanta Fairfax contract and the hauling contract with Lucky Dog effective through November 1, 2021).

Hauling costs for the landfill scenarios were estimated using the District's incurred hauling costs and adjusting for mileage differences.

Since private landfills do not have set rates (tipping fees are negotiable and vary widely), disposal costs for the landfill scenarios were compared to the Covanta Fairfax disposal cost to determine what the tipping fee would need to be to provide a comparable cost.

2.9 Vehicle Collisions

The number of vehicle collisions attributed to transfer trucks traveling to and from the disposal facilities was estimated from fatality, injury, and property damage rates per 100 million VMT. VMT collision rates were developed using national data from the Federal Motor Carrier Safety Administration (FMCSA), National Highway Traffic Safety Administration (NHTSA), Federal Highway Administration, and the Bureau of Economic Analysis.

VMT was computed from a single route for each scenario (refer to **Figure 1-4**), resulting in a total of six routes (i.e., two solid waste transfer stations multiplied by three disposal facilities).

2.10 Social and Environmental Justice Impacts

Social costs make the connection between environmental footprint and quality of life impacts. In terms of GHG emissions they represent costs attributed to climate change and for CAPs and HAPs they represent impacts to local air quality. Costs can vary widely since they consider the difference in toxicity between pollutants and their varying impacts to air quality and climate change. Sometimes the difference is in orders of magnitude from each other.

Social costs can be positive (costs) or negative (savings) depending on whether a process is an emission source or reduces emissions.

Costs were calculated by applying social cost metrics ($/ton) to the annual emissions estimates and then summing the annual costs to provide a net present value for the 20-year study period in US 2021 dollars. Additionally, a qualitative assessment of environmental justice and social equity considerations was performed.

2.10.1 Social Costs

2.10.1.1 Social Cost of Greenhouse Gases for Stationary Sources

The social cost of GHG emissions is an estimate of cost damages from climate change across the globe (*see* IPCC 2007) affecting agricultural productivity, human health, flood damage, infrastructure systems disruptions, conflict risks and environmental migration. *See* USG IWG 2021. Four social cost metrics, as recommended by the USG IWG, were used for the study as shown in **Table 2-1**. The first three metrics (from left to right) represent the results of using discount rates ranging from 2.5-5%. The values shown are the average of the values calculated by the models used in the study. The final value (far right column) represents the 95th percentile value of the 3% discount rate scenario, which is a conservative estimate if climate change impacts are more severe than current projections. *See* USG IWG 2021.

Table 2-1. Select Social Cost Metrics of Greenhouse Gases for Stationary Sources (USG IWG 2021)[1]

Year	Social Cost of Carbon Dioxide Metric and Discount Rate ($US 2020)			
	5%, Average	3%, Average	2.5%, Average	3%, 95th Percentile
2018*	$13	$49	$72	$145
2019*	$14	$50	$74	$149
2020	$14	$51	$76	$152

Notes:
* Social cost metrics for these years are extrapolated.
[1] Refer to **Appendix B** for full table of social cost metrics for mobile sources.

2.10.1.2 Social Cost of Criteria Air Pollutants and Hazardous Air Pollutants for Stationary Sources

Social costs of CAPs and HAPs emissions reflect human health impacts, reduced agricultural yields, materials depreciation, lost recreation activities, and reduced visibility. *See* Muller and Mendelsohn 2010. These social costs vary depending on whether the facility is in an urban or rural setting, but only apply one discount rate (3%, average). The social cost metrics are available in **Appendix A**.

2.10.1.3 Social Cost of Emissions for Mobile Sources

The social cost for select CAPs and carbon dioxide were developed for mobile sources based on the United States Department of Transportation (USDOT) *Benefit-Cost Analysis Guidance for Discretionary Grant Programs. See* USDOT 2021. These social cost metrics are based on the NHTSA, USDOT and USEPA study, entitled *The Safer Affordable Fuel-Efficient Vehicles Rule for MY2021-MY2026 Passenger Cars and Light Trucks Final Regulatory Impact Analysis* (USEPA 2020). The USDOT recommends using either a discount rate of 3% or 7% depending on the emissions type and context of the analysis. This study applied a discount rate of 3% to be consistent with the other elements of the social cost analysis.

2.10.2 Environmental Justice and Social Equity

A qualitative assessment was performed for environmental justice and social equity considerations by reviewing demographics and environmental data for the areas around the three disposal facilities. The demographics analysis included a 500-meter corridor along the waste hauling routes and a 5 km radius from the centroid of each disposal facility. The environmental conditions analysis focused on the areas around each of the disposal facilities, although the flood risk analysis did encompass the 500-meter corridor along the hauling routes.

2.11 Sustainability Goals

The relevant sustainability, clean energy, and climate goals established by the District's Sustainable DC Plan 2.0 (2019), Carbon Free DC and Clean Energy DC were addressed in the analysis to determine which, if any, of the three disposal scenarios contribute to goal achievement.

2.12 Items Not Addressed in the Study

The following items were not addressed in the study:

- Ash disposal from Covanta Fairfax was not included because:
  - MSW ash generates an insignificant amount of gas and therefore does not contribute to CAPs, HAPs, or GHG emissions.
  - The ash landfill is located adjacent to the Covanta Fairfax facility on the same site and therefore poses minimal risk of vehicle collisions.
  - The ash landfill is equipped with a bottom liner and leachate collection system that is monitored for groundwater impacts.
- CAPs and HAPs emissions from landfill equipment are not included in the analyses due to their negligible contribution to these types of emissions. However, GHGs from landfill equipment are included in the study.
- All minor emissions from Covanta Fairfax (including emergency diesel generators, solvent degreasers, and other units listed as "Insignificant Emission Units" in Covanta Fairfax's Title V permit) are not included in the analyses due to their negligible contribution.
- Emission calculations and modeling inputs/results will not be sent to Virginia Department of Environmental Quality (DEQ) for review, since DEQ staff declined the offer to review this "non-regulatory" study. However, DEQ did offer to provide informal advice.
- The USEPA Co-Benefits Risk Assessment (COBRA) screening model was not used for this study since the air dispersion modeling and health risk assessment performed for this study provide a more detailed and accurate assessment of health impacts.
- A comprehensive ecological risk assessment was not conducted due to budgetary constraints (an ecological screening analysis was conducted instead).
- Cumulative or antagonistic impacts of various toxins are not readily available from literature for performing health risk assessments. Due to the limited information on the potential interactions of chemicals, this aspect of toxicity assessment is addressed qualitatively in the uncertainty analysis.

Section 3

Comparative Analysis

3.1 Criteria Pollutant and Hazardous Air Pollutant Emissions

Criteria air pollutants (CAPs) and hazardous air pollutants (HAPs) estimates for the three scenarios are presented in **Table** 3-1. CAPs and HAPs are defined in Section 1.2. Examples of common HAPs emitted at Covanta Fairfax are hydrogen chloride, mercury, and lead. Examples of common landfill HAPs are toluene, xylene, and methylene chloride. The complete lists of HAPs for the three scenarios are presented in **Appendix B**.

Table 3-1. Criteria Air Pollutants and Hazardous Air Pollutants Emissions

Emission Source	Criteria Pollutants							HAPs
	VOC	NO_x	CO	SO_2	PM10	PM2.5	Pb	
	Tons/Year							
Covanta Fairfax								
Covanta Fairfax	0.4	130.0	4.6	20.8	2.3	2.1	0.002	3.3
Transportation	0.1	1.4	0.7	0.0016	0.1	0.034	-	0.0056
Total Emissions	***0.5***	***131.3***	***5.3***	***20.8***	***2.4***	***2.2***	***0.002***	***3.3***
King George Landfill								
Surface emissions	7.6	-	1.4	-	-	-	-	1.6
Flares	0.1	1.3	5.8	0.3	0.3	0.3	-	0.03
Generators	0.3	2.0	5.2	0.4	0.5	0.5	-	0.1
Transportation	0.1	3.3	1.6	0.0038	0.2	0.1	-	0.013
Total Emissions	***8.2***	***6.5***	***14.0***	***0.7***	***0.9***	***0.9***	***-***	***1.7***
King & Queen Landfill								
Surface emissions	7.6	-	1.4	-	-	-	-	1.6
Flares	0.025	0.3	1.3	0.1	0.1	0.1	-	0.0066
Generators	0.3	27.1	19.7	0.6	0.6	0.6	-	0.1
Transportation	0.3	7.5	3.5	0.0087	0.4	0.2	-	0.031
Total Emissions	***8.3***	***34.8***	***26.0***	***0.7***	***1.0***	***0.8***	***-***	***1.7***

Notes:
Pb is considered a criteria pollutant as well as a HAP.
NO_x, SO_2, and PM emission are not emitted from landfill surfaces. These pollutants are emitted when the landfill gas is combusted at the flare and/or generator.
Key:
VOC = volatile organic compound, CO = carbon monoxide, NO_x = nitrogen oxides, PM10 = particulate matter that have diameters ≤ 10 micrometers, PM2.5 = particulate matter that have diameters ≤ 2.5 micrometers, SO_2 = sulfur dioxide, HAPs = hazardous air pollutants, “-” = no emissions.

As shown in **Table** 3-1, the VOC and CO emissions from the landfill scenarios are greater than Covanta Fairfax, whereas NO_x and SO_2 emissions are much less. The landfills also have lower

PM10, PM2.5, and HAP emissions than Covanta Fairfax. Note that NO$_x$ and CO emissions from the King & Queen Landfill are higher than for the King George Landfill. This is mainly due to the use of reciprocating engine generators used at the King & Queen Landfill as compared to the cleaner burning turbine generators used at the King George Landfill.

Finally, hauling emissions typically constitute a low percentage compared to total emissions for each scenario. However, NO$_x$ emissions from hauling to the King George Landfill is 50% of total NO$_x$.

3.2 Greenhouse Gas Emissions

The GHG net emissions (facility and hauling emissions minus offsets as described in Section 2.3) are presented in **Table** 3-2**.** Results are based on 20-year GWPs. As noted in Section 2.3, the 20-year GWP time horizon is used, rather than 100-year GWPs, to reflect the urgent time frame for addressing climate change. The 20-year GWP for methane (86) is about three times higher than the 100-year GWP (25). Therefore, landfill GHG emissions, which are predominantly driven by methane, significantly increase when using the 20-year GWP time horizon versus the 100-year GWP time horizon. The annual emissions are provided in **Appendix B**.

Table 3-2. Twenty-year Greenhouse Gas Net Emissions using 20-year Global Warming Potentials

Scenario	GHG Net Emissions – 20-year GWP		
	Disposal Facilities	Hauling	Total
	MTCO$_2$e	MTCO$_2$e	MTCO$_2$e
Covanta Fairfax	695,403	8,624	704,027
King George Landfill	1,231,140	20,618	1,251,758
King & Queen Landfill	1,104,444	46,998	1,151,442

Note:
Total GHGs over 20 years assuming 100,000 tons of MSW disposed annually. Emissions from the landfills beyond Year 20 are excluded.

Key:
MTCO$_2$e = metric tons of carbon dioxide equivalent

The King George Landfill and King & Queen Landfill emissions are 1.8 to 1.6 times higher, respectively, than the Covanta Fairfax emissions. As shown in **Table** 3-2, hauling emissions constitute a small portion of the total emissions of each scenario (1%–4%).

Table 3-3 compares GHG emissions for two future scenarios that reflect anticipated increases in renewable energy sources, as described in Section 2.3. As the grid use more carbon free energy sources, like wind or solar, offsets attributed to the power produced by Covanta Fairfax or the landfills will be significantly reduced. Therefore, net emissions will increase due to the lower offsets.

Table 3-3. Greenhouse Gas Emissions with Anticipated Increase in Non-Baseload Renewable Power[1]

Scenario	Current Energy Mix	Future Mixes	
	Non-Baseload:[2] 100% Fossil Fuel	Non-Baseload: 50% Fossil Fuels and 50% Renewables	Non-Baseload: 10% Fossil Fuels and 90% Renewables
	$MTCO_2e$		
Covanta Fairfax	720,052	1,133,382	1,476,866
King George Landfill	1,251,758	1,264,648	1,274,959
King & Queen Landfill	1,151,442	1,172,534	1,189,408

Notes:

[1] Wind or solar.

[2] Non-baseload WARM emission factors are from Emissions & Generation Resource Integrated Database (eGRID) (USEPA 2020f).

Assuming 50% renewable energy for non-baseload power dramatically increases Covanta Fairfax net GHG emissions although it remains lower than the landfill scenarios. However, when assuming 90% renewable energy for non-baseload power, Covanta Fairfax GHG net emissions are slightly higher than the landfill scenarios.

3.3 Social Cost of Emissions

The social cost of emissions was calculated for the three scenarios by summing the following cost components:

- CAPs and HAPs emitted from the facilities
- GHGs emission and power generation offset from the facilities
- Combined GHGs, CAPs, and HAPs emissions from transfer trucks

3.3.1 Social Cost of Greenhouse Gas Emissions from Disposal Facilities

The social costs associated with GHGs from disposal facilities are shown in **Figure 3-1**. The analysis presented in this section uses the 3% average social cost metric for GHGs which represents a moderate climate change scenario.

The reason for substantially higher GHG social costs at the landfills is the delayed release of GHG emissions. The GHG social cost metrics increase incrementally each year reflecting the escalating levels of damage attributed to GHG emissions as they accumulate in the atmosphere. *See* USG IWG 2021. Therefore, the increasing emissions at the landfills are subject to higher social cost metrics, resulting in higher total social costs over the 20-year study period. Note that social costs do not represent actual accounting costs of damages, rather, they represent the monetized value of damages resulting from the release of these emissions.

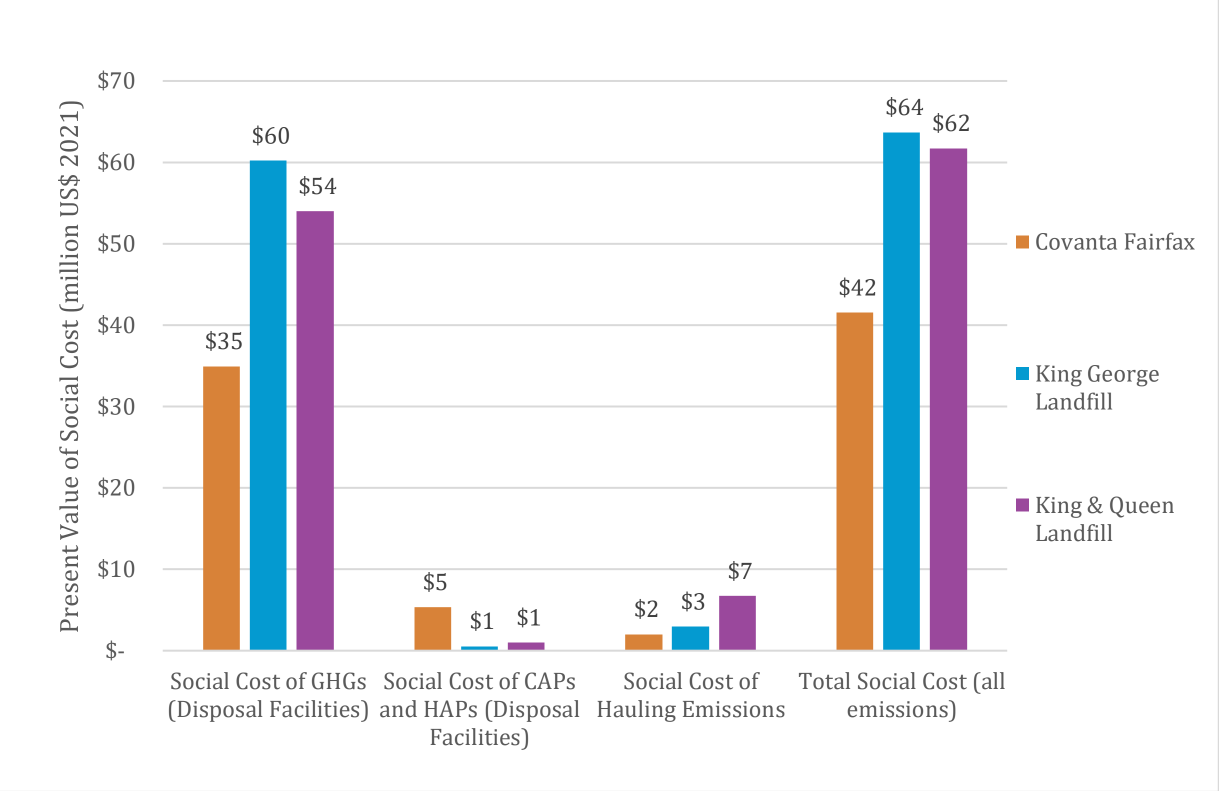


Figure 3-1. Comparing Social Cost for Different Emissions Categories

3.3.2 Social Cost of Criteria Air Pollutants and Hazardous Air Pollutants Emissions from Disposal Facilities

The social cost of CAPs and HAPs represent damages due to human health impacts, reduced agricultural yields, materials depreciation, lost recreation activities, and reduced visibility. *See* Muller and Mendelsohn 2010. Social cost metrics are not available for all the CAPs and HAPs quantified, as explained in **Appendix A**.

