TECHNICAL SUPPORT DOCUMENT
FOR THE
SECOND TIER ANALYSIS
YAHOO, INC.
QUINCY, WASHINGTON
October 8, 2007

1. EXECUTIVE SUMMARY

Proposed nitric oxide (NO) emissions from the Yahoo Data Center complex in Quincy, Washington exceed a regulatory trigger level called an Acceptable Source Impact Level (ASIL).

Based on the Second Tier analysis described here and the modeled NO concentrations, the Washington State Department of Ecology (Ecology) has determined the health risks are within the range that Ecology may approve for proposed new sources of TAPs under Chapter 173-460 Washington Administrative Code (WAC).

Below is the technical analysis performed by Ecology.

2. THE PROCESS

2.1 The Regulatory Process

The requirements for performing a toxics screening are established in Chapter 173-460 WAC. These rules require a review of any increase in toxic emissions for all new or modified stationary sources in the State of Washington.

2.2 The Three Tiers of Toxic Air Pollutant Permitting

There are three levels of review when processing a new or modified emissions unit emitting Toxic Air Pollutants (TAPs): (1) Tier One (toxic screening), (2) Tier Two (health impacts assessment), and (3) Tier Three (risk management decision).

All projects are required to undergo a toxic screening (Tier One analysis) as required by WAC 173-460-040. The objective of the toxic screening is to establish the systematic control of new sources emitting toxic air pollutants in order to prevent air pollution, reduce emissions to the extent reasonably possible, and maintain such levels of air quality and to protect human health and safety. If modeled emissions exceed the trigger levels called ASILs, a Second Tier analysis is performed.

A Second Tier analysis, promulgated in WAC 173-460-090, is a site-specific health impacts assessment. The objective of a Second Tier analysis is to quantify the increase in lifetime cancer risk for persons exposed to the increased concentration of any Class A TAP and to quantify the increased health hazard from any Class B TAP in ambient air that would result from the proposed project. Once quantified, the cancer risk is compared to the maximum risk allowed by a Second Tier analysis, which is one in one hundred thousand, and the concentration of any Class B TAP that would result from the proposed project is compared to its effect threshold concentration.

If the emissions of a toxic pollutant result in a cancer risk of greater than one in one hundred thousand then an applicant may request Ecology perform a Tier Three analysis. A Tier Three is basically a risk management decision in which the Director of the Department of Ecology makes a decision that the risk of the project is acceptable based on determination that emissions will be maximally reduced through available preventive measures; assessment of environmental benefit, disclosure of risk at a public hearing and related factors associated with the facility and the surrounding community.

2.3 Processing Requirements

Ecology shall evaluate a source's Second Tier analysis only if:

- The authority has advised Ecology that other conditions for processing the Notice of Construction have been met,
- Emission controls contained in the conditional notice of construction represent at least Best Available Control Technology for Toxics (T-BACT), and
- Ambient concentrations exceed acceptable source impact levels after using more refined emission quantification and air dispersion modeling techniques.

Ecology's Eastern Regional Office (ERO) submitted the three items listed above to Ecology on July 10, 2007.

2.3.1 Authority's Activities

ERO received the original application on May 15, 2007. ERO determined the application to be complete on September 17, 2007. A draft Notice of Construction (NOC) permit was provided to Ecology on July 10, 2007.

2.3.2 T-BACT Verification

T-BACT is required for any new or modified emission unit that has an increase in emissions of toxic air pollutants. ERO selected on-road specification diesel fuel with a sulfur content of 0.0015 weight percent or less, and compliance with the Environmental Protection Agency (EPA) Tier II standards (40 CFR 89) for non-road engines as T-BACT for the emergency generators. Ecology concurs with the T-BACT proposed by ERO.

2.3.3 Ambient Concentrations of Toxic Air Pollutants

Ecology reviewed the application and verified the emission estimates. Emissions of NO exceed the ASIL and a Second Tier analysis must be performed.

