DEPARTMENT OF ECOLOGY
State of Washington

Technical Support Document for the Second Tier Analysis

for

Washington State Department of Information Services Data Center
Olympia, Washington

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1. EXECUTIVE SUMMARY

The Washington State Department of Information Services (DIS) proposes to construct and operate a new campus near the intersection of 14th Avenue SE and Jefferson Street SE in Olympia, Washington. The campus will consist of a multi-story building to house a data center and offices. A separate building will house a bank of five 2,500 electrical kilowatt (kWe) diesel-powered emergency generators. There will also be a smaller 750 kWe diesel-powered generator that will be used to power building safety equipment. It will be located in the loading dock area of the data center office building.

The proposed diesel engine exhaust particulate (DEEP) and nitrogen dioxide (NO_2) emissions from the emergency generators exceeded a regulatory trigger level called an Acceptable Source Impact Level (ASIL). The project was therefore required to undergo a second tier analysis per Chapter 173-460 Washington Administrative Code (WAC).

Wright Runstad & Company, the developer for the DIS campus, retained ICF International (ICF) to prepare a health impacts assessment (HIA) to evaluate the potential health risks attributable to operation of the diesel-powered generators from the proposed project. Based on a technical review of their analysis, 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 Toxic Air Pollutants (TAP) under Chapter 173-460 WAC. This document describes the technical review performed by Ecology.

2. PERMITTING PROCESS OVERVIEW

2.1. The Regulatory Process

The requirements for performing a toxics screening are established in Chapter 173-460 WAC. This regulatory code requires a review of any increase in toxic emissions for all new or modified stationary sources in the state of Washington.

2.1.1. The Three Tiers of Permitting Toxic Air Pollutants

The requirements for performing a toxics screening are established in Chapter 173-460 WAC. This rule requires a review of any non-*de minimis*[1] increase in toxic air pollutant emissions for all new or modified stationary sources in the state of Washington. Sources subject to review under this rule must apply best available control technology for toxics (tBACT) to control emissions of all toxic air pollutants subject to review.

There are three levels of review when processing a Notice of Construction (NOC) application for a new or modified emissions unit emitting TAPs in excess of the *de minimis* levels: (1) first tier (toxic screening), (2) second tier (health impacts analysis), and (3) third tier (risk management decision).

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[1] If the estimated increase of emissions of a TAP or TAPs from a new or modified project is below the de minimis emissions threshold(s) found in WAC 173-460-150, the project is exempt from review under Chapter 173-460 WAC.

All projects with emissions exceeding the *de minimis* levels are required to undergo a toxics screening (first tier review) as required by WAC 173-460-080. The objective of the toxics 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 to protect human health and safety. If modeled emissions exceed the trigger levels (ASILs), a second tier review is required.

As part of a second tier petition, described in WAC 173-460-090, the applicant submits a site-specific HIA. The objective of a HIA is to quantify the increase in lifetime cancer risk for persons exposed to the increased concentration of any carcinogen, and to quantify the increased health hazard from any non-carcinogen that would result from the proposed project. Once quantified, the cancer risk is compared to the maximum risk allowed for a second tier petition, which is one in one hundred thousand (equivalent to 10 in one million),[2] and the concentration of any non-carcinogen that would result from the proposed project is compared to its effect threshold concentration.

In evaluating a second tier petition, background concentrations of the applicable pollutants must be considered. If the emissions of a toxic air pollutant result in an increased cancer risk of greater than 10 in one million, then an applicant may request Ecology perform a third tier review. For non-carcinogens, a similar path exists, but there is no bright line associated with when a third tier review is triggered.

A third tier review is a risk management decision in which Ecology makes a decision that the risk of the project is acceptable based on a 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.

2.2. Processing Requirements

In order for Ecology to review the HIA for the second tier petition, each of the following regulatory requirements under Chapter 173-460-090 must be satisfied:

(i) The permitting authority (Olympic Region Clean Air Agency (ORCAA)) submits to Ecology a preliminary order of approval that addresses all applicable new source review issues with the exception of the outcome of the second tier review, State Environmental Policy Act review, public notification, and Prevention of Significant Deterioration review (if applicable);

(ii) Emission controls contained in the preliminary approval order represent at least tBACT;

[2] WAC 173-460-090(7)

(iii) The applicant (DIS) has developed a health impacts assessment protocol that has been approved by Ecology;

(iv) The ambient impact of the emissions increase of each TAP that exceeds acceptable source impact levels has been quantified using refined air dispersion modeling techniques as approved in the health impacts assessment protocol; and

(v) The second tier petition contains a health impacts assessment conducted in accordance with the approved health impacts assessment protocol.

