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Northeast Ohio Regional Sewer District

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# 2014-2016 GREENHOUSE GAS EMISSIONS INVENTORY

## Sustainability Program

August 15, 2018

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Sustainability Program

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# 1 BACKGROUND

For the past 45 years, the Northeast Ohio Regional Sewer District (NEORSD or "District) has provided wastewater and stormwater management services to the City of Cleveland and 61 other member communities across the Rocky, Cuyahoga, Lake Erie Direct Tributaries, and Chagrin River watersheds.

As the largest wastewater treatment provider in the State of Ohio, the Sewer District spans 380 square miles, and treats 90 billion gallons of wastewater a year. In addition to its award-winning treatment plant and laboratory performance, the Project Clean Lake construction program will reduce annual Lake Erie pollution by 4 billion gallons by 2036, while the Regional Stormwater Management Program addresses widespread inter-community problems like flooding and erosion.

The Northeast Ohio Regional Sewer District's mission is linked to the natural environment. At the same time, our operations impact service-area communities and the broader region. Integrating sustainability enterprise-wide is critical to our roles as a public utility, steward of the environment, and fiscally responsible organization.

In 2017, the District started a formal sustainability program with the following objectives:

- Be an efficient and financially responsible user of natural and material resources: The District will responsibly use material resources including energy, supplies, and other inputs, and seek to reduce, re-use, and recycle to lessen our contributions to landfill in our operations and construction practices.
- Be a socially responsible utility: Consider the well-being of the environment, communities, and staff when carrying out operations, policies and practices and seek to align equitable outcomes with core business opportunities resulting in positive impact to member communities.
- Protect and enhance the natural environment: The District will measure and mitigate its impacts and embed environmental protection into daily operations; acting to meet long-term environmental challenges, including climate change.

This Greenhouse Gas (GHG) inventory serves as an important baseline metric for measuring the outcomes of the District's sustainability goals and will inform the utility's sustainability strategy. The GHG inventory will cover the years 2014-2016 following the GHG Protocol Corporate Accounting and Reporting Standard and includes seven GHGs: carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), perfluorocarbons (PCFs), sulfur hexafluoride($SF_6$) and nitrogen trifluoride ($NF_3$).

The GHG Protocol *Corporate Standard* categorizes direct and indirect emissions into "scopes" as follows:

**Scope 1:** Direct GHG emissions include those associated with wastewater treatment, stationary fuel combustion (mobile, natural gas for heating and incineration), refrigerant losses and operation of its vehicle fleet.

**Scope 2:** Indirect GHG emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling. For NEORSD, Scope 2 emissions include those associated with purchased power used to operate its own facilities.

**Scope 3:** All other indirect emissions not covered in Scope 2, such as upstream and downstream emissions, transport related activities in vehicles not owned or controlled by the reporting entity (e.g., employee commuting and business travel), recycling of used products, waste disposal, etc. For NEORSD, Scope 3 emissions evaluated include those associated with the contracted services (e.g., mixed solid waste transport and disposal, ash management), employee travel, contracted landscape services, water use, and construction activities.

**Biomass Emissions:** Direct $CO_2$ emissions from biomass combustion in the incineration process which are required to be reported separately from any of the three scopes above.

# 2 FACILITY IDENTIFICATION

The District was created for the purpose of assuming the operation and management of certain wastewater collection, treatment and disposal facilities servicing the Cleveland metropolitan area. The District's service area includes more than 350 square miles, 330 miles of sewers, and a 420-mile regional stormwater system. The District owns and operates three wastewater treatment plants in Ohio: Easterly Treatment Plant, Westerly Treatment Center in Cleveland, and Southerly Treatment Center in Cuyahoga Heights. In addition, the District owns the George J. McMonagle Administration building in Midtown Cleveland and the Environmental Maintenance Services Center in Cuyahoga Heights. All three wastewater treatment facilities provide preliminary, primary, and secondary treatment as well as disinfection, effluent pumping and varying methods of solids handling.

## 2.1 Southerly

Situated on 288 acres, Southerly is the largest of the NEORSD's three wastewater plants, and one of the largest facilities of its kind in the country. The second-stage process uses specialized bacteria to remove ammonia and nitrogen, which deplete oxygen in receiving waters. As a final step, the flow passes through filters and is disinfected by a chlorination/dechlorination process during the recreation season (May to October). Southerly uses fluidized bed incineration to manage biosolids from both the Southerly and Easterly facilities. Southerly serves approximately 530,000 residents treating an average of 120 million gallons (MGD) per day with a 735 MGD flow capacity.

## 2.2 Westerly

The Westerly plant is located on the shore of Lake Erie east of Edgewater Park, Westerly uses multiple hearth incineration to dispose of biosolids. The facility serves 107,000 residents with an average flow of 33 million gallons per day (mgd) and a flow capacity of 1,000 mgd.

## 2.3 Easterly

The oldest of the District's facilities, Easterly treats wastewater from 330,000 residents with average of 85 MGD and a flow capacity of 400 MGD. Recently Easterly completed major construction to expand its secondary treatment capacity to 400 mgd.

## 2.4 Other Facilities

The Environmental and Maintenance Services Center (EMSC) houses the District's Analytical Services, Sewer System Maintenance & Operations, Systems Integration, Stormwater Inspection and Maintenance, Water Quality and Industrial Surveillance, Building Maintenance, and Fleet Services departments. EMSC is located in Cuyahoga Heights, adjacent to the Southerly plant.

The George J. McMonagle Building is the administrative headquarters for the NEORSD's operations. It is where support services originate and where public meetings are hosted including Board of Trustees meetings and project many pre-bid meetings.

# 3 GHG SUMMARY

For the baseline years of 2014, 2015, and 2016, NEORSD operations produced a total of 221,213, 211,522, and 196,720 metric tons carbon dioxide equivalents ($CO_2e$), respectively. A graphical representation of the annual GHG emissions totals (including Scope 1, Scope 2, Scope 3, and biomass emissions) is presented in Figure 1. Table 1 summarizes the emissions totals by source as well as the GHG intensity reported as GHG emissions per million gallons (MG) of wastewater processed. Figure 2 presents GHG emissions by facility.