The total social costs associated with CAPs and HAPs emissions for each of the facilities over 20 years are shown in **Figure 3-1.** Covanta Fairfax has the highest total social cost for CAPs and HAPs at $5.3 million and the King George Landfill has the lowest at $500,000. There are two primary drivers resulting in Covanta Fairfax having the highest costs, which are the urban setting and the higher SO_2 and PM2.5 emissions at Covanta. Due to Covanta Fairfax's location in an urban setting, in contrast with the rural landfill settings, emissions from this facility are subject to higher social cost metrics. *See* Muller and Mendelsohn 2010. Additionally, Covanta Fairfax had higher SO_2 and PM2.5 emissions, which carry the highest social cost metrics of the evaluated CAPs and HAPs.

3.3.3 Emissions from Waste Hauling

The total social costs of GHG, CAPs, and HAPs emissions associated with waste hauling are shown in **Figure 3-1**. The King & Queen Landfill had the highest total social cost for waste hauling emissions due to it having the longest hauling distance.

3.3.4 Social Cost Metrics Summary

The King George Landfill has the highest social cost from GHG emissions, while Covanta Fairfax has the lowest, due to the higher overall GHG emissions at the King George Landfill and the increase of GHGs emissions each year. In contrast, Covanta Fairfax has the highest social cost associated with CAPs and HAPs, while the King George Landfill has the lowest. The King & Queen Landfill has the highest hauling emissions social cost, and Covanta has the lowest. The three categories of social cost are shown for each facility in **Figure 3-1**. Because both the disposal facility CAPs and HAPs social cost and the hauling emissions social cost are so low relative to the GHGs social cost, the King George Landfill is the facility with the highest total social cost.

3.4 Air Pollutant Dispersion Modeling of Disposal Facilities

Table 3-**4** shows CAP peak concentration results for the three scenarios. HAP concentrations are addressed in Section 3.5 in the HHRA.

Table 3-4. Dispersion Modeling Peak Results

Pollutant	Averaging Time[1]	Covanta Fairfax (µg/m^3)	King George Landfill (µg/m^3)	King & Queen Landfill (µg/m^3)
CO	1-hour	0.4	7.5	21.1
	8-hour	0.1	6.5	15.4
NO_2	1-hour	4.8	2.4	18.1
	Annual	0.1	0.1	0.6
PM10	24-hour	0.027	0.4	0.2
PM2.5	24-hour	0.018	0.3	0.1
	Annual	0.00081	0.018	0.015
SO_2	1-hour	1.0	0.5	0.5
Pb	3-month rolling average	0.00001	-	-

Notes:

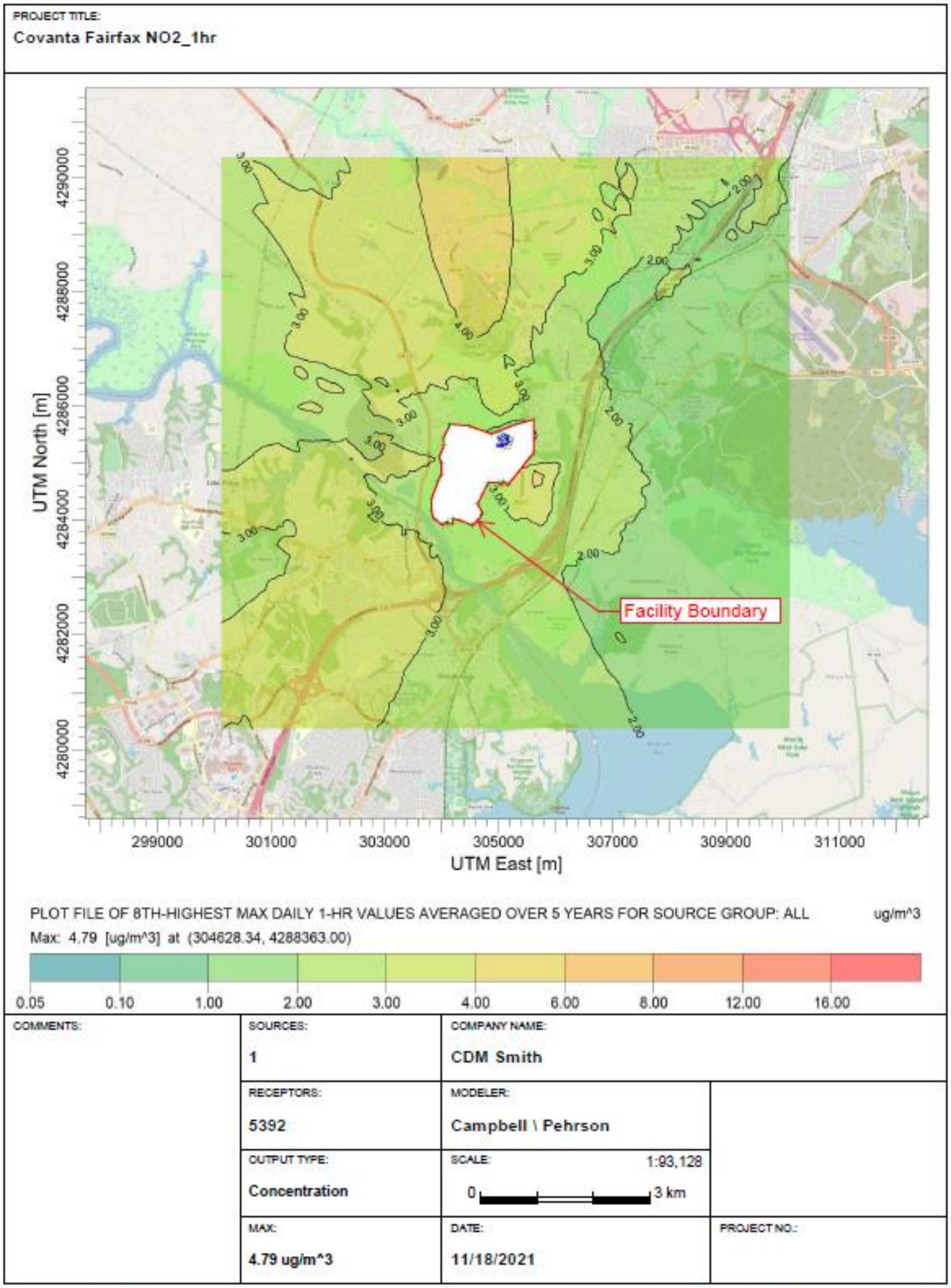
[1] The specific attainment criteria for each pollutant and averaging period are described in Table 1 of **Appendix A.**

Key:

µg/m^3 = microgram per cubic meter

Table 3-**4** shows that the landfill scenarios have higher concentrations for each of the criteria pollutants, except for the Pb three-month rolling average. Note that NO_2 one-hour concentrations for Covanta Fairfax are higher than the King George Landfill but lower than the King & Queen Landfill due to the use of low nitrogen oxides turbine generators at the King George Landfill.

Examples of the isopleths maps developed from the modeling results are provided in **Figure** 3-2 through **Figure** 3-7. Northing and easting coordinates are Universal Transverse Mercator (UTM).



PROJECT TITLE:

Covanta Fairfax NO2_1hr

PLOT FILE OF 8TH-HIGHEST MAX DAILY 1-HR VALUES AVERAGED OVER 5 YEARS FOR SOURCE GROUP: ALL ug/m^3

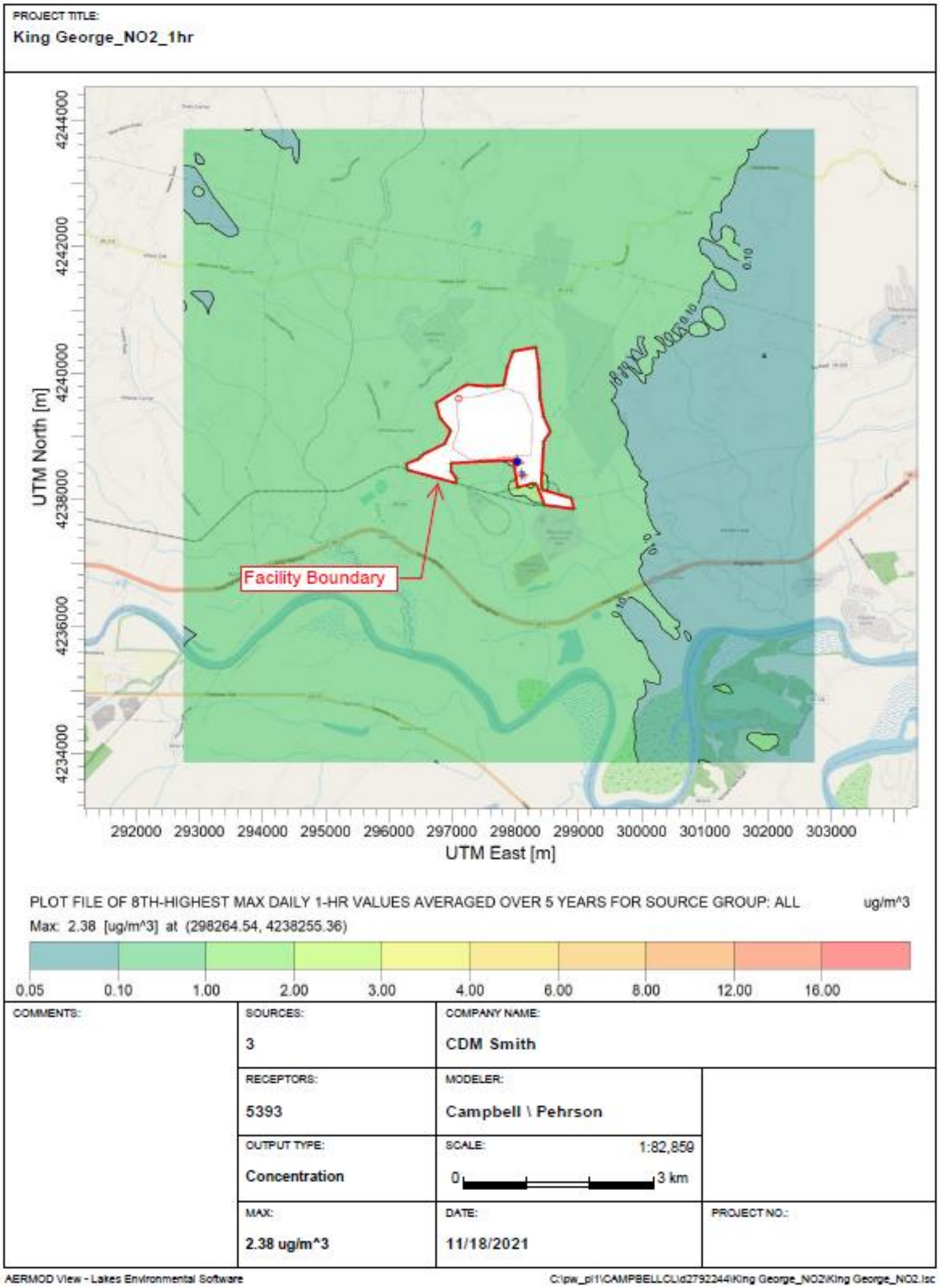
Max: 4.79 [ug/m^3] at (304628.34, 4288363.00)

COMMENTS:	SOURCES: 1	COMPANY NAME: CDM Smith	
	RECEPTORS: 5392	MODELER: Campbell \ Pehrson	
	OUTPUT TYPE: Concentration	SCALE: 1:93,128 0 3 km	
	MAX: 4.79 ug/m^3	DATE: 11/18/2021	PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\pw_pl1\CAMPBELLCL\d2792244\Covanta Fairfax_NO2\Covanta Fairfax_NO2.isc

Figure 3-2. Covanta Fairfax, 1-Hour NO_2 98th Percentile Concentrations



PROJECT TITLE:
King George_NO2_1hr

PLOT FILE OF 8TH-HIGHEST MAX DAILY 1-HR VALUES AVERAGED OVER 5 YEARS FOR SOURCE GROUP: ALL

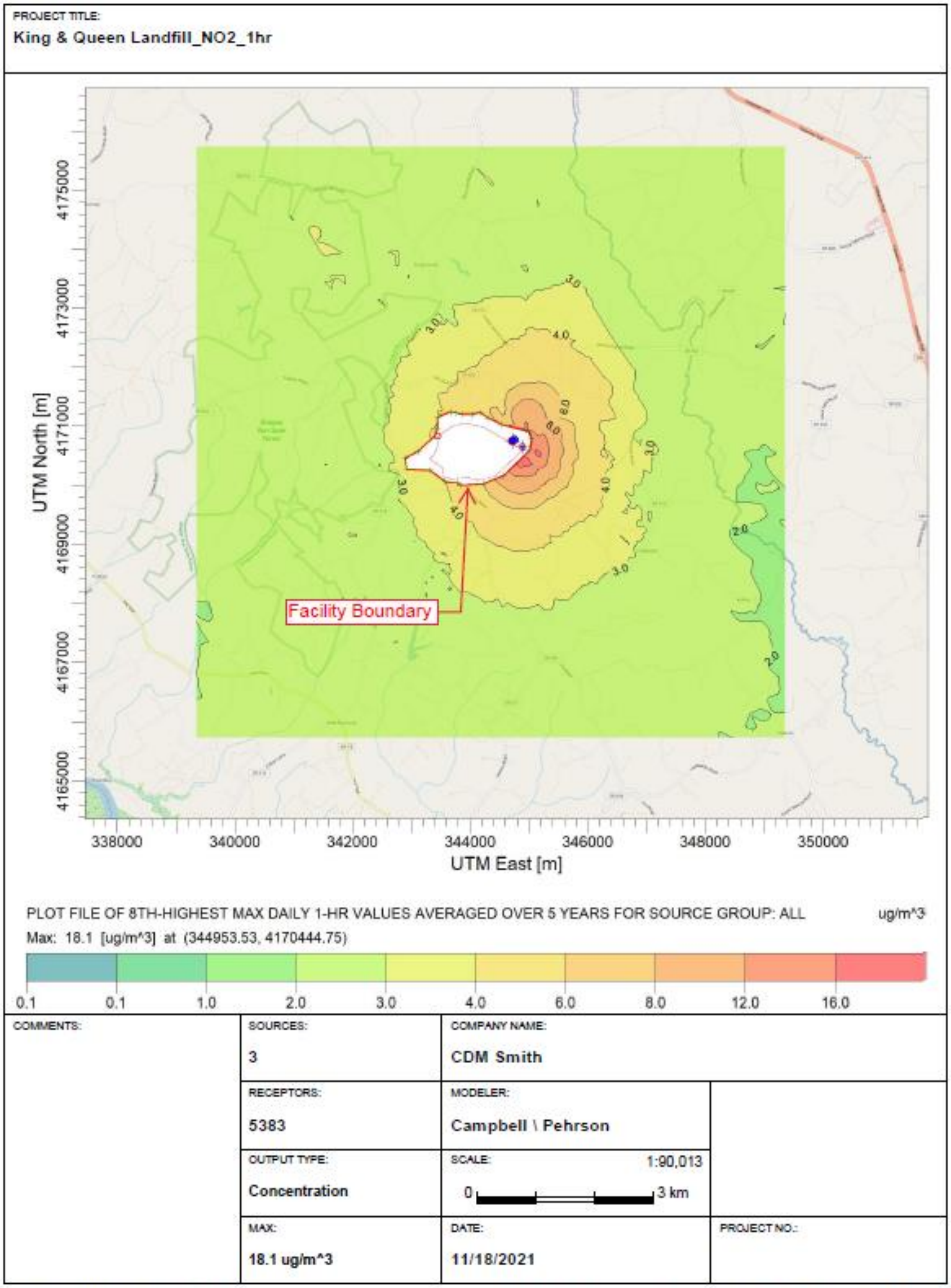
Max: 2.38 [ug/m^3] at (298264.54, 4238255.36)

