Notice of Construction Application
Supporting Information Report
CyrusOne Data Center
Quincy, Washington

December 26, 2018

Prepared for

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THIS REPORT HAS BEEN PREPARED TO PROVIDE SUPPORTING DOCUMENTATION FOR WASHINGTON STATE DEPARTMENT OF ECOLOGY FORM NO. ECY 070-410, *NOTICE OF CONSTRUCTION APPLICATION: NEW PROJECT OR MODIFICATION OF EXISTING STATIONARY SOURCE*. EACH SECTION OF THIS REPORT PROVIDES A CROSS-REFERENCE TO THE SECTION OF FORM NO. ECY 070-410 FOR WHICH SUPPORTING DOCUMENTATION IS BEING PROVIDED.

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LIST OF ABBREVIATIONS AND ACRONYMS

$\mu g/m^3$	microgram per cubic meter
AERMAP	AMS/EPA regulatory model terrain pre-processor
AERMET	AERMOD meteorological pre-processor
AERMOD	AMS/EPA regulatory model
AMS	American Meteorological Society
ASIL	acceptable source impact level
BACT	best available control technology
CFR	Code of Federal Regulations
CO	carbon monoxide
DEEP	diesel engine exhaust particulate matter
DOC	diesel oxidation catalyst
DPF	diesel particulate filter
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
g/kWm-hr	grams per mechanical kilowatt-hour
GEP	good engineering practice
HAP	hazardous air pollutant
ISC	Industrial Source Complex
kW	kilowatts
LAI	Landau Associates, Inc.
MW	megawatts
m	meter
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO_2	nitrogen dioxide
NOC	Notice of Construction
NO_x	nitrogen oxides
NSPS	New Source Performance Standard
NSR	New Source Review
NWS	National Weather Service
PM	particulate matter
$PM_{2.5}$	PM with an aerodynamic diameter less than or equal to 2.5 microns
PM_{10}	PM with an aerodynamic diameter less than or equal to 10 microns
ppm	parts per million
PVMRM	Plume Volume Molar Reaction Model
RCW	Revised Code of Washington
RICE	reciprocating internal combustion engine

LIST OF ABBREVIATIONS AND ACRONYMS (CONTINUED)

SCR	selective catalytic reduction
SIT	site integration test
SO_2	sulfur dioxide
SQER	small-quantity emission rate
TAP	toxic air pollutant
tBACT	BACT for toxic air pollutants
USGS	US Geological Survey
VOC	volatile organic compound
WAAQS	Washington Ambient Air Quality Standards
WAC	Washington Administrative Code

1.0 EXECUTIVE SUMMARY

CyrusOne is a colocation data center, meaning that CyrusOne owns data centers in which other companies lease space for servers and other computing hardware. Colocation data centers fall under Standard Industrial Classification (SIC) code 7376 – Computer Facilities Management Services.

CyrusOne proposes to construct and operate a new data center complex in Quincy, Washington (Figure 1). This document has been prepared to support the submittal of a Notice of Construction (NOC) application for installation and operation of new emergency generators, under air quality regulations promulgated by the Washington State Department of Ecology (Ecology). The proposed CyrusOne data center complex will be located on Grant County Parcel No. 040411075, at 1025 NW D Street in Quincy, Washington.

The data center complex will include one “Colocation” building and one “Cloud Center” building. The Colocation building will house up to nine emergency generators (eight generators for server building backup and one “house generator” serving the office and support areas of the data center complex). The Cloud Center building will house up to 33 emergency generators (32 generators for server building backup and 1 house generator).

A site map for the proposed development is provided on Figure 2.

The list of equipment that was evaluated for this NOC application consists of the following:

- Two (2) model-year 2018, MTU Model 12V2000G85-TB 750-kilowatt (kW) emergency generators, each with 23.9-liter displacement.
- Forty (40) model-year 2018, MTU Model 16V4000G84S 2.25-megawatt (MW) emergency generators, each with 76.3-liter displacement.

Consistent with the recent approach to permitting data centers in Quincy—in which the worst-case emissions are evaluated to allow permitting on a cumulative hours basis rather than on a scenario- and load-specific basis—CyrusOne is requesting the following Approval Order conditions:

- Annual runtime limits of:
    - Limit of 1,520 cumulative generator hours for the proposed 2.25-MW generators:
        - A theoretical maximum year of 3,440 cumulative generator hours without startup and commissioning.
        - A theoretical maximum year of 4,160 cumulative generator hours with startup and commissioning.
    - Limit of 76 cumulative generator hours for the proposed 750-kW generators:
        - A theoretical maximum year of 172 cumulative generator hours without startup and commissioning.

    - A theoretical maximum year of 208 cumulative generator hours with startup and commissioning.
- The operation of several generators concurrently for more than 3 hours in any 24-hour period shall not occur for more than 3 calendar days in any 3-calendar-year period.
- Concurrent operation of several generators shall not occur for more than 9 calendar days in any 3-calendar-year period.
- Operation of one generator at a time must be limited to 10 hours per day, during daytime hours only (7:00 a.m. to 7:00 p.m.). Additionally, one-at-a-time generator operation will be scheduled and coordinated with nearby data centers.
- The limits described above will accommodate requirements for generator startup, commissioning site integration testing (SIT), and stack testing.

The evaluation in this NOC application and the evaluation that will be presented in the second-tier health impact assessment have been completed to allow for Approval Order conditions that do not assign specific fuel or runtime limits to each individual runtime activity (e.g., unplanned power outages). Additionally, CyrusOne is requesting that compliance with the annual generator runtime and fuel usage limitations be based on a 3-year averaging period using monthly rolling totals.

Air pollutant emission rate estimates were calculated based on vendor-provided not-to-exceed emission factors or emission factors from the US Environmental Protection Agency's (EPA's) AP-42 Volume I, Chapter 3.4 (EPA 1995). CyrusOne is requesting flexibility to operate the generators at any load; therefore, the emission rates used for this evaluation were based on emission factors for the highest emitting load for each pollutant. In order to account for slightly higher emissions during the first minute of each engine cold startup, the estimated emission rates of pollutants associated with cold-startup were scaled up using a "black-puff" emission factor.

Based on the results of this evaluation, the recommended Best Available Control Technology for criteria pollutants (BACT) and toxic air pollutants (tBACT) is emission limitations consistent with the EPA's Tier 2 emission standards, which is achieved with combustion controls and the use of ultra-low sulfur diesel fuel. The basis for this recommendation is that the cost of EPA Tier 4-compliant emission controls is disproportionate to the benefit (i.e., emission reduction) achieved. Subject to Ecology's review and approval, the evaluations presented in this NOC application support the proposal of the following emission rates as BACT for the emergency generators to be installed at the proposed CyrusOne data center complex:

Best Available Control Technology Proposal

Pollutant(s)	BACT and tBACT Proposal
Particulate matter (PM), carbon monoxide (CO), volatile organic compounds (VOC), and nitrogen oxides (NO_x)	Use of EPA Tier 2-certified engines when installed and operated as emergency engines, as defined by 40 CFR 60.4219.

Pollutant(s)	BACT and tBACT Proposal
	Compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart III.
Sulfur dioxide (SO_2)	Use of ultra-low sulfur diesel fuel containing no more than 15 parts per million (ppm) by weight of sulfur.
Toxic air pollutants, including CO, acrolein, benzene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, naphthalene, propylene, 1,3-butadiene, diesel engine exhaust particulate matter (DEEP), formaldehyde, xylenes, nitrogen dioxide (NO_2) and SO_2.	Compliance with the proposed BACT requirements for PM, CO, VOCs, NO_x, and SO_2.

Air dispersion modeling was conducted for criteria air pollutants and toxic air pollutants (TAPs). The results of modeling demonstrate that ambient criteria pollutant concentrations that result from operations at CyrusOne data center complex, and other local and regional background sources, are below the National Ambient Air Quality Standards (NAAQS). Additionally, the results of modeling demonstrate that ambient TAP concentrations that result from operations at CyrusOne data center complex are below Washington acceptable source impact levels (ASILs), with the exception of NO_2 and DEEP. Because modeled NO_2 and DEEP concentrations exceed ASILs, a second-tier health impact assessment will be prepared and submitted to Ecology under separate cover.

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2.0 INTRODUCTION

Landau Associates, Inc. (LAI) prepared this document on behalf of CyrusOne to support the submittal of a Notice of Construction (NOC) application for installation and operation of new emergency generators, under air quality regulations promulgated by the Washington State Department of Ecology (Ecology). The proposed CyrusOne data center complex will be located on Grant County Parcel No. 040411075, at 1025 NW D Street, Quincy, Washington. The legal description of the property is as follows:

> THAT PORTION OF FARM UNIT 186 IRRIGATION BLOCK 73, COLUMBIA BASIN PROJECTION IN THE NORTHWEST QUARTER OF SECTION 7, TOWNSHIP 20 NORTH, RANGE 24 E.W.M., GRANT COUNTY, WASHINGTON, DESCRIBED AS FOLLOWS;BEGINNING AT THE WEST QUARTER CORNER OF SAID SECTION; THENCE NORTH 89°57'58""EAST, FOLLOWING THE EAST-WEST MIDSECTION LINE OF SAID SECTION AND THE SOUTH BOUNDARY OF FARM UNIT 187, IRRIGATION BLOCK 73, 719.00 FEET, TO THE SOUTHWEST CORNER OF FARM UNIT 186 AND THE TRUE POINT OF BEGINNING; THENCE NORTH 89°57'58""EAST, FOLLOWING THE SOUTH BOUNDARY OF SAID FARM UNIT 186, 1166.19 FEET; THENCE NORTH 00°01'04""WEST, 1929.25 FEET, TO AN INTERSECTION WITH THE NORTH BOUNDARY OF SAID FARM UNIT 186 AND A POINT ON A CURVE THE CENTER OF WHICH BEARS NORTH 08°35'44""WEST; THENCE FOLLOWING THE BOUNDARIES OF SAID FARM UNIT 186 THROUGH THE FOLLOWING SEVEN (7) COURSES, GOING WESTERLY FOLLOWING SAID CURVE TO THE RIGHT HAVING A CENTRAL ANGLE OF 07°58'44"" A RADIUS OF 286.48 FEET AND AN ARC LENGTH OF 39.90 FEET; THENCE SOUTH 89°23'00""WEST, 185.45 FEET; THENCE WESTERLY FOLLOWING A TANGENTIAL CURVE TO THE LEFT HAVING A CENTRAL ANGLE OF 19°03'00"" A RADIUS OF 286.48 FEET AND AN ARC LENGTH OF 95.25 FEET; THENCE SOUTH 70°20'00""WEST, 428.53 FEET; THENCE SOUTHWESTERLY FOLLOWING A TANGENTIAL CURVE TO THE LEFT HAVING A CENTRAL ANGLE OF 07°09'00"" A RADIUS OF 572.96 FEET AND AN ARC LENGTH OF 71.50 FEET; THENCE SOUTH 63°11'00""WEST, 423.44 FEET, TO THE NORTHWEST CORNER OF SAID FARM UNIT 186; THENCE SOUTH 00°00'00""EAST, 1544.60 FEET, TO THE TRUE POINT OF BEGINNING.

The project will include the construction of two computer server buildings and the installation of 42 emergency generators (40 generators for server building backup and 2 house generators serving the office and support areas of the data center complex).

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3.0 PROJECT DESCRIPTION

(Section III of NOC application form)

3.1 Facility Description

CyrusOne proposes to construct and operate a new data center complex in Quincy, Washington. The proposed data center complex would be located north of D Street NW and approximately 800 feet east of 13th Avenue NW, immediately west of the existing Dell Western Technology Center, northwest of Microsoft's Columbia Data Center, and northeast of Microsoft's MWH Data Center. Vicinity maps are provided on Figures 1 and 3. The site is accessible by D Street NW to the south of the site.

A site map for the proposed project is provided on Figure 2. The data center complex will include one "Colocation" building and one "Cloud Center" building.

The CyrusOne data center complex may house different tenants throughout the facility; therefore, this ambient air impact evaluation assesses exposure to air pollutants within the facility's fence line.

3.1.1 Diesel-Powered Emergency Generators

This section describes emissions from the exhaust stacks of the diesel-fired engines that are included with each emergency generator. The emergency generator includes a diesel-powered engine that drives an alternator section to produce electricity. The alternator section does not emit any air pollutants, so the overall emissions from a diesel generator are produced only from the diesel engine. State and federal air quality regulations apply only to the emissions from the diesel engines. The terms "generator" and "engine" are used interchangeably in this report.

Each generator will be operated only as an emergency generator, with generator usage and runtime hours limited to those for "emergency generators" by the federal New Source Performance Standard (NSPS) Subpart IIII. NSPS Subpart IIII requires that emergency engines satisfy EPA Tier 2 emission standards as defined by the federal regulations (40 CFR Part 89). All emergency generators at the facility will satisfy EPA Tier 2 standards, as required, and will use ultra-low sulfur diesel fuel (15 ppm sulfur content).

Each of the emergency generators will be housed within enclosures with stack locations shown on Figure 2. Each 750-kW generator will have its own exhaust stack extending at least 25 feet above the ground. Each 2.25-MW generator will have its own exhaust stack extending at least 35 feet above ground. Specifications and manufacturer-provided emissions data for the proposed generators are provided in Appendix A. The equipment evaluated for this NOC application consists of two model-year 2018, MTU Model 12V2000G85-TB diesel emergency generators and 40 model-year 2018, MTU Model 16V4000G84S diesel emergency generators. If model numbers change in future years during the planned phased construction, specification sheets for the updated generator models will be provided to Ecology. The generators have the following specifications:

- Two (2) 750-kW generators. The engines will have a displacement of 23.9 liters over 12 cylinders, or 1.99 liters per cylinder. Note, the MTU emissions data sheets for the engine that is included in this model generator package indicate that the maximum power for this unit is 890 kW; however, it is de-rated and sold as a 750-kW standby generator.
- Forty (40) 2.25-MW generators with a combined capacity of 90.0 MW. The engines will have a displacement of 76.3 liters, over 16 cylinders, or 4.8 liters per cylinder. Note, the MTU emissions data sheets for the engine that is included in this model generator package indicate that the maximum power for this unit is 2,500 kW; however, it is de-rated and sold as a 2.25-MW standby generator.

CyrusOne will not install any other diesel engines for use as fire pumps or for life-safety purposes.

3.1.2 Evaporative Cooling Units

There will not be any wet mechanical-draft cooling towers used for the project; however, direct evaporative cooling units will provide cold air to the building's air handling systems. The units are not a source of air emissions (i.e., there is no drift loss), but a description is provided here for informational purposes. The units use direct evaporative cooling to cool data halls, which make up most of the data center complex. The cooling units evaporate City or well water into the airstream serving the data halls, and eventually discharge that air back into the atmosphere. The main impact of the system to the surrounding environment is increased moisture/humidity. No known contaminants will be introduced into the surrounding atmosphere. Specific equipment models have not yet been selected for the project, but standard industry available equipment will be used, as described in the information provided in Appendix A.

3.2 Generator Runtime Scenarios

The emission estimates and ambient impact modeling presented in this NOC application are based on emissions at "full-variable load," which corresponds to the characteristic worst-case emission load of each pollutant. Emission estimates are discussed in more detail in Section 4.0.

On an annual basis, CyrusOne requests that compliance with per-generator runtime limits be demonstrated by summing total actual operating hours for all generators in service and comparing that to the total number of permitted hours for all generators in service. Additionally, CyrusOne is requesting that compliance with the annual fuel usage and operating hour limitations be averaged over a 3-year period using monthly rolling totals. For example, total fuel and operating hours will be summed for the 3-year period and an annual average for that period will be calculated and compared to the annual fuel and hour limits. To demonstrate that these requests will result in facility operations and air pollutant emissions that are below regulatory thresholds, this evaluation considers two annual operating scenarios:

- The following **annual runtime limits** are requested based on CyrusOne operational needs:
  - Limit of 1,520 cumulative generator hours for the proposed 2.0-MW generators

  - Limit of 76 cumulative generator hours for the proposed 750-kW generators.
- A **"theoretical maximum year"** addresses the worst-case consideration that, for fuel usage and hour limitations to be averaged over a 3-year period, there is potential for emitting the 3-year maximum entirely within a single year. Because maintenance would need to be conducted each year, the theoretical maximum year includes one year of hours allotted to maintenance (14 hours) plus three years of hours allotted to power outage use (72 hours) for each generator. The theoretical maximum year also includes up to 756 total cumulative generator run hours that can be used for the purposes of startup and commissioning. The theoretical maximum cumulative hours for all 2.25-MW generators in a single year would be 4,160 (3,440 hours for maintenance and power outage and 720 hours for commissioning). The theoretical maximum cumulative hours for the 750-kW generators in a single year would be 208 (172 hours for maintenance and power outage and 36 hours for commissioning). If more than 756 total cumulative generator operating hours are required for startup and commissioning in a single year, those would be counted against the annual operating runtime limit. This unlikely but possible event is considered the ultra-worst case scenario for project-related emissions from the emergency generators and was used for demonstration of compliance with the annually averaged NAAQS and Washington State TAP standards with an annual averaging period.

Generator operating scenarios for the CyrusOne data center complex are as follows:

- **Monthly maintenance testing**: Routine operation and maintenance on the emergency generators will be conducted approximately twice each month. This runtime activity will be conducted on one emergency generator at a time for up to 1 hour per generator, per month. However, on rare occasions when a problem is identified and a generator requires diagnosis and repair, it may be necessary to operate it longer than 1 hour per month.
- **Annual load bank testing**: A load bank test will be conducted on each generator once per year. The load bank test will be conducted under full-variable load for approximately 2 hours on one generator at a time. Multiple generators will not be run concurrently during load bank testing.
- **Unplanned power outage**: During a power outage at the site, all installed generators will activate in order to supplement power to the server system and the administrative building. All 42 generators will operate concurrently under full-variable load.
- **Generator startup and commissioning**: After a new generator is installed, that generator will require commissioning, which includes up to 12 hours of individual operation under a range of loads. Additionally, after all generators have been installed, the final step of commissioning includes up to 8 hours of SIT, which requires operation of all the generators in service. It is assumed that two cold-startups (per engine) will occur during the individual engine commissioning and two additional cold-startups will occur for the SIT.
- **Stack testing**: It is anticipated that Ecology will require exhaust stack emission testing of a single generator of each make/model and size once every 5 years in order to demonstrate continued compliance with air quality standards. It is assumed that each stack test can take up to 8 hours. The worst-case scenario would be if a generator failed the stack test, requiring two follow-up tests in the same year. The worst-case runtime that could occur in a single year from stack testing would be operation of three generators for 8 hours each. It is assumed that one cold-start event will occur per test.

The evaluation documented in this NOC application demonstrates that the above-described operating scenarios will result in facility operations and air pollutant impacts that are in compliance with all federal and state laws and regulations. In summary, we request the following Approval Order conditions to allow for minimum operational needs:

- Annual runtime limits of:
    - Limit of 1,520 cumulative generator hours for the proposed 2.250-MW generators:
        - A theoretical maximum year of 3,440 cumulative generator hours without startup and commissioning
        - A theoretical maximum year of 4,160 cumulative generator hours with startup and commissioning
    - Limit of 76 cumulative generator hours for the proposed 750-kW generators
        - A theoretical maximum year of 172 cumulative generator hours without startup and commissioning
        - A theoretical maximum year of 208 cumulative generator hours with startup and commissioning.
- The operation of several generators concurrently for more than 3 hours in any 24-hour period shall not occur more than 3 calendar days in any 3-calendar-year period.
- The operation of several generators, operating concurrently at any one time, shall not occur more than 9 calendar days in any 3-calendar-year period.
- Operation of one generator at a time must be limited to no more than 10 hours per day, during daytime hours only (7:00 a.m. to 7:00 p.m.). Additionally, one-at-a-time generator operation will be scheduled and coordinated with other nearby data centers.
- The limits described above will accommodate requirements for generator startup, commissioning SIT, and stack testing.

The evaluation in this NOC application and the evaluation that will be presented in the second-tier health impact assessment have been completed to allow for Approval Order conditions that do not assign specific fuel or runtime limits to each individual runtime activity (e.g., unplanned power outages). Additionally, CyrusOne requests that compliance with the annual generator runtime and fuel usage limitations be based on a 3-year averaging period using monthly rolling totals.

3.3 Compliance with State and Federal Regulations

The CyrusOne data center complex will comply with the following applicable air regulations, in accordance with the federal and state Clean Air Acts. These requirements are specified in:

- Chapter 70.94 Revised Code of Washington (RCW) (Washington Clean Air Act)
- Chapter 173-400 Washington Administrative Code (WAC) (General Regulations for Air Pollution Sources)
- Chapter 173-460 WAC (Controls for New Sources of Toxic Air Pollutants)

- 40 Code of Federal Regulations (CFR) Part 60 Subpart A (General Provisions)
- 40 CFR Part 60 Subpart IIII (Stationary Compression Ignition Internal Combustion Engines)
- 40 CFR Part 63 Subpart ZZZZ (National Emission Standards for Hazardous Air Pollutants [NESHAP] for Reciprocating Internal Combustion Engines [RICEs]).

Specifically, the project includes sources of air contaminants and will follow applicable air contaminant regulations as listed in:

- RCW 70.94.152
- WAC 173-400-113
- WAC 173-460-040.

The project is located in an attainment area for all Clean Air Act criteria pollutants. Since the maximum potential-to-emit for all criteria pollutants will be less than 250 tons per year, the permittee is applying for an approval order to meet minor New Source Review (NSR) requirements. Facilities that produce more than 100 tons per year of any criteria pollutant are considered major sources under the federal regulation 40 CFR Part 70 and the state regulation WAC 173-410 et seq., and those that produce less than 100 tons per year are considered minor sources. Potential-to-emit estimates provided in Section 4.0 demonstrate that the facility will emit:

- Less than 100 tons per year of any criteria pollutant (PM, CO, NO_2, SO_2, and VOCs)
- Less than 10 tons per year of any EPA hazardous air pollutant (HAP)
- Less than 25 tons per year of total HAPs.

As a result, neither a Prevention of Significant Deterioration NSR pre-construction permit nor a Title V operating permit is required.

All of the generators will be operated in a manner that satisfies the definition of “emergency engines” according to the federal regulations NSPS Subpart IIII and NESHAP Subpart ZZZZ. Therefore, NSPS Subpart IIII requires that each generator shall be manufactured and certified to meet EPA Tier 2 emission limits. The applicable sections of NESHAP Subpart ZZZZ indicate that compliance with the NESHAP for emergency engines requires each generator to meet the EPA Tier 2 emission standards, and each generator must be operated and maintained in accordance with the requirements of NSPS Subpart IIII.

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4.0 AIR POLLUTANT EMISSION ESTIMATES

(Section VIII of NOC application form)

Air pollutant emission rates were calculated for the generators per the requirements of WAC 173-400-103 and WAC 173-460-050. Emission rates were calculated for criteria pollutants and TAPs based on peak hourly (worst-case maximum) and long-term (annual maximum) operating scenarios. For comparison of emission rate standards of short-term durations, such as 1-hour, 8-hour, or 24-hour averaging periods, the peak hourly rate was multiplied by the corresponding number of operating hours (i.e., maximum duration of a particular runtime scenario).

The emergency generators will be guaranteed by the manufacturer to meet EPA Tier 2 emission standards for non-road diesel engines. The emergency generator manufacturer is MTU. MTU's reported not-to-exceed generator emission factors for CO, nitrogen oxides (NO_x), and PM were used to estimate emission rates. Additionally, the manufacturer-provided hydrocarbon emission rate was assumed to represent the emission rate for total VOC emissions.

4.1 Derivation of Emission Factors, Facility-Wide Emission Rates, and Fuel Usage

During all operations, the generators will activate at less than or equal to 100 percent load (full-variable load). CyrusOne is requesting the flexibility to operate the emergency generators at any load, which will be set based on electrical demand. Considering that not all pollutant emission rates are maximum under the same operating load and because CyrusOne is requesting the flexibility to operate at any load, the pollutant-specific maximum emission rate, under any load less than or equal to 100 percent, was assumed for calculating the worst-case emission rates. These vendor-reported worst-case emission rates are provided in Table 1 and were used in all compliance demonstrations.

Emissions of DEEP are conservatively assumed to be equal to the manufacturers' not-to-exceed emissions value for total PM emission rates. The emission rates for PM with aerodynamic diameters of less than or equal to 10 microns (PM_{10}) and less than or equal to 2.5 microns ($PM_{2.5}$) include an estimate for "front-half" (filterable PM) and "back-half" (condensable PM) emissions for all modeling scenarios that demonstrate compliance with the NAAQS. The filterable PM estimate is equal to the manufacturer's not-to-exceed emission factor for PM. Condensable PM is assumed to be equal to the manufacturer's not-to-exceed value for total hydrocarbons, which is considered equivalent to an estimate for analysis by EPA Method 202.