2.4 The Project

2.4.1 Permitting History

This is a new facility referred to as a “green field” facility. There has been no air permits previously issued to Yahoo.

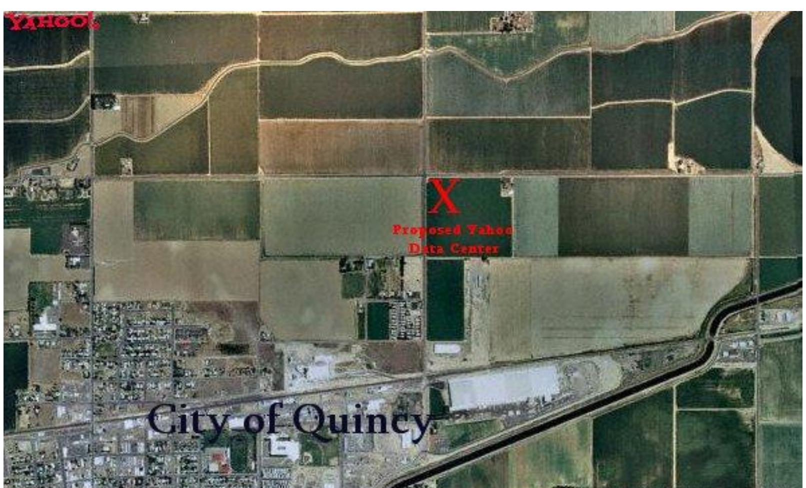
2.4.2 The Proposed Project

Yahoo has proposed to construct and operate a data center complex in Quincy, Washington. This facility will include a 150,000 square foot building. Construction will be phased over several years and expected to be complete in 2009. The data center will house banks of servers to track user internet activity including Yahoo search, e-mail, and business delivery services. It will also be equipped with a stable electrical power delivery system, air cooling and cleaning system, and backup diesel power capacity. The backup diesel power will come from thirteen 2.8 megawatt (MW) diesel-powered emergency generators. The first five generators are expected to be installed immediately with the next four in February of 2008 and the remaining four in April 2009.

After the initial startup testing (approximately 60 hours per unit) the generators will be tested one hour per month. The total operation of the 13 generators will be limited to no more than 400 hours per year to account for testing and any power outage.

2.4.3 Site Description

The proposed facility will be located at 1115 Industrial Road, Quincy, WA 98848 in Grant County, Washington. Its coordinates are 47° 14' 46"N, 119° 49' 40"W. An aerial photo from Yahoos search engine results in the following:



2.4.4 Emissions

Yahoo has estimated its emissions of NO from the 13 emergency generators to be 44 tons per year[1] or 219 pounds per hour. These emissions were based upon a conversion from NO_X to NO using a factor of 62% by weight. The NO_X emissions were derived by an AP-42 emission factor of 5.4 g/kWh.

Pollutant	CAS No.	Emission Factor	Emissions		SQER		Emissions Above SQER Yes or No
			lb/hr	lb/yr	lb/hr	lb/yr	
NO	10102-43-9	62% of NO_X emissions	219	87,511	2.0	17,500	Yes

2.4.5 Point of Compliance

Assessment of potential health risks from the project were based on the maximum modeled concentration of NO at an assumed point of public exposure (nearest point of ambient air) 460 feet away (140 meters). The distance to the maximum 1-hour average concentration is 460 feet (140 meters) and the distance to the maximum 24-hour average concentration is 850 ft (260 meters). The distance to the closest residential receptor is 1,300 feet (400 meters).

2.4.6 Emission Concentrations

Below is the modeling results of the pollutants that exceeded the Small Quantity Emission Rates compared to the ASILs.

Pollutant	Closest Point of Ambient Air (140 m) (μg/m^3)	Highest Concentration (μg/m^3)		Residence (400 m) (μg/m^3)		ASIL (24-hr Ave.) (μg/m^3)
		1-hr ave. (140 m)	24-hr ave. (260 m)	1-hr ave.	24-hr ave.	
NO	477	5337	1352.5	197	1113	100

2.4.7 Pollutants Subject to Second Tier Analysis

Emissions of NO are above the ASIL after being modeled for all three points (closest, highest concentration, and closest residence) and therefore, are subject to review under this Second Tier analysis.