COMMENTS:	SOURCES: 3	COMPANY NAME: CDM Smith
	RECEPTORS: 5393	MODELER: Campbell \ Pehrson
	OUTPUT TYPE: Concentration	SCALE: 1:82,859 0 3 km
	MAX: 2.38 ug/m^3	DATE: 11/18/2021
		PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\pw_pl1\CAMPBELLCL\d2792244\King George_NO2\King George_NO2.isc

Figure 3-3. King George Landfill, 1-Hour NO_2 98th Percentile Concentrations



PROJECT TITLE:

King & Queen Landfill_NO2_1hr

PLOT FILE OF 8TH-HIGHEST MAX DAILY 1-HR VALUES AVERAGED OVER 5 YEARS FOR SOURCE GROUP: ALL ug/m^3

Max: 18.1 [ug/m^3] at (344953.53, 4170444.75)

COMMENTS:

SOURCES: 3

COMPANY NAME: CDM Smith

RECEPTORS: 5383

MODELER: Campbell \ Pehrson

OUTPUT TYPE: Concentration

SCALE: 1:90,013

MAX: 18.1 ug/m^3

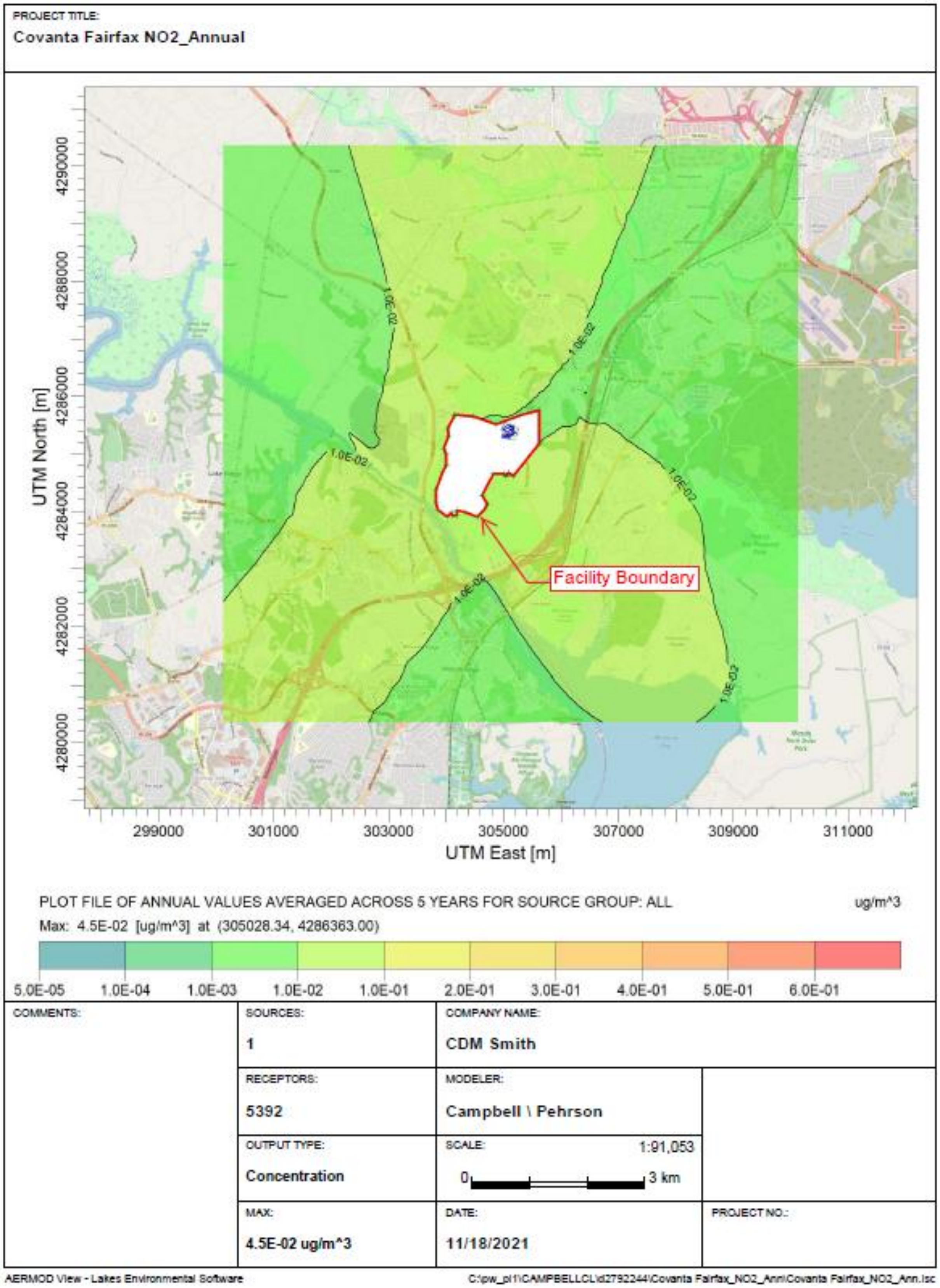
DATE: 11/18/2021

PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\pw_pl1\CAMPBELLCL\d2792244\King and Queen_NO2_1h\King and Queen_NO2_1h.isc

Figure 3-4. King & Queen Landfill, 1-Hour NO_2 98th Percentile Concentrations



PROJECT TITLE:

Covanta Fairfax NO2_Annual

PLOT FILE OF ANNUAL VALUES AVERAGED ACROSS 5 YEARS FOR SOURCE GROUP: ALL

ug/m^3

Max: 4.5E-02 [ug/m^3] at (305028.34, 4286363.00)

COMMENTS:

SOURCES:

1

COMPANY NAME:

CDM Smith

RECEPTORS:

5392

MODELER:

Campbell \ Pehrson

OUTPUT TYPE:

Concentration

SCALE: 1:91,053

MAX:

4.5E-02 ug/m^3

DATE:

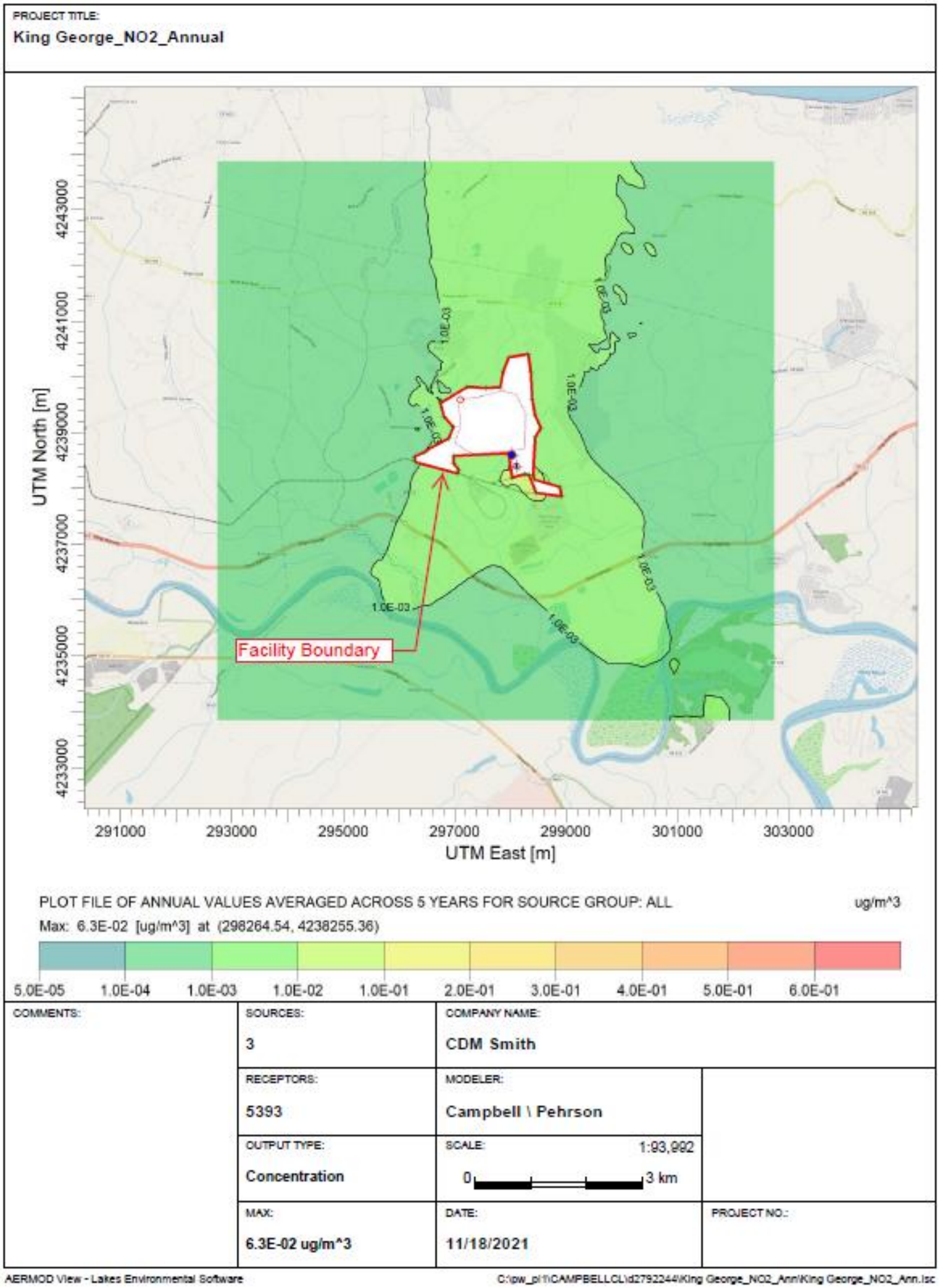
11/18/2021

PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\pw_pl1\CAMPBELLCL\d2792244\Covanta Fairfax_NO2_Ann\Covanta Fairfax_NO2_Ann.isc

Figure 3-5. Covanta Fairfax, NO_2 Annual Average Concentrations



PROJECT TITLE:
King George_NO2_Annual

PLOT FILE OF ANNUAL VALUES AVERAGED ACROSS 5 YEARS FOR SOURCE GROUP: ALL
Max: 6.3E-02 [ug/m^3] at (298264.54, 4238255.36)

COMMENTS:

SOURCES:
3

COMPANY NAME:
CDM Smith

RECEPTORS:
5393

MODELER:
Campbell \ Pehrson

OUTPUT TYPE:
Concentration

SCALE: 1:93,992

MAX:
6.3E-02 ug/m^3

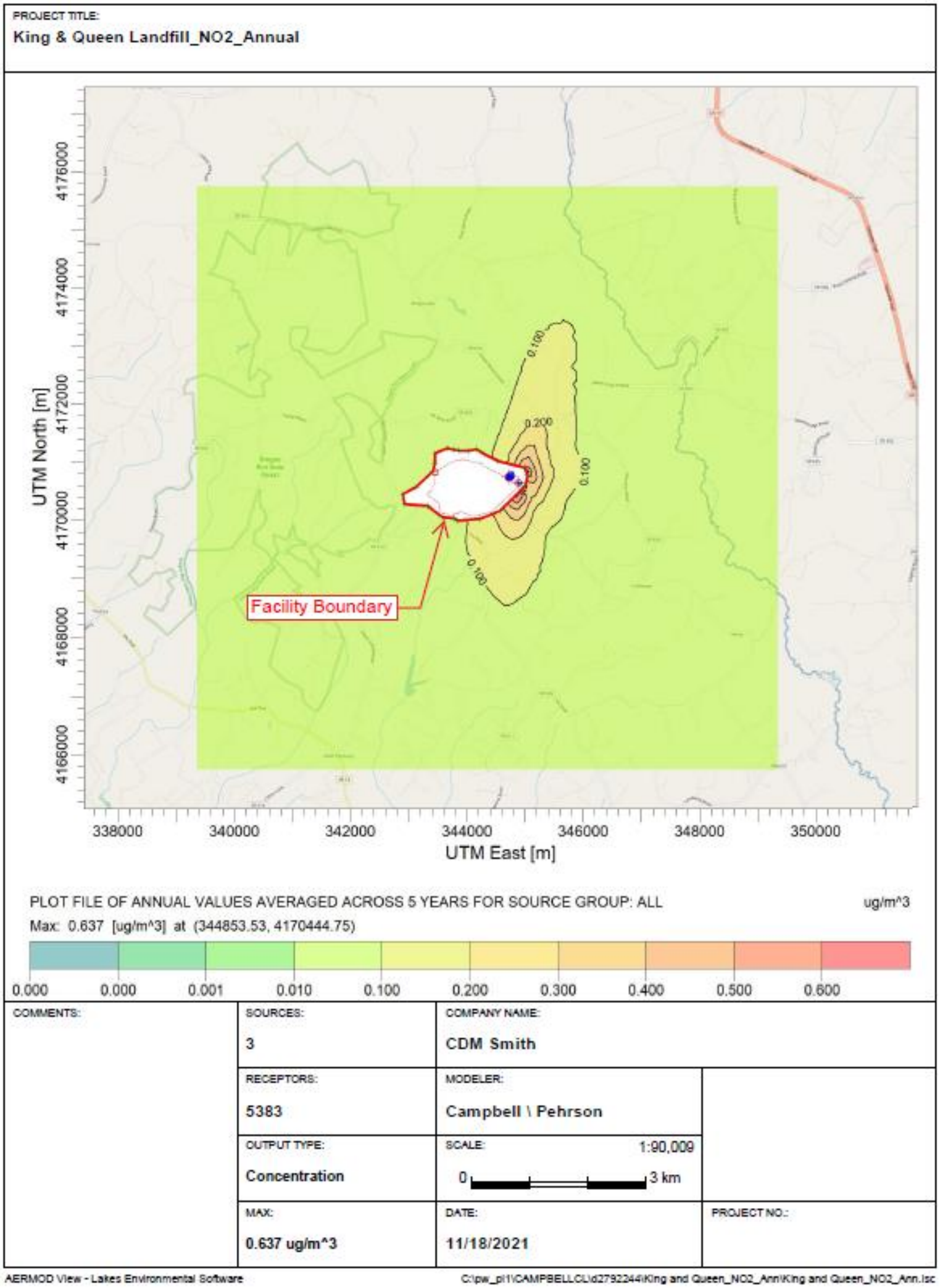
DATE:
11/18/2021

PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\pw_pl1\CAMPBELLCL\d2792244\King George_NO2_Ann\King George_NO2_Ann.isc

Figure 3-6. King George Landfill, NO_2 Annual Average Concentrations



PROJECT TITLE:
King & Queen Landfill_NO2_Annual

PLOT FILE OF ANNUAL VALUES AVERAGED ACROSS 5 YEARS FOR SOURCE GROUP: ALL
Max: 0.637 [ug/m^3] at (344853.53, 4170444.75)

COMMENTS:

SOURCES: 3

COMPANY NAME: CDM Smith

RECEPTORS: 5383

MODELER: Campbell \ Pehrson

OUTPUT TYPE: Concentration

SCALE: 1:90,009
0 3 km

MAX: 0.637 ug/m^3

DATE: 11/18/2021

PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\pw_pl1\CAMPBELLCL\d2792244\King and Queen_NO2_Ann\King and Queen_NO2_Ann.isc

Figure 3-7. King & Queen Landfill, NO_2 Annual Average Concentrations

Note that one-hour and annual NO_2 modeling concentration values for Covanta Fairfax occurred approximately at 2.7 km and 0.75 km, respectively, north of the facility boundary. However, peak one-hour and Annual NO_2 concentrations for the landfills occurred right outside their respective property boundaries. Peak concentrations for Covanta Fairfax occur further away from the facility boundary, compared to the landfills, due to Covanta's higher stack which allows the plume to travel further distance before coming to the ground. Note that the higher stack also allows for the plume to become more diluted and concentrations to be lower once they reach ground level.