All remaining pollutant emission rates, except for SO_2, were calculated using emission factors from the EPA's AP-42, Volume I, Chapter 3.4, which provides emission factors for HAPs from large internal combustion diesel engines (EPA 1995). These factors are based on fuel consumption. However, as listed in the generator specification sheets (provided in Appendix A), fuel consumption is highest at 100 percent load. Therefore, the maximum fuel consumption for full-variable load operations of all 42 generators would be 252,153 gallons of diesel fuel per year, averaged over 3 years. Table 2 summarizes the maximum fuel-based facility-wide emission estimates and fuel consumption rates.

The emission rate for SO_2 was calculated using a mass-balance approach based on the maximum sulfur content in the fuel (i.e., 15 ppm) and the maximum expected fuel usage.

4.2 Cold-Start Emissions

In order to account for slightly higher emissions during the first minute of each engine cold startup, the estimated emission rates of pollutants associated with cold-startup (PM, CO, NO_x, total VOCs, and volatile TAPs) were scaled up using a “black-puff” emission factor. These “black-puff” factors are based on short-term concentration trends for VOC, CO, and NO_x emissions observed immediately after cold-start of a large diesel backup generator. These observations were documented by the California Energy Commission’s report, Air Quality Implications of Backup Generators in California (Miller and Lents 2005). Our derivation of cold-start emission factors are provided in Table 3. Additional details are provided in Appendix B.

This analysis conservatively assumed that 28 cold-starts would be required per engine, per year. All compliance demonstrations assume at least one cold-start per engine for every day the engine is operated.

The resultant facility-wide potential-to-emit is provided in Table 4.

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5.0 EMISSION STANDARD COMPLIANCE

(Section VII of NOC application form)

The emergency diesel generators are subject to the emission control requirements under NSPS Subpart IIII, “Standards of Performance for Stationary Compression Ignition Internal Combustion Engines.” The runtime limits requested for the generators satisfy the definition of “emergency generator” as specified by NSPS Subpart IIII. Based on that definition of “emergency generators,” NSPS Subpart IIII indicates that the new generators are subject to EPA Tier 2 emission limits as specified by 40 CFR Part 89.

CyrusOne will conduct all notifications, generator maintenance, recordkeeping, and reporting as required by NSPS Subpart IIII.

The generators will also be subject to the NESHAP requirements under Subpart ZZZZ, “National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines (RICEs).” NESHAP Section 63.6590(c)(1) specifies requirements for emergency RICEs that are also subject to NSPS Subpart IIII. The CyrusOne facility will be an “area source” of federal HAPs; accordingly, NESHAP Section 63.6590(c)(1) indicates that the emergency generators will not be required to comply with any portions of Subpart ZZZZ as long as the generators comply with EPA Tier 2 emission standards and CyrusOne operates the generators in compliance with NSPS Subpart IIII.

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6.0 BEST AVAILABLE CONTROL TECHNOLOGY ANALYSIS

(Section VIII of NOC application form)

6.1 General Approach for Best Available Control Technology Assessment

BACT is an emission limitation based on the maximum degree of reduction that can be feasibly achieved for each air pollutant emitted from any new or modified stationary source. Ecology determines BACT using a "top-down" approach as described in the EPA's draft New Source Review Workshop Manual: Prevention of Significant Deterioration and Non-Attainment Area Permitting (EPA 1990). The following five steps are involved in the top-down process:

1. The first step in the top-down analysis is to identify all available control technologies that can be practicably applied for each emission unit.
2. The second step is to determine the technical feasibility of potential control options and to eliminate options that are demonstrated to be technically infeasible.
3. The third step is to rank all remaining options based on control effectiveness, with the most effective control alternative at the top.
4. The fourth step is to evaluate the remaining control alternatives. If the top-ranked control alternative is considered unacceptable based on disproportionate economic, environmental, and/or energy impacts, it is discarded. Justifications for discarding top-ranked control options must be approved by Ecology.
5. The fifth and final step is to choose the top-ranked alternative from the list of control options remaining after applying Steps 1 through 4. This option becomes the BACT, including the resulting emission rate.

Control options for potential reductions in criteria pollutant and, as practical, TAP emissions were identified for each source. In Washington State, the term BACT refers to the control technology applied to achieve reductions in criteria pollutant emission rates. The term "tBACT" refers to BACT applied to achieve reductions in TAP emission rates. Technologies were identified by considering Ecology's previous environmental permit determinations for diesel generators in Washington State. Available controls that are judged to be technically feasible are further evaluated taking into account energy, environmental, and economic impacts and other costs.

The following sections summarize the findings and recommended BACT determination. Detailed cost estimates and assumptions that support this BACT assessment are provided in Appendix C. Additionally, electronic calculation spreadsheets in Excel format are provided in Appendix E.

6.2 Steps 1, 2, and 3: Identify Feasible Control Technologies for Diesel Generators

Based on Ecology's prior determinations in permitting diesel generators at computer data centers, the following technologies were considered to be commercially available and technically feasible for use at CyrusOne's proposed data center complex:

- **Tier 4 integrated control package**. This control option consists of an integrated diesel particulate filter (DPF), diesel oxidation catalyst (DOC), and urea-based selective catalytic reduction (SCR). This system is highly efficient for control of NO_x (90 percent), PM_{10}/$PM_{2.5}$/DEEP (88 percent of "front-half"), CO (80 percent), VOCs and gaseous TAPs (70 percent), and meets Tier 4 emission standards as defined by the federal regulations (40 CFR Part 89). Note, when engine or emission control system manufacturers are producing Tier 4-compliant engines, they will typically weld the DOC to the DPF and call it a "catalyzed DPF." While the Tier 4 integrated control package is technically feasible, it does have some operational constraints for emergency generators. For example, SCRs typically do not provide NO_x removal when the engine exhaust temperature is below the target temperature of 575 degrees Fahrenheit. It can take up to 60 minutes to reach the target temperature at low loads.
- **Urea-based SCR**. This control option is highly efficient for control of NO_x (90 percent) and NO_2. While the SCR is technically feasible, it does have some operational constraints for emergency generators as described above.
- **Catalyzed DPF**. This control option is highly efficient for control of PM_{10}/$PM_{2.5}$/DEEP (90 percent of "front-half"), CO (80 percent), VOCs and gaseous TAPs (70 percent). Note, catalyzed DPFs do not remove condensable ("back-half") particulates. Additionally, operation at low loads and exhaust temperatures does not allow for necessary routine regeneration of the DPF; therefore, additional operation at high loads/temperatures can be required.
- **DOC**. This control option is highly efficient for removal of CO (80 percent), VOCs and gaseous TAPs (70 percent). It is marginally effective for removal of PM_{10}/$PM_{2.5}$/DEEP (15 to 25 percent depending on the load). This analysis conservatively assumed 25 percent removal of PM_{10}/$PM_{2.5}$/DEEP ("front-half") for the DOC system.
- **Tier 2-certified**. Tier 2-certified engines rely on combustion controls and the use of ultra-low sulfur diesel fuel (15 ppm sulfur content) to comply with EPA Tier 2 emission standards.

In previous permit applications for data centers, three-way catalysts have also been considered to be technologically feasible for use on diesel generators. However, recent compliance stack tests required at another data center in Grant County, Washington indicated that three-way catalysts were ineffective for removal of NO_x, and that the device actually increased the emission rate for NO_2. Those test results support the conclusion that commercially available three-way catalysts are not technically feasible for emergency generator use; therefore, they were dropped from consideration for this analysis.

6.3 Step 4: Evaluate Technically Feasible Technologies for Diesel Generators

All of the technologies listed above are assumed to be commercially available, reasonably reliable, and safe for use on backup diesel generators. One potential concern with the use of DOCs by themselves is their tendency to increase the emission rate for NO_2. Regardless of that concern, use of DOCs by themselves has not been eliminated from consideration based solely on that tendency since they have been demonstrated to provide effective control for CO and VOCs.

6.3.1 Methodology for Cost-Effectiveness Analyses for Diesel Generators

Detailed calculation spreadsheets for the BACT cost-effectiveness analyses are provided in Appendix C. For the individual pollutants, cost effectiveness was calculated by dividing the total life-cycle annual cost (dollars per year) by the tons of pollutant removed by the control device. The derived cost effectiveness was then compared to the following cost-effectiveness criteria values, which were developed based on Ecology's methodology for previous BACT evaluations for diesel generators in Grant County or were calculated by LAI using the Hanford[1] methodology as recommended by Ecology:

- Criteria air pollutants: Range between $5,000 and $12,000 per ton of removed pollutants (Ecology 2016; Appendix C).
- Toxic air pollutants: Range between $730 and $79,000 per ton of TAP removed based on the Hanford methodology (Haass et al. 2010; Appendix C).

The cost-effectiveness analysis for this NOC application was conducted using generally accepted assumptions that provide a reasonable but conservatively low estimate of the capital and operating costs, and a reasonable but conservatively high estimate of the pollutant removal efficiencies.

The capital cost, operating cost, life-cycle annualized cost, and cost effectiveness (dollars per ton of destroyed pollutant) were calculated using the methodology specified in the EPA Air Pollution Control Cost Manual (EPA 2002).

Cost estimates and pollutant destruction and removal efficiencies were obtained from Johnson Matthey Stationary Emissions Control, LLC, and Stewart & Stevenson Power Products, LLC, for each evaluated emission control option (Pafford 2016). Indirect cost factors to derive a conservatively low total installation cost were obtained from the EPA Air Pollution Control Cost Manual (EPA 2002). The annual capital recovery costs were calculated assuming a 25-year system lifetime and a 4 percent annual discount rate. Conservatively low estimates of annual operation and maintenance costs for each control option were derived by assuming that there would be no operating cost for electricity or

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[1] The Hanford method for evaluating the cost effectiveness of control technologies is documented in a report titled, Evaluation of Best Available Control Technology for Toxics (tBACT), Double Shell Tank Farms Primary Ventilation Systems Supporting Waste Transfer Operations (Haass et al. 2010; on DVD in Appendix E).

equipment maintenance. To provide a conservatively low estimate of the annual operating cost, the operational unit costs for each emission control option were set to zero.

6.4 Best Available Control Technology Cost Effectiveness

This section describes the evaluation conducted to determine the cost effectiveness of controlling criteria pollutant emissions using the technologies identified in Section 6.2. As discussed below, the costs of controlling criteria pollutant emissions using the Tier 4 integrated control package, catalyzed DPF, SCR, and DOC are disproportionate to the benefit received.

6.4.1 Cost Effectiveness Analysis for Tier 4 Integrated Control Package

The cost effectiveness (as dollars per ton of pollutant removed) of installing the Tier 4 integrated control package for control of NO_x ($39,461), PM_{10}/$PM_{2.5}$ ($2.34 million), CO ($203,413), VOCs ($1.04 million), and combined criteria air pollutants ($31,603) is provided in Table 5. As shown in Table 5, the forecast cost effectiveness for control of individual and combined pollutants exceeds Ecology's thresholds for cost effectiveness; therefore, subject to Ecology's review and concurrence, the Tier 4 integrated control package is cost-prohibitive for the purpose of reducing criteria air pollutant emissions.

6.4.2 Cost Effectiveness Analysis for SCR

The cost effectiveness of installing an SCR for control of NO_x is $27,246 per ton (Table 5). As shown in Table 5, the forecast cost effectiveness for control of NO_x exceeds Ecology's cost-effectiveness threshold of $12,000 per ton of NO_x; therefore, subject to Ecology's review and concurrence, an SCR is cost-prohibitive for the purpose of controlling NO_x emissions.

6.4.3 Cost Effectiveness Analysis for Catalyzed DPF

The cost effectiveness of installing a catalyzed DPF for control of PM_{10}/$PM_{2.5}$ ($730,622 per ton), CO ($65,029 per ton), VOCs ($333,881 per ton), and combined pollutants ($50,655 per ton) is provided in Table 5. As shown in Table 5, the forecast cost effectiveness for control of individual and combined pollutants exceeds Ecology's thresholds for cost effectiveness; therefore, subject to Ecology's review and concurrence, the catalyzed DPF is cost-prohibitive for the purpose of controlling criteria air pollutant emissions.

6.4.4 Cost Effectiveness Analysis for DOC

The cost effectiveness of installing a DOC for control of PM_{10}/$PM_{2.5}$ ($546,301 per ton), CO ($13,507 per ton), VOCs ($69,347 per ton), and combined pollutants ($11,076 per ton) is provided in Table 5. As shown in Table 5, the forecast cost effectiveness for control of individual and combined pollutants exceeds Ecology's thresholds for cost effectiveness. Therefore, subject to Ecology's review and concurrence, the DOC is cost-prohibitive for the purpose of reducing individual criteria air pollutant emissions.

6.5 Toxics Best Available Control Technology Cost Effectiveness

This section describes the evaluation conducted to determine the cost effectiveness of controlling TAP emissions using the technologies identified in Section 6.2. As discussed below, the costs of controlling TAP emissions using the Tier 4 integrated control package, catalyzed DPF, SCR, and DOC are disproportionate to the benefit received. Subject to Ecology's review and concurrence, the analysis presented below supports the conclusion that Tier 4 integrated controls are cost-prohibitive for designation as BACT on the basis of control efficiencies for TAPs.

TAPs emitted by the emergency generators at rates exceeding the *de minimis* thresholds consist of: DEEP, CO, NO_2, benzene, 1,3-butadiene, acrolein, naphthalene, formaldehyde, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, xylenes, SO_2, and propylene.

The air pollutant emission control options described in Section 6.2 would be effective at various ranges of efficiencies for control of TAPs. A cost-effectiveness summary for each TAP control option is provided in Appendix C. Table 6 summarizes the calculated TAP cost effectiveness for each control option in comparison to the presumed acceptable thresholds derived using the Hanford methodology. The cost-effectiveness calculations are provided in Excel format in Appendix E.

Emission control technologies and the cost-effectiveness evaluation for control of PM_{10}/$PM_{2.5}$ is the same for control of DEEP, because catalyzed DPFs remove only filterable ("front-half") particulates. The derived cost threshold (i.e., the Hanford "ceiling cost"—or the cost threshold above which controls are considered cost-prohibitive) for removal of DEEP, based on the Hanford method, is \$72,544 per ton. As shown in Table 6, the forecast cost effectiveness to control DEEP using a Tier 4 integrated control package (\$2.34 million per ton), catalyzed DPF (\$730,622 per ton), or a DOC (\$546,301 million per ton) exceeds Ecology's thresholds for cost effectiveness. Therefore, subject to Ecology's review and concurrence, the control options identified are cost-prohibitive for the purpose of controlling DEEP emissions.

A cost-effectiveness evaluation was completed for CO as a criteria pollutant (see Section 6.4 and Table 5). CO is also evaluated as a TAP in this section. The derived cost threshold for removal of CO, based on the Hanford method, is \$731 per ton. As shown in Table 6, the forecast cost effectiveness to control CO using a Tier 4 integrated control package (\$203,413 per ton), catalyzed DPF (\$65,029 per ton), and DOC (\$13,507 per ton) exceeds Ecology's thresholds for cost effectiveness. Therefore, subject to Ecology's review and concurrence, the control options identified are cost-prohibitive for the purpose of controlling CO emissions.

NO_2 is a minor component of NO_x; the in-stack ratio of NO_2 to NO_x is assumed to be 10 percent. Therefore, control technologies evaluated for NO_x (Section 6.4) are applicable to NO_2 and costs are proportionately applicable. The derived cost threshold for removal of NO_2, based on the Hanford method, is \$18,472 per ton. As shown in Table 6, the forecast cost effectiveness to control NO_2 using a Tier 4 integrated control package (\$394,613 per ton) and SCR (\$272,458 per ton) exceeds Ecology's thresholds for cost effectiveness. Therefore, subject to Ecology's review and concurrence, the control options identified are cost-prohibitive for the purpose of controlling NO_2 emissions.

Emissions of acrolein, benzene, 1,3-butadiene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, formaldehyde, naphthalene, propylene, and xylenes are treatable using the same control options applicable to control VOCs. The derived cost thresholds for removal of these VOCs, based on the Hanford method, are:

- $59,359 per ton of removed acrolein
- $61,882 per ton of removed benzene
- $69,951 per ton of removed 1,3-butadiene
- $78,464 per ton of removed benzo(a)pyrene
- $67,964 per ton of removed benzo(b)fluoranthene
- $78,863 per ton of removed dibenz(a,h)anthracene
- $54,691 per ton of removed formaldehyde
- $62,612 per ton of removed naphthalene
- $10,020 per ton of removed propylene
- $21,913 per ton of removed xylenes.

As shown in Table 6, the forecast costs to control these individual VOCs each exceed Ecology's thresholds for cost effectiveness for all applicable control options; therefore, subject to Ecology's review and concurrence, the control options identified are cost-prohibitive for the purpose of controlling individual VOC emissions.

Table 6 also provides the combined cost effectiveness for controlling all TAPs for each emission control option. As shown in Table 6, the combined cost effectiveness for TAPs exceeds Ecology's threshold for cost effectiveness for each control option.

6.6 Step 5: Recommended Best Available Control Technology for Diesel Generators

Although all of the add-on control technology options associated with Tier 4 diesel engine controls (Tier 4 integrated control package, SCR, catalyzed DPF, or DOC) are technically feasible, each of them failed the BACT and tBACT cost-effectiveness evaluations. Therefore, none of the add-on controls is BACT or tBACT because the costs of emission control are disproportionate to the benefit received. Instead, emission limitations consistent with the EPA's Tier 2 emission standards—achieved with combustion controls and the use of ultra-low sulfur diesel fuel—are the recommended BACT and tBACT determination. The proposed BACT recommendation is based on compliance with the EPA's Tier 2 emission standards for a non-road diesel engine: 0.20 grams per mechanical kilowatt-hour (g/kWm-hr) for PM, 3.5 g/kWm-hr for CO, and 6.4 g/kWm-hr for combined NO_x plus VOCs. If field testing will be required to comply with EPA Tier 2 emission standards, the EPA specifies that a 1.25 safety factor should be added to these values in accordance with 40 CFR 60.4212. The 1.25 safety factor accounts for the differences between EPA certification testing in a controlled setting versus testing in the field with variability in test methods and environmental conditions.

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7.0 AMBIENT AIR QUALITY IMPACT ANALYSIS

(Section IX of NOC application form)

This section discusses the air dispersion modeling results and provides a comparison of the results to the NAAQS and Washington Ambient Air Quality Standards (WAAQS) for criteria pollutants and the Washington State small-quantity emission rates (SQERs) and ASILs for TAPs. Air dispersion modeling input values are provided in Appendix D. Copies of the electronic modeling files and inputs are provided in Appendix E.

As discussed in the following sections, the modeled ambient impacts expected from project emissions are less than the NAAQS and WAAQS, even after summing with modeled local background impacts and regional background concentrations. With the exception of two TAPs (DEEP and NO_2), all predicted ambient TAP impacts are less than the ASILs. Therefore, a second-tier health impact assessment will be conducted for DEEP and NO_2.

7.1 First-Tier Screening of Toxic Air Pollutant Impacts

A first-tier TAP assessment compares the forecast emission rates to the SQERs and compares the maximum ambient impacts to ASILs. Table 7 shows the estimated facility-wide emission rates for each TAP expected to be released in the CyrusOne emergency generator exhaust, and compares those emission rates to the corresponding SQER. Each SQER is an emission rate threshold, below which Ecology does not require an air quality impact assessment for the corresponding TAP. As shown in Table 7, estimated facility-wide emissions of DEEP, benzene, CO, NO_2, 1,3-butadiene, acrolein, and naphthalene are greater than their respective SQER, so an ambient impact analysis was completed for those TAPs.

Ecology requires facilities to conduct a first-tier screening analysis for each TAP whose emissions exceed its SQER by modeling the 1st-highest 1-hour, 1st-highest 24-hour, and annual ambient impacts (depending on the TAP of interest), then comparing the modeled values to the ASILs (WAC 173-460-080).

7.2 Air Dispersion Modeling – Model and Assumptions

Air dispersion modeling was conducted in general accordance with the EPA's Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions; Final Rule (EPA 2005). The AERMOD[2] modeling system, introduced by the American Meteorological Society (AMS)/EPA Regulatory Model Improvement Committee, was used in accordance with the EPA's Revision to the Guideline on Air Quality Models (EPA 2005) to estimate

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[2] American Meteorological Society (AMS)/US Environmental Protection Agency (EPA) Regulatory Model.

ambient pollutant concentrations beyond the project property boundary and at selected onsite receptor locations where facility tenants could be exposed.

AERMOD was used to calculate maximum ambient impact concentrations of criteria pollutants and TAPs that would be emitted from the facility. To do this, AERMOD requires input from several models in order to process meteorological parameters, downwash parameters, and terrain heights. The following sections describe these input models, as provided in guidance documents by the EPA, Electric Power Research Institute, and Lakes Environmental.

The most recent version of AERMOD (version 18081) at the time the modeling was completed was used for all CyrusOne data center complex ambient air dispersion modeling. AERMOD incorporates the data from the pre-processors described below with emission estimates and physical emission point characteristics to model ambient impacts. The model was used to estimate ambient concentrations based on various averaging times (e.g., 1 hour, 24 hours, annual, etc.) to demonstrate compliance with air quality standards for a network of receptors.

The AERMOD model was used to estimate the short-term impacts (i.e., 24-hour average or less) of PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2, and acrolein emissions and long-term impacts (i.e., annual average) of DEEP, PM_{10}, $PM_{2.5}$, NO_2, SO_2, benzene, naphthalene, and 1,3-butadiene emissions.

Each AERMOD setup was arranged to simulate the generator configuration that corresponds to the modeled operating scenario. The modeling setup for short-term impacts at full-variable load included load-specific stack parameters (i.e., flow rate and exhaust exit temperature), which correspond to the characteristic worst-case emission load of each pollutant. For example, since the worst-case emission rate for CO is at 100 percent load, then the input stack parameters for all CO modeling was set up for the corresponding flow rate and temperature reported for 100 percent load conditions. The stack parameters setup for long-term impacts conservatively used the vendor-reported load-specific exhaust flow rate and temperature that would result in the worst-case dispersion conditions (i.e., the load condition with the lowest reported exhaust temperature and velocity).

7.2.1 Stack Heights and Building Downwash Input Parameter Modeling

Generator stack heights and diameters were modeled as follows:

- Stack height = 35 feet (2.25-MW generators) 25 feet (750-kW generators)
- Stack diameter = 18 inches (2.25-MW generators), 12 inches (750-kW generators)
- Stacks will discharge vertically with no obstructions.

Building downwash occurs when the aerodynamic turbulence induced by nearby buildings causes a pollutant emitted from an elevated source to be mixed rapidly toward the ground (downwash), resulting in higher ground-level pollutant concentrations. The software program Building Profile Input Program-Plume Rise Model Enhancements was used to determine if exhaust from emission units would be affected by nearby building structures. In general, these determinations are made if a stack's height is less than the height defined by the EPA's Good Engineering Practice (GEP) stack height.

GEP stack height is defined as the height of the nearby structure(s) measured from the ground-level elevation at the base of the stack plus 1.5 times the lesser dimension, height, or projected width of the nearby structure(s). Stack height for any emission source must be less than 65 meters or GEP, whichever is greater. CyrusOne's generator exhaust stacks will be lower than 65 meters.

7.2.2 Receptor Grid Spacing and Terrain Height Input Modeling

To model complex terrain, AERMOD requires information about the surrounding terrain. This information includes a height scale and a base elevation for each receptor. The AMS/EPA Regulatory Model Terrain Pre-processor (AERMAP) was used to obtain a height scale and the base elevation for a receptor, and to develop receptor grids with terrain effects.

A receptor grid was extended from beyond the facility boundary consisting of Cartesian flagpole receptor grids placed at a height of 1.5 meters (m) above ground to approximate the human breathing zone. The grid spacing varied with distance from the facility, as listed below:

- 12.5-m spacing from the property boundary to 150 m from the nearest emission source
- 25-m spacing from 150 m to 400 m
- 50-m spacing from 400 m to 900 m
- 100-m spacing from 900 m to 2,000 m
- 300-m spacing between 2,000 m and 4,500 m
- 600-m spacing beyond 4,500 m.

Considering that each onsite building will house tenants (independent of other tenants within the facility) where employees may spend their working hours, the onsite structures were evaluated as if they were neighboring (offsite) commercial properties, subject to exposure from project-related ambient impacts. For this reason, modeling receptors were placed on the rooftop of each onsite building (location of air handling units that introduce air into the buildings) and in the ground-level parking lot. The project generator stack located closest to the property line is a 2.25-MW generator, located approximately 33 m from the eastern property boundary.

AERMAP requires the use of topographic data to estimate surface elevations above mean sea level. Digital topographic data (in the form of Shuttle Radar Topography Mission files) for the analysis region were obtained from the Web GIS website (http://www.webgis.com) and processed for use in AERMOD. The Shuttle Radar Topography Mission data used for this project have a resolution of approximately 30 m (1 arc-second).