[1] (5.4 g/kWh)*(2280 kW)/(1 lb/453.6 g)*(400 hr/yr)*(13 generators)*(0.62)*
(1 lb/2000lb) = 44 tons per year NO.

2.4.8 Background Emissions

Nitric oxide is produced during combustion and has been found in urban atmospheres, as well as indoor environments. Although it normally converts to nitrogen dioxide (NO_2) readily in the presence of ozone, high levels of NO are found immediately downwind of combustion sources, especially during stagnant conditions, and near heavy traffic.

Background emissions were determined by the EPA. They have published the National-scale Air Toxic Assessments (NATA). The NATA reports did not identify a background level for NO. Therefore, Ecology concluded that background emissions of NO are zero in the project area.

2.5 T-BACT

T-BACT is required for any new or modified emission unit that has an increase in emissions of toxic air pollutants. Ecology ERO has determined that T-BACT for controlling emissions of NO from emergency generators is on-road specification diesel fuel with a sulfur content of 0.0015 weight percent or less, and compliance with EPA Tier II standards (40 CFR 89) for non-road engines.

2.6 Air Dispersion Modeling

The applicant used ISC-AERMOD version 5.4.0. Three types of meteorological data were used. They were:

- National Weather Service hourly surface observations from Grant County International Airport in Moses Lake. This source is approximately 24 miles from the Yahoo Data Center. The data was for a 5-year period from January 2001 through December 2005.
- National Weather Service twice-daily upper air soundings from Spokane, Washington. The data was for a 5-year period from January 2001 through December 2005.
- Site-specific data including Albedo, Bowen ratio, and surface roughness.

2.7 Health Impacts Assessment

A health impacts assessment was prepared by the applicant and was reviewed and approved by Ecology. A team was assigned to this project consisting of an engineer, a toxicologist, and a modeler.

Mr. Clint Bowman, Senior Modeler for the Washington State Department of Ecology evaluated the information submitted by the applicant. Mr. Bowman concluded the modeling was performed correctly in an e-mail to Richard Hibbard on September 10, 2007.

Dr. Matt Kadlec, Senior Toxicologist for the Washington State Department of Ecology evaluated the information submitted by the applicant. Dr. Kadlec concluded the Health Impacts

Assessment showed the risk from the NO emissions resulted in a Hazard Quotient of less than one in an e-mail to Richard Hibbard on September 14, 2007.

Below are descriptions of the content of each part of the Health Impacts Assessment.

2.7.1 Hazard Identification

Hazard identification involves gathering and evaluating toxicity data on the types of health injury or disease that may be produced by a chemical and on the conditions of exposure under which injury or disease is produced. It may also involve characterization of the behavior of a chemical within the body and the interactions it undergoes with organs, cells, or even parts of cells. This information may be of value in determining whether the forms of toxicity known to be produced by a chemical agent in one population group or in experimental settings are also likely to be produced in human population groups of interest. Note: Risk is not assessed at this stage; hazard identification is conducted to determine whether and to what degree it is scientifically correct to infer that toxic effects observed in one setting will occur in other settings (i.e., are chemicals found to be carcinogenic or teratogenic in experimental animals also likely to be so in adequately exposed humans?).

2.7.2 Identification of Potentially Exposed Populations

This step involves describing the nature and size of the various populations exposed to a chemical agent in the vicinity of the proposed project.

2.7.3 Discussion of TAP Concentrations

This step involves the identification of the toxicological profiles of all toxic air pollutants that exceed the ASIL. It includes a discussion of the toxicological effects of hazardous substances, chemicals, and compounds. Each profile includes an examination, summary, and interpretation of available toxicological and epidemiological data evaluations on the hazardous substance.