**Figure 1. GHG Emissions By Scope**

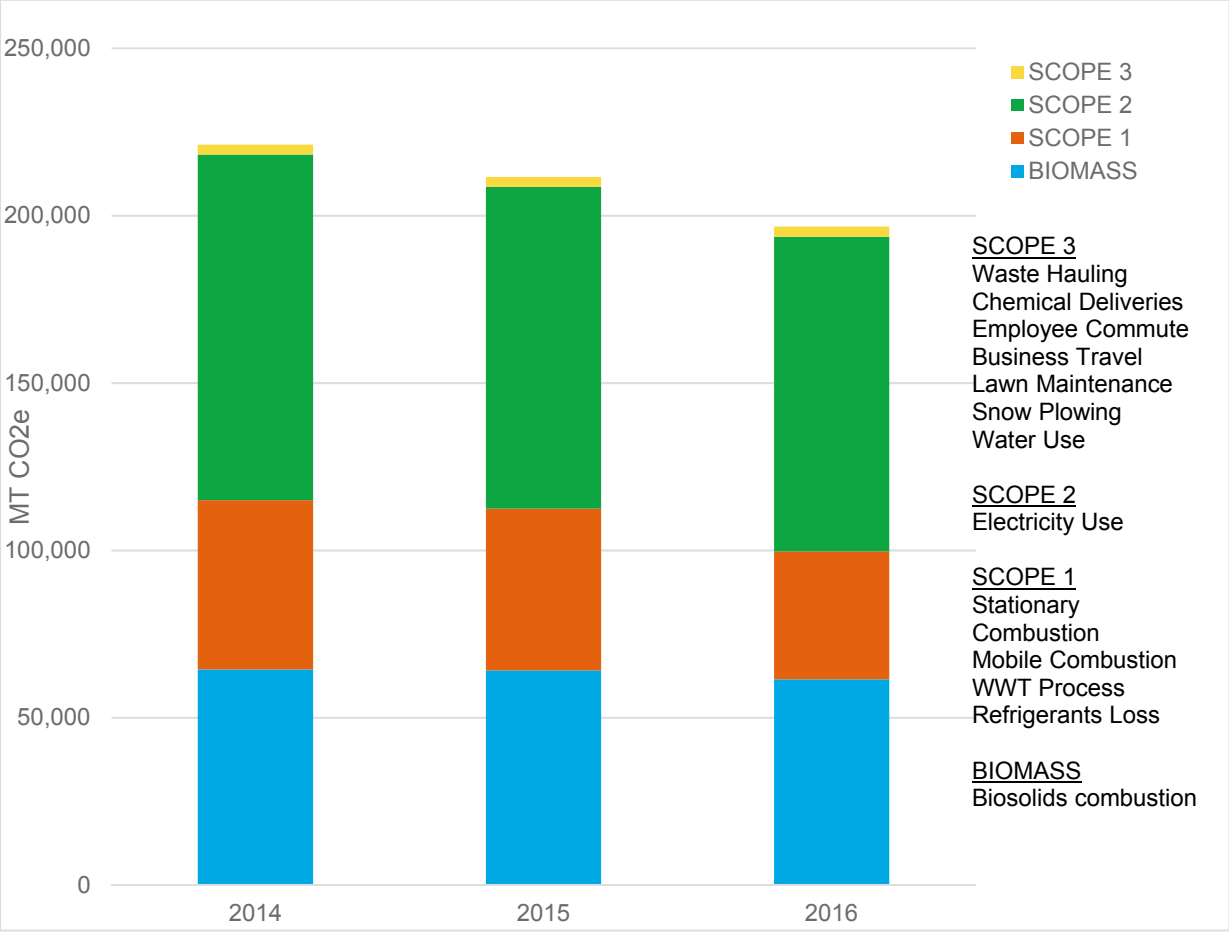
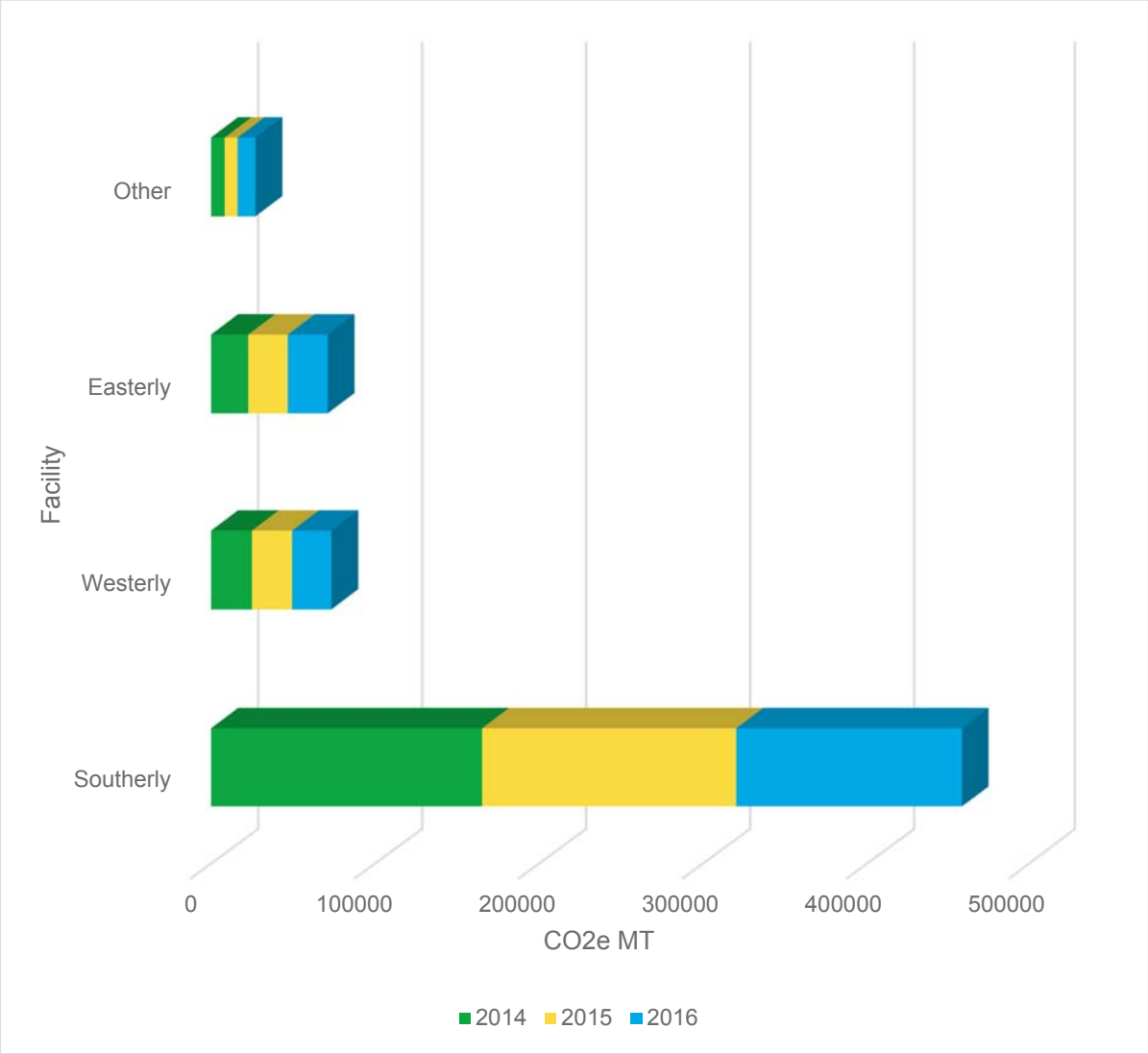



**Table 1. GHG Emissions Summary**

| Source | Emissions (MT $CO_2e$) | | |
|---|---|---|---|
| | 2014 | 2015 | 2016 |
| Biomass | 64,425 | 64,176 | 61,500 |
| Scope 1 | 50,599 | 48,307 | 38,233 |
| Scope 2 | 103,210 | 96,119 | 93,929 |
| Scope 3 | 2,979 | 2,949 | 3,058 |
| **Total Emissions (MT $CO_2e$)** | **221,213** | **211,552** | **196,720** |
| **GHG Intensity (MT $CO_2e$/MG)** | **1.48** | **1.64** | **1.78** |

**Figure 2. GHG Emissions By Facility**




# 4 BIOMASS EMISSIONS

Multiple hearth incinerators and/or fluidized bed incinerators are used to combust sewage sludge (biomass or biosolids) at the Southerly and Westerly treatment centers. Combustion of the sewage sludge results in GHG emissions. Although a direct emission source, biosolids combustion is separated from Scope 1 emissions, per the GHG Protocol. Table 2 summarizes the amount of biosolids generated and the corresponding GHG emissions released.

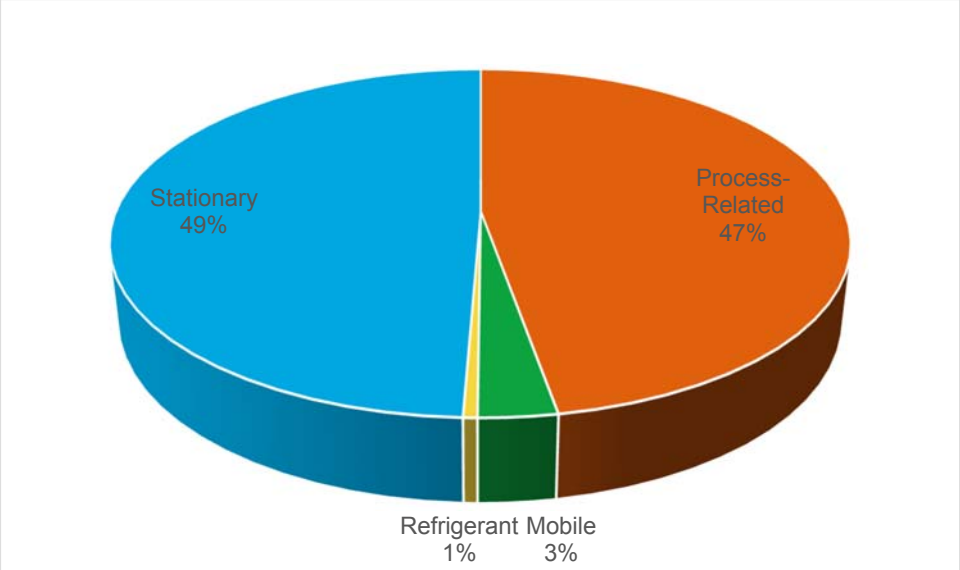
**Table 2. Emissions from Biosolids Combustion**

| Facility | Emissions (MT $CO_2e$) | | |
|---|---|---|---|
| | 2014 | 2015 | 2016 |
| Southerly | 58,247 | 58,231 | 55,282 |
| Westerly | 6,179 | 5,945 | 6,217 |
| **Total Emissions (MT $CO_2e$)** | **64,425** | **64,176** | **61,500** |

# 5 SCOPE 1 EMISSIONS

The District generates GHG from sources and processes for direct emissions that include: stationary combustion, mobile combustion, process-related, and fugitive (refrigerant usage). A summary of Scope 1 emissions by source is shown in Figure 3.

**Figure 3. Scope 1 GHG Emissions By Source**




## 5.1 Stationary Source Fuel Combustion

Stationary source emissions result from combustion of natural gas, kerosene and diesel fuel in equipment such as boilers, heaters, generators, pumps, and incinerators in a fixed location. During calendar years

2014-2016, NEORSD used a total of 1,250,270 million cubic feet of natural gas, 1,019 gallons of kerosene and 85,934 gallons of diesel fuel to power the stationary sources. Table 3 presents the emissions associated with fuel combustion from stationary sources.

**Table 3. Emissions from Stationary Source Fuel Combustion**

| Facility | Fuel | Emissions (MT $CO_2e$) | | |
|---|---|---|---|---|
| | | 2014 | 2015 | 2016 |
| Southerly | Natural Gas | 18,951 | 10,161 | 10,598 |
| | Kerosene | 5 | 3 | 1 |
| | Diesel | 32 | 64 | 26 |
| Easterly | Natural Gas | 2,373 | 1,664 | 2,275 |
| | Kerosene | -- | -- | -- |
| | Diesel | 39 | 84.02 | -- |
| Westerly | Natural Gas | 6,538 | 6,329 | 6,134 |
| | Kerosene | 0.00 | 0.56 | 0.00 |
| | Diesel | 2 | 41 | 10 |
| Other Facilities | Natural Gas | 741 | 636 | 698 |
| | Kerosene | -- | -- | -- |
| | Diesel | 18 | 197 | 76 |
| **Total Emissions (MT $CO_2e$)** | | **28,605** | **18,790** | **19,705** |

## 5.2 Mobile Source Fuel Combustion

The District operates a vehicle fleet that uses gasoline and diesel vehicles, which result in GHG emissions from fuel combustion. During calendar years 2014-2016, NEORSD's gasoline powered vehicle fleet used a total of 179,552 gallons. Likewise, NEORSD's diesel powered vehicle fleet used a total of 53,721 gallons. For calendar years 2014-2016, fuel combustion emissions from the operation of this fleet of vehicles are reported below.