Table 3-**5** through **Table** 3-**7** compare the modeled criteria pollutant concentrations and the representative background concentrations to the Primary National Ambient Air Quality Standards for the three scenarios. Note that HAPS are not included since there are no National Ambient Air Quality Standards for HAPs. Combine background and facility values are rounded to the nearest whole number for comparison to the National Ambient Air Quality Standards values with the exception of lead.

Table 3-5. AERMOD-Predicted Peak Concentrations and Comparison to Primary National Ambient Air Quality Standards – Covanta Fairfax

Pollutant	Averaging Time	Background (µg/m³)[1]	Covanta Fairfax (µg/m³)	Covanta + Background (µg/m³)	National Ambient Air Quality Standard (µg/m³)[2]	Exceed Standard?
CO	1-hour	1,714.3	0.4	1,715	40,000	No
	8- hour	1,222.2	0.1	1,222	10,000	No
NO_2	1-hour	87.1	4.8	92	188	No
	Annual	30.0	0.1	30	100	No
PM10	24-hour	22.3	0.027	22	150	No
PM2.5	24-hour	21.3	0.018	21	35	No
	Annual	9.0	0.00081	9	12	No
SO_2	1-hour	11.3	1.0	12	196	No
Pb	3-month rolling average	0.004	0.00001	0.004	0.15	No

Notes:

[1] Background data are from USEPA's Monitor Values Reports (https://www.epa.gov/outdoor-air-quality-data/monitor-values-report) for the years 2017 through 2019 (2020 data were not used since it was assumed not representative of a normal year due to COVID-19) from monitoring stations closest to the modeled sites.

[2] USEPA National Ambient Air Quality Standards Table (https://www.epa.gov/criteria-air-pollutants/naaqs-table).

Table 3-6. AERMOD-Predicted Peak Concentrations and Comparison to Primary National Ambient Air Quality Standards – King George Landfill

Pollutant	Averaging Time	Background (µg/m³)[1]	King George Landfill (µg/m³)	Landfill + Background (µg/m³)	National Ambient Air Quality Standards (µg/m³)[2]	Exceed Standard?
CO	1-hour	1,714.3	7.5	1,722	40,000	No
	8-hour	1,222.2	6.5	1,229	10,000	No
NO_2	1-hour	87.1	2.4	89	188	No
	Annual	30.0	0.1	30	100	No
PM10	24-hour	19.3	0.4	20	150	No
PM2.5	24-hour	21.3	0.3	22	35	No
	Annual	9.0	0.018	9	12	No
SO_2	1-hour	11.3	0.5	12	196	No

Notes:

[1] Background data are from USEPA's Monitor Values Reports (https://www.epa.gov/outdoor-air-quality-data/monitor-values-report) for the years 2017 through 2019 (2020 data were not used since it was assumed not representative of a normal year due to COVID-19) from monitoring stations closest to the modeled sites.

[2] USEPA National Ambient Air Quality Standards Table (https://www.epa.gov/criteria-air-pollutants/naaqs-table).

Table 3-7. AERMOD-Predicted Peak Concentrations and Comparison to Primary National Ambient Air Quality Standards – King & Queen Landfill

Pollutant	Averaging Time	Background (µg/m³)[1]	King & Queen Landfill (µg/m³)	Landfill + Background (µg/m³)	National Ambient Air Quality Standards (µg/m³)[2]	Exceed Standard?
CO	1-hour	1,257.1	21.1	1,278	40,000	No
	8-hour	1,000.0	15.4	1,015	10,000	No
NO_2	1-hour	63.3	18.1	81	188	No
	Annual	14.5	0.6	15	100	No
PM10	24-hour	26.7	0.2	27	150	No
PM2.5	24-hour	15.7	0.1	16	35	No
	Annual	7.2	0.015	7	12	No
SO_2	1-hour	10.5	0.5	11	196	No

Notes:

[1] Background data are from USEPA's Monitor Values Reports (https://www.epa.gov/outdoor-air-quality-data/monitor-values-report) for the years 2017 through 2019 (2020 data were not used since it was assumed not representative of a normal year due to COVID-19) from monitoring stations closest to the modeled sites.

[2] USEPA National Ambient Air Quality Standards Table (https://www.epa.gov/criteria-air-pollutants/naaqs-table).

Note that the modeled facilities plus background do not exceed the National Ambient Air Quality Standards for any of the three scenarios.

The screening level dispersion analysis of transfer truck emission concentrations on roadways indicated that the contribution of the transfer trucks to ambient concentrations would not cause any of the CAP standards to be exceeded as shown in **Table 3-8**. Background and transfer truck values are rounded to the nearest whole number for comparison to the National Ambient Air Quality Standards values.

Table 3-8. Screening Level Dispersion Modeling Peak Results – Transfer Truck Emissions (All Scenarios)

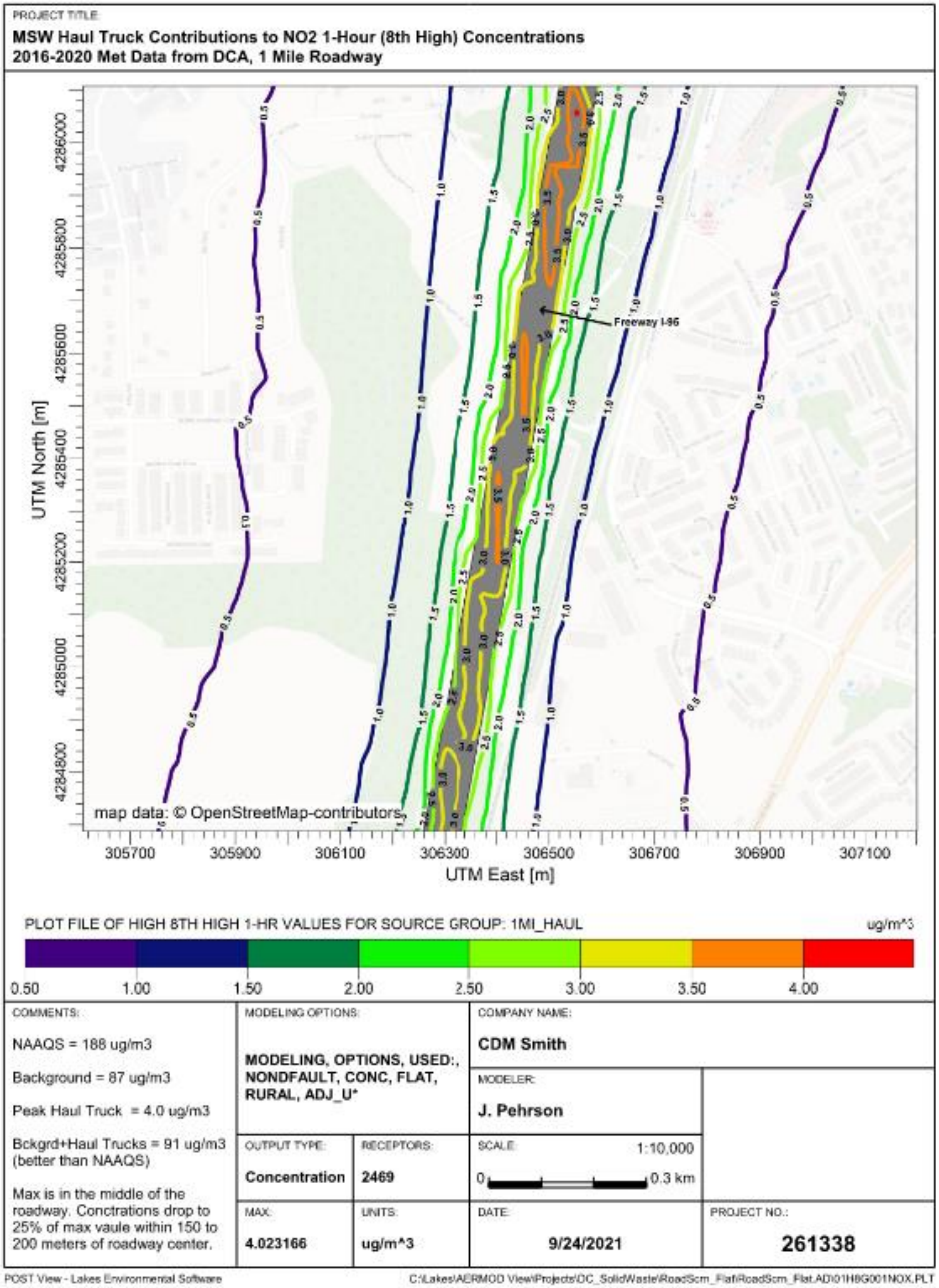
Pollutant	Averaging Time	Background (µg/m³)[1]	Transfer Trucks (µg/m³)	Transfer Trucks + Background (µg/m³)	National Ambient Air Quality Standards (µg/m³)[2]	Exceed Standard?
CO	1-hour	1,714.3	2.3	1,717	40,000	No
	8-hour	1,222.2	0.6	1,223	10,000	No
NO_2	1-hour	87.1	4.0	91	188	No
	Annual	30.0	0.1	30	100	No
PM10	24-hour	22.3	0.028	22	150	No
PM2.5	24-hour	21.3	0.019	21	35	No
	Annual	9.0	0.0022	9	12	No
SO_2	1-hour	11.3	0.01	11	196	No
Pb	3-month rolling average	0.004	NA	0.004	0.15	No

Notes:

[1] Background data are from USEPA's Monitor Values Reports (https://www.epa.gov/outdoor-air-quality-data/monitor-values-report) for the years 2017 through 2019 (2020 data were not used since it was assumed not representative of a normal year due to COVID-19) from monitoring stations closest to the modeled sites.

[2] USEPA National Ambient Air Quality Standards Table (https://www.epa.gov/criteria-air-pollutants/naaqs-table).

As shown in **Figure** 3-8**,** the peak concentrations occur in the middle of the roadway and drop to roughly one half of the peak value within 50 to 100 meters of the roadway centerline and decrease to roughly one--fourth of the peak value with 150 to 200 meters of the roadway centerline.



PROJECT TITLE:

MSW Haul Truck Contributions to NO2 1-Hour (8th High) Concentrations
2016-2020 Met Data from DCA, 1 Mile Roadway

COMMENTS:

NAAQS = 188 ug/m3

Background = 87 ug/m3

Peak Haul Truck = 4.0 ug/m3

Bckgrd+Haul Trucks = 91 ug/m3 (better than NAAQS)

Max is in the middle of the roadway. Conctrations drop to 25% of max vaule within 150 to 200 meters of roadway center.

MODELING OPTIONS:

MODELING, OPTIONS, USED:, NONDFAULT, CONC, FLAT, RURAL, ADJ_U*

COMPANY NAME: **CDM Smith**

MODELER: **J. Pehrson**

OUTPUT TYPE: **Concentration**

RECEPTORS: **2469**

SCALE: 1:10,000

0 — 0.3 km

MAX: **4.023166**

UNITS: **ug/m^3**

DATE: **9/24/2021**

PROJECT NO.: **261338**

POST View - Lakes Environmental Software

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Figure 3-8. Transfer Truck 1-Hour NO_2 98th Percentile Concentrations

3.5 Health Risk

The HHRA assessed incremental changes to health impacts for residential receptors subject to inhalation exposure of HAPs resulting from disposal related activities. Cancer risk and chronic and acute non-cancer health hazard estimates were calculated using estimated emissions and air dispersion modeling and combining them with exposure parameters for the receptors and toxicity values. In addition, estimated eight-hour HAP concentrations were compared to their respective eight-hour time-weighted average permissible exposure levels (TWA-PELs) for commercial worker exposure.

3.5.1 Cancer Risks

Cancer risks associated with inhalation exposure are summarized in **Table** 3-**9**. The USEPA risk management range is one-in-a-million to 100-in-a-million. For this evaluation, a cancer risk threshold of 10-in-a-million was selected for comparison as this is the risk level used by the Maryland's Air Toxics Office in their development of screening levels for toxic air pollutants. Virginia does not have established thresholds for cancer risk.

The scenarios do not emit the same types of HAPs. As described in **Appendix D**, cancer risks for the landfills are primarily attributed to inhalation exposure to acrylonitrile, 1,1,2,2-tetrachloroethane, vinyl chloride, and trichloroethylene. Cancer risk for Covanta Fairfax is primarily attributable to inhalation exposure to dioxins.

Cancer risks at Covanta Fairfax are much lower than the landfills, although all are less than the 10-in-a-million cancer risk threshold.

Table 3-9. Incremental Cancer Risks for Maximally Exposed Individuals from Inhalation Exposure for the Disposal Scenarios

Receptor Type	Cancer Risk Threshold[2] (per million people)	Incremental Cancer Risks[1] (per million people)		
		Covanta Fairfax	King George Landfill[3]	King & Queen Landfill[3]
Adult resident, 70 years[4]	10	0.08	5.2	3.8
Adult resident, 30 years	10	0.07	4.5	3.3
Child resident, 9 years	10	0.05	3.1	2.3
Child resident, 6 years	10	0.04	2.5	1.8

Source: **Appendix D**, Attachment 1.

Notes:

[1] Values provided are changes in the number of cancer cases per million people. None of the values were greater than the EPA acceptable risk range of 10^{-6} (1 in a million) to 10^{-4} (10 in a million) human health risk threshold.

[2] Upper bound of EPA's risk management range.

[3] The MEI risk locations identified for the landfills are not in residentially zoned area according to USGS and county zoning data. Risks for actual residents in the vicinity of the landfills are estimated to be lower than the MEI values in this table.

[4] Although the 30-year residential scenario was used for the comparison to the human health risk threshold, the 70-year residential scenario was also calculated to determine cancer burden for evaluation of population-wide risks in **Appendix D**.

3.5.2 Chronic Non-Cancer Human Health Hazards

Maximum chronic non-cancer health hazards associated with inhalation exposure from operations of the disposal scenarios are summarized in **Table 3-10**3-. A hazard index (HI) equal to or greater than one would indicate the potential for chronic adverse health effects. The maximum chronic non-cancer hazards for all three disposal scenarios are more than a magnitude less than the threshold. Because the totals of the chronic HI estimates were less than the threshold of one for all three scenarios, categorizing the chemicals by target organ was unnecessary.

Table 3-103- Incremental Chronic Non-Cancer Human Health Hazards for Maximally Exposed Individuals from Inhalation Exposure for the Disposal Scenarios

Receptor Type	Hazard Threshold	Incremental Non-Cancer Chronic Hazards[1]		
		Covanta Fairfax	King George Landfill[2]	King & Queen Landfill[2]
Residential	1	0.00009	0.02	0.01

Source: **Appendix D**, Attachment 1.

Notes:

[1] Hazard indices (HI) are unitless. None of the values were greater than the HI human health risk threshold of one.

[2] The MEI hazard locations identified for the landfills are not in residentially zoned area according to USGS and county zoning data. Hazards for actual residents in the vicinity of the landfills are estimated to be lower than the MEI values in this table.