2.7.4 Exposure Assessment

This step includes characterization of exposure pathways, and total daily intake based on the magnitude and duration of exposure to toxic air pollutants that exceed the ASIL from these pathways. The evaluation could include past exposures, current exposures, or exposures expected in the future.

2.7.5 Risk/Hazard Assessment

This step involves the integration of data analyses from each step of the risk assessment to determine the likelihood that the human population of interest will experience any of the various forms of toxicity associated with a chemical under its known or anticipated conditions of exposure.

2.7.6 Uncertainty

In almost all risk assessments undertaken in support of regulatory decisions, especially in regard to chronic hazards, risk assessors are required to go beyond available data and make inferences about risks expected for conditions of exposure under which direct evidence of risk cannot now be collected. When scientific uncertainty is encountered in a risk assessment, the integration of any assumptions is required to fill information gaps. The following are examples of components that constitute significant gaps in the scientific basis for assessing human cancer risk:

- How relevant is the data to humans?
- How relevant to humans are results from animal studies using a different route of exposure?
- How relevant are results from studies using an exposure regimen (in terms of frequency and duration) that differs from the human situation?
- Which species/strains of animals are most appropriate for dose-response assessment in humans?
- How should risk estimates be developed?
- Using most sensitive species/strain/sex?
- Combining incidents of benign and malignant tumors?
- Using pooled tumor incidence (tumor bearing animals)?
- Can results of an animal study that does not extend over a lifetime be extrapolated to lifetime?
- How does the dose-response relation relate to the unobservable dose-response relation in the dose region of concern for the human population under study?
- How should low-dose risk be modeled?
- Do agents operate by threshold or non-threshold mechanisms?

3. HEALTH IMPACTS ASSESSMENT

3.1 Introduction

The Second Tier analysis described below was conducted according to the requirements promulgated in Chapter 173-460 WAC. It addressed the public health risk associated with exposure to the NO emissions from operating diesel powered emergency generators in the health effects assessment prepared by the consultant (Landau Associates) for Yahoo.

3.2 Hazard Identification

NO is a colorless gas with a sharp sweet odor. It turns brown in the air at high concentrations. Its molecular weight is 30 g/mole and its vapor pressure is 26,000 millimeters of mercury. NO's boiling point is -241^{0}F and it is not combustible.

3.2.1. Acute and Chronic Effects

Most of the toxic effects of NO have been attributed to its reaction with O_2^-, with a rate constant of about 7 x 10^9 $M^{-1}\cdot sec^{-1}$ to form $ONOO^-$. The protonated form of $ONOO^-$, peroxynitrous acid

(ONOOH), forms nitrogen dioxide (NO_2) and an intermediate with reactivity equivalent to the $^{\cdot}OH$ derived from the *trans*-isomerization of ONOOH, as shown in the equation:

$$O_2^- + NO \rightarrow ONOO^- + H^+ \rightarrow ONOO \rightarrow [OH \cdot \cdot \cdot \cdot NO_2]$$

$ONOO^-$ initiates iron-independent lipid peroxidation and oxidizes thiols at rates at least 1000-fold greater than that of H_2O_2 at pH 7, damages the mitochondria electron transport chain, and causes lipid peroxidation of human low density lipoproteins. $ONOO^-$-mediated thiol oxidation occurs at physiologic pH and in some cases may be irreversible (i.e., oxidized sulfhydryl groups cannot be reduced by physiologic reductants). In addition, $ONOO^-$ nitrates phenolics, including tyrosine and tryptophan residues in several proteins.

Results of a recent literature review suggest that ambient levels of NO may be sufficient to induce health effects, especially in asthmatics and people with platelet dysfunction. It may also alter the body's response to infection. Recent epidemiological studies suggest a link between exposure and childhood respiratory infection, lung cell damage, asthma, bronchitis, croup, and adverse changes in immune system functions.

3.2.2 Reproductive/Developmental Effects

A literature search identified a 1998 study[2] that presented evidence that $ONOO^-$ has been identified in a number of organs, including lungs of infants who died with respiratory failure.