**Table 4. Emissions from Mobile Source Fuel Combustion**

| Facility | Fuel | Emissions ($MT CO_2e$) | | |
|---|---|---|---|---|
| | | 2014 | 2015 | 2016 |
| Southerly | Gasoline | 138 | 112 | 50 |
| | Diesel | 1 | 63 | 26 |
| Westerly | Gasoline | 10 | 13 | 7 |
| | Diesel | 19 | 15 | 10 |
| Easterly | Gasoline | 42 | 37 | 42 |
| | Diesel | -- | -- | -- |
| Other Facilities | Gasoline | 383 | 467 | 376 |
| | Diesel | 249 | 91 | 75 |
| **Total Emissions ($MT CO_2e$)** | | **841** | **799** | **586** |

## 5.3 Refrigerant Loss

The District operates several domestic refrigerators and air conditioning units which have the potential to release refrigerants during operation. Emissions from refrigerant loss from these units are presented below. Estimates are based on an equipment survey conducted by NEORSD. It is assumed that this survey would be consistent for each of the evaluated years.

**Table 5. Annual Emissions from Refrigerant Loss**

| Facility | Emissions ($MT CO_2e$) |
|---|---|
| Southerly | 107 |
| Easterly | 56 |
| Westerly | 64 |
| Other Facilities | 10 |
| **Total Emissions ($MT CO_2e$)** | **237** |

Note: Survey data is assumed to be applicable for each of the evaluated years.

## 5.4 Process Operations

GHG emissions result from wastewater treatment plant operation of the treatment units and are calculated based on the wastewater flow and water quality. Wastewater treatment plant and overall process-related GHG emissions for each calendar year are shown below.

**Table 6. Emissions from Process Operations**

| Facility | Emissions (MT $CO_2e$) | | |
|---|---|---|---|
| | 2014 | 2015 | 2016 |
| Southerly | 16,236 | 22,499 | 12,523 |
| Westerly | 1,095 | 1,244 | 1,195 |
| Easterly | 2,816 | 3,760 | 3,386 |
| **Total Emissions (MT $CO_2e$)** | **20,146** | **27,503** | **17,104** |

# 6 SCOPE 2 EMISSIONS

Scope 2 emissions due to NEORSD's consumption of purchased power have been allocated to each facility that purchased electricity for its own operation. Emissions from the consumption of purchased power are presented below.

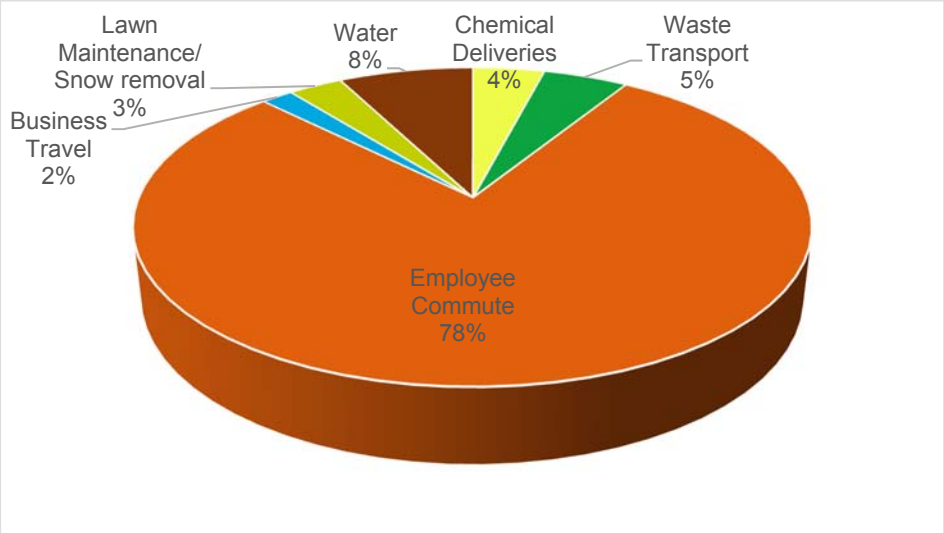
**Table 7. Emissions from Purchased Power**

| Facility | Emissions (MT $CO_2e$) | | |
|---|---|---|---|
| | 2014 | 2015 | 2016 |
| Easterly | 16,544 | 17,774 | 17,863 |
| Southerly | 70,783 | 62,995 | 58,254 |
| Westerly | 10,738 | 10,645 | 9,986 |
| Other Facilities | 5145 | 4704 | 7827 |
| **Total Emissions (MT $CO_2e$)** | **103,210** | **96,119** | **93,929** |

# 7 SCOPE 3 EMISSIONS

Scope 3 emissions, or other indirect emissions, are those generated by activities over which NEORSD has influence and that occur within NEORSD's operational boundaries but are not owned or controlled by NEORSD. The major sources of Scope 3 emissions are contracted services (such as chemical hauling, mixed solid wastes transport and disposal, and landscaping/snow removal), water use, and employee travel. A summary of Scope 3 emissions by source is shown in Figure 4.

**Figure 4. Scope 3 GHG Emissions By Source**




## 7.1 Emissions from Waste Transport

Mobile emissions associated with contracted services include the use of contractor-owned trucks for transporting mixed solid wastes to a landfill. Table 8 details emissions from the transportation of mixed solid wastes to their final disposal destination and the corresponding GHG emissions. This does not include the hauling of soil or shale from District capital and construction projects. Table A-16 in the appendix includes emissions estimates from recent contracted construction activities, but those emissions are not included in the inventory totals.

**Table 8. Emissions from Waste Transport**

| Facility | Emissions (MT $CO_2e$) | | |
|---|---|---|---|
| | 2014 | 2015 | 2016 |
| Easterly | 11 | 15 | 35 |
| Southerly | 25 | 23 | 95 |
| Westerly | 11 | 13 | 27 |
| Other Facilities | 39 | 50 | 90 |
| **Total Emissions (MT $CO_2e$)** | **86** | **101** | **246** |

## 7.2 Emissions from Chemical Deliveries

Mobile emissions associated with contracted services include the use of contractor-owned trucks for chemical deliveries. Table 9 details emissions from the transportation of chemical to their final disposal destination and the corresponding GHG emissions. It is assumed that chemical deliveries would be consistent for each of the evaluated years.

**Table 9. Annual Emissions from Chemical Deliveries**

| Facility | Miles Traveled | Emissions (MT $CO_2e$) |
|---|---|---|
| Easterly | 13,437 | 19 |
| Southerly | 55,986 | 80 |
| Westerly | 15,569 | 22 |
| Other Facilities | -- | -- |
| **Total Emissions (MT $CO_2e$)** | | **122** |

Note: Delivery data is assumed to be applicable for each of the evaluated years.

## 7.3 Emissions from Employee Commute

District employees use personal vehicles that emit GHGs for their commute to work. Table 10 lists the total mileage incurred by employees to commute to work in personal vehicles. Estimates are based on

employee survey conducted by NEORSD. It is assumed that this survey would be consistent for each of the evaluated years.

**Table 10. Annual Emissions from Employee Travel**

| Facility | Miles Traveled | Emissions (MT $CO_2e$) |
|---|---|---|
| Easterly | 358,644 | 128 |
| Southerly | 1,344,917 | 479 |
| Westerly | 381,060 | 136 |
| Other Facilities | 4,527,887 | 1,612 |
| **Total Emissions (MT $CO_2e$)** | | **103,210** |

Note: Survey data is assumed to be applicable for each of the evaluated years.

## 7.4 Emissions from Business Travel

GHG emissions associated with business travel are listed in Table 11, which lists the total mileage incurred by employees to complete business travel in personal vehicles and airplanes.

**Table 11. Emissions from Business Travel and Travel Mileage**

| Mileage Type | 2014 | 2015 | 2016 |
|---|---|---|---|
| Personal Vehicle Travel (miles) | 69,002 | 67,865 | 79,520 |
| Air Travel (miles) | 216,984 | 143,246 | 235,962 |
| **Total Emissions (MT CO2e)** | **56** | **45** | **62** |

## 7.5 Emissions from Water Use

Energy is required to source, convey, and treat water used by the District. The GHG emissions generated due to the District's water use are listed in Table 12.

**Table 12. Emissions from Water Use**

| Facility | 2014 | 2015 | 2016 |
|---|---|---|---|
| Easterly | 193 | 140 | 109 |
| Southerly | 18 | 54 | 47 |
| Westerly | 22 | 19 | 16 |
| Other Facilities | 35 | 23 | 10 |
| **Total Emissions ($MT CO_2e$)** | 268 | 236 | 182 |

## 7.6 Emissions from Landscaping and Snow Removal

NEORSD contracts outside companies to provide landscaping and snow removal services. These companies employ small gasoline-powered equipment such as lawn mowers, snow blowers and chainsaws, as well as vehicles for snow plowing. Emissions from landscaping and snow plowing services are presented below.

**Table 13. Emissions from Landscaping and Snow Plowing**

| Use | Emissions ($MT CO_2e$) | | |
|---|---|---|---|
| | 2014 | 2015 | 2016 |
| Landscaping | 92 | 92 | 92 |
| Snow Plowing | <1 | <1 | <1 |
| **Total Emissions ($MT CO_2e$)** | **92** | **92** | **92** |

# APPENDIX A

## Emission Methodology and Calculations

**Biomass Combustion**

Multiple hearth incinerators and/or fluidized bed incinerators are used to combust sewage sludge at the Southerly and Westerly treatment plants. GHG Emissions are emitted during the combustion of sewage sludge in the incinerators. Fuel used to assist with the combustion (i.e., natural gas) is not accounted for in the biomass combustion as it is included in the stationary source emissions. These emissions are estimated using the amount of sludge incinerated, the heat content of the sludge, and the emissions factors for biomass fuel combustion provided in Tables C-1 and C-2 of 40 CFR Part 98, Subpart C. The amount of sludge incinerated for the years 2014 through 2016 and the average heat content of the sludge was provided by the NEORSD.

**Stationary Emissions and Electricity Emissions**

Emissions from Scope 1 stationary sources and Scope 2 electricity were provided by NEORSD which utilized the District's EMS system.