AERMAP produces a Receptor Output File (*.rou) containing the calculated terrain elevations and scale height for each receptor. The *.rou file was used as an input runstream file (AERMOD Input File) for the Receptor Pathway in the Terrain Options page of the Control Pathway. AERMAP also produces a Source Output File (*.sou). This file contains the calculated base elevations for all sources.

7.2.3 Meteorological Input Parameter Modeling

The AERMOD Meteorological Pre-Processor (AERMET; Version 18081) is the meteorological pre-processor model that estimates boundary-layer parameters for use in AERMOD. AERMET processes three types of meteorological input data in three stages, and from this process it generates two input files for the AERMOD model. The two AERMOD input files produced by AERMET are: the Surface File with hourly boundary-layer parameter estimates; and the Profile File with multi-level observations of wind speed, wind direction, temperature, and standard deviations of fluctuating wind components. The three types of meteorological data used by AERMET for this project are described below.

- National Weather Service (NWS) hourly surface observations from Grant County International Airport in Moses Lake, Washington located approximately 24 miles from the CyrusOne site. Five years (January 1, 2012 through December 31, 2016) of hourly surface data processed in AERMET.
  - AERMINUTE was run to reduce the instance of “calms.” A potential concern related to the use of meteorological data for dispersion modeling is the high incidence of “calms,” or periods of time with low wind speeds. NWS and Federal Aviation Administration data coding defines a wind speed of less than 3 knots as “calm” and assigns a value of 0 knots. This results in an overestimation of the amount of calm conditions. Similarly, if wind speed is up to 6 knots, but wind direction varies more than 60 degrees during a 2-minute averaging period, wind direction is reported as “missing.” AERMINUTE reprocesses ASOS 1-minute wind data at a lower threshold and calculates hourly average wind speed and directions to supplement the standard hourly data processed in AERMET.
  - To further enhance AERMOD’s treatment of calms, the ADJ_U* processing method in Stage 3 of AERMET was used.
- NWS twice-daily upper air soundings from Spokane, Washington. Five years (January 1, 2012 through December 31, 2016) of upper air data were processed in AERMET.
- The surface characteristic data required for AERMET are Albedo, Bowen ratio, and surface roughness. Albedo is a measure of the solar radiation reflected back from earth into space. The Bowen ratio is an evaporation-related measurement and is defined as the ratio of sensible heat to latent heat. The surface roughness length is the theoretical height above ground where the wind speed becomes zero. Surface characteristic data were based on land use data surrounding the surface observation site. AERSURFACE was used to determine the Albedo, Bowen ratio, and surface roughness within 12 equal sectors of a circle centered on the surface station tower. The default study radius of 1 km for surface roughness and 10 km for Bowen ratio and albedo was used. Looking at each sector individually, AERSURFACE determines the percentage of land-use type within each sector. Land cover data from the US Geological Survey (USGS) National Land Cover Data 1992 archives were used as an input to AERSURFACE (USGS 1992). Default seasonal categories are used in AERSURFACE to represent the four

seasonal categories as follows: 1) midsummer with lush vegetation; 2) autumn with unharvested cropland; 3) winter with continuous snow; and 4) transitional spring with partial green coverage or short annuals. The AERSURFACE designation for an airport location (with the assumed surface roughness calculated based on 95 percent transportation and 5 percent commercial and industrial) is appropriate for this site. Annual precipitation for Moses Lake for each modeled year was obtained from the Western Regional Climate Center database. The annual precipitation was within the top 30th percentile of the past 30 years of annual precipitation totals for 2012, 2015, and 2016. Therefore, in accordance with EPA guidance, surface moisture conditions are considered wet when compared to historical norms and Bowen ratio values for wet surface moisture was used for those 3 years. The annual precipitation was between the top and bottom 30th percentile of the past 30 years of annual precipitation totals for 2013 and 2014 so Bowen ratio values for average surface moisture is used for those 2 years.

7.2.4 Demonstration of Compliance with Standards that are Based on an Annual Averaging Period

Annual emission rates were established based on the annual runtime limit of 38 hours of operation per generator with a total of 28 cold-start events per generator.

To demonstrate compliance for the “theoretical maximum year” during which CyrusOne would operate the emergency generators 1 times the annual allotment for maintenance, plus 3 times the annual allotment for power outage (86 hours per generator in a 12-month period), emission rates for input to AERMOD were calculated by summing the annual average maintenance runtime of 14 hours per engine, 3 times the annual average power outage runtime of 24, and 18 hours for startup and commissioning. The total theoretical maximum year emission rate is divided by the number of hours in a year (8,760 hours) to establish the pounds per hour emission rate input into AERMOD. This unlikely but possible scenario was considered for the following AERMOD compliance demonstrations:

- $PM_{2.5}$ annual average NAAQS
- NO_2 annual average NAAQS
- TAPs with an annual averaging period (e.g., DEEP ASIL).

The ambient NO_2 annual average concentrations were modeled using the Plume Volume Molar Ratio Method (PVMRM) option. This AERMOD option calculates ambient NO_2 concentrations surrounding the site by applying a default NO_2/NO_x equilibrium ratio of 0.90 and a NO_2/NO_x in-stack ratio of 0.1. The estimated ambient ozone concentration was assumed to be 49 parts per billion (WSU; accessed August 16, 2018).

The results of the criteria pollutant modeling are provided in Table 8. The results of the TAP modeling are discussed in Section 7.3. Emission rate estimates and stack parameters for these scenarios are provided in Appendix D. The modeled annual average ambient impacts for NO_2, PM_{10}, and $PM_{2.5}$ are less than the NAAQS.

7.2.5 Demonstration of Compliance with Standards that are Based on a 1-Hour, 3-Hour, 8-Hour, or 24-Hour Averaging Period (Worst-Case 1-Hour)

To determine the worst-case ambient impacts for CO and SO_2, each with a 1-hour averaging period, the modeling setup assumed the worst-case scenario of all generators facility-wide operating concurrently. The model assumed 42 generators operating under full-variable load for 24 hours per day, 365 days per year, for 5 years. These assumptions are to address the conservative consideration that a power outage could occur at any time of day or night on any day of the year. To account for a worst-case scenario, the hour of activation for the power outage scenario was assumed (i.e., cold-start emissions of all 42 engines are accounted for in this single-hour scenario). These modeling assumptions are used in the setups for:

- CO 1st-highest, 1-hour average NAAQS
- CO 1st-highest, 8-hour average NAAQS
- SO_2 1st-highest, 1-hour average NAAQS
- SO_2 1st-highest, 3-hour average NAAQS
- Any applicable TAP with a 1-hour averaging period (i.e., NO_2 and CO ASIL).

The results of this scenario are provided in Table 8. The results of the TAP modeling are discussed in Section 7.3. The modeled ambient impacts for CO and SO_2 are less than the NAAQS.

7.2.6 Demonstration of Compliance with Standards that are Based on 24-Hour Averaging Periods (Worst-Case 24-Hour)

To estimate worst-case ambient impacts for pollutants regulated on other short-term averages (i.e., 3-hour, 8-hour, or 24-hour), the modeling setup assumed a worst-case scenario of all generators facility-wide operating concurrently. The air dispersion models were set up for all 42 generators to operate 24 hours per day, 365 days per year, for 5 years. A single cold-start event for each engine was assumed to occur once during each simulation. This modeling setup included:

- Any applicable TAP with a 24-hour averaging period (e.g., acrolein).

The results of this scenario are provided in Table 8. The results of the TAP modeling are discussed in Section 7.3.

7.2.7 Demonstration of Compliance with the NO_2 1-hour Average NAAQS

7.2.7.1 Stochastic Monte Carlo Analysis

Project generator operations will be intermittent and on any given day, the operating scenarios and arrangement of activated engines will vary, as will the meteorological conditions that affect the pollutant dispersion. Due to the random unpredictability of weather patterns and variable timing of operation for intermittent emission sources, a statistical approach has been developed by Ecology using a stochastic Monte Carlo analysis to demonstrate compliance[3] with air quality standards that are based on a percentile of the daily maximum ambient impacts, such as the 24-hour averaged $PM_{2.5}$, 1-hour NO_2, and 1-hour SO_2 NAAQS.

Ecology has generated a Monte Carlo script, for the statistical freeware "R," that was designed specifically to evaluate compliance of intermittent emissions, such as from emergency generators at data centers (Dhammapala 2016), and it has been previously used to demonstrate compliance with the NO_2 1-hour and $PM_{2.5}$ 24-hour average NAAQS for emergency generators at other data centers located in Grant County, Washington. This script processes output files from several AERMOD runs that are representative of each engine operating scenario. The script iteratively tests a thousand combinations of results from all the generator runtime scenarios, wind directions, and wind speeds to estimate the probability, at any given receptor location, that the NAAQS standard will be violated. For the 1-hour NO_2 NAAQS analysis, the script estimates the 98th-percentile concentration at each individual receptor location within the modeling domain.

7.2.7.2 NO_2 1-Hour Average Modeling and Statistical Analysis

For demonstration of project compliance with the NO_2 1-hour average NAAQS, each project-specific engine runtime scenario has been characterized and ranked, based on worst-case potential facility emissions, as shown in Table 9. The 1st- through 3rd-highest emitting days are assumed to occur when all 42 generators activate concurrently at full-variable load (unplanned outage or commissioning scenarios). The 4th-through 76th-highest ranked emitting days are assumed to be days during which scheduled operations, such as monthly maintenance or load bank testing will occur. The scheduled operation scenarios may occur on any generator throughout the facility; therefore, four representative AERMOD runs were analyzed at different locations throughout the facility. Testing of the 600-kW generators could occur on the same day as testing of the 2,250-kW generators; therefore, it was conservatively assumed that a representative AERMOD run of a 2,250-kW generator is a conservative estimate for worst-case scheduled operations on the 750-kW generators. The representative AERMOD runs for the scheduled operation scenarios assumed a single generator at a time operates only during daylight hours (7:00 a.m. to 7:00 p.m.) and at full-variable load.

Each of the above-listed engine runtime scenarios were modeled using the PVMRM option within AERMOD on 5 years of meteorological data. The NO_2/NO_x equilibrium ratio, NO_2/NO_x in-stack ratio, and ambient ozone concentration were set equal to the values used for modeling NO_2 annual average impacts, as described in Section 7.2.4. The resultant 1st-highest impact of the above listed AERMOD runs were post-processed using Ecology's Monte Carlo script in "R." This script was used to establish the 98th-percentile impact value at every receptor location within the modeling domain.

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[3] Compliance with the 1-hour NO_2, SO_2, and 24-hour $PM_{2.5}$ NAAQS.

7.2.7.3 Background Modeling

This evaluation assumed a "regional background" concentration of 16 micrograms per cubic meter (μg/m^3), which was obtained from the Washington State University NW Airquest website (WSU; accessed August 16, 2018) and accounts for local highway and railroad emission impacts.

Local background estimates were modeled in a manner consistent with Monte Carlo simulations required for other recent data center permit applications in Quincy, Washington. The local background impacts were modeled from neighboring source operations that are assumed to occur during each operating scenario. These assumptions are described in Section 7.2.10.

7.2.7.4 Project Compliance with the NO_2 1-hour Average NAAQS

Table 10 summarizes these Monte Carlo analysis results and input to the "R" script. Electronic copies of the AERMOD and Monte Carlo simulation output files are provided in Appendix E.

Based on the assumptions outlined above for the stochastic Monte Carlo analysis, the 3-year rolling average of the 98th-percentile of the project plus local background was predicted to be 139 μg/m^3. As shown in Table 10, the estimated cumulative concentration[4] at this maximum project impact location was 155 μg/m^3, which is less than the NO_2 1-hour average NAAQS of 188 μg/m^3.

7.2.8 Demonstration of Compliance with the $PM_{2.5}$ 24-hour Average NAAQS

The $PM_{2.5}$ 24-hour average NAAQS is also a probabilistic standard based on the 98th percentile (averaged over 3 years) of the 24-hour average concentration. Ecology allows compliance to be demonstrated with this standard by modeling the 8th-highest daily impact. Therefore, this demonstration compares the 5th-highest 24-hour average $PM_{2.5}$ concentration for the modeled 4th-highest emitting day.

As shown in Table 9, the 4th-highest emitting day is expected to be the scenario for scheduled operations. Twenty single cold-start events were assumed to occur during each simulation. The 10-hour emissions total for this event was divided by 12 hours to develop the hourly emission rate input to AERMOD, which also assumes operation in this scenario will be restricted to daylight hours (7:00 a.m. to 7:00 p.m.). The local background impacts were modeled from neighboring source operations that are assumed to occur during each operating scenario. These assumptions are described in Section 7.2.10.

The results of this scenario are provided in Table 8. The modeled project emissions plus local background 24-hour average ambient impact for $PM_{2.5}$ is less than the NAAQS. Modeled cumulative concentration results are below the NAAQS where the project-related concentration is significant.

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[4] Project + local and regional background concentrations.

7.2.9 Demonstration of Compliance with the PM_{10} 24-hour Average NAAQS

The PM_{10} 24-hour average NAAQS is not to be exceeded more than once per year on average over 3 years; therefore, compliance with this standard was modeled based on the 2nd-highest emitting day, which is a scenario that assumes all generators are operating concurrently facility-wide. Note, because CyrusOne is requesting a 4-hour operational limit on the 2nd and 3rd days of concurrent generator operation in a calendar year, this modeling scenario assumed a 4-hour utility outage and the 1st-highest concentration in AERMOD was compared to the PM_{10} 24-hour average NAAQS. Forty-two single cold-start events were assumed to occur during the simulation. The 4-hour emissions total for this event was divided by 24 hours to develop the hourly emission rate input into AERMOD. The local background impacts were modeled from neighboring source operations that are assumed to occur during each operating scenario. These assumptions are described in Section 7.2.10.

The results of this scenario are provided in Table 8. The modeled project emissions plus local background 24-hour average ambient impact for PM_{10} is less than the NAAQS. Modeled cumulative concentration results are below the NAAQS where the project-related concentration is significant.

7.2.10 Assumed Background Impacts

This evaluation included regional background values contributed by existing regional emission sources in the project vicinity (e.g., permitted sources, highway vehicles, area sources) and local background values contributed by the other nearby data centers and the Con Agra facility. Project coordinate-specific regional background values were obtained from the Washington State University NW Airquest website (WSU; accessed August 16, 2018).

Local background values for $PM_{2.5}$, PM_{10}, and NO_2 consisted of the ambient impacts, at the project's maximum impact location, caused by emissions from the industrial emission sources at the neighboring NTT DATA Data Center, Microsoft Columbia Data Center, MWH Data Center, and the Con Agra industrial facility. Emissions from each of these facilities were assumed to be equal to their respective permit limits. The locations of the maximum project-related impacts were determined, and AERMOD was used to model the local background ambient impacts at that location caused by simultaneous activity of the local background sources. The modeling assumptions for local background sources were as follows:

- **Compliance with PM_{10} 24-hour average NAAQS**. This evaluation assumes that the permitted sources at the NTT DATA Data Center (emergency generators), Microsoft Columbia Data Center (emergency generators and cooling towers), MWH Data Center (emergency generators and cooling towers), and the boilers at Con Agra would operate at their respective permitted limits.
- **Compliance with PM_{10} and $PM_{2.5}$ 24-hour average NAAQS**. This evaluation assumes that the permitted cooling towers at the Microsoft Columbia Data Center and MWH Data Center and the boilers at Con Agra would operate at their respective permitted limits. Because CyrusOne will be required to coordinate maintenance testing with other data centers in the area, this

evaluation assumes that generators at the Microsoft Columbia, MWH, and Dell data centers will not operate at the same time as CyrusOne generators in a maintenance operating scenario.

- **Compliance with NO_2 1-hour average NAAQS**. This evaluation assumes that the Con Agra industrial facility would operate at its permitted limit. The applicant will coordinate scheduled generator operations with other data centers in the vicinity; therefore, emergency generator emissions from other data centers were not included in the background models for scheduled CyrusOne maintenance operating scenarios. For the power outage scenario, the permitted sources at the NTT DATA Data Center (emergency generators), Microsoft Columbia Data Center (emergency generators), MWH Data Center (emergency generators), and the boilers at Con Agra would operate at their respective permitted limits.

7.3 Toxic Air Pollutant Ambient Impacts Compared to Acceptable Source Impact Levels

The first-tier ambient concentration screening analysis is summarized in Table 11. This screening analysis was conducted on all TAPs with expected emission rates that exceed the SQER (as presented in Table 7). The facility-wide emission rates listed in Table 11 represent full-buildout operations. As shown in Table 11, the maximum modeled ambient concentrations for benzene, 1,3-butadiene, naphthalene, CO, and acrolein are less than their respective ASILs.

7.3.1 Annual Average DEEP Impacts

The DEEP modeling analysis was conducted by assuming all generators at the facility would operate for the theoretical maximum annual runtime hours with commissioning, under full-variable load conditions. Modeling assumptions are discussed in Section 7.2. Further details on the modeling input parameters are provided in Appendix D. The maximum modeled annual average ambient DEEP concentration was 0.660 $\mu g/m^3$ (Table 11), which exceeds the ASIL of 0.00333 $\mu g/m^3$. The location of the modeled maximum ambient impact is shown on Figure 3.

Since the maximum modeled ambient DEEP concentration (attributable to project-related sources) was modeled to be greater than the ASIL, a second-tier health impact assessment will be conducted for DEEP (to be provided to Ecology under separate cover).

7.3.2 1-Hour NO_2 Impacts During Facility-Wide Concurrent Generator Operation

The maximum ambient 1-hour average NO_2 concentrations were modeled using the PVMRM option within AERMOD. The NO_2/NO_x equilibrium ratio, NO_2/NO_x in-stack ratio, and ambient ozone concentration were set equal to the values used for modeling NO_2 annual average impacts, as described in Section 7.2.4. The AERMOD model for this scenario was set up to assume that CyrusOne would operate 42 generators for 24 hours per day, 365 days per year, for 5 years. The maximum modeled 1st-highest 1-hour average ambient NO_2 concentration was 1,446 $\mu g/m^3$ (Table 11). The location of the modeled maximum ambient impact is shown on Figure 3.

Since the maximum modeled ambient NO_2 concentration (attributable to project-related sources) was modeled to be greater than the ASIL, a second-tier health impact assessment will be conducted for NO_2 (to be provided to Ecology under separate cover).

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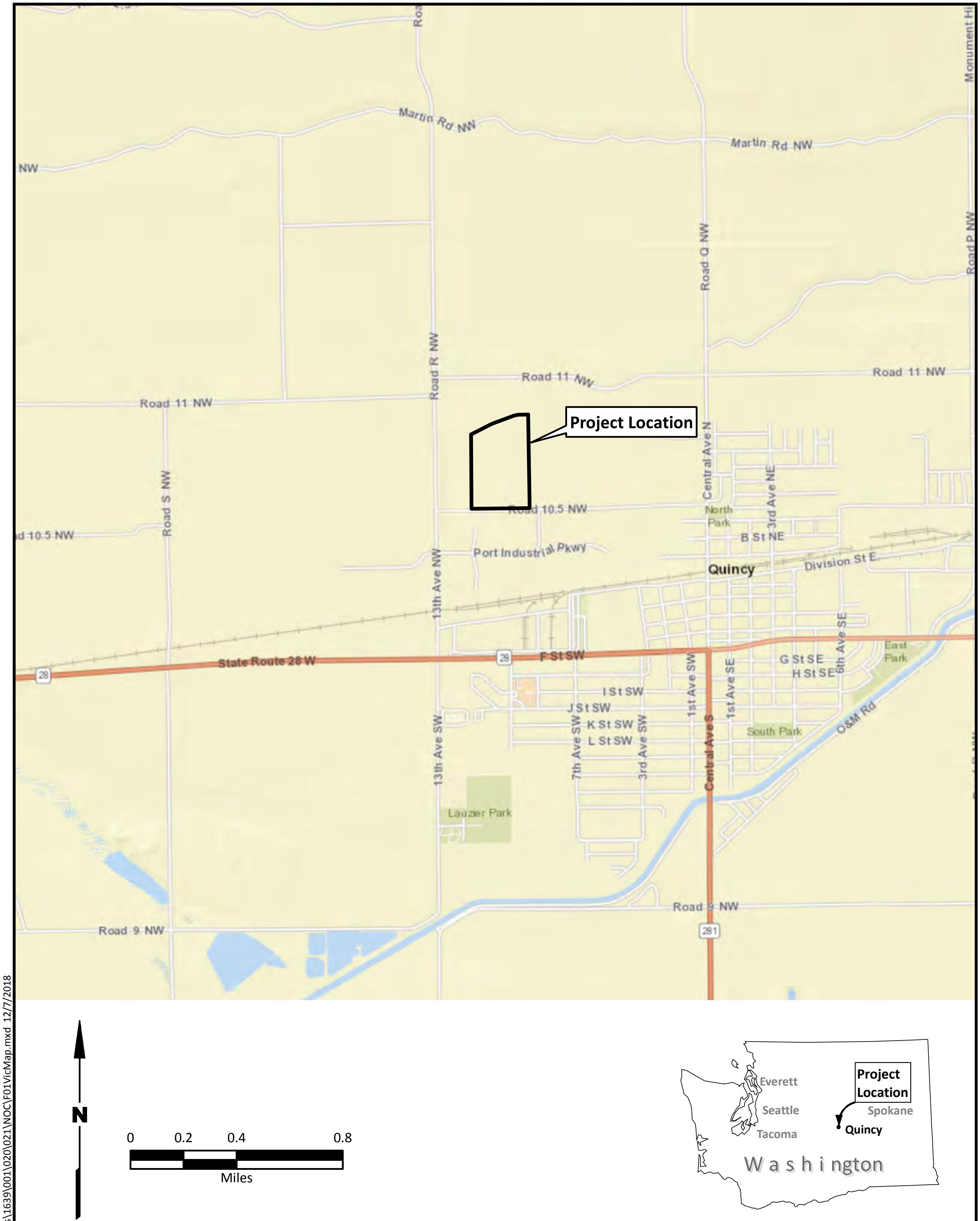

Data Source: Esri 2018.

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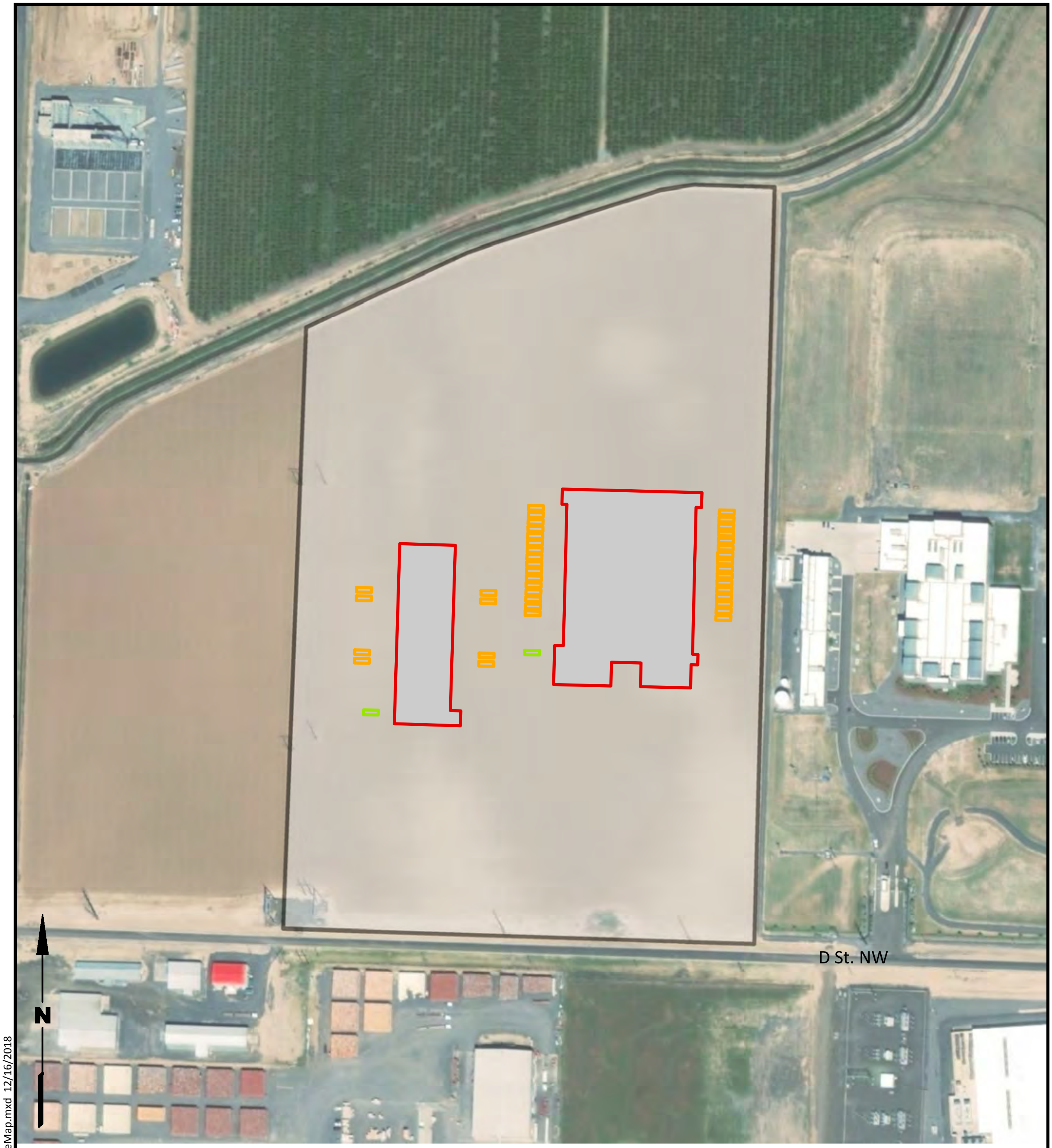
CyrusOne Data Center Notice of Construction Application Quincy, Washington	**Vicinity Map**	Figure 1



Legend

▢ Property Boundary

🟥 Building

🟧 2,250-kW Generator

🟩 750-kW Generator

Note

Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 360 720

Scale in Feet

Data Source: Esri World Imagery.