As described in **Appendix D**, chronic hazards for the landfills are primarily attributable to inhalation exposure to acrylonitrile, trichloroethylene, and tetrachloroethylene. Chronic hazard for Covanta is primarily attributable to inhalation exposure to hydrogen chloride, dioxins, cadmium, and arsenic. Chronic hazards at the landfills are comparable, while the chronic hazard at Covanta is several orders of magnitude lower, although all are less than one; thus, indicating a low potential for chronic adverse health effects from inhalation exposure.

3.5.3 Acute Non-Cancer Health Hazards

Maximum acute non-cancer health hazards associated with inhalation exposure from operations of the disposal scenarios are summarized in **Table** 3-**11**. An HI equal to or greater than one would indicate the potential for acute adverse health effects. The acute non-cancer hazards for all three disposal scenarios are several magnitudes less than the threshold. Because the totals of the acute HI estimates were less than the threshold of one for all three scenarios, categorizing the chemicals by target organ was unnecessary.

The scenarios do not have the same list of HAPs. As shown in the table, acute hazards for the landfills are primarily attributable to inhalation exposure to benzene, while the acute hazard for Covanta is primarily attributable to inhalation exposure to hydrogen chloride and arsenic. Acute hazards at the landfills are comparable while the acute hazard at Covanta is approximately an order of magnitude lower, although all are less than one indicating low potential for acute adverse health effects from inhalation exposure.

Table 3-11. Range of Peak Operations-Related Incremental Acute (1-Hour) Non-Cancer Hazard Indices from Inhalation Exposure for the Disposal Scenarios

Hazardous Air Pollutant	Hazard Threshold	Maximum Acute Hazard Indices for each HAP at Any Location[1]		
		Covanta Fairfax	King George Landfill	King & Queen Landfill
Benzene	-	-	0.004	0.003
Carbon disulfide	-	-	5.0E-06	4.0E-06
Carbon tetrachloride	-	-	2.0E-07	2.0E-07
Carbonyl sulfide	-	-	0.00003	0.00003
Chloroform	-	-	0.00002	0.00001
Methyl ethyl ketone	-	-	0.00003	0.00002
Toluene	-	-	0.0005	0.0004
Tetrachloroethylene	-	-	0.00002	0.00002
Vinyl chloride	-	-	2.0E-06	1.0E-06
Xylene (total)	-	-	0.00004	0.00003
Hydrogen chloride	-	0.0002	0.00001	0.00002
Hydrogen fluoride	-	0.00003	-	-
Arsenic	-	0.0001	-	-
Mercury	-	0.00005	0.00007	0.00006
Total	1	0.0003	0.005	0.004

Source: **Appendix D**, Attachment 2.
Notes:
[1] Residential receptor assumed at all grid points
- = no value

3.5.4 Permissible Exposures Limits Comparison

Commercial worker exposure to HAPs from the disposal scenarios were evaluated by comparing modeled maximum eight-hour concentrations for each HAP, against the corresponding eight-hour PEL-TWAs. PELs are established by the Occupational Safety and Health Administration (OSHA) to protect workers from hazardous exposure. Estimated -hour air concentrations and PELTWAs for HAPs of concern for operation of the disposal scenarios are presented in **Table** 3-**12**. The eight- -hour air concentrations ranged from a few to several orders of magnitude below PELs for all HAPs. This result indicates that air concentrations from operational emissions of the disposal scenarios would not be expected to exceed PEL standards, indicating low potential for health impacts to workers.

Table 3-12. Comparison of Permissible Exposures Limits to Maximum 8-Hour Concentrations for the Disposal Scenarios

Hazardous Air Pollutant (HAP)	PEL[1] (µg/m³)	Maximum 8-Hour HAP Concentration (µg/m³)		
		Covanta Fairfax	King George Landfill	King & Queen Landfill
Acrylonitrile	70,000	NV	0.10	0.10
Benzene	3,190	NV	0.06	0.06
Carbon disulfide	3,000	NV	0.02	0.02

Hazardous Air Pollutant (HAP)	PEL[1] ($\mu g/m^3$)	Maximum 8-Hour HAP Concentration ($\mu g/m^3$)		
		Covanta Fairfax	King George Landfill	King & Queen Landfill
Carbon tetrachloride	12,600	NV	0.0002	0.0002
Carbonyl sulfide	10[2]	NV	0.01	0.01
Chlorobenzene	46,000	NV	0.01	0.01
Chloroethane (ethyl chloride)	264,000	NV	0.03	0.03
Chloroform	9,780	NV	0.001	0.001
Chloromethane (methyl chloride)	105,000	NV	0.02	0.02
Dichlorobenzene	60,000	NV	0.01	0.01
1,1-Dichloroethane (ethylidene dichloride)	400,000	NV	0.09	0.09
1,1-Dichloroethene (vinylidene chloride)	4,000	NV	0.007	0.007
1,2-Dichloroethane (ethylene dichloride)	4,000	NV	0.02	0.02
1,2-Dichloropropane (propylene dichloride)	350,000	NV	0.008	0.008
Dichloromethane (methylene chloride)	87,000	NV	0.4	0.5
Ethylene dibromide	1,000	NV	0.00007	0.00007
Ethylbenzene	22,000	NV	0.2	0.2
Hexane, n-	180,000	NV	0.2	0.2
Methyl ethyl ketone	590,000	NV	0.2	0.2
Methyl isobutyl ketone	205,000	NV	0.07	0.07
Toluene	37,000	NV	1.4	1.4
1,1,1-Trichloroethane (methyl chloroform)	1,900,000	NV	0.02	0.02
1,1,2,2-Tetrachloroethane	7000	NV	0.07	0.07
Perchloroethylene (tetrachloroethylene)	170,000	NV	0.2	0.2
Trichloroethylene (trichloroethene)	135,000	NV	0.1	0.1
Vinyl chloride	2,556	NV	0.2	0.2
Xylene (total)	435,000	NV	0.5	0.5
Hydrogen chloride	450	0.1	0.02	0.04
Hydrogen fluoride	330	2.0E-03	NV	NV
Dioxins	NA	5.0E-08	1.2E-09	2.7E-09
Arsenic	10	6.0E-06	NV	NV
Antimony	500	0.00005	NV	NV
Beryllium	0.2	5.0E-07	NV	NV
Cadmium	5	6.0E-06	NV	NV
Lead	50	0.00007	NV	NV

Hazardous Air Pollutant (HAP)	PEL[1] (µg/m^3)	Maximum 8-Hour HAP Concentration (µg/m^3)		
		Covanta Fairfax	King George Landfill	King & Queen Landfill
Mercury	25	0.00001	0.00002	0.00002

Source: Appendix D.

Notes:

[1] CalOSHA PEL are permissible exposure levels for chemical contaminants for workers as detailed in the California Code of Regulations, Title 8, Section 5155, Airborne Contaminants. Although the project is located in Washington D.C., Federal Occupational Safety and Health Administration (OSHA) does not update its PEL values and recommends the use of other sources of PELs, such as CalOSHA, National Institute for Occupational Safety & Health and American Conference of Governmental Industrial Hygienists. CalOSHA is recognized as having one of the most comprehensive lists of updated PELs and was used as the source of PELs for this analysis.

[2] California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) 8hr REL (value obtained from OEHHA Online Toxicity Criteria database, accessed October 2021).

Key:
NV = no value

3.6 Ecological Screening Assessment

Criteria pollutant dispersion modeling results were compared to the USEPA Secondary National Ambient Air Quality Standards which are standards designed to protect the environment from adverse effects, including effects on soil, water, crops, animals and wildlife, and vegetation. *See* USEPA 2021f. Comparison to this standard is used as a screening assessment to determine areas of potential impacts on ecology.

Table 3-**13** through **Table** 3-**15** compare the sum of modeled criteria pollutant concentrations and representative background concentrations to the Secondary National Ambient Air Quality Standards for the three scenarios. Background and facility values are rounded to the nearest whole number for comparison to the National Ambient Air Quality Standards values.

Table 3-13. AERMOD-Predicted Concentrations and Comparison to Secondary National Ambient Air Quality Standards – Covanta Fairfax

Pollutant	Averaging Time	Background (µg/m^3)[2]	Covanta Fairfax (µg/m^3)	Covanta Fairfax + Background (µg/m^3)	Secondary National Ambient Air Quality Standards (µg/m^3)[1]	Exceed Standard?
NO$_2$	Annual	30.0	0.1	30	100	No
PM10	24-hour	22.3	0.027	22	150	No
PM2.5	24-hour	21.3	0.018	21	35	No
	Annual	9.0	0,00081	9	12	No
SO$_2$	1-hour	11.3	1.0	12	196	No
Pb	3-month rolling average	0.004	0.00001	0.004	0.15	No

Notes:

[1] Background data are from USEPA's Monitor Values Reports (https://www.epa.gov/outdoor-air-quality-data/monitor-values-report) for the years 2017 through 2019 (2020 data were not used since it was assumed not representative of a normal year due to COVID-19) from monitoring stations closest to the modeled sites.

[2] USEPA National Ambient Air Quality Standards Table (https://www.epa.gov/criteria-air-pollutants/naaqs-table).

Table 3-14. AERMOD-Predicted Concentrations and Comparison to Secondary National Ambient Air Quality Standards – King George Landfill

Pollutant	Averaging Time	Background (µg/m^3)[2]	King George Landfill (µg/m^3)	King George Landfill + Background (µg/m^3)	Secondary National Ambient Air Quality Standards (µg/m^3)[1]	Exceed Standard?
NO_2	Annual	30.0	0.1	30	100	No
PM10	24-hour	19.3	0.4	20	150	No
PM2.5	24-hour	21.3	0.3	22	35	No
	Annual	9.0	0.018	9	12	No
SO_2	1-hour	11.3	0.5	12	196	No

Notes:

[1] Background data are from USEPA's Monitor Values Reports (https://www.epa.gov/outdoor-air-quality-data/monitor-values-report) for the years 2017 through 2019 (2020 data were not used since it was assumed not representative of a normal year due to COVID-19) from monitoring stations closest to the modeled sites.

[2] USEPA National Ambient Air Quality Standards Table (https://www.epa.gov/criteria-air-pollutants/naaqs-table).

Table 3-15. AERMOD-Predicted Concentrations and Comparison to Secondary National Ambient Air Quality Standards – King & Queen Landfill

Pollutant	Averaging Time	Background (µg/m^3)[1]	King & Queen Landfill (µg/m^3)	King & Queen Landfill + Background (µg/m^3)	Secondary National Ambient Air Quality Standards (µg/m^3)[12]	Exceed Standard?
NO_2	Annual	14.5	0.6	15	100	No
PM10	24-hour	26.7	0.2	27	150	No
PM2.5	24-hour	15.7	0.1	16	35	No
	Annual	7.2	0.015	7	12	No
SO_2	1-hour	10.5	0.5	11	196	No

Notes:

[1] Background data are from USEPA's Monitor Values Reports (https://www.epa.gov/outdoor-air-quality-data/monitor-values-report) for the years 2017 through 2019 (2020 data were not used since it was assumed not representative of a normal year due to COVID-19) from monitoring stations closest to the modeled sites.

[2] USEPA National Ambient Air Quality Standards Table (https://www.epa.gov/criteria-air-pollutants/naaqs-table).

As shown in **Table** 3-**13** through **Table** 3-**15**, none of the scenarios exceed the Secondary National Ambient Air Quality Standards indicating minimal to no potential adverse impacts on soil, water, crops, animals and wildlife, and vegetation based on criteria emissions from the modeled facilities.

3.7 Power Generation

Table 3-**16** presents the 20-year power generation estimates for the three scenarios. A 20-year timeline was used to account for the delayed release of landfill gas as it provides a more accurate depiction of power generation at landfills over time. The results are based on 100,000 tons of waste disposed at each facility over a 20-year period (2022 through 2041). Refer to **Appendix B** for the power generation calculations.

Table 3-16. Annual Power Generation

Study Period Year	Year	Covanta Fairfax (MWh)	King George Landfill (MWh)	King & Queen Landfill (MWh)
1	2022	58,780	688	1,126
2	2023	58,780	1,336	2,186
3	2024	58,780	1,946	3,185
4	2025	58,780	2,521	4,125
5	2026	58,780	3,062	5,011
6	2027	58,780	3,572	5,845
7	2028	58,780	4,052	6,631
8	2029	58,780	4,504	7,371
9	2030	58,780	4,930	8,068
10	2031	58,780	5,331	8,724
11	2032	58,780	5,709	9,342
12	2033	58,780	6,064	9,924
13	2034	58,780	6,399	10,472
14	2035	58,780	6,715	10,988
15	2036	58,780	7,012	11,474
16	2037	58,780	7,292	11,932
17	2038	58,780	7,555	12,363
18	2039	58,780	7,803	12,769
19	2040	58,780	8,037	13,152
20	2041	58,780	8,257	13,512
	Total MWh:	**1,175,600**	**102,793**	**168,208**

Key:
MWh = megawatt hour

3.8 Hauling and Disposal Cost Estimates

Table 3-**17** shows the current contract costs to dispose of waste at Covanta Fairfax.

Table 3-17. Covanta Fairfax Hauling and Disposal Costs

Parameters	Covanta Fairfax	Source
Annual vehicle miles traveled	247,943	Routes provided by DC DPW
Annual waste tonnage	100,000	Study parameter
Covanta Fairfax tipping fee	$36.76/ton	DC contract extension with Covanta Fairfax, 02/21/21 to 12/31/21
Annual disposal cost	$3,676,000	
Hauling rate to Covanta Fairfax	$16.42/ton	DC contract with Lucky Dog, price through 11/01/21
Annual hauling cost	$1,641,000	
Total annual cost	$5,317,000	

Table 3-18 shows the hauling costs for each scenario based on the current hauling rate per VMT to Covanta Fairfax with adjustment for mileage difference. The tons per truckload were assumed to be the same for all scenarios for this cost analysis.

Table 3-18. Hauling Costs

Parameters	Covanta Fairfax	King George Landfill	King & Queen Landfill
Round trip VMT	247,943	649,071	1,447,946
Cost per VMT	$6.62	$6.62	$6.62
Annual hauling cost	$1,641,000	$4,296,900	$9,585,400

Due to mileage differences the landfill scenarios have much higher hauling costs. **Table 3-19** provides the combined hauling and disposal costs assuming the same cost per VMT and disposal facility tipping fee for all three scenarios. For the King George Landfill to have a comparable cost to Covanta Fairfax the landfill tipping fee would need to be $10/ton. Since the King & Queen Landfill hauling cost is more than the combined hauling and disposal cost for Covanta Fairfax there is no landfill tipping fee that would result in a comparable cost.

Table 3-19. Hauling and Disposal Costs

Parameters	Covanta Fairfax	King George Landfill	King & Queen Landfill
Annual Hauling Cost	$1,641,000	$4,296,900	$9,585,400
Annual Disposal Cost	$3,676,000	$3,676,000	$3,676,000
Annual Combined Cost	**$5,317,000**	**$7,972,900**	**$13,261,400**
Combined Cost Per Ton	**$53.17**	**$79.73**	**$132.61**

3.9 Waste Hauling Collisions

Collisions were estimated from fatality, injury, and property damage rates per-100 million VMT. Such collision rates were interpolated from the FMCSA and NHTSA. *See* FMCSA 2018; NHTSA 2021. Fatality, injury, and property-damage-only (PDO) rates per 100 million VMT were culled from the FMCSA for national combination tractor-trailer trucks. Fatality rates were adjusted downward to reflect the state of Virginia's lower average rate, and injuries were proportioned into incapacitating, non--incapacitating, and other injuries, using data from the NHTSA.

Based on VMT and applied accident rates, total incidences would range between 0.398 and 2.324 collisions, resulting mostly in property damage only, with few injuries and almost no fatalities. The complete results are tabulated in **Table 3-20**.