**Mobile Sources**

The GHG emissions associated with the mobile sources at the facility (maintenance vehicles, fork lifts, portable generators etc.) are estimated using the fuel usage data provided by the NEORSD for the years 2014 through 2016. GHG emission factors are based on EPA's GHG inventory guidance document "Direct Emissions from Mobile Sources" dated January 2016. The methane and nitrous oxide emission factors are provided in the units of gram/mile, therefore, a conservative assumption of 15 miles/gallon was assumed to convert the fuel usage to miles travelled. Also, because the emission factors are provided by type and year of the vehicle, the maximum emission factor provided for all the vehicle types from years 2000 through present was used for the calculations.

**Refrigerant Use**

The GHG emissions result from the use of equipment with refrigerants (refrigerators, water dispensers, ice machines etc.). Operating emissions from the refrigerant use are estimated using the methodology provided in EPA's "Greenhouse Gas Inventory Guidance: Direct Fugitive Emissions from Refrigeration, Air Conditioning, Fire Suppression, and Industrial Gases" dated November 2014. Operating emissions are estimated using the equation - $C \times (x/100) \times T$

where:

C = refrigerant capacity of the piece of equipment

x = annual leak rate in percent of capacity (0.5% or 15% depending on the capacity)

T = time in years used during the reporting period = 1 yr

The information required to complete the calculations i.e. number of equipment, refrigerant capacity of the equipment, type of refrigerant in use etc. was obtained from the NEORSD.

**Process Operation Emissions**

The methodology used for process emissions was primarily referenced from Greenhouse Gas Emissions Estimation Methodologies for Biogenic Emissions from Selected Source Categories: Solid Waste Disposal, Wastewater Treatment, Ethanol Fermentation by Research Triangle Institute (RTI) International.

Aerobic wastewater treatment systems produce primarily $CO_2$, whereas anaerobic systems produce a mixture of $CH_4$ and $CO_2$[1]. Because each treatment center is well-managed and not designed with anoxic areas, the systems were treated as aerobic systems that only produce $CO_2$. The biomass yield, λ was selected from Table 3-1 of the referenced document and the oxygen demand removal efficiency, $Eff_{OD}$, was calculated as the percent reduction in BOD5 or COD from influent to effluent. The values used were CBOD measurements taken from locations further upstream and downstream of the aeration process in each plant.

**Waste Transport**

The GHG emissions associated with waste hauling from the NEORSD facilities are emitted from the fuel combustion of the haul trucks. The annual mileage travelled by the vehicles involved with waste hauling was estimated from locations provided by NEORSD. The emissions are estimated using the product transport emission factors provided in Table 9 of the EPA's "Emission Factors for Greenhouse Gas Inventories", modified in November 2015.

**Chemical Deliveries**

The GHG emissions associated with chemical deliveries to the NEORSD facilities are emitted from the fuel combustion of the delivery vehicles. The annual mileage travelled by the vehicles involved with chemical deliveries was estimated from locations provided by NEORSD. The emissions are estimated using the product transport emission factors provided in Table 9 of the EPA's "Emission Factors for Greenhouse Gas Inventories", modified in November 2015.

**Employee Commute**

The GHG emissions associated with employee daily commute to work are calculated using the annual mileage travelled by the employees estimated based on the commuter survey conducted by the NEORSD. The annual mileage is speciated among the five NEORSD facilities using the ratio of employees per facility who took the commuter survey. The emissions are estimated using the business travel emission factors provided in Table 8 of the EPA's "Emission Factors for Greenhouse Gas Inventories", modified in November 2015.

**Employee Business Travel**

The GHG emissions associated with employee business travel are calculated using the employee travel records provided by the NEORSD. The annual mileage travelled by road is based on the reimbursed mileage from the employee records. Air travel mileage was estimated assuming Cleveland-Hopkins International Airport as the point of origin for all departures. The emissions are estimated using the business travel emission factors provided in Table 8 of the EPA's "Emission Factors for Greenhouse Gas Inventories", modified in November 2015.

**Water**

The GHG emissions associated with water use are calculated using water records provided by the NEORSD. Energy requirements for the distribution, treatment and conveyance was estimated using a factor of 2,000 kwh/MG obtained from Table 2.2 for the Carbon Footprint of Water by River Network dated May 2009. The regional electricity emission factor provided in the Emissions & Generation Resource Integrated Database (eGRID)2014v2 was used.

[1] GHG Estimation Methodology for Selected Biogenic Source Categories, RTII, 2010

**Lawn Maintenance**

The GHG emissions are emitted from the fuel combustion of the lawn maintenance equipment. The emissions from lawn maintenance are estimated using the default usage rates and the emission factors of the landscape equipment obtained from California Emission Estimator Model (CalEEMod®), Appendix D, Default Data Tables, dated October 2017. The type of landscape equipment used for maintenance activities at the NEORSD facilities was assumed based on the type of maintenance service provided. The type of service, frequency of the service, and the acreage information was obtained from the NEORSD.

**Snow Plowing**

The GHG emissions are emitted from the fuel combustion of the snow plowing vehicles. The annual mileage travelled by the snow plowing vehicles is estimated based on the frequency of service provided during the year and the size of the paved area. This information was obtained from the NEORSD for the years 2014 through 2016. A typical snow plow blade width of 120 inch is assumed for the calculations. GHG emission factors are based on EPA's GHG inventory guidance document "Direct Emissions from Mobile Sources" dated January 2016. The methane and nitrous oxide emission factors for nonroad vehicle type was used in the calculations.

**Construction**

At the request of NEORSD, construction emissions were estimated using available data provided by the District. The information available and corresponding emission factors were not sufficient to provide emission calculations at a high confidence level and thus were not included in the GHG inventory. However, the emission calculations are provided in the emission spreadsheets and the methodology is presented here. Construction activities at the NEORSD would result in GHG emissions from sources such as consumption of fossil fuels, use of electricity, and embedded GHG emissions of building materials. For this analysis, only fossil fuels and electricity use were considered. These emissions are one-time activities for the evaluated years and are usually not included in GHG inventories. All construction emissions for projects were associated with the year of completion. No attempt to amortize emissions over the lifetime of the structure was conducted. Emission factors were obtained from USEPA's Potential for Reducing Greenhouse Gas Emissions in the Construction Sector, Appendix B dated February 2009. This appendix details emission intensity for construction subsectors in MTCO2e per 2002 thousand dollars which were adjusted for dollars in the three evaluated years using the website https://www.officialdata.org.

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**Table A-1: NEORSD 2014-2016 Greenhouse Gas (GHG) Emissions Summary**

| Facility | Total $CO_2e$ (metric tons) | | |
|---|---|---|---|
| | 2014 | 2015 | 2016 |
| **BIOMASS** | | | |
| **Biosolids Combustion** | | | |
| Southerly | 58,246.60 | 58,231.15 | 55,282.07 |
| Westerly | 6,178.88 | 5,944.92 | 6,217.48 |
| **Biosolids Combustion - Total** | **64,425.48** | **64,176.08** | **61,499.55** |
| **BIOSOLIDS** | **64,425** | **64,176** | **61,500** |
| **SCOPE 1** | | | |
| **Stationary Source Emissions** | | | |
| Easterly | 2,411.86 | 1,748.04 | 2,274.98 |
| Southerly | 18,989.09 | 10,228.89 | 10,625.73 |
| Westerly | 6,540.34 | 6,370.07 | 6,144.25 |
| EMSC | 279.35 | 397.74 | 226.72 |
| GJM | 433.97 | 392.07 | 407.17 |
| Collection System | 0.13 | 0.19 | 101.03 |
| Fleet Building | 41.77 | 32.05 | 33.67 |
| Pump Stations | 4.70 | 10.97 | 4.94 |
| **Stationary Source Emissions - Total** | **28,701.21** | **19,180.02** | **19,818.50** |
| **Mobile Source Emissions** | | | |
| Easterly | 673.56 | 588.74 | 487.24 |
| Southerly | 138.65 | 175.20 | 76.01 |
| Westerly | 70.40 | 65.81 | 59.14 |
| EMSC | 631.97 | 551.27 | 445.56 |
| Pump Stations | 0.00 | 4.93 | 4.94 |
| GJM | 0.00 | 1.66 | 0.84 |
| **Mobile Source Emissions - Total** | **1,514.58** | **1,387.62** | **1,073.72** |
| **Biogenic Emissions** | | | |
| Easterly | 2,815.72 | 3,759.98 | 3,385.53 |
| Southerly | 16,235.59 | 22,498.88 | 12,522.73 |
| Westerly | 1,095.00 | 1,243.96 | 1,195.48 |
| **Biogenic Emissions - Total** | **20,146.31** | **27,502.81** | **17,103.73** |
| **Refrigerants Emissions** | | | |
| Easterly | 56.22 | 56.22 | 56.22 |
| Southerly | 107.49 | 107.49 | 107.49 |
| Westerly | 63.59 | 63.59 | 63.59 |
| EMSC | 9.67 | 9.67 | 9.67 |
| **Refrigerant Emissions - Total** | **236.97** | **236.97** | **236.97** |
| **SCOPE 1 TOTAL** | **50,599** | **48,307** | **38,233** |
| **SCOPE 2** | | | |
| **Electricity Use** | | | |
| Southerly | 70,783.20 | 62,995.45 | 58,253.56 |
| Easterly | 16,544.23 | 17,774.21 | 17,862.53 |
| Westerly | 10,737.63 | 10,644.81 | 9,985.78 |
| EMSC | 3,725.43 | 3,315.55 | 3,065.98 |
| GJM | 1,419.11 | 1,388.80 | 1,573.42 |
| Collection System | 0.00 | 0.00 | 3,187.83 |
| Fleet | 0.00 | 0.00 | 0.00 |
| **Electricity Use Emissions - Total** | **103,209.60** | **96,118.83** | **93,929.10** |
| **SCOPE 2 TOTAL** | **103,210** | **96,119** | **93,929** |
| **SCOPE 3** | | | |
| **Chemical Deliveries** | | | |
| Easterly | 19.27 | 19.27 | 19.27 |
| Southerly | 80.28 | 80.28 | 80.28 |
| Westerly | 22.32 | 22.32 | 22.32 |
| **Chemical Deliveries Emissions - Total** | **121.87** | **121.87** | **121.87** |
| **Waste Hauling** | | | |
| Easterly | 10.99 | 14.68 | 34.53 |
| Southerly | 25.22 | 22.97 | 95.08 |
| Westerly | 11.10 | 13.12 | 26.53 |
| EMSC | 15.36 | 17.51 | 63.33 |
| GJM | 22.67 | 29.97 | 24.98 |
| Pump | 0.96 | 2.51 | 1.33 |
| **Waste Hauling - Total** | **86.30** | **100.75** | **245.78** |