ORCAA submitted a preliminary order of approval to Ecology on August 19, 2010. Ecology considers the preliminary order of approval to satisfy items (i) and (ii) above. Ecology waived the requirement for developing a HIA protocol for this project (item (iii)) because the applicant's consultant (ICF) had recently developed HIAs for other similar data centers in Washington. ICF submitted a HIA on August 9, 2010, that satisfied items (iv) and (v) above.

Therefore, DIS and ORCAA have satisfied the five items listed above.

3. FACILITY INFORMATION

3.1. Facility Location

The proposed DIS campus is located on a 9-acre property near the Washington capitol campus in Olympia, Washington. It is bounded by 14th Avenue SE (to the north), 16th Avenue SE (to the south), Jefferson Street SE (west), and an unoccupied slope overlooking Interstate 5 (I-5) to the east. The property is surrounded by several neighborhoods. The neighborhood directly to the south across 16th Avenue SE consists of single family housing. The neighborhood north of the facility across 14th Avenue SE consists of mixed residential and commercial uses. The property west of Jefferson Street SE consists of state office buildings. Figure 1 shows the facility in relation to the surrounding area.

3.2. Permitting History

The proposed project is a new facility for which no previous air permits have been issued.

3.3. The Proposed Project

DIS proposes to construct and operate a data center complex in Olympia, Washington. This facility will include a large office building, six backup emergency generators, five cooling towers, a parking lot, and landscaping (Figure 2). The current proposal allows for five emergency generators for backing up the data center's servers and one smaller emergency generator for providing power for building lights, ventilation, and firefighting systems during a power outage (ICF 2010a, ICF 2010b). The facility is expected to be operational in 2011. Uninterrupted electrical power to the computers inside the data center building is a requirement for this source. The main power supply to the facility will be reliable due to the fact that an electrical substation will be located immediately adjacent to the same facility. Even with the electrical substation being located so closely, the potential for an unplanned power outage exists.

The facility will emit pollutants to the air from:

- Five mechanical draft cooling towers. These towers will cool the data center when needed. The cooling towers will be located adjacent to the generator building.

- Five Kohler Model 2500REOZDB diesel-powered emergency generators for backing up data center's servers during power outage. These five diesel generators, each rated at 2,500 kilowatts of electricity (kWe), will be located in a single generator building. Exhaust from the diesel engines will be emitted from stacks protruding 10 feet above the roofline.

- One Kohler Model 750RE07DB backup diesel generator, rated at 750 kWe, will provide power to the buildings lights, ventilation, and firefighting systems. This generator will be located near the loading dock of the main building.

Figure 1. Proposed DIS Data Center Location, Olympia, Washington

Figure 2. Proposed DIS site plan showing general location of air emission units (adapted from Wright Runstad, 2009)

3.3.1. Proposed Operation and Fuel Limits

In order to minimize its air quality impacts, DIS agreed to limit the duration of generator testing, maintenance, and emergency outage. Each of the five Kohler Model 2500REOZDB diesel generators will undergo up to 50 hours of testing operation per year (Table 1). Emergency operation of the generators will be limited to no more than 48 hours per single year. Testing and emergency operation of the engines shall be limited to no more than 153 hours over a 3-year period. The Kohler Model 750RE07DB backup generator will be tested no more than 48 hours per year.

Table 1. Operating Time Limits for Each of DIS' Diesel-Powered Emergency Generators

Generator	Event	Frequency	Hr/Event	Total Hours of Operation	
				Maximum Year[a]	Maximum 3-Yr Average[b]
Each of the five Kohler Model 2500REOZDB (2,500 kWe)	Routine Testing [c]	About 1 x per week	1	50	~ 129
	Outage	As needed	As needed	48	24
	Combined Testing + Outage			**98**	**153**
Kohler Model 750RE07DB (750 kWe)	Routine Testing [c]	2 x per month	2	48	144
	Outage	As needed	As needed	48[c]	24[c]
	Combined Testing + Outage			**96**	**168**

a. Averaging time is a 12-continuous month period.
b. Averaging time is a 36-continuous month period
c. Operation of the diesel engines for maintenance and testing shall be performed according to a schedule such that engines are operated one at a time during standard business hours.