Table 3-20. Federal Motor Carrier Safety Administration Collision Rates

Origin	Destinations		
	Covanta Fairfax	King George	King & Queen
Transfer Station MSW (Tons/Year)			
Fort Totten	53,400	53,400	53,400
Benning Road	46,600	46,600	46,600
Total	**100,000**	**100,000**	**100,000**
Transfer MSW (Tons/Trip)			
Both origins	21.9	21.9	21.9
One-Way Vehicle Trips			
Fort Totten	2,438	2,438	2,438
Benning Road	2,127	2,127	2,127
Total	**4,565**	**4,565**	**4,565**
Two-Way Vehicle Trips			
Fort Totten	4,876	4,876	4,876
Benning Road	4,254	4,254	4,254
Total	**9,130**	**9,130**	**9,130**
One-Way Distance (miles)			
Fort Totten	25.2	70.3	157.8
Benning Road	29.4	72.0	159.5
Vehicle Miles Traveled			
Fort Totten	122,875	342,783	769,433
Benning Road	125,068	306,288	678,513
Total	**247,943**	**649,071**	**1,447,946**
Accidents/100 million VMT			
K – Killed	1.6	1.6	1.6
A - Incapacitating	3.0	3.0	3.0
B - Non-incapacitating	12.4	12.4	12.4
C - Possible/other	25.9	25.9	25.9
O - Property damage	117.6	117.6	117.6
Annual Collisions			
K – Killed	0.004	0.010	0.023
A - Incapacitating	0.007	0.019	0.043
B - Non-incapacitating	0.031	0.080	0.180
C - Possible/other	0.064	0.168	0.375
O - Property damage	0.292	0.763	1.703
Total	**0.398**	**1.040**	**2.324**

3.10 Environmental Justice and Social Equity

The social and environmental justice (EJ) impacts of the different waste disposal options were evaluated using the social cost of emissions and sociodemographic data. The following subsections discuss the results of this analysis.

3.10.1 Environmental Justice and Social Equity

A qualitative assessment of EJ and social equity was performed per the methodology detailed in Section 2.10 and **Appendix A.** Figures were prepared showing the location of each of the disposal facilities and hauling routes alongside United States Census American Community Survey (ACS) 2014–2018 five-year estimate demographics data, as well as environmental conditions including nearby polluting facilities and flood zones. These figures are presented in **Appendix C**.

3.10.1.1 Socioeconomic Demographics Data

3.10.1.1.1 Environmental Justice Communities

EJ communities were identified based on two criteria, low-income and minority populations. The EJ community classifications are shown on Figure C-1. These communities were identified at the Census block group level relative to their respective county. Generally, the portion of the hauling route with the greatest concentration of EJ communities is the portion from the solid waste transfer stations to Covanta Fairfax. The portion of the hauling route between Covanta Fairfax and the King George Landfill has the next highest concentration of EJ communities. The portion of the hauling route leading to the King & Queen Landfill has the lowest concentration of EJ communities, though a portion of the route between Fredericksburg and Richmond consistently contains minority populations. Because the hauling routes are continuous (the hauling route to the southernmost facility is an extension of the routes to the northern facilities), if the hauling route is longer, then more EJ communities will be affected by waste hauling activities.

In contrast, the location of EJ communities relative to the disposal facilities did show some noticeable trends. Since Census block groups are defined in part by population density, and Covanta Fairfax is in an area with higher population density than either of the landfills, the analysis included more geographically smaller Census block groups in the vicinity of Covanta. Several of the Census block groups in the immediate vicinity to Covanta Fairfax (either the one in which the facility is located, or those immediately adjacent) are classified as either low-income, minority, or both. Only the Census block group in which the King George Landfill is located is classified as both low-income and minority, and only one of the surrounding Census block groups meets one of the evaluated EJ criteria. The King & Queen Landfill is in a Census block group that does not qualify as an EJ population, and none of the nearby Census block groups meet both EJ criteria, with one nearby Census block group classified as low-income, and one adjacent Census block group classified as minority.

3.10.1.1.2 Median Household Income

As shown in Figure C-2, the portions of the hauling route with the lowest median household income (MHI) are between Covanta Fairfax and the King George Landfill and between the King George Landfill and the King & Queen Landfill, specifically the portion of the route between Fredericksburg and Richmond. However, overall, the MHI along the hauling routes is lower than the MHI in the areas around each of the disposal facilities. The MHI of the Census block groups in which both Covanta Fairfax and the King George Landfill are located is between $103,125 and $146,250, whereas the MHI of the Census block group in which the King & Queen Landfill is located is between $38,409 and $103,125. The area around Covanta Fairfax generally has higher

MHI than the area around the other two facilities, and the area around the King George Landfill generally has higher MHI than the area around the King & Queen Landfill.

3.10.1.1.3 Percentage of the Population Belonging to One or More Minority Groups

The portions of the hauling route with the greatest percentage of the population that belongs to one or more minority groups (herein referred to as "percent minority") is the portion from the solid waste transfer stations to Covanta Fairfax. *See* Figure C-3 for more information. Additionally, there are areas with a higher percent minority immediately south of Covanta Fairfax. The area around Covanta Fairfax generally has a higher percent minority population, as compared to either of the landfills. Between the two landfills, there is no overall trend for this demographic metric in the areas surrounding the landfills. With respect to the Census block group in which each facility is located, Covanta Fairfax has the highest percent minority population with between 55.1% and 78.5% of the population belonging to one or more minority group. The King George Landfill is next highest with between 19% and 35.9% of the population belonging to one or more minority group. The King & Queen Landfill is the lowest with less than 19% of the population belonging to one or more minority group.

3.10.1.1.4 Percentage of Housing Units that are Owner-Occupied

As shown in Figure C-4, there are no evident trends in owner-occupied housing rates between the three facilities, or in any distinct portion of the hauling routes. The areas with the lowest owner--occupied housing rates are the portions of the hauling routes from the solid waste transfer stations to Covanta Fairfax, but these portions of the routes are common to all three facilities and therefore not evaluated in this study. The Census block groups in which both the landfills are located have over 78% owner-occupied housing, while Covanta Fairfax has slightly less with between 58.3% and 78.2% owner-occupied housing.

3.10.1.1.5 Percentage of Households Living in Poverty

The Census block groups with the highest percentage of households living in poverty are located along the hauling routes, as compared to the area around the disposal facilities, although there is no portion of the hauling routes that is distinct between the different disposal facilities that has a greater concentration over another. *See* Figure C-5 for more information. The portion of the hauling routes that have the highest amount of Census block groups with high rates of households living in poverty is the portion between the Benning Road transfer station and the Potomac River, which is used for all three disposal facilities. Between the disposal facilities, generally the area around Covanta Fairfax has lower rates of households living in poverty as compared to the King George Landfill and the King & Queen Landfill. For both Covanta Fairfax and the King George Landfill, the Census block groups closest to the facility have higher rates of households living in poverty than the areas further away. With respect to the Census block groups in which each facility is located, the King & Queen Landfill is the lowest with less than 5%, while Covanta Fairfax and the King George Landfill both have between 5% and 11.7%.

3.10.1.1.6 Percentage of Non-Institutionalized Population without Health Insurance

As shown on Figure C-6, the portion of the study area with the highest rates of non-institutionalized population without health insurance is the segment of the hauling routes from the solid waste transfer stations to Covanta Fairfax. Specifically, this is the case in the segment that is Virginia, as compared to the segment within the District, which has lower rates. Additionally, the area just south of the Covanta Fairfax facility has higher rates of population without health insurance. With respect to the Census block groups in which each of the facilities are located, the King George Landfill has the highest uninsured population with 9.6% to 16.7% and the King & Queen Landfill has the lowest with less than 4.1%.

3.10.1.1.7 Percentage of Households Receiving Public Assistance Income or Food Stamps in the Past 12 Months

Similar to owner-occupied housing, the areas with the highest percentage of households receiving public assistance are along the hauling route between the solid waste transfer stations and Covanta Fairfax, especially the portion of the route between the Benning Road transfer station and the Potomac River. *See* Figure C-7 for more information. Within the rest of the study area, the percentage of households receiving public assistance generally increases along the hauling routes, with the portion of the route with the lowest percentage between Covanta Fairfax and the King George Landfill.

With respect to the Census block groups in which the facilities are located, the King George Landfill has the highest rate of households receiving public assistance at 11.9% to 22.7%. Covanta Fairfax and the King & Queen Landfill both have lower rates at 4.3% to 11.8%. Of the three facilities, the Census block groups surrounding the King & Queen Landfill has the highest rates of households receiving public assistance, whereas the areas around Covanta Fairfax and the King George Landfill have slightly lower rates of households receiving public assistance. Public assistance rates in all of the adjacent Census block groups are greater than 4.3%,

3.10.1.1.8 Socioeconomic Demographics Data Findings

The trends in socioeconomic demographic indicators vary between the different disposal facilities and the respective portions of the hauling routes dedicated to each disposal facility. **Table** 3**21** shows the relative EJ and social equity impact rankings for each of the disposal facilities and the respective hauling routes, quantified on a scale of one to three, with one reflecting the lowest rates or concentrations of vulnerable communities and 3 reflecting the highest rates or concentrations of vulnerable communities. **Table** 3**21** displays the rankings for the socioeconomic demographic indicators discussed in the subsections above, as well as the environmental conditions discussed in Section 3.10.1.2. As shown in **Table** 3**21**, King George Landfill had the highest combined score (hauling route and area around the disposal facility) at 34, while King & Queen Landfill had the next highest combined score at 31 and Covanta Fairfax the lowest at 29.

Hauling Routes

Socioeconomic demographic indicators representative of social and environmental equity are more prominent along the hauling routes from the solid waste transfer stations to Covanta Fairfax, and just south of Covanta Fairfax. These hauling route areas generally include a larger concentration of EJ communities, both low income and minority, as well as higher rates of households receiving public assistance income and households living in poverty. However, since the King George Landfill and the King & Queen Landfill are located further south of Covanta Fairfax, additional EJ communities are affected by the elongated hauling routes. Thus, waste hauling to Covanta Fairfax has an overall less impact on EJ communities based on the use of the shortest hauling route.

Relative rankings for each of the hauling routes for the socioeconomic demographic and environmental conditions indicators (discussed in Section 3.10.1.2 below) are shown in **Table** 3**21**. Because the hauling routes for each of the three disposal facilities are continuous, the King George Landfill and King & Queen Landfill hauling route rankings were at a minimum the rankings identified for the Covanta Fairfax hauling route. Similarly, the King & Queen Landfill hauling route rankings were at a minimum the rankings identified for King George Landfill. This approach reflects the conclusion above that additional vulnerable or EJ communities will be affected by longer hauling routes. Therefore, the King & Queen Landfill hauling route had the highest relative EJ and social equity impact ranking at 18, King George Landfill had the next highest ranking at 16, and Covanta Fairfax had the lowest at 14.

Disposal Facilities

The area around Covanta Fairfax has a higher concentration of EJ communities as compared to the two other disposal facilities. This indicates that the area around Covanta Fairfax generally has a higher concentration of low-income and/or minority communities relative to the rest of Fairfax County; and King George Landfill and King & Queen Landfill both have a lower concentration of EJ communities relative to their respective counties. Because EJ communities are defined relative to the respective county, and the sociodemographic indicators vary widely between each county, additional sociodemographic indicators were also evaluated for each disposal facility to support a comparative analysis of social equity between the three disposal facilities. Regarding these other socioeconomic demographic indicators, the area around King George Landfill had the highest rates of households living in poverty and highest rates of individuals without health insurance, and the area around King & Queen Landfill had the highest rates of households with lower MHI and households receiving public assistance income. The area around Covanta Fairfax had the highest rates of population belonging to one or more minority groups.

Table 321 shows the relative rankings for each of the facilities from one to three (least impact to greatest impact). The area around King George Landfill had the highest total relative EJ and social equity impact ranking at 18, Covanta Fairfax had the next highest at 15, and King & Queen Landfill had the lowest at 13.

Table 321. Environmental Justice and Social Equity Relative Impact Rankings

	Covanta Fairfax		King George Landfill		King & Queen Landfill	
Relative Ranking of:	**Facility**	**Hauling Route**	**Facility**	**Hauling Route**	**Facility**	**Hauling Route**
EJ communities (low income and minority)	3	2	2	3	1	3
Lower median household income	1	1	2	1	3	1
Minority population	3	3	2	3	1	3
Households living in poverty	1	2	3	2	2	2
Population without health insurance	2	3	3	3	1	3
Need for public assistance	1	2	2	2	3	3
Proximity to facilities with environmental conditions	3	-	3	-	1	-
1% annual chance flood hazard risk	1	1	1	2	1	3
Subtotal	**15**	**14**	**18**	**16**	**13**	**18**
Total (Facility and hauling route combined)	**29**		**34**		**31**	

3.10.1.2 Environmental Conditions

Environmental conditions, including the presence of other facilities that may be emitting environmental emissions and a proximity to flood zones, were evaluated alongside the demographics discussed above. Figures showing the results of this analysis are presented in **Appendix C**. Observations pertaining to each of the disposal facilities are presented in the following subsections. Two data sets were reviewed, but ultimately not included in the analysis. No sites were identified within the study areas that were registered with the Comprehensive Environmental Response and Liability Act (CERCLA Superfund) database. The National Emissions Inventory was queried for applicable sites, but no sites were identified that were not already represented in the ICIS-AIR data set.

3.10.1.3 Covanta Fairfax

Flood risk areas are shown on Figure C-8 through Figure C-14. Generally, areas with a 1% annual chance flood hazard risk (100-year flood area) are either located in the same Census block group as Covanta Fairfax, or Census block groups immediately adjacent. Many of these Census block groups also meet at least one EJ criteria, though the Census block group with the largest flood-risk area is to the north of the facility and is not identified as an EJ population. The facility itself is not within the 1% flood hazard risk area. The portion of the hauling route between the solid waste transfer stations and Covanta Fairfax contains few intersections with flood risk areas. Figure C-8 shows substantial flood risk areas in the vicinity of the route, but these areas are simply the current location of major water bodies, namely the Potomac River and the Anacostia River.

As shown on Figure C-15 through Figure C-21, Covanta Fairfax has the highest number of nearby facilities identified with environmental conditions, as compared to the other disposal facilities. Facilities identified in the vicinity of Covanta include:

- 7 facilities registered under the Toxic Release Inventory (TRI) database
- 75 facilities registered in the Resource Conservation and Recovery Act (RCRA) database (namely hazardous waste facilities)
    - These facilities may include any facility that is registered as a hazardous waste generator, transporter, or disposer; or a facility subject to a RCRA corrective action
- 35 facilities registered in the ICIS-AIR database

Note that one facility may be registered in more than one of the above databases based on the nature of their operations. Many of the facilities are located to the south of Covanta Fairfax, rather than in the immediate vicinity. Almost all of the identified facilities are located in an area that meets at least one of the two EJ criteria evaluated in this study, though relatively few sites are located in areas that meet both of the EJ criteria.

NATA 2014 total cancer risk and respiratory hazard index levels for the study area are shown on Figure C-22 and Figure C-23. Relative to the two other disposal facilities, the area around Covanta Fairfax had similar levels of total cancer risk from air toxics exposure (between 0.1 and 34.5 in 1 million). In contrast, the area around Covanta Fairfax had higher non-cancer respiratory hazard index levels relative to the two other disposal facilities, with a hazard index generally ranging from 0.51 to 0.59. The portion of the hauling route with the highest NATA total cancer risk and respiratory hazard index levels was the portion from the solid waste transfer stations to Covanta Fairfax.

3.10.1.4 King George Landfill

Flood risk areas are shown in Figure C-8 through Figure C-14. The area around the King George Landfill contains the several areas with flood risk, though most of those areas do not overlap with EJ populations. The facility itself is not within the 1% flood hazard risk area. The portion of the hauling route between Covanta Fairfax and King George Landfill contains several small intersections with flood risk areas.

As shown on Figure C-15 through Figure C-21, the King George Landfill has the next highest number of nearby facilities as compared to the other disposal facilities. Facilities identified in the vicinity of the King George Landfill include the following:

- 4 facilities registered under the TRI database
- 9 facilities registered in the RCRA database (namely hazardous waste facilities)
    - These facilities may include any facility that is registered as a hazardous waste generator, transporter, or disposer; or a facility subject to a RCRA corrective action.
- 13 facilities registered in the ICIS-AIR database

Most of these facilities are located in close proximity to and in the same Census block group as the King George Landfill, which is classified as both low-income and minority.