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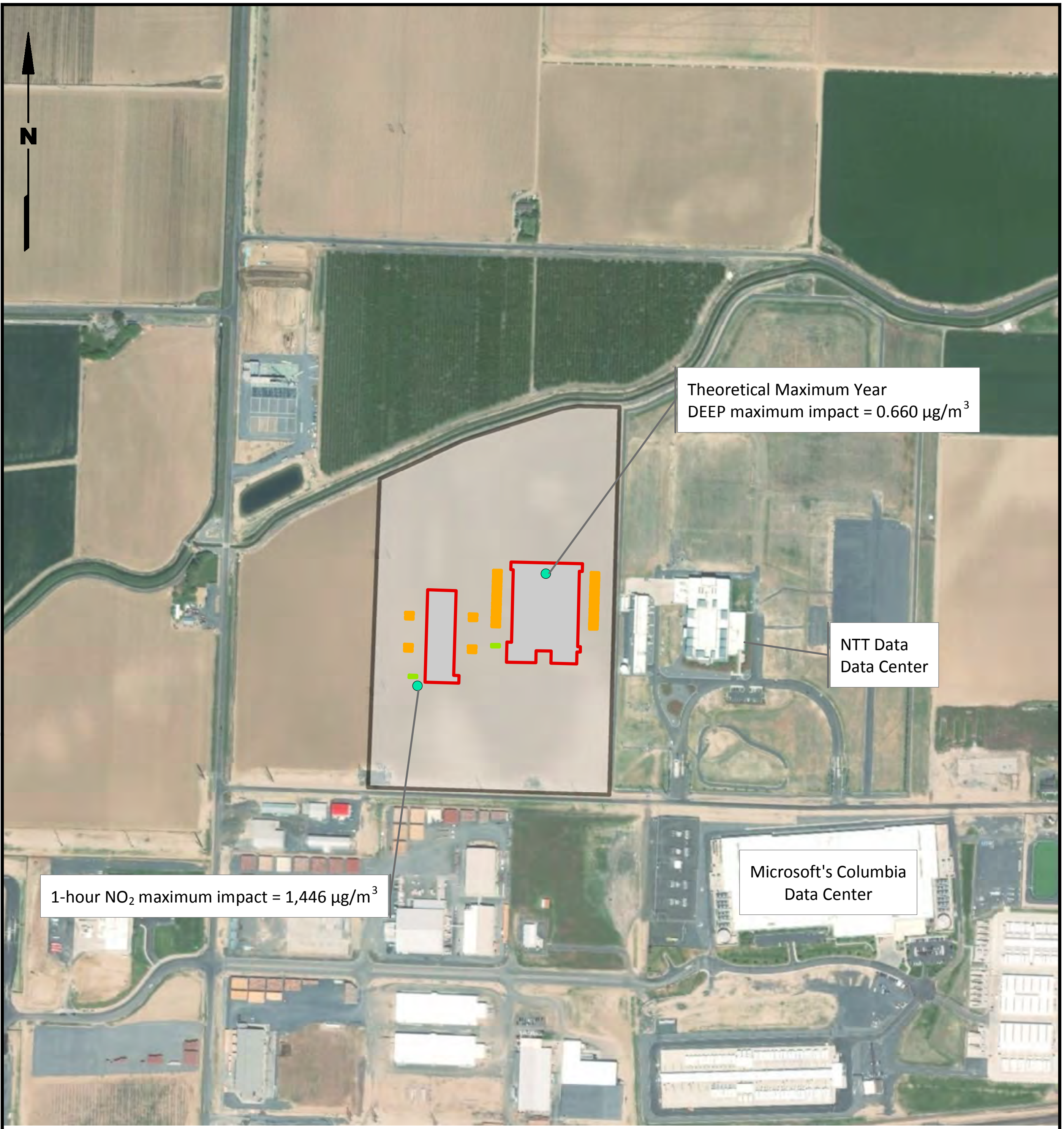
CyrusOne Data Center
Notice of Construction Application
Quincy, Washington

Site Map

Figure
2



Theoretical Maximum Year
DEEP maximum impact = 0.660 µg/m^3

1-hour NO_2 maximum impact = 1,446 µg/m^3

0 700 1,400

Scale in Feet

Legend

🟩	750-kW Generator	▭	Property Boundary
🟧	2,250-kW Generator	●	NAAQS selection
🟥	Building		

Notes
1. Impacts are based on the Theoretical Maximum Year.
2. DEEP = diesel engine exhaust particulates
3. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Data Source: Esri World Imagery, AERMOD files NAAQS/ncDPM_ANN and HIA/NO2_1HR_ASIL

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CyrusOne Data Center
Notice of Construction Application
Quincy, Washington

Project Impacts

Figure
3

Table 1
Vendor-Reported Air Pollutant Emission Rates
CyrusOne Data Center
Quincy, Washington

750-kW genset Pollutant	Load-Specific NTE Emission Rate (lbs/hr) 10%	25%	50%	75%	100%	Full-variable Load Emission Rate (lbs/hr)[a] ≤ 100% load
Nitrogen oxides (NO_x)	3.2	4.4	6.4	9.7	16	16
Carbon monoxide	1.2	1.2	1.18	1.18	2.0	2.0
Hydrocarbons	0.38	0.45	0.37	0.22	0.14	0.45
DEEP[b]	0.055	0.123	0.10	0.07	0.06	0.12
PM (FH+BH)[c]	0.43	0.57	0.47	0.29	0.20	0.57
Exhaust Temp. (°F)	473	666	795	878	993	473
Exhaust Flow (cfm)	1,390	2,218	3,758	5,237	6,332	1,390

2,250-kW genset Pollutant	Load-Specific NTE Emission Rate (lbs/hr) 10%	25%	50%	75%	100%	Full-variable Load Emission Rate (lbs/hr)[a] ≤ 100% load
Nitrogen oxides (NO_x)	5.5	6.2	16	31	47	47
Carbon monoxide	4.2	3.6	3.9	5.8	9.4	9.4
Hydrocarbons	1.3	2.20	2.04	1.86	1.60	2.2
DEEP[b]	0.58	0.66	0.50	0.78	0.50	0.78
PM (FH+BH)[c]	1.9	2.9	2.5	2.6	2.1	2.9
Exhaust Temp. (°F)	464	635	703	795	934	464
Exhaust Flow (cfm)	4,719	8,474	12,075	15,196	18,443	4,719

Notes:

BH = "Back-half" condensable emissions
cfm = cubic feet per minute
FH = "Front-half" filterable emissions
NTE = Not to exceed
lbs/hr = Pounds per hour

[a] "Full-variable load" is the pollutant-specific worst-case emission rate at any load ≤100 percent load.

[b] DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

[c] PM (particulate matter) attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.

Table 2
Fuel-Based Emissions Estimation Summary
CyrusOne Data Center
Quincy, Washington

Parameter	Units	Value	Value
Generator Size	MW	2.25 MW	0.75 MW
No. of Generators	--	40	2
Fuel Usage (per genset)	gph	163	58
Fuel Type	--	Ultra-low Sulfur Diesel	
Fuel Density	lbs/gallon	7.1	
Fuel Heat Content	Btu/gallon	137,000	
Fuel Sulfur Content	ppm weight	15	

Annual Hours of Operation	
Average	38
Theoretical Maximum Year	86
Max Year with Commissioning	136

Duration	Units	Per Hour	Per Day	Per Year (average)	Per Year (Theoretical)	Per Year (Theoretical + Commissioning)
Fuel Usage (per period)	Gallons	6,636	159,254	252,153	570,662	902,442
Heat Input (per period)	MMBtu	909	21,818	34,545	78,181	123,634

Pollutant	CAS Number	Emission Factor			Peak Emission Rate[b]		Annual Emission Rate (TPY)		
		Factor	Units	Source[b]	Hourly (lbs/hr)[a]	Daily (lbs/day)	Average	Theoretical Maximum	Theoretical Max + Commissioning
Nitrogen dioxide (NO_2)	10102-44-0	10% of primary NO_x			-	-	3.6	8.2	--
Sulfur dioxide (SO_2)	7446-09-5	0.0015% $_W$ Sulfur			1.41	34	0.027	0.061	--
Benzene	71-43-2	7.8E-04	lbs/MMBtu	AP-42 Sec 3.4	0.74	17	0.014	0.032	0.050
Toluene	108-88-3	2.8E-04	lbs/MMBtu	AP-42 Sec 3.4	0.27	6.1	0.0050	0.011	0.018
Xylenes	95-47-6	1.9E-04	lbs/MMBtu	AP-42 Sec 3.4	0.19	4.2	0.0035	0.0078	0.012
1,3-Butadiene	106-99-0	3.9E-05	lbs/MMBtu	AP-42 Sec 3.4	0.037	0.86	7.0E-04	0.0016	2.5E-03
Formaldehyde	50-00-0	7.9E-05	lbs/MMBtu	AP-42 Sec 3.4	0.076	1.73	0.0014	0.0032	5.1E-03
Acetaldehyde	75-07-0	2.5E-05	lbs/MMBtu	AP-42 Sec 3.4	0.024	0.55	4.5E-04	0.0010	1.6E-03
Acrolein	107-02-8	7.9E-06	lbs/MMBtu	AP-42 Sec 3.4	0.0076	0.172	1.4E-04	3.2E-04	5.1E-04
Benzo(a)pyrene	50-32-8	2.6E-07	lbs/MMBtu	AP-42 Sec 3.4	2.5E-04	0.0056	4.6E-06	1.0E-05	1.7E-05
Benzo(a)anthracene	56-55-3	6.2E-07	lbs/MMBtu	AP-42 Sec 3.4	6.0E-04	0.014	1.1E-05	2.5E-05	4.0E-05
Chrysene	218-01-9	1.5E-06	lbs/MMBtu	AP-42 Sec 3.4	0.0015	0.033	2.7E-05	6.2E-05	9.8E-05
Benzo(b)fluoranthene	205-99-2	1.1E-06	lbs/MMBtu	AP-42 Sec 3.4	0.0011	0.024	2.0E-05	4.5E-05	7.1E-05
Benzo(k)fluoranthene	207-08-9	2.2E-07	lbs/MMBtu	AP-42 Sec 3.4	2.1E-04	0.0048	3.9E-06	8.9E-06	1.4E-05
Dibenz(a,h)anthracene	53-70-3	3.5E-07	lbs/MMBtu	AP-42 Sec 3.4	3.3E-04	0.0076	6.2E-06	1.4E-05	2.2E-05
Ideno(1,2,3-cd)pyrene	193-39-5	4.1E-07	lbs/MMBtu	AP-42 Sec 3.4	4.0E-04	0.0091	7.4E-06	1.7E-05	2.7E-05
Naphthalene	91-20-3	1.3E-04	lbs/MMBtu	AP-42 Sec 3.4	0.12	2.8	0.0023	5.3E-03	8.4E-03
Propylene	115-07-1	0.0028	lbs/MMBtu	AP-42 Sec 3.4	2.7	61	0.050	1.1E-01	0.18

Notes:

Btu = British thermal unit
gph = Gallons per hour
lbs = Pounds

lbs/hr = Pounds per hour
MMBtu = Million British thermal units
MW = Megawatts

ppm = Parts per million
TPY = Tons per year
Sec = Section

[a] Fuel-based emission rates also account for cold-start emissions.

[b] EPA 1995.

Table 3
Cold-Start Emissions Summary
CyrusOne Data Center
Quincy, Washington

"Black-Puff" Emissions Test Data (see Appendix B)

Pollutant	Spike Duration (seconds)	Measured Concentration (ppm)		Cold-Start Emission Factor
		Cold-Start Emission Spike	Steady-State (Warm) Emissions	
PM+HC	14	900	30	4.3
Nitrogen oxides (NO$_x$)	8.0	40	38	0.94
Carbon monoxide	20	750	30	9.0

Pollutant	Worst-case Emission Rate (lbs/hr)			
	2,250-kW genset		750-kW genset	
	Warm	Cold-start[a]	Warm	Cold-start[a]
HC	2.2	9.4	0.45	1.9
Nitrogen oxides (NO$_x$)[c]	47	47	16	16
Carbon monoxide	9.4	84	1.96	18
DEEP[b]	0.78	3.3	0.12	0.5
PM (FH+BH)	2.9	12.2	0.57	2.4

Startup emission rate applied to one hour (full-variable Load (≤100% Load) emissions)

Pollutant	2,250-kW - Single Hour Emissions (lb/hr)			750-kW Single Hour Emissions (lb/hr)		
	Startup (1 min)	Warm (59 min)	Total (1 hr)	Startup (1 min)	Warm (59 min)	Total (1 hr)
HC	0.037	9.23	9.26	0.007	1.88	1.88
NO$_X$	0.78	46.0	46.8	0.26	15.6	15.9
CO	0.16	82.78	82.94	0.033	17.3	17.4
DEEP[b]	0.0131	3.287	3.300	0.0020	0.515	0.517
PM (FH+BH)	0.048	11.99	12.04	0.009	2.39	2.40

Notes:
BH = "Back-half" condensable emissions
FH = "Front-half" filterable emissions
HC = Hydrocarbons
lbs/hr = Pounds per hour
NA = Not applicable
NTE = Not to exceed
PM = Particulate matter
ppm = Parts per million

[a] Cold-start emission factor applies to the first 60 seconds of emissions after engine startup.

[b] DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions.

[c] Although the cold-start emission factor derived for NO$_x$ is less than 1 (i.e., decreased emissions), this evaluation will conservatively assume a factor of 1.0.

Table 4
Project Potential-to-Emit Emissions Summary
CyrusOne Data Center
Quincy, Washington

Pollutant[a]	Facility-wide Emission Rates		
	Peak Hourly (lbs/hr)	Yearly (average) TPY	Theoretical Maximum Year (TPY)
Criteria Pollutants			
Nitrogen oxides (NO_x)	1,903	36	82
Carbon monoxide (CO)	428	7.9	17
Sulfur dioxide (SO_2)[b]	1.4	0.027	0.061
$PM_{2.5}$ / PM_{10} (FH+BH)[c]	122	2.3	5.1
VOCs	94	1.8	3.9
Toxic Air Pollutants (TAPs)			
Primary NO_2[d]	190	3.6	8.2
DEEP[e]	33	0.62	1.4
CO	428	7.9	17
SO_2[b]	1.4	0.027	0.061
Carbon-based TAPs			
Acrolein	0.0076	1.4E-04	3.2E-04
Benzene	0.74	0.014	0.032
Propylene	2.7	0.050	0.11
Toluene	0.27	0.0050	0.011
Xylenes	0.19	0.0035	0.0078
Formaldehyde	0.076	0.0014	0.0032
Acetaldehyde	0.024	4.5E-04	0.0010
1,3-Butadiene	0.037	7.0E-04	0.0016
Polycyclic Aromatic Hydrocarbons			
Naphthalene	0.12	0.0023	0.0053
Benz(a)anthracene	6.0E-04	1.1E-05	2.5E-05
Chrysene	0.0015	2.7E-05	6.2E-05
Benzo(b)fluoranthene	0.0011	2.0E-05	4.5E-05
Benzo(k)fluoranthene	2.1E-04	3.9E-06	8.9E-06
Benzo(a)pyrene	2.5E-04	4.6E-06	1.0E-05
Indeno(1,2,3-cd)pyrene	4.0E-04	7.4E-06	1.7E-05
Dibenz(a,h)anthracene	3.3E-04	6.2E-06	1.4E-05

Notes:

BH = "Back-half" condensable emissions
CO = Carbon monoxide
DEEP = Diesel engine exhaust particulate matter
FH = "Front-half" filterable emissions
lbs/hr = Pounds per hour
NO_2 = Nitrogen dioxide
NO_x = Nitrogen oxide
NTE = Not to exceed
PM = Particulate matter
TAPs = Toxic air pollutants
SO_2 = Sulfur dioxide
TPY = Tons per year
VOCs = Volatile organic compounds

[a] Cold-start emissions are accounted for in the project emissions.

[b] SO_2 emissions are based on emission factor for sulfur oxides from AP-42 Section 3.4 (EPA 1995) with an assumed fuel sulfur content of 15 ppm.

[c] FH+BH (Front-half and back-half emissions) are assumed equal to the sum of vendor NTE values for PM and hydrocarbons.

[d] NO_2 is assumed to be 10% of the NO_x.

[e] Value assumed to be equal the front-half NTE particulate emissions, as reported by the vendors.

Table 5
Summary of Cost Effectiveness for Removal of Criteria Pollutants
CyrusOne Data Center
Quincy, Washington

	$PM_{10}/PM_{2.5}$	CO	Total VOCs	NO_x	Actual Cost for Combined Criteria Pollutants
Acceptable Unit Cost (dollars per ton)	$12,000	$5,000	$12,000	$12,000	
Control Option	**Actual Cost to Control (dollars per ton)**				
Tier 4 Integrated Control Package[a]	$2,337,337	$203,413	$1,044,383	$39,461	$31,603
SCR[b]	--	--	--	$27,246	$27,246
Catalyzed DPF[c]	$730,622	$65,029	$333,881	--	$50,655
DOC[d]	$546,301	$13,507	$69,347	--	$11,076

Notes:

-- = Ineffective control technology
CO = Carbon monoxide
DEEP = Diesel engine exhaust particulate matter is assumed equal to front-half NTE particulate emissions, as reported by the vendor
DOC = Diesel oxidation catalyst
DPF = Diesel particulate filter
NO_x = nitrogen oxides
$PM_{2.5}/PM_{10}$ = Particulate matter attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.
SCR = Selective catalytic reduction
VOC = volatile organic compound

[a] The expected control efficiency for a Tier 4 integrated control package to reduce emission is 90% for NO_x, 85% for PM (front half), 80% for CO, and 70% for VOCs.

[b] The expected control efficiency for an SCR is 90% for NO_x.

[c] The expected control efficiency for a catalyzed DPF is 85% for PM (front half), 80% for CO, and 70% for VOCs.

[d] The expected control efficiency for a DOC is 80% for CO, 70% for VOCs, and 25% for filterable $PM_{10}/PM_{2.5}$.

Table 6
Summary of Cost Effectiveness for Removal of Toxic Air Pollutants
CyrusOne Data Center
Quincy, Washington

Toxic Air Pollutant	ASIL (μg/m^3)	Hanford Method Cost Factor	Hanford Method Ceiling Cost (dollar per ton)	Emission Control Option - Actual Cost to Control (dollars per ton)			
				Tier 4 Integrated Control Package[a]	SCR[b]	Catalyzed DPF[c]	DOC[d]
DEEP	0.0033	6.9	$72,544	$2,337,337	--	$730,622	$546,301
CO	23,000	0.1	$731	$203,413	--	$65,029	$13,507
NO_2 (10% of NO_x)	470	1.8	$18,472	$394,613	$272,458	--	--
Benzene	0.035	5.9	$61,882	$131,551,959	--	$42,056,087	$8,735,058
1,3-Butadiene	0.0059	6.7	$69,951	$2,610,852,173	--	$834,668,112	$173,360,742
Acrolein	0.06	5.7	$59,359	$12,954,862,938	--	$4,141,563,857	$860,203,680
Naphthalene	0.029	6.0	$62,612	$785,264,000	--	$251,042,486	$52,141,577
Formaldehyde	0.17	5.2	$54,691	$1,293,844,359	--	$413,631,473	$85,911,343
Benzo(a)pyrene	0.00091	7.5	$78,464	$397,215,252,723	--	$126,986,471,557	$26,375,116,727
Benzo(b)fluoranthene	0.0091	6.5	$67,964	$91,967,855,811	--	$29,401,372,243	$174,046,681,621
Dibenz(a,h)anthracene	0.00083	7.5	$78,863	$295,041,387,138	--	$94,322,321,359	$19,590,765,892
Xylenes	221	2.1	$21,913	$528,934,300	--	$169,095,975	$35,121,269
SO_2	660	1.6	$16,924	--	--	--	--
Propylene	3,000	1.0	$10,020	$36,589,362	--	$11,697,320	$2,429,536
Carcinogenic VOCs	NA	NA	NA	$99,255,827	--	$31,731,277	$6,590,593
Non-Carcinogenic VOCs	NA	NA	NA	$31,200,509	--	$9,974,548	$2,071,716
Combined TAPs Cost-effectiveness				$126,304	$272,458	$59,279	$13,079
Presumed Acceptable Annual Cost for Combined TAP Control (based on the Hanford Method)				$10,438	$18,472	$6,775	$2,681

Notes:

-- = Ineffective control technology
ASIL = Acceptable source impact level
CO = Carbon monoxide
DEEP = Diesel engine exhaust particulate matter is assumed equal to front-half "not-to-exceed" vendor particulate emissions
DOC = Diesel oxidation catalyst
DPF = Diesel particulate filter
NA = Not applicable
SCR = Selective catalytic reduction
SO_2 = Sulfur dioxide
TAP = Toxic air pollutant
μg/m^3 = Micrograms per cubic meter

[a] The expected control efficiency of a Tier 4 integrated control package to reduce emission of VOCs and gaseous TAPs is 70%.

[b] There is no expected control of VOCs and gaseous TAPs using SCR.

[c] The expected control efficiency to reduce emission of VOCs and gaseous TAPs using the catalyzed DPF is 70%.

[d] The expected control efficiency to reduce emission of VOCs and gaseous TAPs using the DOC is 70%.

Table 7
Project Emissions Compared to Small-Quantity Emission Rates
CyrusOne Data Center
Quincy, Washington

Pollutant	CAS Number	Averaging Period	Facility-wide Emission Rate	*De Minimis*	SQER	Required Action
			(pounds per averaging period)			
NO_2	10102-44-0	1-hr	190	0.457	1.03	Model
DEEP	--	year	3,362	0.032	0.639	Model
SO_2	7446-09-5	1-hr	1.41	0.457	1.45	Report
Carbon monoxide (CO)	630-08-0	1-hr	428	1.14	50.4	Model
Benzene	71-43-2	year	100	0.331	6.62	Model
Toluene	108-88-3	24-hr	6.1	32.9	657	
Xylenes	95-47-6	24-hr	4.2	1.45	29	Report
1,3-Butadiene	106-99-0	year	5.0	0.0564	1.13	Model
Formaldehyde	50-00-0	year	10.1	1.6	32	Report
Acetaldehyde	75-07-0	year	3.2	3.55	71	
Acrolein	107-02-8	24-hr	0.17	3.94E-04	0.00789	Model
Benzo(a)pyrene	50-32-8	year	0.033	0.00872	0.174	Report
Benzo(a)anthracene	56-55-3	year	0.080	0.0872	1.74	
Chrysene	218-01-9	year	0.20	0.872	17.4	
Benzo(b)fluoranthene	205-99-2	year	0.143	0.0872	1.74	Report
Benzo(k)fluoranthene	207-08-9	year	0.028	0.0872	1.74	
Dibenz(a,h)anthracene	53-70-3	year	0.044	0.00799	0.16	Report
Ideno(1,2,3-cd)pyrene	193-39-5	year	0.053	0.0872	1.74	
Naphthalene	91-20-3	year	17	0.282	5.64	Model
Propylene	115-07-1	24-hr	61	19.7	394	Report

Notes:

Highlighted cells indicate pollutants that require ambient air dispersion model analysis
DEEP = Diesel engine exhaust particulate matter
CAS = Chemical Abstract Service
hr = Hour
NO_2 = Nitrogen dioxide
SO_2 = Sulfur dioxide
SQER = Small-quantity emission rate

Table 8
Estimated Project and Background Impacts Compared to National Ambient Air Quality Standards
Cyrus One Data Center
Quincy, Washington

Criteria Pollutant/ Hazardous Air Pollutant	National Standards Primary ($\mu g/m^3$)	National Standards Secondary ($\mu g/m^3$)	Washington State Standards ($\mu g/m^3$)	Modeled Operating Scenario	AERMOD Filename	Modeled Project	Modeled Project + Local Background[a]	Regional Background [b]	Estimated Cumulative Concentration
						Impact ($\mu g/m^3$)			
Carbon Monoxide (CO)									
8-hour average	10,000	--	10,000	Unplanned power outage	CO_1HR8HR.ADI	4,888 [c]	--	3,308	8,196
1-hour average	40,000	--	40,000	Unplanned power outage		7,490 [c]	--	5,776	13,266
Sulfur Dioxide (SO_2)									
3-hour average	--	1,310	1,310	Unplanned power outage	SO2_1HR3HR.ADI	8.0 [c]	--	2.1	10
1-hour average	200	--	200	Unplanned power outage		7.8 [c]	--	2.6	10
Particulate Matter (PM_{10})									
24-hour average	150	150	150	Unplanned power outage 2nd Day (3 hr limit)	PM10_24HR_PO3.ADI	66 [c]	85	62	147
Particulate Matter ($PM_{2.5}$)									
Annual average	15	15	12	Theoretical Max. Year	PM25_ANN.ADI	2.3	2.9	6.5	9.4
24-hour average	35	35	35	Scheduled operations (i.e., maintenance)	PM25_24HR_MT.ADI	11 [e, f]	11	21	32
Nitrogen Oxides (NO_x)									
Annual average	100	100	100	Theoretical Max. Year	NO2_ANN.ADI	34	37	2.8	39
1-hour average	188	--	--	Monte Carlo Analysis	Refer to Monte Carlo Evaluation (Appendix E)	--	139	16	154

Notes:

$PM_{2.5}$ = Particulate matter with aerodynamic diameter less than or equal to 2.5 microns.