3.2.3. Cancer Risk

In addition to its acute toxicity, there is some evidence that nitric oxide is mutagenic (Schmutte, *et al*. 1994[3]).

3.2.4. Terrestrial Fate

NO is a gas, not a solid or liquid. Therefore, its terrestrial deposition and fate are not significant.

3.2.5. Aquatic Fate

Nitric oxide is relatively insoluble in water. Its transport and fate in environmental media are predominantly within the atmospheric medium.

3.3. Identification of Exposed Populations

Potentially exposed populations were identified based upon zoning classifications for Grant County and the City of Quincy. Within one kilometer of the proposed facility there is industrial, agricultural, medium-density residential, and high-density residential land zoning within Grant County. Within the City Of Quincy (which is within one kilometer of the proposed site), there is light industrial and low-density residentially zoned land within the City of Quincy. The table below identifies the distances to the nearest buildings.

[2] http://www.ehponline.org/members/1998/Suppl-5/1157-1163zhu/zhu-full.html
[3] http://carcin.oxfordjournals.org/cgi/content/abstract/15/12/2899

Distance from Receptors to Yahoo Property Boundary		
Receptor	Kilometers	Miles
Nearest residential building (R1)	0.4	0.25
Closest point of ambient air (C1)	0.14	0.09
Nearest industrial building to the north (I1)	0.88	0.55
Nearest industrial building to the south (I2)	0.31	0.19
Nearest industrial building to the northeast (I3)	1.09	0.68
Point of maximum concentration (24-hr average)	0.26	0.16
Point of maximum concentration (1-hr average)	0.14	0.09

3.4. Discussion of TAP Concentrations

The table below is based upon all 13 units running at full operation.

NO at Exposed Receptors						
Averaging Time Exposure Duration	R1: Closest Residential Building	C1: Closest Point of Ambient Air	I1: Closest Industrial Building to the North	I2: Closest Industrial Building to the South	I3: Closest Industrial Building to the Northeast	Point of Maximum Concentration
24-Hr Concentration (ug/m^3)	361	959.9	132.6	669.7	170	1352.5
1-Hr Concentration (ug/m^3)	2499	5337	1202.8	2864	1547	5337

3.5. Exposure Assessment (daily intake and risk)

The risk-based concentration levels used in Second Tier analysis are based on existing data. Ecology evaluated these data and developed the following exposure limits:

RBC (µg/m^3)	Hours	Basis
2350	1	1-hr Reference exposure limit for NO_2 (470-µg/m^3) x 5:1[4]
1030	24	ASIL without a non-recovery factor[5]
103	40.5	ASIL with a non-recovery factor[6]

At exposure periods 40.5 hours and longer, the ASIL (103-µg/m^3) should be used. Based on data available to Ecology, we do not recommend using risk-based concentration limits higher (less protective) than those in the table.

[4] The 1-hr reference exposure limit (REL)-equivalent for nitric oxide derived from the 5:1 ratio based on the NIOSH Immediately Dangerous to Life or Health values of 20-ppm for NO_2 and 100-ppm for nitric oxide.

[5] The nitric oxide ASIL multiplied by a factor of 10 to remove the non-recovery factor to obtain a 24-hr risk-based concentration (RBC) = 3100-µg/m^3 x (8/24) / 10 [for healthy worker to sensitive populations.

[6] The nitric oxide ASIL (103-µg/m^3) derived from the ACGIH Threshold Limit Value (TLV)-Time-Weighted Average (TWA) concentrations for workplace exposures. The TLV-TWA is defined as the concentration for a conventional 8-hour workday and 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, without excessive health risk.

The >40-h RBC, the RBCs, noted in the table, are plotted and interpolated in the Figure. The time-varying RBC range shown in the figure accounts for diminishing carryover of recovery time effects over five consecutive 8-hr periods (a workweek).