NATA 2014 total cancer risk and respiratory hazard index levels for the study area are shown in Figure C-22 and Figure C-23. Relative to the two other disposal facilities, the area around King George Landfill had similar levels of total cancer risk from air toxics exposure (between 0.1 and 34.5 in 1 million). The area around King George Landfill generally had respiratory hazard index levels ranging less than 0.41, which was lower than Covanta Fairfax and similar to King & Queen Landfill. The portion of the hauling route between Covanta Fairfax and King George Landfill had similar total cancer risk levels to the areas around the disposal facilities, though it generally had higher respiratory hazard index levels as compared to the area around the King George Landfill (0.51 to 0.59).

3.10.1.5 King & Queen Landfill

Flood risk areas are shown in Figure C-8 through Figure C-14. There were no discernable trends regarding the location of flood-risk areas relative to EJ populations in the vicinity of the King & Queen Landfill, as all of the evaluated Census block groups appear to be similarly impacted by flood risk. The facility itself is not within the 1% flood hazard risk area. The portion of the hauling route between the King George Landfill and the King & Queen Landfill contains several small intersections with flood risk areas, as well as continuous overlap with the larger flood risk area south of Richmond.

As shown in Figure C-15 through Figure C-21, the King & Queen Landfill has the least number of nearby facilities as compared to the other disposal facilities. Facilities identified in the vicinity of the King & Queen Landfill include:

- 1 facility registered under the TRI database
- 2 facilities registered in the RCRA database (herein referred to as hazardous waste facilities)
    - These facilities may include any facility that is registered as a hazardous waste generator, transporter, or disposer; or a facility subject to a RCRA corrective action
- 5 facilities registered in the ICIS-AIR database

The area around the King & Queen Landfill has more ICIS-AIR facilities than any other environmental condition indicator evaluated. The majority of the facilities are located to the northwest of the King & Queen Landfill in an adjacent Census block group that is classified as minority.

NATA 2014 total cancer risk and respiratory hazard index levels for the study area are shown in Figure C-22 and Figure C-23. Relative to the two other disposal facilities, the area around King & Queen Landfill had similar levels of total cancer risk from air toxics exposure (between 0.1 and 34.5 in 1 million). The area around King & Queen Landfill generally had respiratory hazard index levels ranging less than 0.41, which was lower than Covanta Fairfax and similar to King George Landfill. The portion of the hauling route between King George Landfill and King & Queen Landfill had similar total cancer risk levels to the areas around the disposal facilities, though it generally had higher respiratory hazard index levels as compared to the area around the King & Queen Landfill (0.51 to 0.59).

3.10.1.6 Environmental Conditions Data Findings

Covanta Fairfax has substantially greater amounts of nearby facilities with environmental conditions relative to the two landfills. However, proximity of these facilities to an evaluated disposal facility is most prominent at the King George Landfill. The Census block group associated with the King George Landfill is classified as both low-income and minority and contains several of the nearby facilities, in contrast with Covanta Fairfax and the King & Queen Landfill. Therefore, the two facilities with the greatest potential for contribution to existing EJ considerations is Covanta Fairfax and the King George Landfill.

None of the disposal facilities evaluated are within a designated 1% annual chance flood hazard risk area. The area surrounding Covanta Fairfax had the most EJ-classified Census block groups that also contained areas with flood risk. The portion of the hauling route from the King George Landfill to the King & Queen Landfill had the highest overlap with flood risk areas.

Relative rankings for each of the disposal facilities and the respective hauling routes for environmental conditions are shown in **Table** 3**21.** Refer to Section 3.10.1.1.8 for a comparative analysis of the subtotal and total rankings for each of the disposal facilities.

Section 4

Conclusions

The purpose of this study was to compare environmental, social and economic impacts of landfilling to waste-to-energy to assist the District in making informed decisions regarding solid waste disposal. Eight categories were assessed to identify sustainability impacts:

- USEPA Criteria Air Pollutants and Hazardous Air Pollutants
- Greenhouse Gases
- Social Costs and Environmental Justice
- Human Health Risk Assessment
- Ecological Screening
- Power Generation
- Vehicle Collisions
- Hauling and Disposal Costs

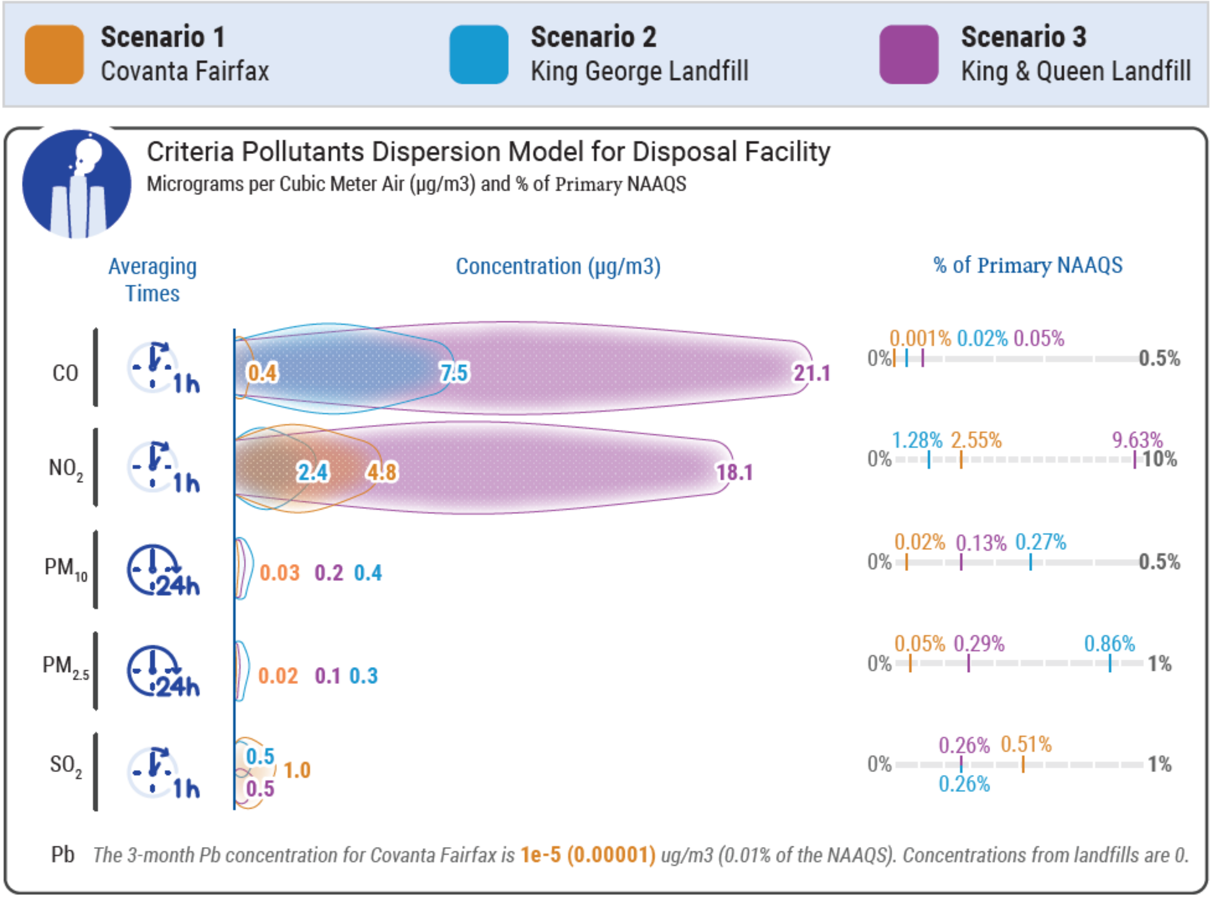
The King George Landfill and the King & Queen Landfill were found to impart higher sustainability impacts than Covanta Fairfax due to higher facility GHG emissions and social costs attributed to those GHG emissions. Health risk modeling and ecological screening indicate localized air emissions from the three facilities pose minimal to no impact to ambient air quality and the environment. Collisions resulting from waste hauling were also found to impart minimal impact for all scenarios. Analysis of waste hauling and disposal costs, based on the information available at this time, determined that Covanta Fairfax is the lowest cost scenario due to a shorter hauling distance. And, while it is possible that landfilling could be cost competitive if the three scenarios were subject to a price bid, the social cost borne by society due to waste disposal at either the King George Landfill or the King & Queen Landfill would outweigh the potential cost savings.

4.1 Conclusions by Criterion

Conclusions related to each of the eight categories are provided below with comparative graphics to visualize the impacts.

4.1.1 Criteria Air Pollutants

As shown in **Figure 4-1**, criteria air pollutant (CAPs) results do not exceed the National Ambient Air Quality Standards for any of the three scenarios. In fact, except for NO_2 which is less than 10% of the standard, all the facility CAPs are less than 1% of the standards. CAPs from transfer trucks on the haul routes also do not exceed the National Ambient Air Quality Standards.



The 3-month Pb concentration for Covanta Fairfax is **1e-5 (0.00001)** *ug/m3 (0.01% of the NAAQS). Concentrations from landfills are 0.*

Figure 4-1. Criteria Pollutants Dispersion Model Results and Comparison with Primary National Ambient Air Quality Standards

4.1.2 Greenhouse Gases

As shown in **Table** 4-1 the two landfills have 1.8 to 1.6 times more GHG emissions than Covanta Fairfax. The longer haul distances to the two landfills results in hauling GHG emissions that are 2 times (King George Landfill) and 6 times (King & Queen Landfill) greater than for Covanta Fairfax. Because of the higher percentage of landfill gas directed to engine generators rather than flared, the King & Queen Landfill (90% captured gas directed to generators), has slightly lower GHG emissions than the King George Landfill (55% captured gas directed to generators) due to GHG offsets for energy production.

Table 4-1. Greenhouse Gas Emissions using 20-year Global Warming Potentials

Scenario	GHG Emissions Over 20 Years		
	Disposal Facilities	Hauling	Total
	MTCO₂e	MTCO₂e	MTCO₂e
Covanta Fairfax	695,403	8,624	704,027
King George Landfill	1,231,140	20,618	1,251,758
King & Queen Landfill	1,104,444	46,998	1,151,442

4.1.3 Social Cost of Emissions

The King George Landfill's total social cost is slightly higher than the King & Queen Landfill, and substantially higher than Covanta Fairfax. Additional social cost findings were:

- Total social cost is driven by the social cost of GHGs, which were highest for the King George Landfill.
- Covanta Fairfax has the highest social cost of CAPs and HAPs at $5.3 million, while the landfills were than $1 million.
- The King & Queen Landfill has the highest social cost of hauling emissions due to it having the longest hauling route.

Figure 4-2 illustrates the social costs of GHGs, CAPs, and HAPs and hauling emissions side-by-side. The social cost over 20 years of GHGs emissions are six to 100 times greater than the social costs of CAPs and HAPs or hauling emissions.

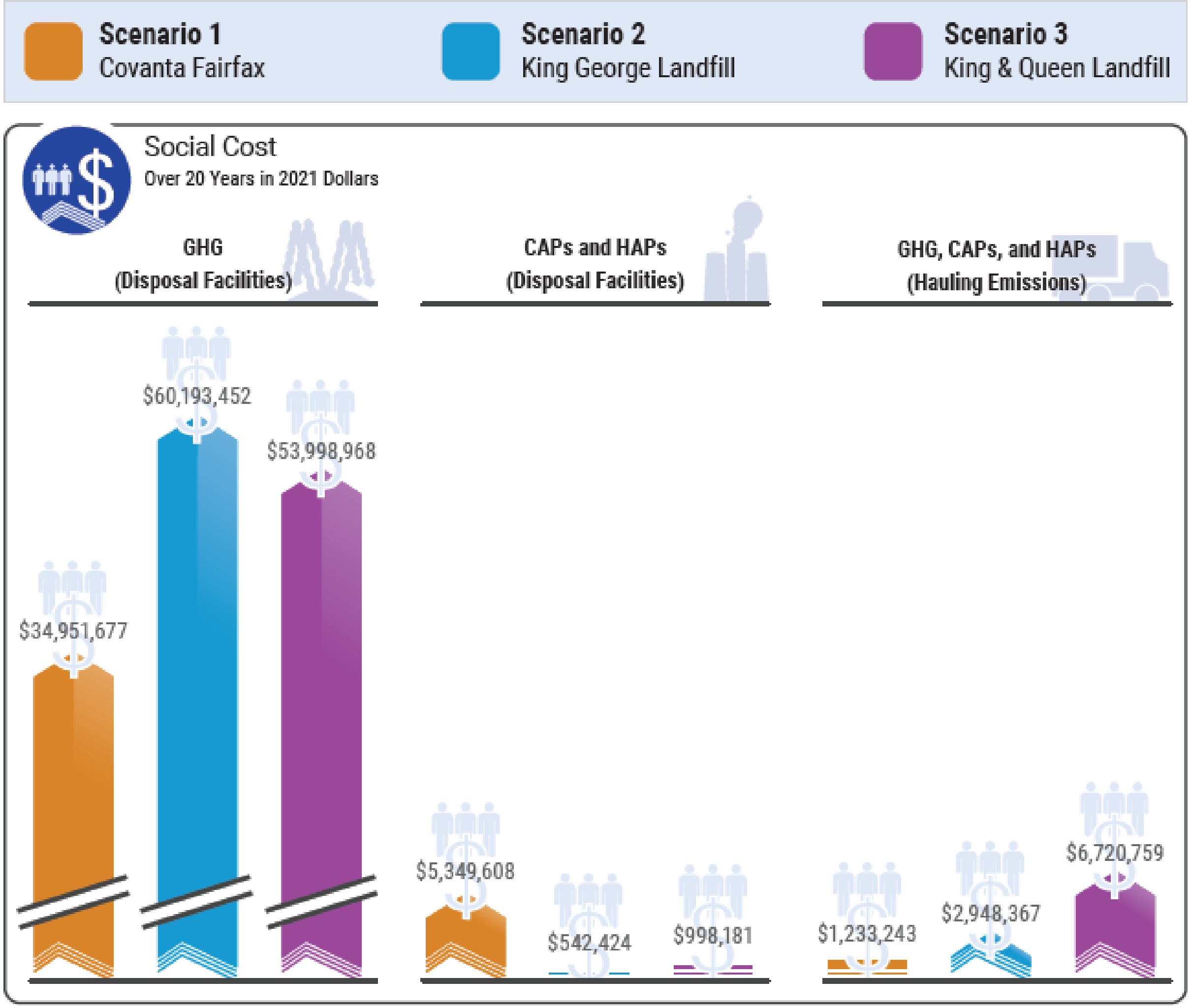


Figure 4-2. Comparison of Social Costs of Greenhouse Gas, Criteria Air Pollutants, and Hazardous Air Pollutants Emissions Over 20 Years

4.1.4 Human Health Risk Assessment

The HHRA results indicate that the calculated incremental cancer risks from inhalation exposure for all three disposal scenarios are less than the threshold of 10 in 1 million.

Similarly, incremental chronic and acute non-cancer health hazards from inhalation exposure for all three disposal scenarios are less than the significance threshold of one, indicating low potential for chronic and acute adverse health effects from inhalation exposure. A hazard greater than one indicates an exposure concentration greater than that what is considered safe. Also, estimated eight-hour concentrations of each HAP for all three disposal scenarios were found to be less than their respective CalOSHA PELs, indicating low potential for health impacts to workers.

4.1.5 Ecological Screening

The air pollutant dispersion concentration results do not exceed the Secondary National Ambient Air Quality Standards for any of the three scenarios, as illustrated in **Figure 4-3**. The results indicate minimal to no potential adverse impacts on soil, water, crops, animals and wildlife, and vegetation based on criteria emissions from the modeled facilities.