PM_{10} = Particulate matter with aerodynamic diameter less than or equal to 10 microns.

$\mu g/m^3$ = Micrograms per cubic meter

[a] Modeled impact, including local background sources, at the project-related maximum impact location.

[b] Regional background level obtained from Ecology's Air Monitoring Network website (WSU; accessed August 16, 2018).

[c] Reported values represent the 1st-highest modeled impacts.

[e] Simulation evaluated impacts due to the estimated 4th highest emitting day.

[f] Reported values represent the 5th-highest modeled impacts.

Table 9
Summary of Ranked Generator Runtime Scenarios
CyrusOne Data Center
Quincy, Washington

Ranked Day	Runtime Regime	Assumed Duration (hours per day)	Assumed Days of Operation (per year)	Maximum Generators Concurrently Operating	Max. Hourly Facility-wide NO_2 Emissions (lbs/hr) ≤100% Operating Load	Max. Daily Facility-wide $PM_{2.5}$ Emissions (lbs/day) ≤100% Operating Load
1	Unplanned power outage	24	1	42	1,903	2,778
2-3	Unplanned power outage	3	2	42	1,903	44
4-21	Scheduled operations (i.e., maintenance or loadbank testing) - Location A - North (general) area	8[a]	18	1	47	21
22-39	Scheduled operations (i.e., maintenance or loadbank testing) - Location B - Northeast area	8[a]	18	1	47	21
40-57	Scheduled operations (i.e., maintenance or loadbank testing) - Location C - West (general) area	8[a]	19	1	47	21
58-76	Scheduled operations (i.e., maintenance or loadbank testing) - Location D - South (general) area	8[a]	18	1	47	21

Notes:

lbs/hr = Pounds per hour

lbs/day = Pounds per day

NO_2 = Nitrogen dioxide

$PM_{2.5}$ = Particulate matter with an aerodynamic diameter less than or equal to 2.5 microns

Operating conditions of the modeling scenarios may be subject to change.

[a] This scenario will be modeled as if operations occur for 12 hours of daylight time (7 a.m. to 7 p.m.). The assumed 8 hours of operation listed here is to conservatively estimate a maximum number of days of operation per year.

Table 10
Summary of Monte Carlo Analysis
CyrusOne Data Center
Quincy, Washington

UTM Zone 11, NAD 83	(m East)	(m North)
Monte Carlo Predicted: NO_2 Max. Impact Location	282,734.73	5,236,246.22
	98th-percentile Impact ($\mu g/m^3$)	
Project + Local Background Concentration	139	
Regional Background Concentration	16	
Estimated Cumulative Concentration	155	
Regulatory Limit (based on 98th-percentile)	188	

Generator Runtime Activity[a]	**AERMOD Filename** **Script Input Filename** **Source Group**	**Simulation Days of Operation**
Unplanned power outage	NO2_PO.ADI MAXDAILY_APO_NO2.DAT (APO)	3
Scheduled operations[b,c,d] (i.e., maintenance or loadbank testing) - Location A - North (general) area	NO2_MT1.ADI MAXDAILY_AMT1_NO2.DAT (AMT1)	18
Scheduled operations[b,c,d] (i.e., maintenance or loadbank testing) - Location B - Northeast area	NO2_MT2.ADI.ADI MAXDAILY_AMT2_NO2.DAT (AMT2)	18
Scheduled operations[b,c,d] (i.e., maintenance or loadbank testing) - Location C - West (general) area	NO2_MT3.ADI MAXDAILY_AMT3_NO2.DAT (AMT3)	19
Scheduled operations[b,c,d] (i.e., maintenance or loadbank testing) - Location D - South (general) area	NO2_MT4.ADI MAXDAILY_AMT4_NO2.DAT (AMT4)	18

NAD = North American Datum
E = East
m = Meters
N = North
NO_2 = Nitrogen dioxide
$PM_{2.5}$ = Particulate matter with aerodynamic diameter less than or equal to 2.5 microns
UTM = Universal transverse mercator coordinate system zone
$\mu g/m^3$ = micrograms per cubic meter

Notes:

[a] All operations are assumed to run at full-variable load (≤100% Load).

[b] This model assumed project operations will occur between daylight hours only (assumed 7 a.m. to 7 p.m.)

[c] Local data centers coordinate routine operations to prevent concurrent diesel engine activities. For local background, assumed ConAgra facility was emitting at permit limit.

[d] Testing of the 750-kW generators could occur in the same day as testing of the 2,250-kW generators; therefore, it was conservatively assumed that a representative AERMOD run of a 2,250-kW generator is a conservative estimate for worst-case scheduled operations on the 750-kW generators.

Table 11
Estimated Project Impacts Compared to Acceptable Source Impact Levels
Cyrus One Data Center
Quincy, Washington

Pollutant	CAS Number	Averaging Period	AERMOD Filename	Facility-wide Emission Rate (lbs/avg. period)	Modeled Max. Project-Impact ($\mu g/m^3$)	ASIL ($\mu g/m^3$)
NO_2	10102-44-0	1-hr	NO2_1HR_ASIL.ADI	190	1,446	470
CO	630-08-0	1-hr	CO_1HR8HR.ADI	428	7,490	23,000
Acrolein	107-02-8	24-hr	ACR_1HR24HR.ADI	0.17	0.024	0.06
DEEP	--	year[a]	ncDPM_ANN.ADI	3,362	0.660	0.00333
Benzene	71-43-2	year[a,b]	- dispersion factor -	100	0.020	0.0345
1,3-Butadiene	106-99-0	year[a,b]	- dispersion factor -	5.0	0.00099	0.00588
Naphthalene	91-20-3	year[a,b]	- dispersion factor -	17	0.0033	0.0294

Notes:

[a] Predicted maximum impacts are based on emissions for the theoretical maximum year.

[b] Predicted impacts were derived using a dispersion factor based on the DEEP model.

Highlighted cells indicate pollutants that require a human health impact assessment

ASIL = Acceptable source impact level
avg = Averaging
CAS = Chemical Abstract Service
CO = Carbon monoxide
DEEP = Diesel engine exhaust particulate matter
hr = hour
lbs = pounds
NO_2 = Nitrogen dioxide
$\mu g/m^3$ = micrograms per cubic meter

APPENDIX A

Vendor Specification Sheets

DIESEL GENERATOR SET
MTU 16V4000 DS2250

2250 kWe / 60 Hz / Standby
380 - 13.8kV

Reference MTU 16V4000 DS2250 (2045 kWe) for Prime Rating Technical Data

SYSTEM RATINGS

Standby

Voltage (L-L)	380V	480V*	600V	4160V	12470V	13200V	13800V
Phase	3	3	3	3	3	3	3
PF	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Hz	60	60	60	60	60	60	60
kW	2250	2250	2250	2250	2250	2250	2250
kVA	2812	2812	2812	2812	2812	2812	2812
Amps	4273	3383	2706	390	130	123	117
skVA@30% Voltage Dip	3625	8400	3900	5000	4120	4120	4900
Generator Model	1020FDL1102	744RSL4058	1020FDS1120	744FSM4376	1020FDH1246	1020FDH1244	1020FDH1246
Temp Rise	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C
Connection	6 LEAD WYE	4 LEAD WYE	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE	6 LEAD WYE

* UL 2200 Offered

CERTIFICATIONS AND STANDARDS

// **Emissions –** EPA Tier 2 Certified

// **Generator set is designed and manufactured in facilities certified to standards ISO 9001:2008 and ISO 14001:2004**

// **Seismic Certification – Optional**
- – IBC Certification
- – OSHPD Pre-Approval

// **UL 2200 Listed – Optional**

// **Performance Assurance Certification (PAC)**
- - Generator Set Tested to ISO 8528-5 for Transient Response
- - Verified product design, quality and performance integrity
- - All engine systems are prototype and factory tested

// **Power Rating**
- - Accepts Rated Load in One Step Per NFPA 110
- - Permissible average power output during 24 hours of operation is approved up to 85%.

STANDARD FEATURES*

- // MTU Onsite Energy is a single source supplier
- // Global Product Support
- // 2 Year Standard Warranty
- // 16V4000 Diesel Engine
  - 76.3 Liter Displacement
  - Common Rail Fuel Injection
  - 4-Cycle
- // Complete Range of Accessories
- // Generator
  - Brushless, Rotating Field Generator
  - 2/3 Pitch Windings
  - PMG (Permanent Magnet Generator) supply to regulator
  - 300% Short Circuit Capability
- // Digital Control Panel(s)
  - UL Recognized, CSA Certified, NFPA 110
  - Complete System Metering
  - LCD Display
- // Cooling System
  - Integral Set-Mounted
  - Engine-Driven Fan

STANDARD EQUIPMENT*

// Engine

Air Cleaners
Oil Pump
Oil Drain Extension and S/O Valve
Full Flow Oil Filter
Closed Crankcase Ventilation
Jacket Water Pump
Inter Cooler Water Pump
Thermostats
Blower Fan and Fan Drive
Radiator - Unit Mounted
Electric Starting Motor - 24V
Governor – Electronic Isochronous
Base - Structural Steel
SAE Flywheel and Bell Housing
Charging Alternator - 24V
Battery Box and Cables
Flexible Fuel Connectors
Flexible Exhaust Connection
EPA Certified Engine

// Generator

NEMA MG1, IEEE and ANSI standards compliance for temperature rise and motor starting
Sustained short circuit current of up to 300% of the rated current for up to 10 seconds
Self-Ventilated and Drip-Proof
Superior Voltage Waveform
Digital, Solid State, Volts-per-Hertz Regulator
No Load to Full Load Regulation
Brushless Alternator with Brushless Pilot Exciter
4 Pole, Rotating Field
130 °C Max. Standby Temperature Rise
1 Bearing, Sealed
Flexible Coupling
Full Amortisseur Windings
125% Rotor Balancing
3-Phase Voltage Sensing
±0.25% Voltage Regulation
100% of Rated Load - One Step
5% Max. Total Harmonic Distortion

// Digital Control Panel(s)

Digital Metering
Engine Parameters
Generator Protection Functions
Engine Protection
CANBus ECU Communications
Windows®-Based Software
Multilingual Capability
Remote Communications to RDP-110 Remote Annunciator
Programmable Input and Output Contacts
UL Recognized, CSA Certified, CE Approved
Event Recording
IP 54 Front Panel Rating with Integrated Gasket
NFPA110 Compatible

---

* Represents standard product only. Consult Factory/MTU Onsite Energy Distributor for additional configurations.

APPLICATION DATA

// Engine

Manufacturer	MTU
Model	16V4000G84S
Type	4-Cycle
Arrangement	16-V
Displacement: L (in^3)	76.3 (4,656)
Bore: cm (in)	17 (6.69)
Stroke: cm (in)	21 (8.27)
Compression Ratio	16.5:1
Rated RPM	1,800
Engine Governor	Electronic Isochronous (ADEC)
Max. Power: kWm (bhp)	2,500 (3,353)
Speed Regulation	±0.25%
Air Cleaner	Dry

// Liquid Capacity (Lubrication)

Total Oil System: L (gal)	300 (79.3)
Engine Jacket Water Capacity: L (gal)	175 (46.2)
After Cooler Water Capacity: L (gal)	50 (13.2)
System Coolant Capacity: L (gal)	547 (145)

// Electrical

Electric Volts DC	24
Cold Cranking Amps Under -17.8 °C (0 °F)	2,800

// Fuel System

Fuel Supply Connection Size	-16 JIC 37° Female 1” NPT Adapter Provided
Fuel Return Connection Size	-16 JIC 37° Female 1” NPT Adapter Provided
Max. Fuel Lift: m (ft)	1 (3)
Recommended Fuel	Diesel #2
Total Fuel Flow: L/hr (gal/hr)	1,200 (317)

// Fuel Consumption

At 100% of Power Rating: L/hr (gal/hr)	617 (163)
At 75% of Power Rating: L/hr (gal/hr)	467 (123)
At 50% of Power Rating: L/hr (gal/hr)	325 (86)

// Cooling - Radiator System

Ambient Capacity of Radiator: °C (°F)	40 (104)
Max. Restriction of Cooling Air: Intake and Discharge Side of Rad.: kPa (in. H_20)	0.12 (0.5)
Water Pump Capacity: L/min (gpm)	1,350 (357)
After Cooler Pump Capacity: L/min (gpm)	583 (154)
Heat Rejection to Coolant: kW (BTUM)	930 (52,888)
Heat Rejection to After Cooler: kW (BTUM)	680 (38,671)
Heat Radiated to Ambient: kW (BTUM)	206 (11,711)
Fan Power: kW (hp)	95.4 (128)

// Air Requirements

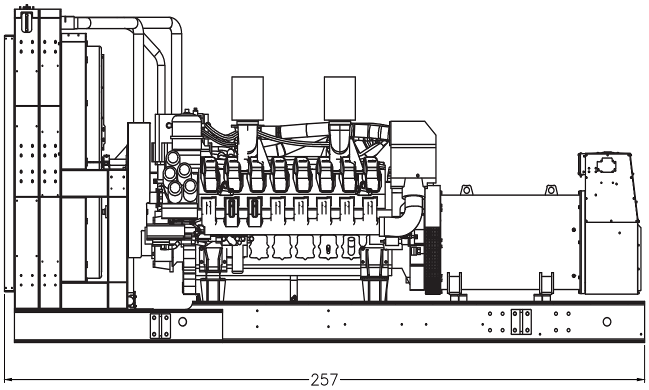
Aspirating: *m^3/min (SCFM)	192 (6,780)
Air Flow Required for Rad. Cooled Unit: *m^3/min (SCFM)	2,053 (72,500)
Remote Cooled Applications; Air Flow Required for Dissipation of Radiated Generator Set Heat for a Max. of 25 °F Rise: *m^3/min (SCFM)	752 (26,412)

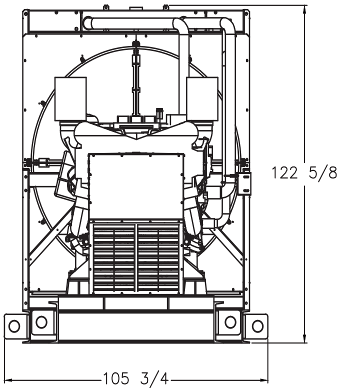
* Air density = 1.184 kg/m^3 (0.0739 lbm/ft^3)

// Exhaust System

Gas Temp. (Stack): °C (°F)	505 (941)
Gas Volume at Stack Temp: m^3/min (CFM)	504 (17,799)
Max. Allowable Back Pressure: kPa (in. H_20)	8.5 (34.1)

WEIGHTS AND DIMENSIONS





Drawing above for illustration purposes only, based on standard open power 480 volt generator set. Lengths may vary with other voltages. Do not use for installation design. See website for unit specific template drawings.

System	Dimensions (L x W x H)	Weight (less tank)
Open Power Unit (OPU)	6,528 x 2,686 x 3,115 mm (257 x 105.7 x 122.6 in)	16,429 kg (36,220 lb)

Weights and dimensions are based on open power units and are estimates only. Consult the factory for accurate weights and dimensions for your specific generator set.

SOUND DATA

Unit Type	Standby Full Load
Level 0: Open Power Unit dB(A)	98.7

Sound data is provided at 7 m (23 ft). Generator set tested in accordance with ISO 8528-10 and with infinite exhaust.

EMISSIONS DATA

NO_x + NMHC	CO	PM
5.07	0.52	0.04

All units are in g/hp-hr and shown at 100% load (not comparable to EPA weighted cycle values). Emission levels of the engine may vary with ambient temperature, barometric pressure, humidity, fuel type and quality, installation parameters, measuring instrumentation, etc. The data was obtained in compliance with US EPA regulations. The weighted cycle value (not shown) from each engine is guaranteed to be within the US EPA Standards.

RATING DEFINITIONS AND CONDITIONS

// Standby ratings apply to installations served by a reliable utility source. The standby rating is applicable to varying loads for the duration of a power outage. No overload capability for this rating. Ratings are in accordance with ISO 8528-1, ISO 3046-1, BS 5514, and AS 2789. Average load factor: ≤ 85%.

// Deration Factor:
Altitude: Consult your local MTU Onsite Energy Power Generation Distributor for altitude derations.
Temperature: Consult your local MTU Onsite Energy Power Generation Distributor for temperature derations.

C/F = Consult Factory/MTU Onsite Energy Distributor
N/A = Not Available

Inhaltsverzeichnis

Contents

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	16V4000G84S				
Rated power [kW]	2500				
Rated speed [rpm]	1800				
Application group	3D				
Emission Stage/Optimisation	EPA Stationary EMERG T2 (40CFR60)				
Test cycle	D2				
Data Set No.	XZ59554101095				
Data Set Basis	EPA Stationary EMERG T2 (40CFR60)				
Fuel sulphur content [ppm]	8,1				

Unterschriftenweg	EDS erstellt	TETC Teamleiter	TET Leiter Org.-Einheit	Baureihen - Teamleiter	Baureihen Leiter Org.-Einheit	Freigabe im Windchill
Datum	07.06.2018	-	-	07.06.2018	07.06.2018	07.06.2018
Org.-Einheit	TETE	-	-	TKFV1	TKF	TKM
Name	T.Lenhof	-	-	Dr. Kneifel	Dr. Baumgarten	Link

MTU
Friedrichshafen GmbH

WORD	Datum/ Date	Name
Erstell. Drawn	2018-02-12 13:49:48	link
Bearb. Change	2018-06-14 11:06:11	link
Inhalt Content	07.06.2018	Lenhof
Gepr. Checked	2018-06-14 11:06:11	baumgarten

Motortyp / Engine Type
16V4000G84S

Projekt-/Auftrags-Nr. Project/Order No.

Verwendbar f.Typ Applicable to Model

Format/Size **A3**

Material-Nr./Material No.
EDS 4000 1234

Benennung/ Title
EMISSIONSDATENBLATT
EMISSION DATA SHEET

Zeichnungs-Nr./Drawing No. **ZNG00013267**

Beschreibung/Description

Blatt/ Sheet **1** von/of **3**

Aenderungsbeschreibung/Description of Revision
Freigabe

Kommt vor/Frequency

Buchst./Rev. Ltr.	Aenderungs-Nr./Revision Notice No.	Bearbeitungsstatus/Lifecycle
-.3	PR030109	Released

Revision ***Change index***					

Motordaten

engine data

	Genset	**Marine**	**O & G**	**Rail**	**C & I**
Application	**X**				
Engine model	16V4000G84S				
Application group	3D				
Emission Stage/Optimisation	EPA Stationary EMERG T2 (40CFR60)				
Test cycle	D2				
fuel sulphur content [ppm]	8,1				
mg/mN³ values base on residual oxygen value of [%]	measured				

Motor Rohemissionen*

*Engine raw emissions**

Cycle point	[-]	**n1**	**n2**	**n3**	**n4**	**n5**	**n6**	**n7**	**n8**
Power (P/Pcycle)	[-]	1	0,75	0,50	0,25	0,10			
Power	[kW]	2498	1872	1250	624	250			
Speed (n/nN)	[-]	1	1	1	1	1			
Speed	[rpm]	1800	1800	1801	1801	1801			
Exhaust temperature after turbine	[°C]	501	424	373	335	240			
Exhaust massflow	[kg/h]	14327	13109	11239	8380	5530			
Exhaust back pressure (static)	[mbar]	88	69	48	26	11			
NOx	[g/kWh]	6,5	5,7	4,4	3,0	8,3			
	[mg/mN³]	1533	1076	639	286	483			
CO	[g/kWh]	1,0	0,8	0,7	1,3	4,2			
	[mg/mN³]	244	168	113	131	257			
HC	[g/kWh]	0,17	0,26	0,39	0,80	1,63			
	[mg/mN³]	42	53	61	82	101			
O2	[%]	10,1	12,4	14,1	15,9	17,7			
Particulate measured	[g/kWh]	0,06	0,12	0,12	0,32	0,76			
	[mg/mN³]	15	24	19	33	47			
Particulate calculated	[g/kWh]	-	-	-	-	-			
	[mg/mN³]	-	-	-	-	-			
Dust (only TA-Luft)	[mg/mN³]	-	-	-	-	-			
FSN	[-]	0,6	0,7	0,3	0,7	0,4			
NO/NO2**	[-]	-	-	-	-	-			
CO2	[g/kWh]	659,6	665,6	713,0	854,0	1044,0			
	[mg/mN³]	164166	133820	110475	87696	64408			
SO2	[g/kWh]	0,003	0,003	0,004	0,004	0,005			
	[mg/mN³]	0,8	0,7	0,6	0,5	0,3			
CH2O	[g/kWh]	-	-	-	-	-			
	[mg/mN³]	-	-	-	-	-			

* Emission data measurement procedures are consistent with the respective emission evaluation process. Noncertified engines are measured to sales data (TVU/TEN) standard conditions.
These boundary conditions might not be representative for detailed dimensioning of exhaust gas aftertreatment, in this case it is recommended to contact the responsible department for more information.
Measurements are subject to variation. The nominal emission data shown is subject to instrumentation, measurement, facility, and engine-to-engine variations.
All data applies to an engine in new condition and were measured after combined exhaust streams. Over extended operating time deterioration may occur which might have an impact on emission. Exhaust temperature depends on engine ambient conditions.

** No standard test. To be measured on demand.

Aenderungsbeschreibung/Description of Revision Freigabe		Kommt vor/Frequency
Buchst./Rev. Ltr.	Aenderungs-Nr./Revision Notice No.	Bearbeitungsstatus/Lifecycle
-.3	PR030109	Released

MTU
Friedrichshafen GmbH

WORD	Datum/ Date	Name
Erstell. Drawn	2018-02-12 13:49:48	link
Bearb. Change	2018-06-14 11:06:11	link
Inhalt Content	07.06.2018	Lenhof
Gepr. Checked	2018-06-14 11:06:11	baumgarten

Motortyp / Engine Type
16V4000G84S

Projekt-/Auftrags-Nr. Project/Order No.
Verwendbar f.Typ Applicable to Model
Format/Size **A3**

Material-Nr./Material No.
EDS 4000 1234

Benennung/ Title

EMISSIONSDATENBLATT

EMISSION DATA SHEET

Zeichnungs-Nr./Drawing No. **ZNG00013267**

Beschreibung/Description

Blatt/ Sheet **2** von/of **3**

Revision ***Change index***					

Motordaten

engine data

	Genset	**Marine**	**O & G**	**Rail**	**C & I**
Application	**X**				
Engine model	16V4000G84S				
Application group	3D				
Emission Stage/Optimisation	EPA Stationary EMERG T2 (40CFR60)				
Test cycle	D2				
fuel sulphur content [ppm]	8,1				
mg/mN³ values base on residual oxygen value of [%]	measured				

Not to exceed Werte*

*not to exceed values**

Cycle point	[-]	**n1**	**n2**	**n3**	**n4**	**n5**	**n6**	**n7**	**n8**
Power (P/Pcycle)	[-]	1	0,75	0,50	0,25				
Power	[kW]	2498	1872	1250	624				
Speed (n/nN)	[-]	1	1	1	1				
Speed	[rpm]	1800	1800	1801	1801				
Exhaust back pressure (static)	[mbar]	88	69	48	26				
NOx	[g/kWh]	8,5	7,4	5,7	4,5				
	[mg/mN³]	1993	1399	831	429				
CO	[g/kWh]	1,7	1,4	1,4	2,6				
	[mg/mN³]	415	286	215	262				
HC	[g/kWh]	0,29	0,45	0,74	1,60				
	[mg/mN³]	71	90	116	164				
O2	[%]	10,1	12,4	14,1	15,9				
Particulate measured	[g/kWh]	0,09	0,19	0,18	0,48				
	[mg/mN³]	23	39	28	50				
CH2O	[g/kWh]	-	-	-	-				
	[mg/mN³]	-	-	-	-				

* Calculated values are not proven by tests and therefore the accuracy cannot be guaranteed.