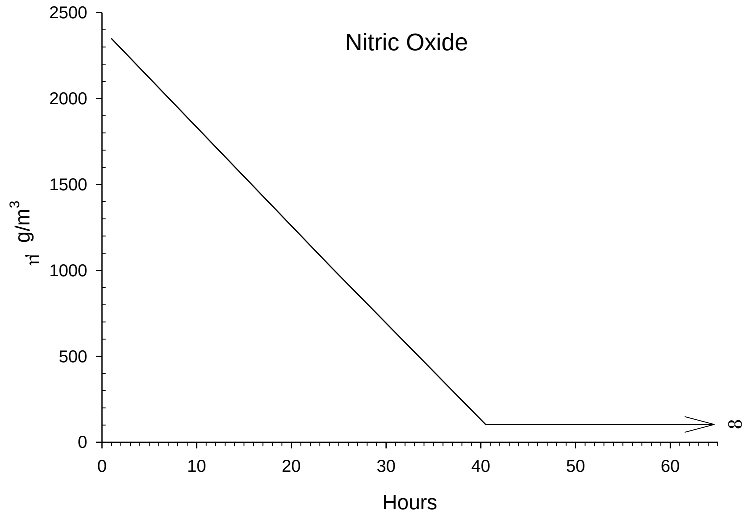


Figure.

As a result, the following table was developed to measure against the proposed modeled emissions:

NO Concentration Limits at Exposed Receptors						
Averaging Time Exposure Duration	R1: Closest Residential Building	C1: Closest Point of Ambient Air	I1: Closest Industrial Building to the North	I2: Closest Industrial Building to the South	I3: Closest Industrial Building to the Northeast	Point of Maximum Concentration
24-Hr Exposure Limit (ug/m^3)	1030	1030	1030	1030	1030	1030
1-Hr Exposure Limit (ug/m^3)	2350	2350	2350	2350	2350	2350

3.6. Risk/Hazard Assessment

A comparison of the modeled concentration at select receptors is compared to the exposure limit in the table below. The calculation is referred to as the Hazard Quotient (HQ). The definition of a HQ was taken from the EPA NATA glossary.[7]

The HQ is the ratio of the potential exposure to the substance and the level at which no adverse effects are expected. If the Hazard Quotient is calculated to be less than one, then no adverse

[7] http://www.epa.gov/ttn/atw/nata/gloss.html

health effects are expected because of exposure. If the Hazard Quotient is greater than one, then adverse health effects are possible. The Hazard Quotient cannot be translated to a probability that adverse health effects will occur, and is unlikely to be proportional to risk. It is especially important to note that a Hazard Quotient exceeding one does not necessarily mean that adverse effects will occur.

NO Hazard Quotients at Exposed Receptors						
Averaging Time Exposure Duration	R1: Closest Residential Building	C1: Closest Point of Ambient Air	I1: Closest Industrial Building to the North	I2: Closest Industrial Building to the South	I3: Closest Industrial Building to the Northeast	Point of Maximum Concentration
24-Hr Concentration (ug/m^3)	361	959.9	132.6	669.7	170	1352.5
24-Hr Exposure Limit (ug/m^3)	1030	1030	1030	1030	1030	1030
24-Hr HQ	0.35	0.93	0.13	0.65	0.17	1.31
1-Hr Concentration (ug/m^3)	2499	5337	1202.8	2864	1547	5337
1-Hr Exposure Limit (ug/m^3)	2350	2350	2350	2350	2350	2350
1-Hr HQ	1.06	2.27	0.51	1.22	0.66	2.27

As you can see the HQ has been exceeded for the 1-Hr exposure period at the closest residential building, closest point of ambient air, closest industrial building to the south, and the point of maximum concentration. In addition the 24-Hr exposure HQ has been exceeded at the point of maximum concentration. As a point of reference Toxicologists normally refer to a Hazard Quotient of less than one as being an acceptable risk in a risk assessment. However Hazard Quotients of greater than one are not necessarily an indication of severe risk. The definition of a Hazard Quotient is: *The ratio of estimated site-specific exposure to a single chemical from a site over a specified period to the estimated daily exposure level, at which no adverse health effects are likely to occur*[8].