4. TOXIC AIR POLLUTANT EMISSIONS

4.1. tBACT for the DIS Data Center Project

ORCAA determined that tBACT for the proposed generators shall consist of:

- Use of EPA Tier 2 certified diesel engines.
- Limits on the total amount of hours that engines operate.
- Use of Diesel Oxidation Catalysts (DOC) on each of the six engines.
- Use of a five percent biodiesel fuel blend (B5) as fuel for all diesel generators.
- Use of ultra-low sulfur diesel fuel (15 parts per million sulfur content).
- Strict adherence to manufacture-specified maintenance, as required by New Source Performance Standard Subpart IIII.

Ecology has reviewed ORCAA's tBACT decision and concluded that it satisfies the tBACT requirement.

4.2. First Tier Review Toxics Screening for the DIS Data Center Project

ICF used EPA emission factors and Tier 2 diesel engine emission limits and EPA's AP-42 emission factors to estimate emission rates of TAPs from DIS' diesel-powered generators (ICF 2010a, ICF 2010b). Table 2 shows proposed emissions of each TAP compared to its respective small quantity emission rate (SQER).[3] Only DEEP and NO_2 exceed their respective SQER.

[3] An SQER is an emission rate that is not expected to result in offsite concentration that exceeds an ASIL.

Table 2. Comparison of Emissions Rates to SQER

Pollutant	Averaging Period	Total Emissions	SQER	Emissions Above SQER?
		See Averaging Period for Units	See Averaging Period for Units	Yes or No
Acetaldehyde	lb/yr	0.1	71	No
Acrolein	lb/24-hr	0.0069	0.00789	No
Benzene	lb/yr	2.8	6.62	No
Benzo(a)pyrene (TEQ)[a]	lb/yr	0.0018	0.174	No
1,3-Butadiene	lb/yr	0.07	1.13	No
DEEP[b]	lb/yr	199	0.639	**Yes**
Formaldehyde	lb/yr	0.28	32	No
NO_2	lb/hr	11.8	1.03	**Yes**
Toluene	lb/24-hr	0.24	657	No
Xylenes	lb/24-hr	0.17	29	No

a. TEQ – (toxic equivalent) the sum of x carcinogenic PAHs toxicity equivalence to benzo(a)pyrene
b. Average long-term DEEP emission rate

4.3. Second Tier Review Toxics Screening for the DIS Data Center Project

ICF used refined modeling techniques (briefly described in Section 5.2.2) to evaluate the ambient impacts from the proposed project. Any pollutants exceeding SQERs were then compared to respective ASILs in Table 3. Both DEEP and NO_2 exceeded their respective ASIL. Therefore, DIS was required to prepare a HIA (second tier analysis).

Table 3. Comparison of Modeled Off-Site Concentrations to ASIL

Pollutant	CAS #	Averaging Time	Highest Modeled Off-Site Concentration ($\mu g/m^3$)	ASIL ($\mu g/m^3$)
DEEP	--	Annual (maximum year)[a]	0.017	0.00333
NO_2	10102-44-0	1-hr	712	470

-- No chemical abstracts service number (CAS#) exists for DEEP.
a. The highest off-site annual concentration assuming DIS' engines operate 48 hours during power outage and 50 hours maintenance and testing.

5. HEALTH IMPACTS ASSESSMENT

The HIA described below was conducted according to the requirements promulgated in Chapter 173-460 WAC. It addressed the public health risk associated with exposure to DEEP and NO_2 emissions from DIS' diesel-powered emergency generators in Olympia, Washington. While the HIA is not a complete risk assessment, it loosely follows the four steps of the standard health risk assessment approach proposed by the National Academy of Sciences (NAS 1983, 1994). The four steps of the risk assessment process are (1) hazard identification, (2) exposure assessment, (3) dose-response assessment, and (4) risk characterization.

5.1. 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 that 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 (e.g., are chemicals found to be carcinogenic or teratogenic in experimental animals also likely to be so in adequately exposed humans?).

5.1.1. Overview of DEEP Toxicity

Diesel engines emit very small fine (<2.5 micrometers [μm]) and ultrafine (<0.1 μm) particles. These particles can easily enter deep into the lung when inhaled. Mounting evidence indicates that inhaling fine particles can cause numerous adverse health effects.

Studies of humans and animals specifically exposed to DEEP show that diesel particles can cause both acute and chronic health effects including cancer. Ecology has summarized these health effects in "Concerns About Adverse Health Effects of Diesel Engine Emissions" available at http://www.ecy.wa.gov/pubs/0802032.pdf.