| | | | |
|---|---|---|---|
| **Employee Commute** | | | |
| Easterly | 127.67 | 127.67 | 127.67 |
| Southerly | 478.77 | 478.77 | 478.77 |
| Westerly | 135.65 | 135.65 | 135.65 |
| EMSC | 518.67 | 518.67 | 518.67 |
| GJM | 1,093.19 | 1,093.19 | 1,093.19 |
| **Employee Commute Emissions - Total** | **2,353.96** | **2,353.96** | **2,353.96** |
| **Employee Business Travel** | | | |
| All Facilities | 55.86 | 44.82 | 62.34 |
| **Employee Business Travel - Total** | **55.86** | **44.82** | **62.34** |
| **Lawn Maintenance** | | | |
| Southerly | 4.23 | 4.23 | 4.22 |
| Westerly | 0.70 | 0.70 | 0.70 |
| EMSC | 4.01 | 4.00 | 4.00 |
| GJM | 0.06 | 0.06 | 0.06 |
| Remaining Areas | 83.42 | 83.24 | 83.08 |
| **Lawn Maintenance Emissions - Total** | **92.43** | **92.23** | **92.05** |
| **Snow Plowing** | | | |
| All Areas | **0.18** | **0.08** | **0.07** |
| **Water Use** | | | |
| Southerly | **193.16** | **139.85** | **109.48** |
| Easterly | **18.09** | **54.33** | **46.64** |
| Westerly | **22.25** | **18.53** | **16.07** |
| Remaining Areas | **34.83** | **22.86** | **10.23** |
| Water Use Emissions - Total | **268.32** | **235.57** | **182.42** |
| **SCOPE 3 TOTAL** | **2,979** | **2,949** | **3,058** |
| **Total GHG Emissions (metric tons)** | **221,213** | **211,552** | **196,720** |
| **GHG Emissions per MG of WW processed (metric tons/MG)** | **1.48** | **1.64** | **1.78** |

**Table A-2: NEORSD 2014-2016 Emissions from Biosolids Combustion**

| Site Name | Fuel type | Sludge Incinerated[1] | | | High Heat Value[1] | Emission Factors[2] | | | 2014 Emissions | | | | 2015 Emissions | | | | 2016 Emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2014 | 2015 | 2016 | | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$[3] | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$[3] | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$[3] |
| | | Dry tons | | | MMBtu/ short ton | Kg/MMBtu | Kg/MMBtu | Kg/MMBtu | Metric Tons | | | | Metric Tons | | | | Metric Tons | | | |
| Southerly | Sewage Sludge | 40,870.4 | 40,859.5 | 38,790.2 | 13.25 | 105.51 | 0.0042 | 0.032 | 57,158.26 | 2.28 | 17.34 | 58,246.60 | 57,143.10 | 2.27 | 17.33 | 58,231.15 | 54,249.12 | 2.16 | 16.45 | 55,282.07 |
| Westerly | Sewage Sludge | 5,018.0 | 4,828.0 | 5,049.4 | 11.45 | 105.51 | 0.0042 | 0.032 | 6,063.42 | 0.24 | 1.84 | 6,178.88 | 5,833.84 | 0.23 | 1.77 | 5,944.92 | 6,101.31 | 0.24 | 1.85 | 6,217.48 |

**Footnotes:**

1. Based on the biosolids data provided by the facility.
2. Emission factors for biomass fuels (solid) provided in 40 CFR Part 98, Subpart C, Table C-1 and C-2.
3. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

**Sample Calculations:**

2014 CO2 emissions (Mt) = 40,870.4 tons x 13.25 MMBtu/short ton x 105.51 Kg/MMBtu x 1 Mt/1,000 Kg

## Table A-3: NEORSD 2014-2016 Scope 1 Emissions from Natural Gas Combustion

| Site Name | 2014 Emissions[1] | | | | 2015 Emissions[1] | | | | 2016 Emissions[1] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2e$[3] | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2e$[3] | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2e$[3] |
| | Metric Tons | | | | Metric Tons | | | | Metric Tons | | | |
| Southerly | 18,896 | 1.70 | 0.03 | 18952 | 10,131 | 0.91 | 0.02 | 10161 | 10,567 | 0.95 | 0.02 | 10598 |
| Easterly | 2,366 | 0.21 | 0.00 | 2373 | 1,659 | 0.15 | 0.00 | 1664 | 2,268 | 0.20 | 0.00 | 2275 |
| Westerly | 6,519 | 0.59 | 0.01 | 6539 | 6,310 | 0.57 | 0.01 | 6329 | 6,116 | 0.55 | 0.01 | 6134 |
| Other[2] | 739 | 0.07 | 0.00 | 742 | 634 | 0.06 | 0.00 | 636 | 696 | 0.06 | 0.00 | 698 |

**Footnotes:**

1. Emissions from Electricity Use Estimates from NEORSD EMS
2. "Other" Sites include the aggregate emissions from GJM, EMSC, Collection System, and Fleet Building
3. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

## Table A-4: NEORSD 2014-2016 Scope 1 Emissions from Diesel and Kerosene Combustion

| Site Name | Fuel type | 2014 | 2015 | 2016 | Emission Factor[2] | | | 2014 Emissions | | | | 2015 Emissions | | | | 2016 Emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fuel Usage[1] | Fuel Usage[1] | Fuel Usage[1] | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ |
| | | gallons/yr | | | Kg/MMBtu | | | Metric Tons | | | | Metric Tons | | | | Metric Tons | | | |
| Southerly | Diesel | 3,104.3 | 6,295.6 | 2,546.1 | 73.96 | 0.001 | 0.003 | 31.68 | 2.57E-04 | 1.29E-03 | 31.79 | 64.26 | 5.21E-04 | 2.61E-03 | 64.47 | 25.99 | 2.11E-04 | 1.05E-03 | 26.07 |
| | Kerosene | 534.3 | 291.8 | 138.2 | 75.20 | 0.001 | 0.003 | 5.42 | 4.33E-05 | 2.16E-04 | 5.44 | 2.96 | 2.36E-05 | 1.18E-04 | 2.97 | 1.40 | 1.12E-05 | 5.60E-05 | 1.41 |
| Westerly | Diesel | 150.1 | 3,981.6 | 975.7 | 73.96 | 0.001 | 0.003 | 1.53 | 1.24E-05 | 6.21E-05 | 1.54 | 40.64 | 3.30E-04 | 1.65E-03 | 40.77 | 9.96 | 8.08E-05 | 4.04E-04 | 9.99 |
| | Kerosene | 0.0 | 55.0 | 0.0 | 75.20 | 0.001 | 0.003 | 0.00 | 0.00E+00 | 0.00E+00 | 0.00 | 0.56 | 4.46E-06 | 2.23E-05 | 0.56 | 0.00 | 0.00E+00 | 0.00E+00 | 0.00 |
| Easterly | Diesel | 3,820.0 | 8,232.1 | 0.0 | 73.96 | 0.001 | 0.003 | 38.99 | 3.16E-04 | 1.58E-03 | 39.12 | 84.02 | 6.82E-04 | 3.41E-03 | 84.30 | 0.00 | 0.00E+00 | 0.00E+00 | 0.00 |
| | Kerosene | 0.0 | 0.0 | 0.0 | 75.20 | 0.001 | 0.003 | 0.00 | 0.00E+00 | 0.00E+00 | 0.00 | 0.00 | 0.00E+00 | 0.00E+00 | 0.00 | 0.00 | 0.00E+00 | 0.00E+00 | 0.00 |
| Other | Diesel | 1,793.60 | 19,243.70 | 7,376.70 | 221.88 | 0.00 | 0.01 | 18.31 | 0.00 | 0.00 | 18.37 | 196.41 | 0.00 | 0.01 | 197.06 | 75.29 | 0.00 | 0.00 | 75.54 |
| | Kerosene | 0.00 | 0.00 | 0.00 | 225.60 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Footnotes:**

1. Fuel usage data is based on the information provided by the facility
2. Emission factors from 40 CFR Part 98, Subpart C, Table C-1 and C-2. High heat value is 0.138 for diesel and 0.135 for kerosene
3. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