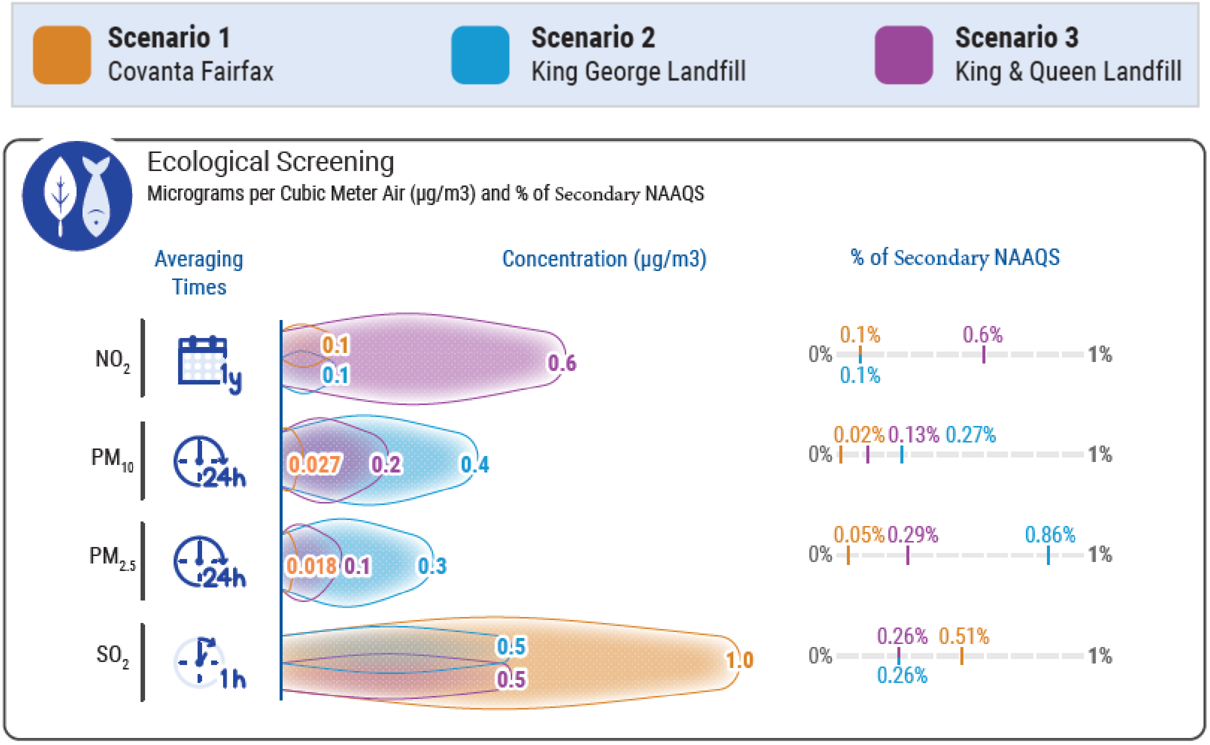


Figure 4-3. Criteria Pollutants Dispersion Model Results and Comparison with Secondary National Ambient Air Quality Standards

4.1.6 Power Generation

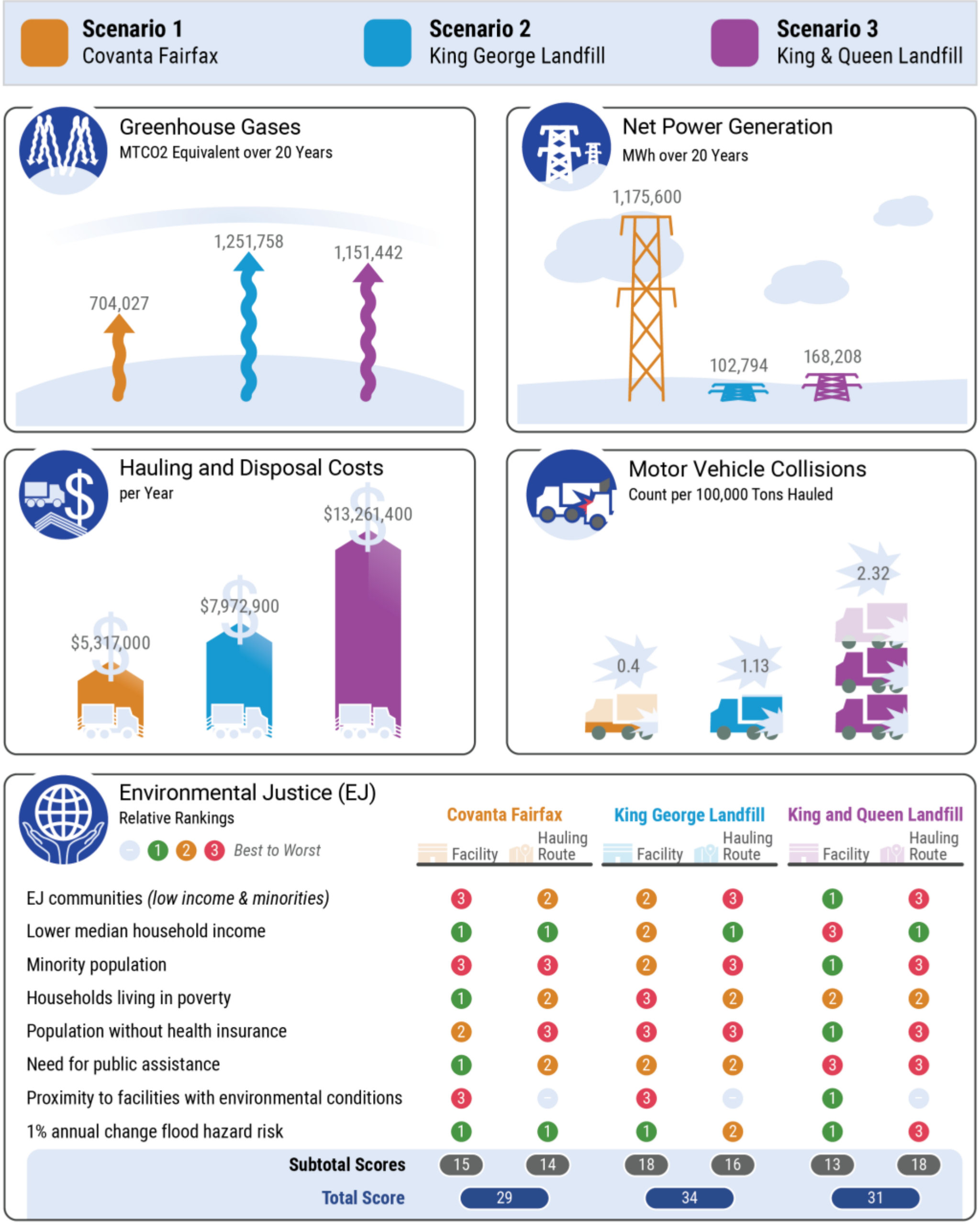
As shown in **Figure 4-4** Covanta Fairfax generates seven to 11 times more electricity from 100,000 tons of waste than the King & Queen Landfill and King George Landfill, respectively. While both landfills have the same landfill gas collection efficiency, the King & Queen Landfill diverts more gas to the engine generators and hence generates more power from methane than the King George landfill.

4.1.7 Hauling and Disposal Cost Estimate

Hauling costs for the landfill scenarios were estimated using the District's current hauling costs for delivery to Covanta Fairfax and adjusting for mileage differences. Based on a typical truck load of 22 tons and the same cost per mile for all scenarios, the hauling cost for the two landfills would be two to five times more expensive than hauling to Covanta Fairfax. Since landfills do not have set rates (tipping fees are negotiable and vary widely), disposal costs for the landfill scenarios were compared to the Covanta Fairfax disposal cost to determine what the tipping fee would need to be to provide a comparable combined cost. For the King George Landfill to have a comparable combined cost to Covanta Fairfax the landfill tipping fee would need to be $10/ton. Since the King & Queen Landfill hauling cost is more than the combined hauling and disposal cost for Covanta Fairfax there is no landfill tipping fee that would result in a comparable cost. Combined hauling and disposal costs assuming the same cost per mile and tipping fee for all scenarios are provided in **Figure 4-4**.

4.1.8 Motor Vehicle Collisions

Probabilities for motor vehicle collisions are based on VMT and vehicle type. Since the vehicle type is the same for all scenarios the collision probability varies only by VMT. Due to the longer haul distances to the two landfills the collision probabilities are higher as shown in **Figure 4-4**. The majority of collisions involve only property damage.



	Covanta Fairfax		King George Landfill		King and Queen Landfill	
	Facility	Hauling Route	Facility	Hauling Route	Facility	Hauling Route
EJ communities *(low income & minorities)*	3	2	2	3	1	3
Lower median household income	1	1	2	1	3	1
Minority population	3	3	2	3	1	3
Households living in poverty	1	2	3	2	2	2
Population without health insurance	2	3	3	3	1	3
Need for public assistance	1	2	2	2	3	3
Proximity to facilities with environmental conditions	3	○	3	○	1	○
1% annual change flood hazard risk	1	1	1	2	1	3
Subtotal Scores	15	14	18	16	13	18
Total Score	29		34		31	

Figure 4-4. Comparison of Greenhouse Gases, Net Power Generation, Hauling and Disposal Costs, Motor Vehicle Collisions, and Environmental Justice

4.1.9 Environmental Justice and Social Equity Impacts

King George Landfill had the highest total relative environmental justice (EJ) and social equity impact ranking, while King & Queen Landfill had the next highest and Covanta Fairfax had the lowest. The results of the EJ and social equity impacts analysis are summarized in **Figure** 4-4. Key findings from the analysis are as follows:

- The areas with the highest concentration of EJ communities is the hauling route between the solid waste transfer stations and Covanta Fairfax, around Covanta Fairfax and along the hauling route just south of Covanta Fairfax. Most of these areas are common to all three disposal facilities, with the exception of the area south of Covanta Fairfax, which only applies to King George Landfill and King & Queen Landfill.
- Because the hauling routes for the landfill scenarios overlap with the Covanta Fairfax scenario, the King George Landfill and King & Queen Landfill received either the same or higher relative rankings as Covanta Fairfax for all of the EJ and social equity metrics - resulting in King & Queen Landfill having the highest total ranking for the hauling route and Covanta having the lowest.
- The areas around the King George Landfill and the King & Queen Landfill generally have a lower median household income, a greater percentage of households receiving public assistance, and a greater percentage of households below the poverty line. Although the area around Covanta Fairfax had more EJ communities, which included consideration of median household income and the percentage of the population belonging to minority groups, the areas around the landfills both had a higher concentration of census block groups with a lower median household income relative to the area around Covanta Fairfax. Therefore, the landfills both scored higher rankings for the median household income metric.
- Proximity and quantity of facilities with environmental conditions relative to the location of each disposal facility were evaluated as potential indicators for compounding EJ and social equity impacts. Covanta Fairfax has the highest number of nearby facilities with environmental conditions, reflecting the potential for compounding EJ and society equity impacts, but these facilities were not necessarily located near Covanta Fairfax. At the King George Landfill, there are several nearby facilities that are near the landfill, but the overall quantity is fewer than Covanta Fairfax. Therefore, both facilities were identified as having relatively higher potential for compounding EJ and social equity impacts.
- All three facilities had similar exposure to flood risk areas. The area surrounding Covanta Fairfax has the most EJ-classified census block groups that also contained areas with flood risk.

4.2 Impact on DC Sustainability Goals

The Sustainable DC 2.0 Plan identifies goals, actions and targets for climate, waste, transportation, health, water, and other aspects of sustainability. While many of these goals address waste source reduction and reuse, several are relevant to the hauling and disposal of waste analyzed in this study. Specifically, the Mayor's goal to achieve carbon neutrality by 2050 (Carbon Free DC) and the District's roadmap to reduce GHGs at least 50% below 2006 levels by 2032 are directly relevant. Other goals include reducing GHGs from transportation by 60% compared to 2006 and increasing the share of renewable energy in DC to 50% of the District's energy supply by 2032. Sustainable DC 2.0 Plan's health goals include improving population health by systemically addressing the link between community health and place and providing high quality, safe, and sustainable places to be healthy and active. The Sustainable DC 2.0 Plan also applied an equity filter across all goal areas. The following subsections present the study findings alongside applicable Sustainable DC 2.0 Plan goals to inform decision makers on waste disposal scenario planning.

4.2.1 Climate Goal 1: Achieve Carbon Neutrality by 2050

In all scenarios, the hauling and disposal of waste results in carbon emissions. Disposal at Covanta Fairfax results in the lowest GHG emissions due to the absence of methane production at WTE facilities and greater power production. The ambitious goal of eliminating all carbon emissions by 2050 (Climate Goal 1) will not be obtainable employing either disposal option. To further reduce carbon emissions, the District should continue efforts to reduce waste disposal as much as possible through source reduction, reuse, recycling and composting.

The year 2032 target on the path to meeting Climate Goal 1 is to reduce GHG emissions by at least 50% below 2006 levels. As of the Sustainable DC 2020 progress report covering calendar year 2019, DC had cut GHG emissions by 30% compared to 2006 levels. Converting to landfilling would erode the progress made toward the 2032 reduction goal, while continued disposal at Covanta Fairfax would keep GHGs at a similar level as they were when this metric was evaluated in 2020.

4.2.2 Transportation Goal 4: Reduce Greenhouse Gases and Air Pollution from the Transportation Sector

The target for this goal is to reduce GHGs from transportation by 60% by 2032. According to the 2020 Sustainable DC 2.0 progress report covering calendar year 2019, transportation emissions had been reduced by 16.2% compared to 2006 and stood at 1.6 million $MTCO_2e$ as of 2020. Hauling waste results in transportation emissions. Covanta Fairfax is 24 miles from the two solid waste transfer stations, compared to the 70-mile haul distance to King George and 160-mile haul distance to King & Queen. Hauling waste to Covanta Fairfax yields the lowest transportation emissions of the three scenarios. Further reduction of GHG emissions compared to 2020 (when DC DPW hauled waste to Covanta Fairfax using diesel engine transfer trucks) could be achieved through several actions:

1. Waste diversion efforts will decrease transportation emissions by reducing the number of truck trips required for disposal.
2. Although electric waste transfer trucks are not yet available, switching to electric trucks for residential collection as is being done in New York City and Los Angeles would significantly reduce GHG emissions in the District.

4.2.3 Energy Goal 2: Increase the Proportion of Energy Sourced from Clean and Renewable Supplies

The target to meet the clean and renewable energy proportion goal is to increase renewable energy to 50% of the District's energy supply by 2032. The power generation analysis showed the Covanta Fairfax generates the most power, followed by King & Queen landfill, and King George landfill. However, DC does not recognize power from waste-to-energy to be renewable. Therefore, only the landfill scenarios contribute to this goal.

4.2.4 Health Goal 3: Improve Population Health by Systematically Addressing the Link Between Community Health and Place

Community health and place were evaluated in terms of motor vehicle collisions and localized air quality impacts related to waste hauling and disposal operations. Due to the longer waste hauling distances to the two landfills, the potential for property damage and fatalities from motor vehicle collisions were higher for landfilling but all scenarios resulted in minimal impacts. Health risk and ecological risk modeling determined localized air quality impacts are minimal, with CAPs and HAPs emissions below protective air quality standards and below human health cancer risk and non-cancer hazard significance thresholds for all three disposal scenarios.

Additional opportunities exist for improving population health. Switching to electric trucks for collection and hauling (not yet commercially available) would reduce impact to air quality and reduce noise pollution. Furthermore, traffic volumes could be reduced by implementing “Zero Waste” policies that reduce waste generation.

4.2.5 Equity Filter

The Sustainable DC 2.0 Plan strives to maintain social equity by utilizing an equity filter. This study’s equity filter was the performance of an environmental justice and social equity analysis. Sociodemographic and environmental condition indicators were evaluated in the vicinity of each disposal facility and along the hauling routes. The communities around the Covanta Fairfax facility have the highest concentration environmental justice communities (based on low-income and/or minority populations) and the greatest number of nearby facilities with environmental conditions. The communities around the landfilling facilities have a larger percentage of lower median household income, have a need for public assistance, and are living below the poverty line.

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Section 5

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