The following health effects have been associated with exposure to diesel particles:

- Inflammation and irritation of the respiratory tract
- Eye, nose, and throat irritation along with coughing, labored breathing, chest tightness, and wheezing
- Decreased lung function
- Worsening of allergic reactions to inhaled allergens

- Asthma attacks and worsening of asthma symptoms
- Heart attack and stroke in people with existing heart disease
- Lung cancer and other forms of cancer
- Increased likelihood of respiratory infections
- Male infertility
- Birth defects
- Impaired lung growth in children

Based in part on Ecology's concern about these adverse health effects, Ecology ranked DEEP as the number one priority toxic air pollutant in our state (Ecology 2008). To ensure individual projects do not add significantly to DEEP exposure in nearby communities, Ecology uses the HIA to determine the level of DEEP exposure from DIS and how much these exposures add to health risks. Ecology quantifies and presents non-cancer hazards and cancer risks to people exposed to DIS emitted pollutants in the remaining sections of this document.

5.1.2. Overview of NO_2 Toxicity

Nitrogen dioxide (NO_2) is a red-brown gas that is present in diesel exhaust. It forms when nitrogen, present in diesel fuel and as a major component of air, combines with oxygen to produce oxides of nitrogen.

NO_2 and other oxides of nitrogen are of concern for ambient air quality because they are part of a complex chain of reactions responsible for the formation of ground-level ozone. Additionally, exposure to NO_2 can cause both long-term (chronic) and short-term (acute) health effects.

Long-term exposure to NO_2 can lead to chronic respiratory illness such as bronchitis and increase the frequency of respiratory illness due to respiratory infections.

Short-term exposure to extremely high concentrations (> 180,000 $\mu g/m^3$) of NO_2 may result in serious effects including death (NAC AEGL Committee, 2008). Moderate levels (around 30,000 $\mu g/m^3$) may irritate eyes nose, throat, and respiratory tract. Lower level NO_2 exposure (< 1,000 $\mu g/m^3$), such as that experienced near major roadways, or perhaps downwind from stationary sources of NO_2, may cause increased bronchial reactivity in some asthmatics, decreased lung function in patients with chronic obstructive pulmonary disease, and increased risk of respiratory infections, especially in young children (CalEPA, 2008). For this project, the maximum short-term ambient concentration has been estimated to be 712 $\mu g/m^3$.

Related to DIS' NO_2 emissions from their diesel engines, power outage emissions present the greatest potential for producing high enough short-term concentrations of NO_2 to be of concern for susceptible individuals, such as people with asthma. Ecology calculates and presents numerical estimates of exposure and hazard in the remaining sections of this document.

5.2. Exposure Assessment

Exposure assessment involves estimating the extent that the public is exposed to a chemical substance emitted from a facility. This includes:

- Identifying routes of exposure.
- Estimating off-site pollutant long-term and/or short-term concentrations.
- Identifying exposed receptors.
- Estimating the duration and frequency of receptors' exposure.

5.2.1. Routes of Potential Exposure

Humans can be exposed to chemicals in the environment through inhalation, ingestion, or dermal contact. The primary route of exposure to most air pollutants is inhalation; however, some air pollutants may also be absorbed through ingestion or dermal contact. Ecology uses guidance provided in California's Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments to determine which routes and pathways of exposure to assess for chemicals emitted from a facility (CalEPA, 2003). Appendix A shows a table of chemicals for which Ecology assesses multiple routes and pathway of exposure. In the case of DIS' emergency generator emissions, Ecology will only evaluate inhalation exposure to DEEP and NO_2.

5.2.2. Estimating Pollutant Concentrations

DIS' DEEP and NO_2 emissions will be carried by the wind and possibly impact people living and working in the immediate area. The level of these pollutants in off-site air depends in part on the quantity (mass) of pollutants emitted, wind direction, and other weather-related variables at the time the pollutants are emitted. To estimate where DEEP and NO_2 will disperse after they are emitted from DIS' diesel engines, ICF conducted air dispersion modeling. Air dispersion modeling incorporates emissions, meteorological, geographical, and terrain information to estimate pollutant concentrations downwind from a source.

ICF used the following model and inputs to estimate ambient impacts:

- American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD, Version 09292) with Plume Rise Model Enhancements (PRIME) algorithm for building downwash.