**Sample Calculations:**

2014 Diesel $CO_2$ emissions (Mt) = 3,104.3 gallons/yr x 73.96 Kg/MMBtu x 0.138 MMBtu/gal x 1 Mt/1,000 Kg

## Table A-5: NEORSD 2014-2016 Scope 1 Emissions from Mobile Sources

| Site Name | Fuel type | 2014 | | 2015 | | 2016 | | Emission Factor[3] | | | 2014 Emissions | | | | 2015 Emissions | | | | 2016 Emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Fuel Usage[1] | Miles Travelled[2] | Fuel Usage[1] | Miles Travelled[2] | Fuel Usage[1] | Miles Travelled[2] | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$[4] | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$[4] | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$[4] |
| | | gallons/yr | Miles/yr | gallons/yr | Miles/yr | gallons/yr | Miles/yr | Kg/gal | g/mile | g/mile | Metric Tons | | | | Metric Tons | | | | Metric Tons | | | |
| Southerly | Gasoline | 14,765.3 | 221,479.5 | 12,005.0 | 180,075.0 | 5,349.0 | 80,235.0 | 8.78 | 0.135 | 0.055 | 129.64 | 2.99E-02 | 1.21E-02 | 137.90 | 105.40 | 0.02 | 0.01 | 112.12 | 46.96 | 0.01 | 0.00 | 49.96 |
| | Diesel | 72.8 | 1,092.0 | 6,165.4 | 92,481.0 | 2,546.1 | 38,191.5 | 10.21 | 0.0048 | 0.0051 | 0.74 | 5.24E-06 | 5.57E-06 | 0.74 | 62.95 | 4.44E-04 | 4.72E-04 | 63.08 | 26.00 | 1.83E-04 | 1.95E-04 | 26.05 |
| Westerly | Gasoline | 1,042.2 | 15,633.0 | 1,414.0 | 21,210.0 | 800.9 | 12,013.5 | 8.78 | 0.135 | 0.055 | 9.15 | 2.11E-03 | 8.54E-04 | 9.73 | 12.41 | 0.00 | 0.00 | 13.21 | 7.03 | 0.00 | 0.00 | 7.48 |
| | Diesel | 1,864.7 | 27,970.5 | 1,478.5 | 22,177.5 | 975.7 | 14,635.5 | 10.21 | 0.0048 | 0.0051 | 19.04 | 1.34E-04 | 1.43E-04 | 19.08 | 15.10 | 1.06E-04 | 1.13E-04 | 15.13 | 9.96 | 7.03E-05 | 7.46E-05 | 9.98 |
| Easterly | Gasoline | 4,452.9 | 66,793.5 | 4,012.6 | 60,189.0 | 4,462.0 | 66,930.0 | 8.78 | 0.135 | 0.055 | 39.10 | 9.02E-03 | 3.65E-03 | 41.59 | 35.23 | 0.01 | 0.00 | 37.48 | 39.18 | 0.01 | 0.00 | 41.67 |
| | Diesel | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.21 | 0.0048 | 0.0051 | 0.00 | 0.00E+00 | 0.00E+00 | 0.00 | 0.00 | 0.00E+00 | 0.00E+00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Other | Gasoline | 40,971.00 | 614,565.00 | 50,032.00 | 750,480.00 | 40,244.60 | 603,669.00 | 8.78 | 0.135 | 0.055 | 359.73 | 0.08 | 0.03 | 382.65 | 439.28 | 0.10 | 0.04 | 467.28 | 353.35 | 0.08 | 0.03 | 375.87 |
| | Diesel | 24,368.70 | 365,530.50 | 8,854.10 | 132,811.50 | 7,376.70 | 110,650.50 | 10.21 | 0.0048 | 0.0051 | 248.80 | 0.00 | 0.00 | 249.32 | 90.40 | 0.00 | 0.00 | 90.59 | 75.32 | 0.00 | 0.00 | 75.47 |

**Footnotes:**

1. Fuel usage data is based on the information provided by the facility
2. Estimated based on a conservative assumption of 15 miles per gallon
3. Emission factors based on EPA's GHG inventory guidance document "Direct Emissions from Mobile Sources" dated January 2016. For estimating methane and nitrous oxide emissions, maximum emission factor provided for the vehicle
4. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

**Sample Calculations:**

2014 Gasoline $CO_2$ emissions (Mt) = 14,765.25 gallon/yr x 8.78 Kg/gal x 1 Mt/1,000 Kg

2014 Gasoline N2O emissions (Mt) = 221,479.5 miles/yr x 0.135 g/mile x 1 Mt/1,000,000 g

**Table A-6: NEORSD Scope 3 WWTP Biogenic Emissions**

| Site Name | 2014 | | | 2015 | | | 2016 | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$[1] (tons/year) | $CH_4$[1] (tons/year) | CO2e MT | $CO_2$[1] (tons/year) | $CH_4$[1] (tons/year) | CO2e MT | $CO_2$[1] (tons/year) | $CH_4$[1] (tons/year) | CO2e MT |
| Southerly | 17,897 | 0.00 | 16,236 | 24,801 | 0.00 | 22,499 | 13,804 | 0.00 | 12,523 |
| Westerly | 1,207 | 0.00 | 1,095 | 1,371 | 0.00 | 1,244 | 1,318 | 0.00 | 1,195 |
| Easterly | 3,104 | 0.00 | 2,816 | 4,145 | 0.00 | 3,760 | 3,732 | 0.00 | 3,386 |
| Total | 22,207.51 | 0.00 | 20,146.31 | 30,316.66 | 0.00 | 27,502.81 | 18,853.64 | 0.00 | 17,103.73 |

**Footnotes:**

1. Emission estimation methodology is based on EPA's "Greenhouse Gas Emissions Estimation Methodologies for Biogenic Emissions from Selected Source Categories: Solid Waste Disposal, Wastewater Treatment, Ethanol Fermentation" draft dated December 2010.

$CO2\ (Mg/yr) = 10^{-6} \times Qww \times OD \times Eff_{OD} \times CF_{CO2} \times [(1- MCFww \times BG_{CH4}) (1-\lambda)]$
$CH4\ (Mg/yr) = 10\text{-}6 \times Qww \times OD \times EffOD \times CF_{CH4} \times [(MCFww \times BGCH4) (1-\lambda)]$

where:
CO2 = CO2 emission rate (Mg CO2/hr)
CH4 = CH4 emission rate (Mg CH4/hr)
10-6 = Units conversion factor (Mg/g)
QWW = Wastewater influent flow rate (m3/hr)
OD = Oxygen demand of influent wastewater to the biological treatment unit determined as either BOD5 or COD (mg/L = g/m3)
$Eff_{OD}$ = Oxygen demand removal efficiency of the biological treatment unit
$CF_{CO2}$ = Conversion factor for maximum CO2 generation per unit of oxygen demand = 44/32 = 1.375 g CO2/ g oxygen demand
$CF_{CH4}$ = Conversion factor for maximum CH4 generation per unit of oxygen demand = 16/32 = 0.5 g CH4/ g oxygen demand
MCFWW = methane correction factor for wastewater treatment unit, indicating the fraction of the influent oxygen demand that is converted anaerobically in the wastewater treatment unit = 0 for well managed aerated treatment process.
BGCH4 = Fraction of carbon as CH4 in generated biogas (default is 0.65)
λ = Biomass yield (g C converted to biomass/g C consumed in the wastewater treatment process) =0.65 for well managed aerated treatment process

*1st stage aeration flows were taken from the raw data for 1/1/2014 – 1/31/2015. However, the data showed unusual trends after that point. NEORSD provided information indicating that, in August 2015, new meters for the first stage aeration tank were installed, but due to communication issues with the District's data historian, only partial flow data is available. The data suggests the meters first began to fail in February. Based on how the plant is designed to operate and the observed relationship between stage 1 and stage 2 aeration flows, 1st stage aeration flows from 2/1/15 – 12/31/16 were calculated as follows:

- For influent flow < 175 MGD, total flow through 1st stage aeration = 1.2 x total flow through 2nd stage aeration (capped at 175 MGD)
- For influent flow ≥ 175 MGD, total flow through 1st stage aeration = 175 MGD

**Table A-7: NEORSD Scope 1 GHG Emissions from Refrigerants Use**

| Facility | Refrigerant | 2014 $CO_2e^2$ (metric tons) | 2015 $CO_2e^2$ (metric tons) | 2016 $CO_2e^2$ (metric tons) |
|---|---|---|---|---|
| Easterly | | | | |
| | R22 | 28.51 | 28.51 | 28.51 |
| | R410a | 27.70 | 27.70 | 27.70 |
| | R134a | 1.10E-02 | 1.10E-02 | 1.10E-02 |
| | R600 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **Total** | | **56.22** | **56.22** | **56.22** |
| Southerly | | | | |
| | R22 | 55.44 | 55.44 | 55.44 |
| | R410a | 51.93 | 51.93 | 51.93 |
| | R12 | 5.1E-02 | 5.1E-02 | 5.1E-02 |
| | R134a | 4.9E-02 | 4.9E-02 | 4.9E-02 |
| | R600 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | R404A | 2.0E-02 | 2.0E-02 | 2.0E-02 |
| **Total** | | **107.49** | **107.49** | **107.49** |
| Westerly | | | | |
| | R22 | 23.76 | 23.76 | 23.76 |
| | R410a | 39.82 | 39.82 | 39.82 |
| | R12 | 3.05E-03 | 3.05E-03 | 3.05E-03 |
| | R134a | 8.08E-03 | 8.08E-03 | 8.08E-03 |
| **Total** | | **63.59** | **63.59** | **63.59** |
| EMSC | | | | |
| | R22 | 7.92 | 7.92 | 7.92 |
| | R410a | 1.73 | 1.73 | 1.73 |
| | R134a | 1.46E-02 | 1.46E-02 | 1.46E-02 |
| **Total** | | **9.67** | **9.67** | **9.67** |

**Footnotes:**

1.Emission estimation methodology is based on EPA's "Greenhouse Gas Inventory Guidance: Direct Fugitive Emissions from Refrigeration, Air Conditioning, Fire Suppression, and Industrial Gases "dated November 2014. Operating emissions are estimated using the equation - C × (x/100) x T
where:
C = refrigerant capacity of the piece of equipment
x = annual leak rate in percent of capacity (0.5% or 15% based on the capacity)
T = time in years used during the reporting period = 1 yr

2. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

## Table A-8: NEORSD 2014-2016 Scope 2 Emissions from Electricity Use

| Site Name | 2014 Emissions[1] | | | | 2015 Emissions[1] | | | | 2016 Emissions[1] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2e$[3] | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2e$[3] | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2e$[3] |
| | Metric Tons | | | | Metric Tons | | | | Metric Tons | | | |
| Southerly | 70277 | 7.57 | 1.11 | 70783 | 62545 | 6.74 | 0.99 | 62995 | 57837 | 6.23 | 0.91 | 58254 |
| Easterly | 16426 | 1.77 | 0.26 | 16544 | 17647 | 1.90 | 0.28 | 17774 | 17735 | 1.91 | 0.28 | 17863 |
| Westerly | 10661 | 1.15 | 0.17 | 10738 | 10569 | 1.14 | 0.17 | 10645 | 9914 | 1.07 | 0.16 | 9986 |
| Other[2] | | | | 5145 | | | | 4704 | | | | 7827 |