Emissions data measurement procedures are consistent with those described in the applicable rules and standards.

The NOx, CO, HC and PM emission data tabulated here were taken from a single new engine under the test conditions shown above and are valid for the following conditions:

- Ambient air pressure 1 bar
- Air intake temperature approx. 25°C
- Rel. Humidity 30%-60%
- New Engine
- New standard- air filter
- Exhaust gas back pressure according the given value in this EDS
- Fuel according to EN 590 or US EPA 40CFR89
- Coolant and Lubricants according MTU Fuels and Lubricants Specification
- measured after combined exhaust streams.

The nominal emissions data shown is subject to instrumentation, measurement, facility and engine to engine variations. Emissions data is based on single operating points and thus cannot be used to compare to EPA regulations which use values based on a weighted cycle. Emissions data may vary depending on the type of exhaust gas aftertreatment that may be installed on the engine, therefore it is suggested that the engine manufacturer be contacted directly for further information.

Field emission test data are not guaranteed to these levels. Actual field test results may vary due to test site conditions, installation, fuel specification, test procedures, and instrumentation. Over time deterioration may occur which may have an impact on emission levels. Engine operation with excessive air intake or exhaust restriction beyond published maximum limits, or with improper maintenance, may results in elevated emission levels.

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GASEOUS EMISSIONS DATA MEASUREMENTS ARE CONSISTENT WITH THOSE DESCRIBED IN EPA 40 CFR PART 60 SUBPART IIII FOR MEASURING HC, CO, PM, AND NOX.

Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max. Limit G/(kW -HR)**		
					T2	T3
U.S. (INCL CALIF)	EPA	Stationary	Emergency Stationary Tier 2 (>560kW) Tier 3 (<560kW)	NOx+ NMHC:	6,4	4,0
				CO:	3,5	3,5
				PM:	0,20	0,20

** No standard test. To be measured on demand.

MTU Friedrichshafen GmbH	**WORD**	Datum/ Date	Name	Projekt-/Auftrags-Nr. Project/Order No. Verwendbar f.Typ Applicable to Model	Format/Size **A3**
	Erstell. Drawn	2018-02-12 13:49:48	link	Material-Nr./Material No. **EDS 4000 1234**	
	Bearb. Change	2018-06-14 11:06:11	link		
	Inhalt Content	07.06.2018	Lenhof	Benennung/ Title **EMISSIONSDATENBLATT** **EMISSION DATA SHEET**	
	Gepr. Checked	2018-06-14 11:06:11	baumgarten		
	Motortyp / Engine Type **16V4000G84S**				

Aenderungsbeschreibung/Description of Revision
Freigabe

Kommt vor/Frequency

Zeichnungs-Nr./Drawing No. **ZNG00013267**

Beschreibung/Description

Blatt/ Sheet **3** von/of **3**

Buchst./Rev. Ltr.	Aenderungs-Nr./Revision Notice No.	Bearbeitungsstatus/Lifecycle
-.3	PR030109	Released

DIESEL GENERATOR SET
MTU 12V2000 DS750

750 kWe / 60 Hz / Standby
208 - 4160V

Reference MTU 12V2000 DS750 (680 kWe) for Prime Rating Technical Data

SYSTEM RATINGS

Standby

Voltage (L-L)	208V**	240V**	380V	480V**	600V**	4160V
Phase	3	3	3	3	3	3
PF	0.8	0.8	0.8	0.8	0.8	0.8
Hz	60	60	60	60	60	60
kW	750	750	750	750	750	750
kVA	937	937	937	937	937	937
Amps	2602	2255	1424	1127	902	130
skVA@30% Voltage Dip	2600	2600	1850	2120	3050	1850
Generator Model*	574RSL4037	574RSL4037	575RSL4044	573RSL4035	574RSS4278	574FSM4358
Temp Rise	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C	130 °C/40 °C
Connection	12 LEAD LOW WYE	12 LEAD HI DELTA	4 BAR WYE	12 LEAD HI WYE	4 LEAD WYE	6 LEAD WYE

* Consult the factory for alternate configuration.
** UL 2200 Offered

CERTIFICATIONS AND STANDARDS

// **Emissions –** EPA Tier 2 Certified

// **Generator set is designed and manufactured in facilities certified to standards ISO 9001:2008 and ISO 14001:2004**

// **UL 2200 / CSA – Optional**
- UL 2200 Listed
- CSA Certified

// **Performance Assurance Certification (PAC)**
- Generator Set Tested to ISO 8528-5 for Transient Response
- Verified product design, quality and performance integrity
- All engine systems are prototype and factory tested

// **Power Rating**
- Accepts Rated Load in One Step Per NFPA 110
- Permissible average power output during 24 hours of operation is approved up to 85%.

STANDARD FEATURES*

- // MTU Onsite Energy is a single source supplier
- // Global Product Support
- // 2 Year Standard Warranty
- // 12V 2000 Diesel Engine
  - 23.9 Liter Displacement
  - Electronic Unit Pump Injection
  - 4-Cycle
- // Complete Range of Accessories
- // Generator
  - Brushless, Rotating Field Generator
  - 2/3 Pitch Windings
  - PMG (Permanent Magnet Generator) supply to regulator
  - 300% Short Circuit Capability
- // Digital Control Panel(s)
  - UL Recognized, CSA Certified, NFPA 110
  - Complete System Metering
  - LCD Display
- // Cooling System
  - Integral Set-Mounted
  - Engine Driven Fan

STANDARD EQUIPMENT*

// Engine

- Air Cleaners
- Oil Pump
- Oil Drain Extension & S/O Valve
- Full Flow Oil Filter
- Closed Crankcase Ventilation
- Jacket Water Pump
- Inter Cooler Water Pump
- Thermostats
- Blower Fan & Fan Drive
- Radiator - Unit Mounted
- Electric Starting Motor - 24V
- Governor – Electronic Isochronous
- Base - Structural Steel
- SAE Flywheel & Bell Housing
- Charging Alternator - 24V
- Battery Box & Cables
- Flexible Fuel Connectors
- Flexible Exhaust Connection
- EPA Certified Engine

// Generator

- NEMA MG1, IEEE and ANSI standards compliance for temperature rise and motor starting
- Sustained short circuit current of up to 300% of the rated current for up to 10 seconds
- Self-Ventilated and Drip-Proof
- Superior Voltage Waveform
- Digital, Solid State, Volts-per-Hertz Regulator
- No Load to Full Load Regulation
- Brushless Alternator with Brushless Pilot Exciter
- 4 Pole, Rotating Field
- 130 °C Maximum Standby Temperature Rise
- 1 Bearing, Sealed
- Flexible Coupling
- Full Amortisseur Windings
- 125% Rotor Balancing
- 3-Phase Voltage Sensing
- ±0.25% Voltage Regulation
- 100% of Rated Load - One Step
- 5% Maximum Total Harmonic Distortion

// Digital Control Panel(s)

- Digital Metering
- Engine Parameters
- Generator Protection Functions
- Engine Protection
- CANBus ECU Communications
- Windows®-Based Software
- Multilingual Capability
- Remote Communications to RDP-110 Remote Annunciator
- Programmable Input and Output Contacts
- UL Recognized, CSA Certified, CE Approved
- Event Recording
- IP 54 Front Panel Rating with Integrated Gasket
- NFPA 110 Compatible

---

* Represents standard product only. Consult Factory/MTU Onsite Energy Distributor for additional configurations.

APPLICATION DATA

// Engine

Manufacturer	MTU
Model	12V 2000 G85 TB
Type	4-Cycle
Arrangement	12-V
Displacement: L (in^3)	23.9 (1,457)
Bore: cm (in)	13 (5.1)
Stroke: cm (in)	15 (5.9)
Compression Ratio	16:1
Rated RPM	1,800
Engine Governor	Electronic Isochronous (ADEC)
Maximum Power: kWm (bhp)	890 (1,193)
Speed Regulation	±0.25%
Air Cleaner	Dry

// Liquid Capacity (Lubrication)

Total Oil System: L (gal)	77 (20.3)
Engine Jacket Water Capacity: L (gal)	110 (29.1)
After Cooler Water Capacity: L (gal)	20 (5.3)
System Coolant Capacity: L (gal)	274 (72.4)

// Electrical

Electric Volts DC	24
Cold Cranking Amps Under -17.8 °C (0 °F)	2,800

// Fuel System

Fuel Supply Connection Size	3/4" NPT
Fuel Return Connection Size	1/4" NPT
Maximum Fuel Lift: m (ft)	3 (10)
Recommended Fuel	Diesel #2
Total Fuel Flow: L/hr (gal/hr)	480.7 (127)

// Fuel Consumption

At 100% of Power Rating: L/hr (gal/hr)	218.8 (57.8)
At 75% of Power Rating: L/hr (gal/hr)	164.6 (43.5)
At 50% of Power Rating: L/hr (gal/hr)	111.3 (29.4)

// Cooling - Radiator System

Ambient Capacity of Radiator: °C (°F)	40 (104)
Maximum Restriction of Cooling Air, Intake, and Discharge Side of Rad.: kPa (in. H$_2$0)	0.12 (0.5)
Water Pump Capacity: L/min (gpm)	833 (220)
After Cooler Pump Capacity: L/min (gpm)	257 (68)
Heat Rejection to Coolant: kW (BTUM)	315 (17,913)
Heat Rejection to After Cooler: kW (BTUM)	270 (15,354)
Heat Radiated to Ambient: kW (BTUM)	84.5 (4,805)
Fan Power: kW (hp)	38 (50.9)

// Air Requirements

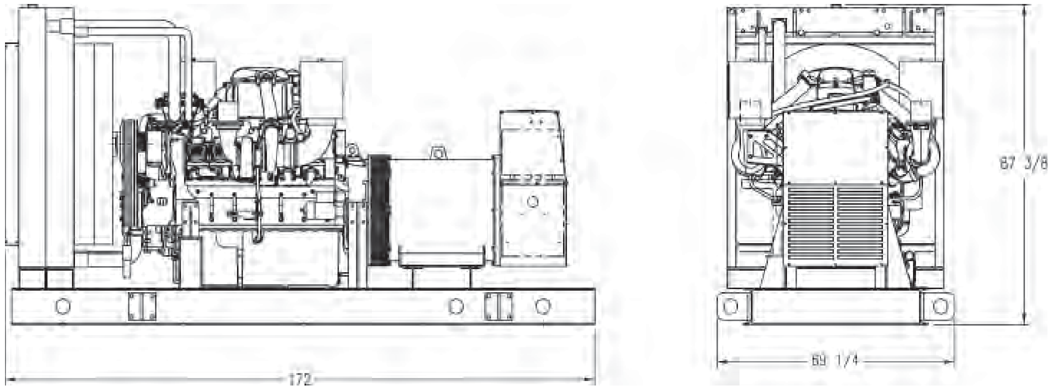
Aspirating: *m^3/min (SCFM)	66 (2,331)
Air Flow Required for Rad. Cooled Unit: *m^3/min (SCFM)	828 (29,248)
Remote Cooled Applications; Air Flow Required for Dissipation of Radiated Gen-set Heat for a Max of 25 °F Rise: *m^3/min (SCFM)	307 (10,840)

* Air density = 1.184 kg/m^3 (0.0739 lbm/ft^3)

// Exhaust System

Gas Temp. (Stack): °C (°F)	580 (1,076)
Gas Volume at Stack Temp: m^3/min (CFM)	174 (6,145)
Maximum Allowable Back Pressure: kPa (in. H$_2$0)	8.5 (34.1)

WEIGHTS AND DIMENSIONS



Drawing above for illustration purposes only, based on standard open power 480 volt generator set. Lengths may vary with other voltages. Do not use for installation design. See website for unit specific template drawings.

System	Dimensions (L x W x H)	Weight (less tank)
Open Power Unit (OPU)	4,369 x 1,759 x 2,219 mm (172 x 69.3 x 87.4 in)	5,592 kg (12,328 lb)

Weights and dimensions are based on open power units and are estimates only. Consult the factory for accurate weights and dimensions for your specific generator set.

SOUND DATA

Unit Type	Standby Full Load
Level 0: Open Power Unit dB(A)	92

Sound data is provided at 7 m (23 ft). Generator set tested in accordance with ISO 8528-10 and with infinite exhaust.

EMISSIONS DATA

NO_x + NMHC	CO	PM
4.66	0.45	0.01

All units are in g/hp-hr and shown at 100% load (not comparable to EPA weighted cycle values). Emission levels of the engine may vary with ambient temperature, barometric pressure, humidity, fuel type and quality, installation parameters, measuring instrumentation, etc. The data was obtained in compliance with US EPA regulations. The weighted cycle value (not shown) from each engine is guaranteed to be within the US EPA Standards.

RATING DEFINITIONS AND CONDITIONS

// Standby ratings apply to installations served by a reliable utility source. The standby rating is applicable to varying loads for the duration of a power outage. No overload capability for this rating. Ratings are in accordance with ISO 8528-1, ISO 3046-1, BS 5514, and AS 2789. Average load factor: ≤ 85%.

// Deration Factor:
Altitude: Consult your local MTU Onsite Energy Power Generation Distributor for altitude derations.
Temperature: Consult your local MTU Onsite Energy Power Generation Distributor for temperature derations.

C/F = Consult Factory/MTU Onsite Energy Distributor
N/A = Not Available

Inhaltsverzeichnis
Contents

	Genset	Marine	O & G	Rail	C & I
Application	X				
Engine model	12V2000G85-TB				
Application group	3D				
Emission Stage/Optimisation	EPA Tier 2				
Test cycle	D2				
Data Set	EPA Tier 2				
Fuel sulphur content [ppm]	5				

				MTU Friedrichshafen GmbH			Benennung/Title **Emissionsdatenblatt** **Emission Data Sheet**
					Datum/Date	Name/Name	Zeichnungs-Nr./Drawing No.
				Bearbeiter/Drawn by	07.03.2012	Lenhof	
a	„Not-to-exceed“-Werte hinzugefügt	24.04.15	Lenhof	Geprüft/Checked	07.09.2012	Peitz	**EDS 2000 0136**
Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name	Org.-Einheit/Dept.	TKV	Schmitz	

Vers.2.0

Revision ***Change index***					

Motordaten

engine data

	Genset	**Marine**	**O & G**	**Rail**	**C & I**
Application	**X**				
Engine model	12V2000G85-TB				
Application group	3D				
Emission Stage/Optimisation	EPA Tier 2				
Test cycle	D2				
fuel sulphur content [ppm]	5				
mg/mN³ values base on residual oxygen value of [%]	measured				

Motor Rohemissionen*

*Engine raw emissions**

Cycle point	[-]	**n1**	**n2**	**n3**	**n4**	**n5**	**n6**	**n7**	**n8**
Power (P/PN)	[-]	1	0,75	0,50	0,25	0,10			
Power	[kW]	890	668	445	223	89			
Speed (n/nN)	[-]	1	1	1	1	1			
Speed	[rpm]	1800	1800	1800	1800	1800			
Exhaust temperature after turbine	[°C]	534	470	424	352	245			
Exhaust massflow	[kg/h]	4718	4238	3242	2134	1613			
Exhaust back pressure	[mbar]	32	23	13	5	2			
NOx	[g/kWh]	6,2	5,1	5,0	5,9	13,5			
	[mg/mN³]	1702	1110	964	868	1007			
CO	[g/kWh]	0,6	0,5	0,6	1,2	3,4			
	[mg/mN³]	159	103	119	175	256			
HC	[g/kWh]	0,04	0,09	0,20	0,45	1,29			
	[mg/mN³]	11	19	38	65	97			
O2	[%]	8,2	10,2	11,5	13,2	15,6			
Particulate measured	[g/kWh]	0,02	0,03	0,07	0,17	0,20			
	[mg/mN³]	6	7	13	24	15			
Particulate calculated	[g/kWh]	-	-	-	-	-			
	[mg/mN³]	-	-	-	-	-			
Dust (only TA-Luft)	[mg/mN³]	-	-	-	-	-			
FSN	[-]	0,2	0,2	0,5	0,7	0,1			
NO/NO2**	[-]	-	-	-	-	-			
CO2	[g/kWh]	663,3	674,7	682,0	735,7	945,3			
	[mg/mN³]	178552	150249	130908	105958	71038			
SO2	[g/kWh]	0,002	0,002	0,002	0,002	0,003			
	[mg/mN³]	0,6	0,5	0,4	0,3	0,2			

* Emission data measurement procedures are consistent with the respective emission evaluation process. Noncertified engines are measured to sales data (TVU/TEN) standard conditions.
These boundary conditions might not be representative for detailed dimensioning of exhaust gas aftertreatment, in this case it is recommended to contact the responsible department for more information.
Measurements are subject to variation. The nominal emission data shown is subject to instrumentation, measurement, facility, and engine-to-engine variations.
All data applies to an engine in new condition. Over extended operating time deterioration may occur which might have an impact on emission.
Exhaust temperature depends on engine ambient conditions.

** No standard test. To be measured on demand.

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					Datum/Date	Name/Name	Zeichnungs-Nr./Drawing No.
				Bearbeiter/Drawn by	07.03.2012	Lenhof	
a	„Not-to-exceed“-Werte hinzugefügt	24.04.15	Lenhof	Geprüft/Checked	07.09.2012	Peitz	**EDS 2000 0136**
Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name	Org.-Einheit/Dept.	TKV	Schmitz	

Vers.2.0

Revision ***Change index***	**a**				

Motordaten

engine data

	Genset	**Marine**	**O & G**	**Rail**	**C & I**
Application	**X**				
Engine model	12V2000G85-TB				
Application group	3D				
Emission Stage/Optimisation	EPA Tier 2				
Test cycle	D2				
fuel sulphur content [ppm]	5				
mg/mN³ values base on residual oxygen value of [%]	measured				

Not to exceed Werte*

*not to exceed values**

Cycle point	[-]	**n1**	**n2**	**n3**	**n4**	**n5**	**n6**	**n7**	**n8**
Power (P/PN)	[-]	1	0,75	0,50	0,25				
Power	[kW]	890	668	445	223				
Speed (n/nN)	[-]	1	1	1	1				
Speed	[rpm]	1800	1800	1800	1800				
Exhaust back pressure	[mbar]	32	23	13	5				
NOx	[g/kWh]	8,1	6,6	6,5	8,9				
	[mg/mN³]	2213	1442	1253	1301				
CO	[g/kWh]	1,0	0,8	1,2	2,4				
	[mg/mN³]	270	175	225	350				
HC	[g/kWh]	0,07	0,15	0,38	0,91				
	[mg/mN³]	19	33	73	130				
O2	[%]	8,2	10,2	11,5	13,2				
Particulate measured	[g/kWh]	0,03	0,05	0,10	0,25				
	[mg/mN³]	9	11	19	36				

* Calculated values are not proven by tests and therefore the accuracy cannot be guaranteed.

Emissions data measurement procedures are consistent with those described in the applicable rules and standards.

The NOx, CO, HC and PM emission data tabulated here were taken from a single new engine under the test conditions shown above and are valid for the following conditions:

- Ambient air pressure 1 bar
- Air intake temperature approx. 25°C
- Rel. Humidity 30%-60%
- New Engine
- New standard- air filter
- Exhaust gas back pressure according the given value in this EDS
- Fuel according to EN 590 or US EPA 40CFR89
- Coolant and Lubricants according MTU Fuels and Lubricants Specification

The nominal emissions data shown is subject to instrumentation, measurement, facility and engine to engine variations. Emissions data is based on single operating points and thus cannot be used to compare to EPA regulations which use values based on a weighted cycle. Emissions data may vary depending on the type of exhaust gas aftertreatment that may be installed on the engine, therefore it is suggested that the engine manufacturer be contacted directly for further information.

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Locality	**Agency**	**Regulation**	**Tier/Stage**	**Max. Limit G/(kW -HR)**		
					T2	T3
U.S. (INCL CALIF)	EPA	Stationary	Emergency Stationary Tier 2 (>560kW) Tier 3 (<560kW)	NOx+ NMHC:	6,4	4,0
				CO:	3,5	3,5
				PM:	0,20	0,20

** No standard test. To be measured on demand.

a	„Not-to-exceed“-Werte hinzugefügt	24.04.15	Lenhof
Buchstabe/ Revision	Änderung Modifikation	Datum Date	Name Name

MTU Friedrichshafen GmbH

	Datum/Date	Name/Name
Bearbeiter/Drawn by	07.03.2012	Lenhof
Geprüft/Checked	07.09.2012	Peitz
Org.-Einheit/Dept.	TKV	Schmitz

Benennung/Title

Emissionsdatenblatt
Emission Data Sheet

Zeichnungs-Nr./Drawing No.

EDS 2000 0136

Vers.2.0

APPENDIX B

Cold-Start Emissions Estimation Method

APPENDIX B

Diesel Generator "Cold-Start Spike" Adjustment Factors

Short-term concentration trends for emissions of volatile organic compounds (VOCs), carbon monoxide (CO), and oxides of nitrogen (NO_x) immediately following a cold startup of a large diesel backup generator were measured by the California Energy Commission (CEC) in its document entitled Air Quality Implications of Backup Generators in California (Miller and Lents 2005)[1]. CEC used continuous monitors to measure the trends shown in the attached figure (Figure B-1), which are discussed below.

As shown on Figure B-1, during the first 14 seconds after a cold start, the VOC concentration spiked to a maximum value of 900 parts per million (ppm) before dropping back to the steady-state exhaust concentration of 30 ppm. The measured (triangular) area under the 14-second concentration-vs-time curve represents emissions during a "VOC spike," which is 6,300 ppm-seconds.

Unlike VOC emissions, the NO_x exhaust concentration did not "spike" during cold-start. It took 8 seconds for the exhaust concentration of NO_x to rise from the initial value of zero to its steady-state concentration of 38 ppm. The measured area under the concentration-vs-time curve represents the "NO_x deficit" emissions of 160 ppm-seconds.

The CEC was unable to measure the time trend of diesel engine exhaust particulate matter (DEEP) concentrations during the first several seconds after a cold start. Therefore, for the purpose of estimating the DEEP trend, it was assumed that DEEP would exhibit the same concentration-vs-time trend as VOC emissions.

The numerical value of the Cold-start Spike Adjustment Factor was derived by dividing the area under the "cold-start spike" by the area under the steady-state concentration profile for the 1-minute averaging period.

Example: Cold-Start Spike Factor for VOCs, first 1-minute after cold-start at low load.

The "VOC spike" was observed 14 seconds after cold-start and reached a concentration of 6,300 ppm-seconds. The **<u>triangular</u>** area under the curve is $\frac{14\text{ seconds } \times 900\ ppm}{2} = 6{,}300\ ppm\text{-}seconds$.

The steady-state VOC concentration is 30 *ppm*. For the 1-minute (60-seconds) steady-state period the area under the curve is $(60\ seconds - 14\ seconds) \times 30\ ppm\ = 1{,}380\ ppm\text{-}seconds.$

Therefore, the cold-start emission factor (to be applied to the warm-emission rate estimate for the first 1-minute after cold-start) was estimated by $\frac{6{,}300\ ppm{-}seconds + 1{,}380\ ppm{-}seconds}{30\ ppm \times 60\ seconds}$.