- Five years sequential hourly meteorological data from Olympia Airport (2001-2005).

- Twice-daily upper air data from Quillayute to define mixing heights.

- Olympia area digital elevation model files (which describe local topography and terrain).

- Exhaust for each Kohler Model 2500REOZDB generators was modeled with a stack height of 35.5 feet above local ground level and a stack inside diameter of 18 inches (0.457 meters). Engine load-specific exhaust gas temperature and velocity were used.

- Exhaust from the Kohler Model 750RE07DB generator was modeled with a stack height of 20 feet above local ground level. Because the stack exhausts horizontally instead of vertically, ICF assumed a stack diameter of 41-ft diameter equivalent vertical stack with an exit velocity of 0.01 m/sec.

- Plume Volume Molar Ratio Method (PVMRM) option, which is used to model the conversion of nitrogen oxides (NO_X) to NO_2.

5.2.3. Potentially Exposed Receptors

As described in Section 3.1, the proposed DIS campus is located between a residential neighborhood and a mixed residential and commercial area. Based on air modeling results, Ecology estimates roughly 75 single- and multi-family residences, and 10 workplaces potentially impacted by DEEP at concentrations in excess of the ASIL (0.0033 $\mu g/m^3$).

Figure 3 shows a color-coded map of estimated average DEEP concentrations attributable to DIS' generator emissions. The "green" shaded area indicates that the estimated impact from DIS' generators is below the ASIL. For the purpose of evaluating worst-case DEEP exposures and health risk, Ecology identifies a maximally exposed residence and a maximally exposed off-site workplace. For acute NO_2 exposure, Ecology also evaluated exposure at the maximally impacted residence and workplace, but also considered other off-site locations where people could potentially be exposed for short time periods. Table 4 shows each maximally exposed receptor's approximate distance from the generators' exhaust stacks and the estimated average exposure concentration. Figure 3 and Figure 4 show maps of each receptor relative to the DIS campus.

Table 4. Maximally Exposed Receptors' Distance and Direction From DIS' Emergency Engine Exhaust Stacks

Receptor	Direction From Center of Source	Estimated Distance in Feet From Center of Source	Estimated Distance in Meters From Center of Source	Estimated Average Annual DEEP Concentration (μg/m^3) at Receptor Location
Residence A	N	550	170	0.0078
Office A	N	350	110	0.0107
				Estimated 1-Hr Maximum NO_2 Concentration (μg/m^3) at Receptor Location
Residence B	SW	520	160	473
Office B	NW	1000	305	533
Substation	S	180	55	712
NW Sidewalk	NW	560	170	499