**Footnotes:**

1. Emissions from Electricity Use Estimates from NEORSD EMS
2. "Other" Sites include the aggregate emissions from GJM, EMSC, Collection System, and Fleet Building
3. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

## Table A-9: NEORSD 2014-2016 Scope 3 Emissions from Chemical Deliveries

| Site Name | Fuel type | 2014 | 2015 | 2016 | Emission Factor[2] | | | 2014 Emissions | | | | 2015 Emissions | | | | 2016 Emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Miles Travelled[1] | | | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ |
| | | Miles/yr | | | Kg/mile | g/mile | g/mile | Metric Tons | | | | Metric Tons | | | | Metric Tons | | | |
| Southerly | Diesel | 55,986.4 | 55,986.4 | 55,986.4 | 1.43 | 0.013 | 0.015 | 80.06 | 7.28E-04 | 8.40E-04 | 80.28 | 80.06 | 7.28E-04 | 8.40E-04 | 80.28 | 80.06 | 7.28E-04 | 8.40E-04 | 80.28 |
| Westerly | | 15,569.3 | 15,569.3 | 15,569.3 | 1.43 | 0.013 | 0.015 | 22.26 | 2.02E-04 | 2.34E-04 | 22.32 | 22.26 | 2.02E-04 | 2.34E-04 | 22.32 | 22.26 | 2.02E-04 | 2.34E-04 | 22.32 |
| Easterly | | 13,437.2 | 13,437.2 | 13,437.2 | 1.43 | 0.013 | 0.015 | 19.22 | 1.75E-04 | 2.02E-04 | 19.27 | 19.22 | 1.75E-04 | 2.02E-04 | 19.27 | 19.22 | 1.75E-04 | 2.02E-04 | 19.27 |

**Footnotes:**

1. Vehicle miles provided by the facility.
2. Product transport emission factors based on Table 9 of the EPA GHG Inventory, last modified in November 2015.
3. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

**Sample Calculations:**

2014 Gasoline N2O emissions (Mt) = 55,986.4 miles/yr x 0.013 g/mile x 1 Mt/1,000,000 g

## Table A-10: NEORSD 2014-2016 Scope 3 Emissions from Chemical Deliveries

| Site Name | Fuel type | 2014 | 2015 | 2016 | Emission Factor[2] | | | 2014 Emissions | | | | 2015 Emissions | | | | 2016 Emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Miles Travelled[1] | | | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ |
| | | Miles/yr | | | Kg/mile | g/mile | g/mile | Metric Tons | | | | Metric Tons | | | | Metric Tons | | | |
| Southerly | Diesel | 17,586.0 | 16,017.4 | 66,308.4 | 1.43 | 0.013 | 0.015 | 25.15 | 2.29E-04 | 2.64E-04 | 25.22 | 22.90 | 2.08E-04 | 2.40E-04 | 22.97 | 94.82 | 8.62E-04 | 9.95E-04 | 95.08 |
| Westerly | | 7,742.0 | 9,152.0 | 18,499.0 | 1.43 | 0.013 | 0.015 | 11.07 | 1.01E-04 | 1.16E-04 | 11.10 | 13.09 | 1.19E-04 | 1.37E-04 | 13.12 | 26.45 | 2.40E-04 | 2.77E-04 | 26.53 |
| Easterly | | 7,664.0 | 10,236.0 | 24,084.6 | 1.43 | 0.013 | 0.015 | 10.96 | 9.96E-05 | 1.15E-04 | 10.99 | 14.64 | 1.33E-04 | 1.54E-04 | 14.68 | 34.44 | 3.13E-04 | 3.61E-04 | 34.53 |
| Pump | | 668.0 | 1,748.0 | 930.0 | 1.43 | 0.013 | 0.015 | 0.96 | 8.68E-06 | 1.00E-05 | 0.96 | 2.50 | 2.27E-05 | 2.62E-05 | 2.51 | 1.33 | 1.21E-05 | 1.40E-05 | 1.33 |
| EMSC | | 10,714.0 | 12,210.0 | 44,170.0 | 1.43 | 0.013 | 0.015 | 15.32 | 1.39E-04 | 1.61E-04 | 15.36 | 17.46 | 1.59E-04 | 1.83E-04 | 17.51 | 63.16 | 5.74E-04 | 6.63E-04 | 63.33 |
| GJM | | 15,812.0 | 20,904.0 | 17,420.0 | 1.43 | 0.013 | 0.015 | 22.61 | 2.06E-04 | 2.37E-04 | 22.67 | 29.89 | 2.72E-04 | 3.14E-04 | 29.97 | 24.91 | 2.26E-04 | 2.61E-04 | 24.98 |

**Footnotes:**

1. Vehicle miles provided by the facility.
2. Product transport emission factors based on Table 9 of the EPA GHG Inventory, last modified in November 2015.
3. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

**Sample Calculations:**

2014 Gasoline N2O emissions (Mt) = 55,986.4 miles/yr x 0.013 g/mile x 1 Mt/1,000,000 g

## Table A-11: NEORSD 2014-2016 Scope 3 Emissions from Employee Travel

| Site Name | Vehicle Type | 2014 | 2015 | 2016 | Emission Factor[2] | | | 2014 Emissions | | | | 2015 Emissions | | | | 2016 Emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Miles Travelled[1] | | | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$[3] | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$[3] | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e$[3] |
| | | Miles/yr | | | Kg/mile | g/mile | g/mile | Metric Tons | | | | Metric Tons | | | | Metric Tons | | | |
| Southerly | Passenger Car | 1,344,917 | 1,344,917 | 1,344,917 | 0.36 | 0.0015 | 0.021 | 477.45 | 2.02E-03 | 2.82E-02 | 478.77 | 477.45 | 2.02E-03 | 2.82E-02 | 478.77 | 477.45 | 2.02E-03 | 2.82E-02 | 478.77 |
| Westerly | | 381,060 | 381,060 | 381,060 | 0.36 | 0.0015 | 0.021 | 135.28 | 5.72E-04 | 8.00E-03 | 135.65 | 135.28 | 5.72E-04 | 8.00E-03 | 135.65 | 135.28 | 5.72E-04 | 8.00E-03 | 135.65 |
| Easterly | | 358,644 | 358,644 | 358,644 | 0.36 | 0.0015 | 0.021 | 127.32 | 5.38E-04 | 7.53E-03 | 127.67 | 127.32 | 5.38E-04 | 7.53E-03 | 127.67 | 127.32 | 5.38E-04 | 7.53E-03 | 127.67 |
| EMSC | | 1,456,993 | 1,456,993 | 1,456,993 | 0.36 | 0.0015 | 0.021 | 517.23 | 2.19E-03 | 3.06E-02 | 518.67 | 517.23 | 2.19E-03 | 3.06E-02 | 518.67 | 517.23 | 2.19E-03 | 3.06E-02 | 518.67 |
| GJM | | 3,070,893 | 3,070,893 | 3,070,893 | 0.36 | 0.0015 | 0.021 | 1,090.17 | 4.61E-03 | 6.45E-02 | 1,093.19 | 1,090.17 | 4.61E-03 | 6.45E-02 | 1,093.19 | 1,090.17 | 4.61E-03 | 6.45E-02 | 1,093.19 |

**Footnotes:**

1. Passenger car mileage estimated by the facility based on commuter survey. The mileage is speciated among the five sites using the employee count per site obtained through the survey.
2. Business travel emission factors based on Table 8 of the EPA GHG Inventory, last modified in November 2015.
3. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

**Sample Calculations:**

2014 $N_2O$ Emissions (Mt) =1,344,916.8 miles/yr x 0.0015 g/mile x 1 Mt/1,000,000 g

## Table A-12: NEORSD 2014-2016 Scope 3 Emissions from Employee Travel

| Type | 2014 | 2015 | 2016 | Emission Factor[2] | | | 2014 Emissions | | | | 2015 Emissions | | | | 2016 Emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Miles Travelled[1] | | | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ |
| | Miles/yr | | | Kg/mile | g/mile | g/mile | Metric Tons | | | | Metric Tons | | | | Metric Tons | | | |
| Reimbursed Mileage | 69,002 | 67,865 | 79,520 | 0.355 | 0.002 | 0.021 | 24.50 | 1.04E-04 | 1.45E-03 | 24.56 | 24.09 | 1.02E-04 | 1.43E-03 | 24.16 | 28.23 | 1.19E-04 | 1.67E-03 | 28.31 |
| Air Travel | 216,984 | 143,246 | 235,962 | 0.143 | 0.005 | 0.000 | 31.03 | 1.02E-03 | 0.00E+00 | 31.30 | 20.48 | 6.73E-04 | 0.00E+00 | 20.66 | 33.74 | 1.11E-03 | 0.00E+00 | 34.04 |

**Footnotes:**

1. Vehicle miles estimated based employee travel records. Air travel mileage was estimated based on employee travel records and Cleveland airport as the place of departure.
2. Business travel emission factors based on Table 8 of the EPA GHG Inventory, last modified in November 2015.
4. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