Ecology believes that for this project exceeding the Hazard Quotient is acceptable for the following reasons:

1) Yahoo has informed Ecology that the last power outage in the town of Quincy was a 90 minute period outage approximately 5 years ago. The likelihood of

[8] http://www.egr.msu.edu/~envirotools/cgi-bin/glossary.php3#h

prolonged operation of the backup generators that would result in ambient concentrations of NO of concern occurring is therefore small.

2) The State of Washington is currently the only state in the US that regulates ambient concentrations of NO in this manner. NO was originally listed as a Toxic Air Pollutant (TAP) under WAC 173-460 on the basis of occupational data. Ecology is currently in the process of revising WAC 173-460 to update the ASIL list according to risk based concentrations (RBCs) established by EPA, California's Office of Environmental Health Hazard Assessment (OEHHA), and the Agency for Toxic Substances and Disease Registry (ASTDR). None of these regulatory authorities have established RBC's for NO. Ecology is therefore recommending that NO be dropped from the list of TAPs regulated in WAC 173-460 as part of this rule revision. The NO ASIL was originally derived on the basis of occupational data. While Ecology's recommendation to delist NO as a TAP is not dispositive, and does not override current regulatory requirements in WAC 173-460, it is likely that the recommendation will be incorporated in the revised rule.

3.7. Uncertainty Characterization

It is unlikely the risk of NO exposure from this project is greater than those analyzed in this Second Tier analysis. The following assumptions were analyzed:

Assumption	Over or Under Estimating	Potential for Over or Under Estimating (High-Medium-Low)
Modeled concentrations are based on an overestimation of Quincy's power grid unreliability	Over	High
Accuracy of value (NO as a percentage of NO_X)	Over or Under	Low

3.8. Length of exposure

The nature of emergency generator operation, which is designed to respond to local loss of electrical power, is conducive to the generation of sporadic short-term air emissions. Nitric oxide is not environmentally persistent; therefore, exposure times for human receptors are considered to be approximately equal to operating times for the emergency generators.

For the purposes of the Second Tier analysis, it was assumed that off-site receptors could be exposed to nitric oxide up to 24 hours in one day, regardless of receptor type (i.e., industrial, commercial, or residential). Based on the reliability of Grant County's electrical system (99.999% with only one power outage of approximately 90 minutes in the past five years), the 24-hour exposure time is conservative. The long-term opportunity for residential exposure is assumed to be 30 years. The long-term opportunity for commercial or industrial exposure is assumed to be 20 years.

4. CONCLUSION

The project will not have a significant adverse impact on air quality. The Washington State Department of Ecology finds the applicant, Yahoo, Inc., has satisfied all requirements for Second Tier analysis.

For additional information, please contact:

Richard B. Hibbard, P.E.
Washington State Department of Ecology
Air Quality Program
P.O. Box 47600
Olympia, WA 98504-7600
(360) 407-6896
rhib461@ecy.wa.gov

5. LIST OF ABBREVIATIONS

ASIL	Acceptable Source Impact Level
BACT	Best Available Control Technology
BTU	British Thermal Unit
CFR	Code of Federal Regulations
Ecology	Washington State Department of Ecology
ERO	Washington State Department of Ecology Eastern Regional Office
EPA	United States Environmental Protection Agency
HAP	Hazardous Air Pollutant
HQ	Hazard Quotient
hr	Hour
MBtu/hr	Thousand British Thermal Units per Hour
MMBtu/hr	Million British Thermal Units per Hour
MW	Megawatt
NATA	National-scale Air Toxic Assessments
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NOC	Notice of Construction
NO_X	Nitrogen Oxides
PTE	Potential to Emit
TAP	Toxic Air Pollutant
T-BACT	Best Available Control Technology for Toxics
tpy	Tons per Year
VOC	Volatile Organic Compounds
WAC	Washington Administrative Code
yr	Year