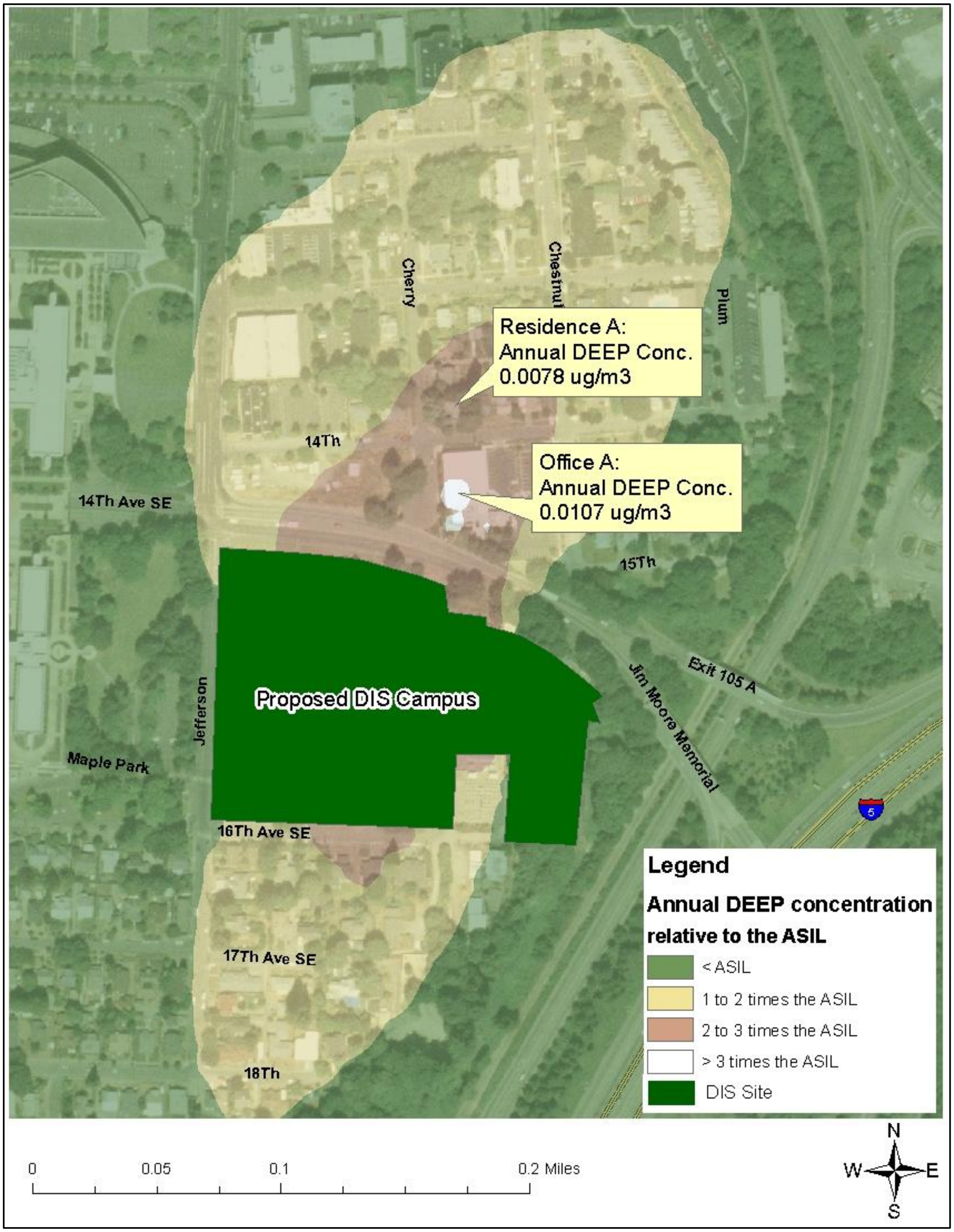

Figure 3. Annual DEEP concentrations attributable to DIS emissions relative to the ASIL (0.0033 µg/m^3)

Figure 4. Maximum 1-hr NO_2 concentrations attributable to DIS emissions (ASIL=470 $\mu g/m^3$)

5.2.4. Exposure Frequency and Duration

The likelihood that someone is exposed to DEEP and NO_2 from DIS' emergency generators depends on local wind patterns (meteorology), how frequently generators operate, and how much time people spend in the immediate area. As discussed previously, the air dispersion model uses emissions and meteorology information (and other assumptions) to determine ambient pollutant concentrations in the vicinity of the proposed DIS property.

Ecology considers the land use surrounding the DIS facility to estimate the amount of time a given receptor could be exposed. For example, people are more likely to be exposed frequently and for a longer duration if the source impacts residential locations because people spend much of their time at home. People working in offices in the area are likely only exposed to DIS-related DEEP during the hours that they spend working near the facility.

Ecology typically makes simplified assumptions about receptors' exposure frequency and duration. As shown in Section 5.4, Ecology assumes residential receptors are potentially continuously exposed, meaning they never leave their property. Ecology recognizes that these behaviors are not typical; however, these assumptions are intended to avoid underestimating exposure so that public health protection is ensured. Workplace exposures are also considered, but adjustments are made when assessing cancer risk because the amount of time that people spend at work is more predictable than time that people could spend at their homes.

5.2.5. Discussion of Background Exposure to Pollutants of Concern

Chapter 173-460-090 WAC states that, "background concentrations of TAPs will be considered as part of a second tier review."[4] The word "background" is often used to describe exposures to chemicals that come from existing sources, or sources other than those being assessed.

DEEP and NO_2 are common pollutants therefore people living near DIS are already exposed to these pollutants.

5.2.5.1. DEEP – Background Levels Near DIS

DEEP is a common pollutant emitted from diesel-powered vehicles and heavy equipment. Because the proposed DIS campus is located near I-5, people in the vicinity are already exposed to DEEP emitted from numerous vehicles that use the freeway. While there is no monitoring in the area and no established method to specifically measure DEEP in the air, EPA and ORCAA previously estimated DEEP levels in the area.

EPA's 2002 National-scale Air Toxics Assessment (NATA) estimated a DEEP concentration of 1.2 $\mu g/m^3$ in the census tract relevant to DIS (EPA, 2009). This estimate, although uncertain, is

[4] http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-090

approximately 100 times greater than the maximum ambient impacts associated with DIS' DEEP emissions.