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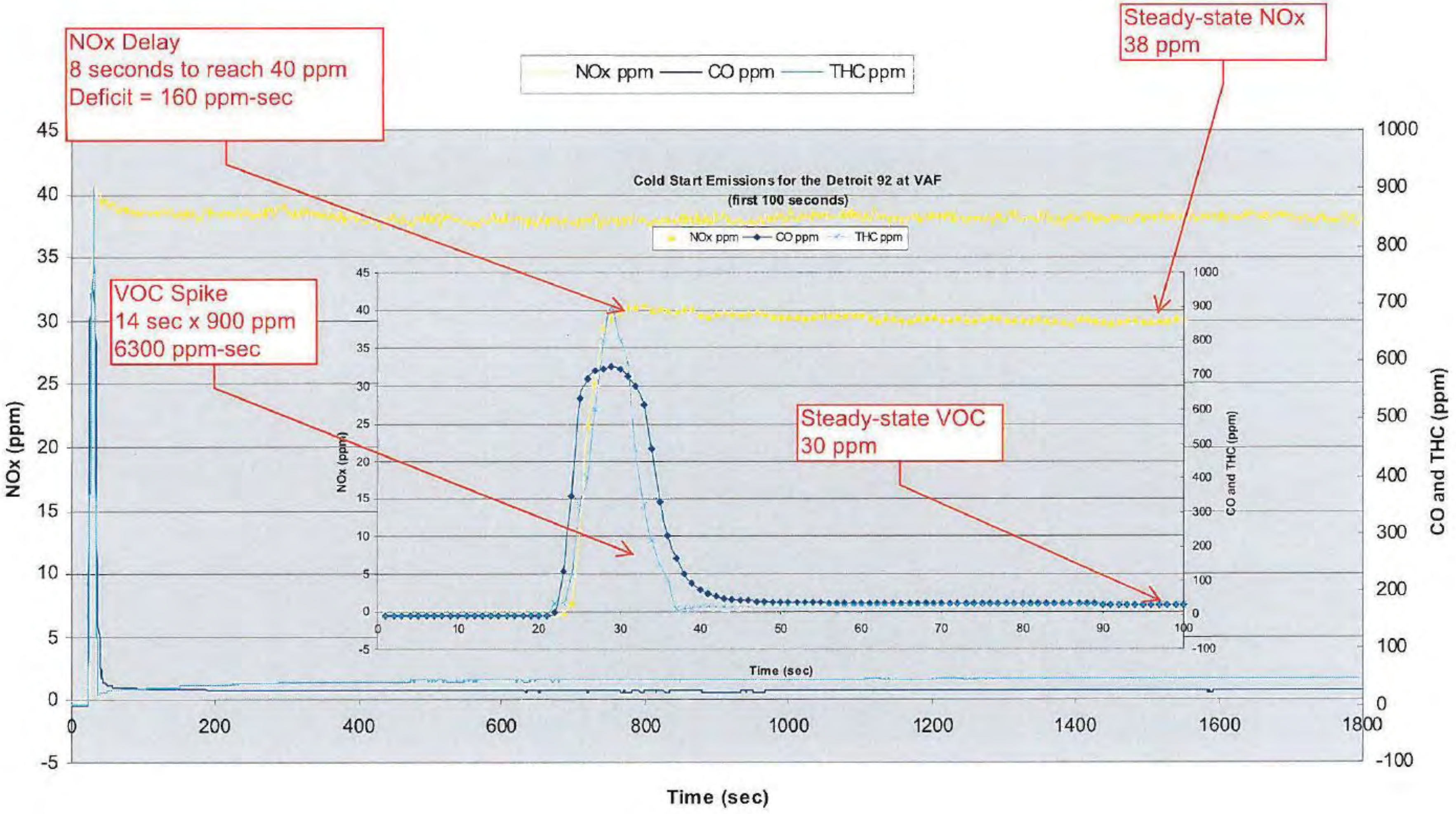
[1] Miller, J.W., and J.M. Lents. 2005. Air Quality Implications of Backup Generators in California - Volume Two: Emission Measurements from Controlled and Uncontrolled Backup Generators. Publication No. CEC-500-2005-049. University of California, Riverside, for the California Energy Commission, Public Interest Energy Research Program. July. https://www.energy.ca.gov/2005publications/CEC-500-2005-049/CEC-500-2005-049.PDF.


NOx Delay
8 seconds to reach 40 ppm
Deficit = 160 ppm-sec

Steady-state NOx
38 ppm

VOC Spike
14 sec x 900 ppm
6300 ppm-sec

Steady-state VOC
30 ppm

Source: Lents et al. 2005.

LANDAU ASSOCIATES

CyrusOne Data Center
Quincy, Washington

Cold-Start Emission Trends

Figure
B-1

APPENDIX C

Best Available Control Technology Cost Summary Tables

Table C-1
Tier 4 Integrated Control Package Capital Cost
CyrusOne Data Center
Quincy, Washington

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2250-KWe emission control package	Cost estimate by Johnson Matthey		40	$207,430	$8,297,200
2250-KWe miscellaneous parts	Assumed no cost			$0	$0
750-KWe emission control package	Cost estimate by Johnson Matthey		2	$133,500	$267,000
750-KWe miscellaneous parts	Assumed no cost			$0	$0
Combined systems FOB cost					$8,564,200
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$556,673
Shipping (2250-KWe)		Johnson Matthey	40	$ 4,500	$180,000
Shipping (750-KWe)		Johnson Matthey	2	$ 4,500	$9,000
Subtotal Purchased Equipment Cost (PEC)					$9,309,873
Direct Installation Costs					
Enclosure structural supports (2250-KWe)	Cost estimate by Johnson Matthey		40	$3,500	$140,000
Onsite Installation (2250-KWe)	Cost estimate by Johnson Matthey		40	$22,000	$880,000.00
Enclosure structural supports (750-KWe)	Cost estimate by Johnson Matthey		2	$3,500	$7,000
Onsite Installation (750-KWe)	Cost estimate by Johnson Matthey		2	$22,000	$44,000
Electrical	Included above		0	$0	$0.00
Piping	Included above		0	$0	$0.00
Insulation	Assumed no cost		0	$0	$0.00
Painting	Assumed no cost		0	$0	$0.00
Subtotal Direct Installation Costs (DIC)					$1,071,000
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0.00
Total Direct Costs, (DC = PEC + DIC + SP)					$10,380,873
Indirect Costs (Installation)					
Engineering		Johnson Matthey	42	$5,000	$210,000
Construction and field expenses		Johnson Matthey	42	$3,000	$126,000
Contractor Fees	From DIS data center		6.8%	--	$630,278
Startup		Johnson Matthey	42	$3,000	$126,000
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$93,099
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$279,296
Subtotal Indirect Costs (IC)					$1,464,673
Total Capital Investment (TCI = DC+IC)					**$11,845,546**

Table C-2
Tier 4 Integrated Control Package Cost Effectiveness
CyrusOne Data Center
Quincy, Washington

Item	Quantity	Units	Unit Cost	Units	Subtotal
Annualized Capital Recovery					
Total Capital Cost					$11,845,546
Capital Recovery Factor:	25	years	4%	discount	0.064
Subtotal Annualized 25-year Capital Recovery Cost					$758,257
Direct Annual Cost					
Increased Fuel Consumption	Insignificant				$0
Reagent Consumption (estimated by Pacific Power Group)	12,928	gallons/year	$4.00	per gallon	$51,710
Catalyst Replacement (EPA Manual)	Insignificant				$0
Annual operation/labor/maintenance costs: Upper-bound estimate would assume CARB's value of $1.50/hp/year and would result in $171,985/year. Lower-bound estimate would assume zero annual O&M. Mid-range value would account for fuel for pressure drop, increased inspections, periodic OEM visits, and the costs for Ecology's increased emission testing requirements. For this screening-level analysis, we assumed the lower-bound annual O&M cost of zero.					$0
Subtotal Direct Annual Cost					$51,710
Indirect Annual Costs					
Annual Admin charges (EPA Manual)	2.0%	of Total Capital Investment			$236,911
Annual Property tax (EPA Manual)	1.0%	of Total Capital Investment			$118,455
Annual Insurance (EPA Manual)	1.0%	of Total Capital Investment			$118,455
Subtotal Indirect Annual Costs					$473,822
Total Annual Cost (Capital Recovery + Direct Annual Costs + Indirect Annual Costs)					**$1,283,789**
Uncontrolled Emissions (Combined Pollutants)					46
Annual Tons Removed (Combined Pollutants)					41
Cost Effectiveness ($ per tons combined pollutant destroyed)					**$31,603**

Annual O&M Cost Based on CARB Factors (lowermost CARB estimate)	
$171,986 per year per generator	$57,329 per year per generator
2,250 KW-hr	750 KW-hr
1,520 annual generator hours	76 annual generator hours
$1.50 per HP$_M$ per year	$1.50 per HP$_M$ per year

MULTI-CRITERIA POLLUTANT COST-EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
NO$_x$	$12,000	33	$390,394 per year
CO	$5,000	6.3	$31,556 per year
VOCs	$12,000	1.23	$14,751 per year
PM	$12,000	0.55	$6,591 per year
Total Reasonable Annual Control Cost for Combined Pollutants			$443,292.46 per year
Actual Annual Control Cost			$1,283,789 per year
		Is The Control Device Reasonable?	**NO (Actual >> Acceptable)**

CRITERIA POLLUTANT CONTROL EFFICIENCIES[a]

Pollutant	PM (FH)	CO	VOCs	NO$_x$
Tier 2 Uncontrolled Emissions (TPY)	0.62	7.9	1.76	36
Controlled Emissions (TPY)	0.075	1.6	0.53	3.6
TPY Removed	0.55	6.3	1.23	33
Combined Uncontrolled Emissions (TPY)	46			
Combined TPY Removed	41			
Expected Removal Efficiency	88%	80%	70%	90%
Annualized Cost ($/year)	$1,283,789			
Individual Pollutant $/Ton Removed	$2,337,337	$203,413	$1,044,383	$39,461

MULTI-TOXIC AIR POLLUTANT COST-EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	ASIL (µg/m^3)	"Hanford Method" Cost Factor	Ecology Guidance "Ceiling Cost" ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
DEEP	0.00333	6.9	$72,544	0.55	$39,845 per year
CO	23,000	0.070	$731	6.3	$4,615 per year
NO$_2$ (10% of NO$_x$)	470	1.8	$18,472	3.3	$60,096 per year
Benzene	0.0345	5.9	$61,882	0.0098	$604 per year
1,3-Butadiene	0.00588	6.7	$69,951	4.9E-04	$34 per year
Acrolein	0.06	5.7	$59,359	9.9E-05	$5.88 per year
Naphthalene	0.0294	6.0	$62,612	0.0016	$102 per year
Formaldehyde	0.167	5.2	$54,691	0.0010	$54 per year
Benzo(a)pyrene	9.09E-04	7.5	$78,464	3.2E-06	$0.25 per year
Benzo(b)fluoranthene	0.00909	6.5	$67,964	1.4E-05	$0.95 per year
Dibenz(a,h)anthracene	8.33E-04	7.5	$78,863	4.4E-06	$0.34 per year
Xylenes	221	2.1	$21,913	0.0024	$53 per year
SO$_2$	660	1.6	$16,924	0.0	$0.00 per year
Propylene	3,000	1.0	$10,020	0.035	$352 per year
Carcinogenic VOCs	n.a.	n.a.	$9,999	0.013	$129 per year
Non-Carcinogenic VOCs	n.a.	n.a.	$5,000	0.041	$206 per year
Total Reasonable Annual Control Cost for Combined Pollutants					$106,097 per year
Actual Annual Control Cost					$1,283,789 per year
				Is The Control Device Reasonable?	**NO (Actual >> Acceptable)**

Notes:
FH ("front-half" filterable emissions)
BH ("back-half" condensable emissions)
PM (particulate matter) attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.
DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

TOXIC AIR POLLUTANT CONTROL EFFICIENCIES[a]

TAP	Tier 2 Uncontrolled Emissions (TPY)	Controlled Emissions (TPY)	TPY Removed	Expected Removal Efficiency	Individual Pollutant $/Ton Removed
DEEP	0.62	0.075	0.55	88%	$2,337,337
CO	7.89	1.6	6.3	80%	$203,413
NO$_2$ (10% of NOx)	3.6	0.36	3.3	90%	$394,613
Benzene	0.014	0.0042	0.0098	70%	$131,551,959
1,3-Butadiene	7.0E-04	2.1E-04	4.92E-04	70%	$2,610,852,173
Acrolein	1.4E-04	4.2E-05	9.91E-05	70%	$12,954,862,938
Naphthalene	2.3E-03	7.0E-04	0.0016	70%	$785,264,000
Formaldehyde	0.0014	4.3E-04	0.0010	70%	$1,293,844,359
Benzo(a)pyrene	4.6E-06	1.4E-06	3.23E-06	70%	$397,215,252,723
Benzo(b)fluoranthene	2.0E-05	6.0E-06	1.40E-05	70%	$91,967,855,811
Dibenz(a,h)anthracene	6.2E-06	1.9E-06	4.35E-06	70%	$295,041,387,138
Xylenes	0.0035	0.0010	0.0024	70%	$528,934,300
SO$_2$	0.027	0.027	0.0	0%	--
Propylene	0.050	0.015	0.035	70%	$36,589,362
Carcinogenic VOCs	0.018	0.0055	0.013	70%	$99,255,827
Non-Carcinogenic VOCs	0.059	0.018	0.041	70%	$31,200,509
Annualized Cost ($/yr)					$1,283,789
Combined Uncontrolled Emissions (TPY)					12.2
Combined TPY Removed					10.2
Combined TAPs $/Ton Removed					$126,304

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

[a] The expected Tier 4 control efficiency to reduce emission is 90% for NO$_x$, 88% for PM (front half), 80% for CO, and 70% for VOCs.

Table C-3
Selective Catalytic Reduction Capital Cost
CyrusOne Data Center
Quincy, Washington

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2250-KWe emission control package	Cost estimate by Johnson Matthey		40	$140,851	$5,634,040
2250-KWe miscellaneous parts	Assumed no cost			$0	$0
750-KWe emission control package	Cost estimate by Johnson Matthey		2	$100,000	$200,000
750-KWe miscellaneous parts	Assumed no cost			$0	$0
Combined systems FOB cost					$5,834,040
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$379,213
Shipping (2250-KWe)		Johnson Matthey	40	$3,500	$140,000
Shipping (750-KWe)		Johnson Matthey	2	$2,200	$4,400
Subtotal Purchased Equipment Cost (PEC)					$6,357,653
Direct Installation Costs					
Enclosure structural supports (2250-KWe)	Cost estimate by Johnson Matthey		40	$2,500	$100,000
Onsite Installation (2250-KWe)	Cost estimate by Johnson Matthey		40	$12,000	$480,000
Enclosure structural supports (750-KWe)	Cost estimate by Johnson Matthey		2	$2,200	$4,400
Onsite Installation (750-KWe)	Cost estimate by Johnson Matthey		2	$10,000	$20,000
Electrical	Included above		0	$0	$0
Piping	Included above		0	$0	$0
Insulation	Assumed no cost		0	$0	$0
Painting	Assumed no cost		0	$0	$0
Subtotal Direct Installation Costs (DIC)					$604,400
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0
Total Direct Costs, (DC = PEC + DIC + SP)					$6,962,053
Indirect Costs (Installation)					
Engineering		Johnson Matthey	42	$3,000	$126,000
Construction and field expenses		Johnson Matthey	42	$3,000	$126,000
Contractor Fees	From DIS data center		6.8%	--	$430,413
Startup		Johnson Matthey	42	$3,000	$126,000
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$63,577
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$190,730
Subtotal Indirect Costs (IC)					$1,062,719
Total Capital Investment (TCI = DC+IC)					**$8,024,772**

Table C-4
Selective Catalytic Reduction Cost Effectiveness
CyrusOne Data Center
Quincy, Washington

Item	Quantity	Units	Unit Cost	Units	Subtotal
Annualized Capital Recovery					
Total Capital Cost					$8,024,772
Capital Recovery Factor:	25	years	4%	discount	0.064
Subtotal Annualized 25-year Capital Recovery Cost					$513,681
Direct Annual Cost					
Increased Fuel Consumption	Insignificant				$0
Reagent Consumption (estimated by Pacific Power Group)	12,928	gallons/year	$4.00	per gallon	$51,710
Catalyst Replacement (EPA Manual)	Insignificant				$0
Annual operation/labor/maintenance costs: Upper-bound estimate would assume CARB's value of $1.50/hp/year and would result in $171,986/year. Lower-bound estimate would assume zero annual O&M. Mid-range value would account for fuel for pressure drop, increased inspections, periodic OEM visits, and the costs for Ecology's increased emission testing requirements. For this screening-level analysis, we assumed the lower-bound annual O&M cost of zero.					$0
Subtotal Direct Annual Cost					$51,710
Indirect Annual Costs					
Annual Admin charges (EPA Manual)	2.0%	of Total Capital Investment			$160,495
Annual Property tax (EPA Manual)	1.0%	of Total Capital Investment			$80,248
Annual Insurance (EPA Manual)	1.0%	of Total Capital Investment			$80,248
Subtotal Indirect Annual Costs					$320,991
Total Annual Cost (Capital Recovery + Direct Annual Costs + Indirect Annual Costs)					**$886,383**
Uncontrolled Emissions (Combined Pollutants)					46
Annual Tons Removed (Combined Pollutants)					33
Cost Effectiveness ($ per tons combined pollutant destroyed)					**$27,246**

Annual O&M Cost Based on CARB Factors (lowermost CARB estimate)			
$171,986	per year per generator	$57,329	per year per generator
2,250	KW-hr	750	KW-hr
1,520	annual generator hours	76	annual generator hours
$1.50	per HP_M per year	$1.50	per HP_M per year

MULTI-CRITERIA POLLUTANT COST-EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
NO_x	$12,000	33	$390,394 per year
CO	$5,000	0	$0 per year
VOCs	$12,000	0	$0 per year
PM	$12,000	0	$0 per year
Total Reasonable Annual Control Cost for Combined Pollutants			$390,394 per year
Actual Annual Control Cost			$886,383 per year
		Is The Control Device Reasonable?	**NO (Actual >> Acceptable)**

CRITERIA POLLUTANT CONTROL EFFICIENCIES[a]

Pollutant	PM (FH)	CO	VOCs	NO_x
Tier 2 Uncontrolled Emissions (TPY)	0.62	7.9	1.76	36
Controlled Emissions (TPY)	0.62	7.9	1.76	3.6
TPY Removed	0	0	0	33
Combined Uncontrolled Emissions (TPY)	46			
Combined TPY Removed	33			
Expected Removal Efficiency	0%	0%	0%	90%
Annualized Cost ($/year)	$886,383			
Individual Pollutant $/Ton Removed	--	--	--	$27,246

MULTI-TOXIC AIR POLLUTANT COST-EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	ASIL ($\mu g/m^3$)	"Hanford Method" Cost Factor	Ecology Guidance "Ceiling Cost" ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
DEEP	0.00333	6.9	$72,544	0.0	$0 per year
CO	23,000	0.070	$731	0.0	$0 per year
NO_2 (10% of NO_x)	470	1.8	$18,472	3.3	$60,096 per year
Benzene	0.0345	5.9	$61,882	0.0	$0 per year
1,3-Butadiene	0.00588	6.7	$69,951	0.0	$0 per year
Acrolein	0.06	5.7	$59,359	0.0	$0 per year
Naphthalene	0.0294	6.0	$62,612	0.0	$0 per year
Formaldehyde	0.167	5.2	$54,691	0.0	$0 per year
Benzo(a)pyrene	9.09E-04	7.5	$78,464	0.0	$0 per year
Benzo(b)fluoranthene	0.00909	6.5	$67,964	0.0	$0 per year
Dibenz(a,h)anthracene	8.33E-04	7.5	$78,863	0.0	$0 per year
Xylenes	221	2.1	$21,913	0.0	$0 per year
SO_2	660	1.6	$16,924	0.0	$0 per year
Propylene	3,000	1.0	$10,020	0.0	$0 per year
Carcinogenic VOCs	n.a.	n.a.	$9,999	0.0	$0 per year
Non-Carcinogenic VOCs	n.a.	n.a.	$5,000	0.0	$0 per year
Total Reasonable Annual Control Cost for Combined Pollutants					$60,096 per year
Actual Annual Control Cost					$886,383 per year
				Is The Control Device Reasonable?	**NO (Actual >> Acceptable)**

TOXIC AIR POLLUTANT CONTROL EFFICIENCIES[a]

TAP	Tier 2 Uncontrolled Emissions (TPY)	Controlled Emissions (TPY)	TPY Removed	Expected Removal Efficiency	Individual Pollutant $/Ton Removed
DEEP	0.62	0.62	0.0	0%	--
CO	7.89	7.9	0.0	0%	--
NO_2 (10% of NO_x)	3.6	0.36	3.3	90%	$272,458
Benzene	0.014	0.014	0.0	0%	--
1,3-Butadiene	7.0E-04	7.0E-04	0.0	0%	--
Acrolein	1.4E-04	1.4E-04	0.0	0%	--
Naphthalene	2.3E-03	0.0023	0.0	0%	--
Formaldehyde	0.0014	0.0014	0.0	0%	--
Benzo(a)pyrene	4.6E-06	4.6E-06	0.0	0%	--
Benzo(b)fluoranthene	2.0E-05	2.0E-05	0.0	0%	--
Dibenz(a,h)anthracene	6.2E-06	6.2E-06	0.0	0%	--
Xylenes	0.0035	0.0035	0.0	0%	--
SO_2	0.027	0.027	0.0	0%	--
Propylene	0.050	0.050	0.0	0%	--
Carcinogenic VOCs	0.018	0.018	0.0	0%	--
Non-Carcinogenic VOCs	0.059	0.059	0.0	0%	--
Annualized Cost ($/yr)					$886,383
Combined Uncontrolled Emissions (TPY)					12
Combined TPY Removed					3.3
Combined TAPs $/Ton Removed					$272,458

Notes:

FH ("front-half" filterable emissions)

BH ("back-half" condensable emissions)

PM (particulate matter) attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

[a] The expected control efficiency using the SCR control option is 90% for NO_x, only.

Table C-5
Catalyzed Diesel Particulate Filter Capital Cost
CyrusOne Data Center
Quincy, Washington

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2250-KWe emission control package	Cost estimate by Johnson Matthey		40	$66,579	$2,663,160
2250-KWe miscellaneous parts	Assumed no cost			$0	$0
750-KWe emission control package	Cost estimate by Johnson Matthey		2	$27,500	$55,000
750-KWe miscellaneous parts	Assumed no cost			$0	$0
Combined systems FOB cost					$2,718,160
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$176,680
Shipping (2250-KWe)		Johnson Matthey	40	$3,000	$120,000
Shipping (750-KWe)		Johnson Matthey	2	$1,500	$3,000
Subtotal Purchased Equipment Cost (PEC)					$3,017,840
Direct Installation Costs					
Enclosure structural supports (2250-KWe)	Cost estimate by Johnson Matthey		40	$1,000	$40,000
Onsite Installation (2250-KWe)	Cost estimate by Johnson Matthey		40	$10,000	$400,000
Enclosure structural supports (750-KWe)	Cost estimate by Johnson Matthey		2	$1,000	$2,000
Onsite Installation (750-KWe)	Cost estimate by Johnson Matthey		2	$7,000	$14,000
Electrical	Included above		0	$0	$0
Piping	Included above		0	$0	$0
Insulation	Assumed no cost		0	$0	$0
Painting	Assumed no cost		0	$0	$0
Subtotal Direct Installation Costs (DIC)					$456,000
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0
Total Direct Costs, (DC = PEC + DIC + SP)					$3,473,840
Indirect Costs (Installation)					
Engineering		Johnson Matthey	42	$2,000	$84,000
Construction and field expenses		Johnson Matthey	42	$0	$0
Contractor Fees	From DIS data center		6.8%	--	$204,308
Startup		Johnson Matthey	42	$1,500	$63,000
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$30,178
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$90,535
Subtotal Indirect Costs (IC)					$472,021
Total Capital Investment (TCI = DC+IC)					**$3,945,862**

Table C-6
Catalyzed Diesel Particulate Filter Cost Effectiveness
CyrusOne Data Center
Quincy, Washington

Item	Quantity	Units	Unit Cost	Subtotal
Annualized Capital Recovery				
Total Capital Cost				**$3,945,862**
Capital Recovery Factor, 25 yrs, 4% discount rate				0.064
Subtotal Annualized 25-year Capital Recovery Cost				$252,582
Direct Annual Costs				
Annual Admin charges	2% of TCI (EPA Manual)		0.02	$78,917
Annual Property tax	1% of TCI (EPA Manual)		0.01	$39,459
Annual Insurance	1% of TCI (EPA Manual)		0.01	$39,459
Annual operation/labor/maintenance costs: Upper-bound estimate would assume CARB's value of $1.00/hp/year and would result in $114,657/year. Lower-bound estimate would assume zero annual O&M. Mid-range value would account for fuel for pressure drop, increased inspections, periodic OEM visits, and the costs for Ecology's increased emission testing requirements. For this screening-level analysis we assumed the lower-bound annual O&M cost of zero.				$0
Subtotal Direct Annual Costs				$157,834
Total Annual Cost (Capital Recovery + Direct Annual Costs)				**$410,417**
Uncontrolled Emissions (Combined Pollutants)				46
Annual Tons Removed (Combined Pollutants)				8.1
Cost Effectiveness ($ per tons combined pollutant destroyed)				**$50,655**

MULTI-CRITERIA POLLUTANT COST-EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
NO_x	$12,000	0	$0 per year
CO	$5,000	6	$31,556 per year
VOCs	$12,000	1	$14,751 per year
PM	$12,000	0.6	$6,741 per year
Total Reasonable Annual Control Cost for Combined Pollutants			$53,048 per year
Actual Annual Control Cost			$410,417 per year
		Is The Control Device Reasonable?	**NO (Actual >> Acceptable)**