**Sample Calculations:**

2014 $N_2O$ emissions (Mt) = 69,002.2 miles/yr x 0.002 g/mile x 1 Mt/1,000,000 g

**Table A-13: NEORSD 2014-2016 Scope 3 Emissions from Lawn Maintenance**

| Site Name/Property | Type of Service | Days/yr[1] | Acerage[1] | 2014 Emission Factor (g/acre/day)[2] | | 2014 Emissions (MT/yr) | | | 2015 Emission Factor (g/acre/day)[2] | | 2015 Emissions (MT/yr) | | | 2016 Emission Factor (g/acre/day)[2] | | 2016 Emissions (MT/yr) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $CO_2$ | $CH_4$ | $CO_2$ | $CH_4$ | $CO_2e$[3] | $CO_2$ | $CH_4$ | $CO_2$ | $CH_4$ | $CO_2e$[3] | $CO_2$ | $CH_4$ | $CO_2$ | $CH_4$ | $CO_2e$[3] |
| EMSC | Landscape Services: Litter and debris collection and removal, mowing and trimming, pruning and shrub trimming as needed, Spring mulching in landscape beds and tree rings, | 22 | 4.25 | 41,521.64 | 49.90 | 3.882 | 4.67E-03 | 4.01 | 41,521.63 | 46.57 | 3.88 | 4.35E-03 | 4.00 | 41,521.64 | 43.71 | 3.88 | 4.09E-03 | 4.00 |
| Southerly: South Fill Area | Litter and debris removal, mowing and trimming | 3 | 16.00 | 41,521.64 | 49.90 | 1.993 | 2.40E-03 | 2.06 | 41,521.63 | 46.57 | 1.99 | 2.24E-03 | 2.06 | 41,521.64 | 43.71 | 1.99 | 2.10E-03 | 2.05 |
| Southerly: Manholes and Paths | Litter and debris removal, mowing and trimming | 14 | 1.25 | 41,521.64 | 49.90 | 0.727 | 8.73E-04 | 0.75 | 41,521.63 | 46.57 | 0.73 | 8.15E-04 | 0.75 | 41,521.64 | 43.71 | 0.73 | 7.65E-04 | 0.75 |
| Southerly: Northern Perimeter Fencing | Litter and debris removal, mowing and trimming a 3 foot buffer on both sides of fence. | 14 | 0.88 | 41,521.64 | 49.90 | 0.512 | 6.16E-04 | 0.53 | 41,521.63 | 46.57 | 0.51 | 5.75E-04 | 0.53 | 41,521.64 | 43.71 | 0.51 | 5.39E-04 | 0.53 |
| Southerly: South Fill Area and Ash Lagoons Perimeter Fencing and Access Paths | Litter and debris removal, mowing and trimming a 3 foot buffer on both sides of fence. | 14 | 0.84 | 41,521.64 | 49.90 | 0.488 | 5.87E-04 | 0.50 | 41,521.63 | 46.57 | 0.49 | 5.48E-04 | 0.50 | 41,521.64 | 43.71 | 0.49 | 5.14E-04 | 0.50 |
| Southerly: Southern Perimeter Fencing | Litter and debris removal, mowing and trimming a 3 foot buffer on both sides of fence. | 14 | 0.65 | 41,521.64 | 49.90 | 0.376 | 4.52E-04 | 0.39 | 41,521.63 | 46.57 | 0.38 | 4.22E-04 | 0.39 | 41,521.64 | 43.71 | 0.38 | 3.96E-04 | 0.39 |
| Westerly | Weed and Vegetation Control of Stone Beds and Gravel, Hand pulling and string trimming | 22 | 0.74 | 41,521.64 | 49.90 | 0.679 | 8.16E-04 | 0.70 | 41,521.63 | 46.57 | 0.68 | 7.61E-04 | 0.70 | 41,521.64 | 43.71 | 0.68 | 7.15E-04 | 0.70 |
| GJM | Landscape Services: Litter and debris collection and removal, mowing and trimming, pruning and shrub trimming as needed, Spring mulching in landscape beds and tree rings, | 22 | 0.06 | 41,521.64 | 49.90 | 0.055 | 6.55E-05 | 0.06 | 41,521.63 | 46.57 | 0.05 | 6.11E-05 | 0.06 | 41,521.64 | 43.71 | 0.05 | 5.74E-05 | 0.06 |
| Remaining Areas | Litter and debris collection and removal, turf mowing and trimming, mulch maintenance and replacement, watering as need, plant replacement as needed, grass seeding as needed, October leaf clean up. | 22 | 88.35 | 41,521.64 | 49.90 | 80.706 | 9.70E-02 | 83.42 | 41,521.63 | 46.57 | 80.71 | 9.05E-02 | 83.24 | 41,521.64 | 43.71 | 80.71 | 8.50E-02 | 83.08 |
| Other | | | | | | | | 87.49 | | | | | 87.30 | | | | | 87.14 |
| **Total $CO_2e$ Emissions (MT/yr)** | | | | -- | -- | -- | -- | **92.43** | -- | -- | -- | -- | **92.23** | -- | -- | -- | -- | **92.05** |

**Footnotes:**

1. Estimated based on the data provided by the facility
2. Emission factor is based on the default usage rates and the emission factors of the landscape equipment estimated by CalEEMod®.
3. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

**Sample Calculations:**

2014 EMSC CH4 emissions (Mt) = 22 days/yr x 4.25 acre x 41,521.64 g/acre/day x 1 Mt/1,000,000 g

## Table A-14: NEORSD 2014-2016 Scope 3 Emissions from Snow Plowing

| Site Name | 2014 | 2015 | 2016 | Emission Factor[2] | | | 2014 Emissions | | | | 2015 Emissions | | | | 2016 Emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fuel Use[1] | | | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ |
| | gal/yr | | | Kg/gal | g/gal | g/gal | Metric Tons | | | | Metric Tons | | | | Metric Tons | | | |
| All areas | 17.5 | 7.8 | 6.8 | 10.21 | 0.26 | 0.57 | 0.18 | 4.56E-06 | 9.99E-06 | 0.18 | 0.08 | 2.03E-06 | 4.44E-06 | 0.08 | 0.07 | 1.77E-06 | 3.88E-06 | 0.07 |

**Footnotes:**

1. Estimated based on the number of snow events and the size of the paved area provided by the facility. A snow plow blade width of 120 inch is assumed for the calculations.
2. Emission factors based on EPA's GHG inventory guidance document "Direct Emissions from Mobile Sources" dated January 2016. Emission factor for nonroad vehicle type was used for methane and nitrous oxide emissions.
3. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

**Sample Calculations:**

2014 Gasoline N2O emissions (Mt) = 17.5 gal/yr x 0.26 g/gal x 1 Mt/1,000,000 g

## Table A-15: NEORSD 2014-2016 Scope 3 Emissions from Water Use

| Site Name | 2014 | 2015 | 2016 | 2014 | 2015 | 2016 | Emission Factor[2] | | | 2014 Emissions | | | | 2015 Emissions | | | | 2016 Emissions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water Use[1] | | | Energy Use | | | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ | $CO_2$ | $N_2O$ | $CH_4$ | $CO_2e^3$ |
| | MCF | | | | | | lb/MWh | lb/GWh | lb/GWh | Metric Tons | | | | Metric Tons | | | | Metric Tons | | | |
| Southerly | 20022 | 14496 | 11349 | 299.53 | 216.86 | 169.78 | 1380.90 | 150.20 | 22.00 | 187.67 | 0.02 | 0.003 | 193.16 | 135.87 | 0.01 | 0.00 | 139.85 | 106.37 | 0.01 | 0.00 | 109.48 |
| Easterly | 1875 | 5632 | 4834 | 28.05 | 84.25 | 72.32 | | | | 17.58 | 0.00 | 0.000 | 18.09 | 52.79 | 0.01 | 0.00 | 54.33 | 45.31 | 0.00 | 0.00 | 46.64 |
| Westerly | 2306 | 1921 | 1665 | 34.50 | 28.74 | 24.91 | | | | 21.61 | 0.00 | 0.000 | 22.25 | 18.00 | 0.00 | 0.00 | 18.53 | 15.61 | 0.00 | 0.00 | 16.07 |
| Other | 3610 | 2370 | 1061 | 42.2 | 35.5 | 15.9 | | | | 33.84 | 0.00 | 0.001 | 34.83 | 22.21 | 0.00 | 0.00 | 22.86 | 9.94 | 0.00 | 0.00 | 10.23 |

**Footnotes:**

1. Water use based on metering information
2. Emission factor based on USEPA's eGRID2014 value for subregion RFCWest
3. $CO_2$ equivalent ($CO_2e$) is calculated using the global warming potentials provided in IPCC Fifth Assessment Report, 2014 (AR5).

**Sample Calculations:**

2014 Water CO2 emissions (MT) = 28,601.6 MCF/yr x 0.00748 MG/MCF x 2 MWh/MG x 1380.9 lbs/MWh x 1 MT/2204 lbs

## Table A-16: NEORSD 2014-2016 Emissions from Construction

| Selected NAICS Subsector | GHG Intensity (MTCO2e/ 2002k$) | 2014 | 2015 | 2016 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|
| | | Construction Costs | | | Construction Emissions (CO2e) | | |
| Land subdivision | 0.11 | $ 6,105,560 | $ - | $ 1,516,082 | 510.36 | - | 125.01 |
| Other heavy and civil engineering construction | 0.37 | $ - | $ 2,547,357 | $ - | - | 715.37 | - |
| Water and sewer line and related structures construction | 0.37 | $ 2,019,254 | $ 195,040,632 | $ 76,198,567 | 567.74 | 54,773.26 | 21,133.82 |
| Industrial building construction | 0.27 | $176,526,965 | $ 57,537,093 | $ 54,490,714 | 36,218.57 | 11,791.08 | 11,028.48 |
| Commercial and Industrial Building Construction | 0.23 | $ 1,329,025 | $ 7,932,737 | $ 3,213,024 | 232.28 | 1,384.82 | 553.95 |
| | | | | | **37,528.95** | **68,664.53** | **32,841.27** |
| Conversion to 2002 $ | | -24.01 | -24.1 | -25.04 | | | |

**Footnotes:**

1. GHG intensity based on USEPA's Potential for Reducing Greenhouse Gas Emissions in the Construction Sector, Appendix B.
2. 2002 Dollars converted to evaluated year Dollars using https://www.officialdata.org

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