5.2.5.2. NO_2 – Background Levels Near DIS

NO_2 is a common pollutant emitted from combustion sources including diesel engines. NO_2 concentrations near roadways are expected to be approximately 30 to 100 percent higher than concentrations away from roadways. Given DIS' proximity to I-5, NO_2 levels are likely elevated compared to areas far removed from I-5. NO_2 is not measured near DIS, but Ecology used regional modeling estimates to derive a "background" NO_2 concentration of approximately 86 $\mu g/m^3$ (personal communication with Clint Bowman, Washington State Department of Ecology, August 31, 2010).

5.3. Dose Response Assessment

Dose-response assessment describes the quantitative relationship between the amounts of exposure to a substance (the dose) and the incidence or occurrence of injury (the response). The process often involves establishing a toxicity value or criterion to use in assessing potential health risk.

5.3.1. Dose Response Assessment – DEEP

The U.S. Environmental Protection Agency (EPA) and California Office of Environmental Health Hazard Assessment (OEHHA) developed toxicological values for DEEP (EPA, 2002; CalEPA, 1998). These toxicological values are derived from studies of animals that were exposed to a known amount (concentration) of DEEP, and from epidemiological studies of exposed humans, and are intended to represent a level at or below which adverse non-cancer health effects are not expected, and a metric by which to quantify increased risk from exposure to a carcinogen. Table 5 shows DEEP non-cancer and cancer toxicity values.

EPA's reference concentration (RfC) and OEHHA's reference exposure level (REL) for diesel engine exhaust (measured as DEEP) was derived on the basis of dose-response data on inflammation and changes in the lung from rat inhalation studies. Each agency established 5-$\mu g/m^3$ as the concentration of DEEP in air at which long-term exposure is not expected to cause adverse non-cancer health effects.

OEHHA derived a unit risk factor (URF) for estimating cancer risk from exposure to DEEP. The URF is based on a meta-analysis of several epidemiological studies of humans occupationally exposed to DEEP. URFs are expressed as the upper-bound probability of developing cancer, assuming continuous lifetime exposure to a substance at a concentration of one microgram per cubic meter, and are expressed in units of inverse concentration [i.e., $(\mu g/m^3)^{-1}$]. OEHHA's URF for DEEP is 0.0003 $(\mu g/m^3)^{-1}$, meaning that a lifetime of exposure to 1 µg/m^3 DEEP results in an excess individual cancer risk of 0.03 percent or a population cancer risk of 300 excess cancers per million people exposed.

5.3.2. Dose Response Assessment – NO_2

OEHHA developed an acute reference exposure level for NO_2 based on inhalation studies of asthmatics exposed to NO_2. These studies found that some asthmatics exposed to about 0.25 ppm (470 µg/m^3) experienced increased airway reactivity following inhalation exposure to NO_2 (CalEPA 2008). Not all asthmatic subjects experienced an effect.

The acute REL derived for NO_2 does contain any uncertainty factor adjustment, and therefore does not provide any additional buffer between the derived value and the exposure concentration at which effects have been observed in sensitive populations. This implies that exposure to NO_2 at levels equivalent to the acute REL (which is also the same as Ecology's ASIL) could result in increased airway reactivity in a subset of asthmatics. People without asthma or other respiratory disease are not likely to experience effects at NO_2 levels at or below the REL.

Table 5. DEEP Toxicity Values Used to Assess and Quantify Non-Cancer Hazard and Cancer Risk

Pollutant	Agency	Non-Cancer	Cancer
DEEP	U.S. Environmental Protection Agency	RfC = 5 µg/m^3	NA[a]
	California EPA – Office of Environmental Health Hazard Assessment	Chronic REL = 5 µg/m^3	URF = 0.0003 per µg/m^3
NO_2	California EPA – Office of Environmental Health Hazard Assessment	Acute (1-hr) REL = 470 µg/m^3	NA

a. EPA considers DEEP to be a probable human carcinogen, but have not established a cancer slope factor or unit risk factor.

5.4. Risk Characterization

Risk characterization involves the integration of data analyses from each step of the HIA to determine the likelihood that the human population in question will experience any of the various forms of toxicity associated with a chemical under its known or anticipated conditions of exposure.