MULTI-TOXIC AIR POLLUTANT COST-EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	ASIL (µg/m^3)	"Hanford Method" Cost Factor	Ecology Guidance "Ceiling Cost" ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
DEEP	0.00333	6.9	$72,544	0.56	$40,750 per year
CO	23,000	0.070	$731	6.3	$4,615 per year
NO_2 (10% of NO_x)	470	1.8	$18,472	0.0	$0.0 per year
Benzene	0.0345	5.9	$61,882	0.0098	$604 per year
1,3-Butadiene	0.00588	6.7	$69,951	4.9E-04	$34 per year
Acrolein	0.06	5.7	$59,359	9.9E-05	$5.9 per year
Naphthalene	0.0294	6.0	$62,612	0.0016	$102 per year
Formaldehyde	0.167	5.2	$54,691	0.0010	$54 per year
Benzo(a)pyrene	9.09E-04	7.5	$78,464	3.2E-06	$0.25 per year
Benzo(b)fluoranthene	0.00909	6.5	$67,964	1.4E-05	$0.95 per year
Dibenz(a,h)anthracene	8.33E-04	7.5	$78,863	4.4E-06	$0.34 per year
Xylenes	221	2.1	$21,913	0.0024	$53 per year
SO_2	660	1.6	$16,924	0.0	$0 per year
Propylene	3,000	1.0	$10,020	0.035	$352 per year
Carcinogenic VOCs	n.a.	n.a.	$9,999	0.013	$129 per year
Non-Carcinogenic VOCs	n.a.	n.a.	$5,000	0.041	$206 per year
Total Reasonable Annual Control Cost for Combined Pollutants					$46,907 per year
Actual Annual Control Cost					$410,417 per year
				Is The Control Device Reasonable?	**NO (Actual >> Acceptable)**

Notes:

FH ("front-half" filterable emissions)

BH ("back-half" condensable emissions)

PM (particulate matter) attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

Annual O&M Cost Based on CARB Factors (lowermost CARB estimate)	
$114,657 per year per generator	$38,219 per year per generator
2,250 KW-hr	750 KW-hr
1,520 annual generator hours	76 annual generator hours
$1.00 per HP_M per year	$1.00 per HP_M per year

CRITERIA POLLUTANT CONTROL EFFICIENCIES[a]

Pollutant	PM (FH)	CO	VOCs	NO_x
Tier 2 Uncontrolled Emissions (TPY)	0.62	7.9	1.76	36
Controlled Emissions (TPY)	0.062	1.6	0.53	36
TPY Removed	0.56	6.3	1.23	0
Combined Uncontrolled Emissions (TPY)	46			
Combined TPY Removed	8.1			
Expected Removal Efficiency	90%	80%	70%	0%
Annualized Cost ($/year)	$410,417			
Individual Pollutant $/Ton Removed	$730,622	$65,029	$333,881	--

TOXIC AIR POLLUTANT CONTROL EFFICIENCIES[a]

TAP	Tier 2 Uncontrolled Emissions (TPY)	Controlled Emissions (TPY)	TPY Removed	Expected Removal Efficiency	Individual Pollutant $/Ton Removed
DEEP	0.62	0.06	0.56	90%	$730,622
CO	7.89	1.6	6.3	80%	$65,029
NO_2 (10% of NO_x)	3.6	3.6	0.0	0%	--
Benzene	0.014	0.0042	0.0098	70%	$42,056,087
1,3-Butadiene	7.0E-04	2.1E-04	4.9E-04	70%	$834,668,112
Acrolein	1.4E-04	4.2E-05	9.9E-05	70%	$4,141,563,857
Naphthalene	2.3E-03	7.0E-04	0.0016	70%	$251,042,486
Formaldehyde	0.0014	4.3E-04	0.0010	70%	$413,631,473
Benzo(a)pyrene	4.6E-06	1.4E-06	3.2E-06	70%	$126,986,471,557
Benzo(b)fluoranthene	2.0E-05	6.0E-06	1.40E-05	70%	$29,401,372,243
Dibenz(a,h)anthracene	6.2E-06	1.9E-06	4.4E-06	70%	$94,322,321,359
Xylenes	0.0035	0.0010	0.0024	70%	$169,095,975
SO_2	0.027	0.027	0.0	0%	--
Propylene	0.050	0.015	0.035	70%	$11,697,320
Carcinogenic VOCs	0.018	0.0055	0.013	70%	$31,731,277
Non-Carcinogenic VOCs	0.059	0.018	0.041	70%	$9,974,548
Annualized Cost ($/yr)					$410,417
Combined Uncontrolled Emissions (TPY)					12.2
Combined TPY Removed					6.9
Combined TAPs $/Ton Removed					$59,279

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

[a] The expected control efficiency using the catalyzed DPF is 85% for PM (front half), 80% for CO, and 70% for VOCs. There is no expected control of NO_x emissions using the catalyzed DPF option.

Table C-7
Diesel Oxidation Catalyst Capital Cost
CyrusOne Data Center
Quincy, Washington

Cost Category	Cost Factor	Source of Cost Factor	Quant.	Unit Cost	Subtotal Cost
Direct Costs					
Purchased Equipment Costs					
2250-KWe emission control package	Cost estimate by Johnson Matthey		40	$11,486	$459,440
2250-KWe miscellaneous parts	Assumed no cost			$0	$0
750-KWe emission control package	Cost estimate by Johnson Matthey		2	$6,500	$13,000
750-KWe miscellaneous parts	Assumed no cost			$0	$0
Combined systems FOB cost					$472,440
Instrumentation	Assumed no cost		0	$0	$0
Sales Tax	WA state tax	WA state tax	6.5%	--	$30,709
Shipping (2250-KWe)		Johnson Matthey	40	$500	$20,000
Shipping (750-KWe)		Johnson Matthey	2	$300	$600
Subtotal Purchased Equipment Cost (PEC)					$523,749
Direct Installation Costs					
Enclosure structural supports (2250-KWe)	Cost estimate by Johnson Matthey		40	$0	$0
Onsite Installation (2250-KWe)	Cost estimate by Johnson Matthey		40	$3,000	$120,000
Enclosure structural supports (750-KWe)	Cost estimate by Johnson Matthey		2	$0	$0
Onsite Installation (750-KWe)	Cost estimate by Johnson Matthey		2	$3,000	$6,000
Electrical	Included above		0	$0	$0
Piping	Included above		0	$0	$0
Insulation	Assumed no cost		0	$0	$0
Painting	Assumed no cost		0	$0	$0
Subtotal Direct Installation Costs (DIC)					$126,000
Site Preparation and Buildings (SP)	Assumed no cost		0	$0	$0
Total Direct Costs, (DC = PEC + DIC + SP)					$649,749
Indirect Costs (Installation)					
Engineering		Johnson Matthey	42	$1,200	$50,400
Construction and field expenses		Johnson Matthey	42	$0	$0
Contractor Fees	From DIS data center		6.8%	--	$35,458
Startup		Johnson Matthey	42	$1,500	$63,000
Performance Test (Tech support)	0.01*PEC	EPA Cost Manual	1.0%	--	$5,237
Contingencies	0.03*PEC	EPA Cost Manual	3.0%	--	$15,712
Subtotal Indirect Costs (IC)					$169,808
Total Capital Investment (TCI = DC+IC)					**$819,556**

Table C-8
Diesel Oxidation Catalyst Cost Effectiveness
CyrusOne Data Center
Quincy, Washington

Item	Quantity	Units	Unit Cost	Subtotal
Annualized Capital Recovery				
Total Capital Cost				**$819,556**
Capital Recovery Factor, 25 yrs, 4% discount rate				0.064
Subtotal Annualized 25-year Capital Recovery Cost				$52,461
Direct Annual Costs				
Annual Admin charges	2% of TCI (EPA Manual)		0.02	$16,391
Annual Property tax	1% of TCI (EPA Manual)		0.01	$8,196
Annual Insurance	1% of TCI (EPA Manual)		0.01	$8,196
Catalyst Replacement	Assume cost of zero.		$0	$0
Annual operation/labor/maintenance costs: Upper-bound estimate would assume CARB's value of $0.20/hp/year and would result in $22,931/year. Lower-bound estimate would assume zero annual O&M. Mid-range value would account for fuel for pressure drop, increased inspections, periodic OEM visits, and the costs for Ecology's increased emission testing requirements. For this screening-level analysis, we assumed the lower-bound annual O&M cost of zero.				$0
Subtotal Direct Annual Costs				$32,782
Total Annual Cost (Capital Recovery + Direct Annual Costs)				**$85,244**
Uncontrolled Emissions (Combined Pollutants)				46
Annual Tons Removed (Combined Pollutants)				7.7
Cost Effectiveness ($ per tons combined pollutant destroyed)				**$11,076**

Annual O&M Cost Based on CARB Factors (lowermost CARB estimate)	
$22,931 per year per generator	$7,644 per year per generator
2,250 KW-hr	750 KW-hr
1,520 annual generator hours	76 annual generator hours
$0.20 per HP_M per year	$0.20 per HP_M per year

MULTI-CRITERIA POLLUTANT COST-EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	Ecology Acceptable Unit Cost ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
NO_x	$12,000	0	$0 per year
CO	$5,000	6.3	$31,556 per year
VOCs	$12,000	1.23	$14,751 per year
PM	$12,000	0.16	$1,872 per year
Total Reasonable Annual Control Cost for Combined Pollutants			$48,180 per year
Actual Annual Control Cost			$85,244 per year
		Is The Control Device Reasonable?	**NO (Actual >> Acceptable)**

CRITERIA POLLUTANT CONTROL EFFICIENCIES[a]

Pollutant	PM (FH)	CO	VOCs	NO_x
Tier 2 Uncontrolled Emissions (TPY)	0.62	7.9	1.76	36
Controlled Emissions (TPY)	0.47	1.58	0.53	36
TPY Removed	0.16	6.3	1.23	0
Combined Uncontrolled Emissions (TPY)	46			
Combined TPY Removed	7.7			
Expected Removal Efficiency	25%	80%	70%	0%
Annualized Cost ($/year)	$85,244			
Individual Pollutant $/Ton Removed	$546,301	$13,507	$69,347	--

MULTI-TOXIC AIR POLLUTANT COST-EFFECTIVENESS (Reasonable vs. Actual Cost to Control)[a]

Pollutant	ASIL (µg/m^3)	"Hanford Method" Cost Factor	Ecology Guidance "Ceiling Cost" ($/ton)	Forecast Removal (TPY)[a]	Subtotal Reasonable Annual Cost ($/year)
DEEP	0.00333	6.9	$72,544	0.16	$11,320 per year
CO	23,000	0.1	$731	6.3	$4,615 per year
NO_2 (10% of NO_x)	470	1.8	$18,472	0.0	$0 per year
Benzene	0.0345	5.9	$61,882	0.0098	$604 per year
1,3-Butadiene	0.00588	6.7	$69,951	4.9E-04	$34 per year
Acrolein	0.06	5.7	$59,359	9.9E-05	$5.9 per year
Naphthalene	0.0294	6.0	$62,612	0.0016	$102 per year
Formaldehyde	0.167	5.2	$54,691	0.0010	$54 per year
Benzo(a)pyrene	9.09E-04	7.5	$78,464	3.2E-06	$0 per year
Benzo(b)fluoranthene	0.00909	6.5	$67,964	1.4E-05	$0.95 per year
Dibenz(a,h)anthracene	8.33E-04	7.5	$78,863	4.4E-06	$0.34 per year
Xylenes	221	2.1	$21,913	0.0024	$53 per year
SO_2	660	1.6	$16,924	0.0	$0 per year
Propylene	3,000	1.0	$10,020	0.035	$352 per year
Carcinogenic VOCs	n.a.	n.a.	$9,999	0.013	$129 per year
Non-Carcinogenic VOCs	n.a.	n.a.	$5,000	0.041	$206 per year
Total Reasonable Annual Control Cost for Combined Pollutants					$17,476 per year
Actual Annual Control Cost					$85,244 per year
				Is The Control Device Reasonable?	**NO (Actual >> Acceptable)**

TOXIC AIR POLLUTANT CONTROL EFFICIENCIES[a]

TAP	Tier 2 Uncontrolled Emissions (TPY)	Controlled Emissions (TPY)	TPY Removed	Expected Removal Efficiency	Individual Pollutant $/Ton Removed
DEEP	0.62	0.47	0.16	25%	$546,301
CO	7.89	1.6	6.3	80%	$13,507
NO_2 (10% of NOx)	3.6	3.6	0.0	0%	--
Benzene	0.014	0.0042	0.0098	70%	$8,735,058
1,3-Butadiene	7.0E-04	2.1E-04	4.9E-04	70%	$173,360,742
Acrolein	1.4E-04	4.2E-05	9.9E-05	70%	$860,203,680
Naphthalene	2.3E-03	7.0E-04	1.6E-03	70%	$52,141,577
Formaldehyde	0.0014	4.3E-04	0.0010	70%	$85,911,343
Benzo(a)pyrene	4.6E-06	1.4E-06	3.2E-06	70%	$26,375,116,727
Benzo(b)fluoranthene	2.0E-05	6.0E-06	1.40E-05	70%	$174,046,681,621
Dibenz(a,h)anthracene	6.2E-06	1.9E-06	4.4E-06	70%	$19,590,765,892
Xylenes	0.0035	0.0010	0.0024	70%	$35,121,269
SO_2	0.027	0.027	0.0	0%	--
Propylene	0.050	0.015	0.035	70%	$2,429,536
Carcinogenic VOCs	0.018	5.5E-03	0.013	70%	$6,590,593
Non-Carcinogenic VOCs	0.059	0.018	0.041	70%	$2,071,716
Annualized Cost ($/yr)					$85,244
Combined Uncontrolled Emissions (TPY)					12.2
Combined TPY Removed					6.5
Combined TAPs $/Ton Removed					$13,079

Notes:

FH ("front-half" filterable emissions)

BH ("back-half" condensable emissions)

PM (particulate matter) attributable to front-half and back-half emissions is assumed equal to the sum of vendor NTE values for PM and hydrocarbons.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

DEEP (diesel engine exhaust particulate matter) is assumed equal to front-half NTE particulate emissions, as reported by the vendors.

[a] The expected control efficiency using the DOC is 80% for CO, and 70% for VOCs. DOCs are marginally effective for removal of PM (15% - 25%) depending on the load). There is no expected control of NO_x emissions using the DOC control option.

APPENDIX D

Summary of AERMOD Inputs

Table D-1
AERMOD Parameter Estimation General Compliance Demonstration
CyrusOne Data Center
Quincy, Washington

AERMOD INPUT - Theoretical Maximum Year with Commissioning

Regulatory Demonstration	AERMOD INPUT (lb/hr) per 2,250-kW Genset[a]	AERMOD INPUT (lb/hr) per 750-kW Genset[a]
NO$_x$ (annual NAAQS)	0.555 [b]	0.189 [b]
DEEP (ASIL / non-cancer risk HQ)	0.00952	0.00149
PM$_{2.5}$ (annual NAAQS)	0.0347 [b]	0.00692 [b]
Worst-case Exhaust Temp. (°F)	464	473
Worst-case Exhaust Flow (cfm)	4,719	1,390

AERMOD INPUT Power Outage Scenario (Worst-case 1-hour & ASIL)

Operating Condition	Cold-start	Warm	Cold-start	Warm
Number of events	1	1	1	1
Duration of each event (hours)	0.017	0.983	0.017	0.983
Hours at each runtime mode	0.017	0.983	0.017	0.983
Maximum Generators Concurrently Operating	40		2	
Regulatory Demonstration	**AERMOD INPUT (lb/hr) per 2,250-kW Genset[a]**		**AERMOD INPUT (lb/hr) per 750-kW Genset[a]**	
CO (1 & 8-hour NAAQS)	10.60		2.22	
Load-Specific Exhaust Temp. (°F)	934		473	
Load-Specific Exhaust Flow (cfm)	18,443		1,390	
SO$_2$ (1 & 3-hour NAAQS)	0.0346		0.01229	
Load-Specific Exhaust Temp. (°F)	934		993	
Load-Specific Exhaust Flow (cfm)	18,443		6,332	
NO$_2$ (1-hour ASIL)	46.8		15.9	
Load-Specific Exhaust Temp. (°F)	934		993	
Load-Specific Exhaust Flow (cfm)	18,443		6,332	

AERMOD INPUT Power Outage Scenario (Worst-case 24-hour)

Operating Condition	Cold-start	Warm	Cold-start	Warm
Regulatory Demonstration	**AERMOD INPUT (lb/hr) per 2,250-kW Genset[a]**		**AERMOD INPUT (lb/hr) per 750-kW Genset[a]**	
Number of events	1	1	1	1
Duration of each event (hours)	0.017	23.983	0.017	23.983
Hours at each runtime mode	0.017	23.983	0.017	23.983
Acrolein (ASIL)	1.76E-04		6.25E-05	
Load-Specific Exhaust Temp. (°F)	934		993	
Load-Specific Exhaust Flow (cfm)	18,443		6,332	

Notes:

[a] All operations are assumed to run at full-variable load (≤100% Load).

[b] For modeling local background impacts, neighboring data centers were assumed to emit at the full potential-to-emit. Cooling towers and the Lamb Weston facility were assumed to be operating at permited limits.

Table D-2
AERMOD Parameter Estimation for NO_2 Monte Carlo Analysis
CyrusOne Data Center
Quincy, Washington

NO_2 1-hour NAAQS Demonstration (Monte Carlo Analysis)

Operating Condition	Cold-start	Warm	Cold-start	Warm
Number of events	1	1	1	1
Duration of each event (hours)	0.017	0.983	0.017	0.983
Hours at each runtime mode	0.017	0.983	0.017	0.983
Regulatory Demonstration	**AERMOD INPUT (lb/hr) per 2,250-kW Genset[a]**		**AERMOD INPUT (lb/hr) per 750-kW Genset[a]**	
NO_2 (1-hour NAAQS)	46.8		15.9	
Load-Specific Exhaust Temp. (°F)	934		993	
Load-Specific Exhaust Flow (cfm)	18,443		6,332	

Additional Modeling Setup Notes

Unplanned Power Outage Scenario		
Maximum Generators Concurrently Operating	40	2
Daily Hours of Operation	24	24
Background Assumptions	All local data centers in power outage mode. Assumed Lamb Weston facility was emitting at permit limit.	
Scheduled Operations Scenario Location A[b,c,d]		
Maximum Generators Concurrently Operating	1 x North (general) area	0
Daily Hours of Operation	12	0
Scheduled Operations Scenario Location B[b,c,d]		
Maximum Generators Concurrently Operating	1 x NE area	0
Daily Hours of Operation	12	0
Scheduled Operations Scenario Location C[b,c,d]		
Maximum Generators Concurrently Operating	1 x West (general) area	0
Daily Hours of Operation	12	0
Scheduled Operations Scenario Location D[b,c,d]		
Maximum Generators Concurrently Operating	1 x South (general) area	0
Daily Hours of Operation	12	0

Notes:

[a] All operations are assumed to run at full-variable load (≤100% Load).

[b] Scheduled operations were assumed to occur between daylight hours, only (7 a.m. to 7 p.m.).

[c] Local data centers coordinate routine operations to prevent concurrent diesel engine activities. For local background, assumed Lamb Weston facility was emitting at permit limit.

[d] Testing of the 750-kW generators could occur in the same day as testing of the 2,250-kW generators; therefore, it was conservatively assumed that a representative AERMOD run of a 2,250-kW generator is a conservative estimate for worst-case scheduled operations on the 750-kW generators.

Table D-3
AERMOD Parameter Estimation for 24-hour PM$_{2.5\ /10}$ NAAQS Demonstration
CyrusOne Data Center
Quincy, Washington

AERMOD Setup: Unplanned power outage 2nd Day (3-hr limit)

Operating Condition	Cold-start	Warm	Cold-start	Warm
Daily Hours of Operation	3		3	
Number of events	1	1	1	1
Duration of each event (hours)	0.017	2.983	0.017	2.983
Hours at each runtime mode	0.017	2.983	0.017	2.983
Maximum Generators Concurrently Operating	40		2	
Regulatory Demonstration	**AERMOD INPUT (lb/hr) per 2,250-kW Genset[a]**		**AERMOD INPUT (lb/hr) per 750-kW Genset[a]**	
PM$_{10}$ (24-hour NAAQS)	0.364		0.0725	
Load-Specific Exhaust Temp. (°F)	635		878	
Load-Specific Exhaust Flow (cfm)	8,474		5,237	
Background Emissions	All local data centers in power outage mode. Assumed Lamb Weston facility and cooling towers were emitting at permit limit.			

AERMOD Setup: Scheduled Operations

Operating Condition	Cold-start	Warm	Cold-start	Warm
Daily Hours of Operation	10		10	
Number of events	2	2	1	1
Duration of each event (hours)	0.017	0.483	0.017	9.983
Hours at each runtime mode	0.033	0.967	0.017	9.983
Maximum Generators Concurrently Operating	1		0	[b]
Regulatory Demonstration	**AERMOD INPUT (lb/hr) per 2,250-kW Genset[a]**		**AERMOD INPUT (lb/hr) per 750-kW Genset[a]**	
PM$_{2.5}$ (24-hour NAAQS)	2.64 [c]		4.77 [b,c]	
Load-Specific Exhaust Temp. (°F)	635		878	
Load-Specific Exhaust Flow (cfm)	8,474		5,237	
Background Emissions	Local data centers coordinate routine operations to prevent concurrent diesel engine activities. For local background, assumed Lamb Weston facility was emitting at permit limit.			

Notes:

[a] All operations are assumed to run at full-variable load (≤100% Load).

[b] Testing of the 750-kW generators could occur in the same day as testing of the 2,250-kW generators; therefore, it was conservatively assumed that a representative AERMOD run of a 2,250-kW generator is a conservative estimate for worst-case scheduled operations on the 750-kW generators.

[c] Scheduled operations were assumed to occur between daylight hours, only (7 a.m. to 7 p.m.).

APPENDIX E

Electronic Files Archive

(on DVD)

LANDAU
ASSOCIATES

February 19, 2019

Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Attn: Gary Huitsing, PE, and Gary Palcisko

Transmitted via e-mail to: *ghui461@ecy.wa.gov*; *gpal461@ecy.wa.gov*

Re: Response to Completeness Letter
CyrusOne Data Center
Quincy, Washington

Dear Messrs. Huitsing and Palcisko:

Landau Associates, Inc. received Washington State Department of Ecology's (Ecology's) completeness letter dated January 28, 2019, which requested additional information regarding the Notice of Construction (NOC) application and Second-Tier Review Application for the CyrusOne LLC data center in Quincy, Washington. Due to a change in the regional background concentration developed by Ecology, the cumulative concentration of nitrogen dioxide (NO_2) is closer to the National Ambient Air Quality Standard (NAAQS) for the 1-hour average. Therefore, Ecology has requested a summary of the conservative assumptions used in the model.

The cumulative NO_2 concentration reported in the NOC application is a conservative estimate of the 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years for the following reasons:

- For all operating scenarios that were evaluated, it was assumed that the generators would operate at 100 percent load, which would result in the highest potential nitrogen oxides (NO_x) and NO_2 emission rates. CyrusOne will operate at 100 percent operating load only during annual loadbank testing for 3 to 4 days per year. Other operations will generally be done at loads lower than 100 percent. NO_x and NO_2 emission rates drop quickly as operating load is decreased. For example, a 25 percent drop in operating load (i.e., operating at 75 percent load) results in a more than 30 percent drop in the NO_x and NO_2 emission rates. A 50 percent drop in operating load results in a more than 65 percent drop in the NO_x and NO_2 emission rates. By assuming all operations are completed at 100 percent operating load, we have estimated an NO_2 impact that is likely biased high, for the purposes of demonstrating compliance with the NO_2 1-hour NAAQS.
- The ambient NO_2 concentrations were modeled using the Plume Volume Molar Ratio Method (PVMRM) option. This AERMOD option calculates ambient NO_2 concentrations surrounding the site by applying a NO_2/NO_x equilibrium ratio of 0.90 and a constant ambient ozone

concentration of 49 parts per billion (WSU; accessed August 16, 2018)[1]. The ambient ozone concentration is based on the month with the highest 75th percentile of daily maximum ozone concentrations. Using a constant value for the entire modeling period does not account for the seasonal variability of ozone concentrations, which are typically higher in the summer months. PVMRM is sensitive to background ozone concentration and overpredicts the NO to NO_2 conversion rate in the winter. This effect is particularly pronounced in this model because most of the maximum daily 1-hour concentrations occurred in the winter.

- The regional background concentration of NO_2 proposed by Ecology represents a maximum daily concentration from the monitored year and is applied at a constant level across the entire modeling period and entire modeling domain. There is significant spatial and temporal variability in NO_2 concentrations. The NO_2 concentration is significantly higher in the winter months, during commute times, and close to transportation sources (vehicles and trains). The proposed sources are located nearly half of a mile from the main transportation areas of Quincy, where existing concentrations are expected to be lower.

In summary, the cumulative modeled NO_2 concentration is a conservatively high estimate due to the use of worst-case emissions, an overprediction of the NO_2 conversion rate in the winter, and a lack of temporal and spatial pairing of regional background with model results.

LANDAU ASSOCIATES, INC.

Mark Brunner
Senior Associate

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cc: Karin Baldwin, Washington State Department of Ecology
Philip O'Dwyer, CyrusOne LLC

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[1] WSU. NW Airquest: Lookup 2009-2011 Design Values of Criteria Pollutants. Northwest International Air Quality Environmental Science and Technology Consortium, Washington State University. http://lar.wsu.edu/nw-airquest/lookup.html.