5.4.1. Quantifying Non-Cancer Effects

5.4.1.1. DEEP Risk Based Concentrations (non-cancer effects)

To evaluate possible non-cancer effects from exposure to DEEP, modeled concentrations at receptor locations were compared to its respective non-cancer toxicological values (i.e., RfC, REL).

National Ambient Air Quality Standards (NAAQS) and other regulatory toxicological values for short-term and intermediate-term exposure to particulate matter have been promulgated, but values specifically for DEEP exposure at these intervals do not currently exist, therefore, only risks from chronic exposure to DEEP are quantified.

As discussed in the previous section, EPA and OEHHA developed non-cancer toxicity values for chronic exposure to DEEP. Because chronic toxicity values (RfCs and RELs) are based on a continuous exposure, an adjustment is sometimes necessary or appropriate to account for people working at commercial properties who are exposed for only eight hours per day, five days per week. While EPA risk assessment guidance recommends adjusting to account for periodic instead of continuous exposure, CA OEHHA does not employ this practice. For the purpose of this evaluation, Ecology determined the RfC or REL (5 $\mu g/m^3$) will be used as the chronic risk-based concentration for all scenarios where receptors could be exposed frequently (e.g., residences, work places, or schools).

5.4.1.2. NO_2 Risk Based Concentrations (non-cancer effects)

To evaluate possible non-cancer effects from exposure to NO_2, modeled concentrations at receptor locations were compared to its respective non-cancer toxicological values. In this case, maximum modeled 1-hr NO_2 concentrations are compared to the acute REL (470 $\mu g/m^3$).

5.4.1.3. Hazard Quotient/Hazard Index

Hazard quotients were calculated for the maximally exposed residential and workplace receptors. A hazard quotient (HQ) is the ratio of the potential exposure to a substance compared to the exposure level that is considered "safe" (e.g., REL, RfC, risk-based concentration).

$$\text{Chronic HQ} = \frac{\text{annual average DEEP concentration } (\mu g/m^3)}{5\ \mu g/m^3}$$

$$\text{Acute HQ} = \frac{\text{maximum 1-hr } NO_2 \text{ concentration}}{470\ \mu g/m^3}$$

A HQ of one or less indicates that the exposure to a substance is not likely to result in adverse health effects. As the HQ increases above one, the probability of human health effects increases by an undefined amount. However, it should be noted that a HQ above one is not necessarily indicative of health impacts due to the application of uncertainty factors in deriving toxicological reference values (e.g., RfC and REL).

Table 6 shows chronic hazard quotients at the maximally exposed residential and occupational receptors attributable to DIS' DEEP emissions. Hazard quotients are < 1 indicating adverse non-cancer effects are not likely to result from chronic exposure to DEEP emitted from DIS' emergency generators.

Table 6 also shows acute hazard quotients at the maximally exposed receptors attributable to DIS' NO_2 emissions. Hazard quotients exceed one at the substation, NW sidewalk, residence B and office B. This means that if someone with asthma or other respiratory illness were present at these locations when both meteorological conditions and engine use during a power outage occurred could experience increased airway reactivity.

Table 6. Non-Cancer Hazards for Residential and Occupational Scenarios

Maximally Exposed Receptors	**Average Annual DEEP Concentration (μg/m³)**			**Chronic Risk-Based Concentration (μg/m³)**	**Chronic Hazard Quotient**	
	Attributable to Project	Estimated "background"	Project + "background"		Attributable to Project	Project + "background"
Residence A	0.0078	1.2	1.208	5	0.002	0.24
Office A	0.011		1.211		0.002	0.24
	Maximum 1-Hr NO_2 Concentration (μg/m³)			**Acute Risk-Based Concentration (μg/m³)**	**Acute Hazard Quotient**	
	Attributable to Project	Estimated "background"	Project + "background"		Attributable to Project	Project + "background"
Residence B	473	86	559	470	1.0	1.2
Workplace B	533		619		1.1	1.3
Substation	712		798		1.5	1.7
Sidewalk	499		585		1.1	1.2

[shaded box] - Project-related DEEP hazard quotient
Note: Background concentration and hazard quotients shown for comparison purposes only.

5.4.1.4. Discussion of Hazard Quotients Greater Than One

DIS' proposed NO_2 emissions could result in hazard quotients greater than one, but it is important to note that the estimated NO_2 concentrations shown above are maximum one-hour concentrations assuming continuous emissions of generators 24 hours per day year round, or 8760 hours per year. In reality, these generators are only permitted to operate during power outage scenarios for a maximum of 48 hours per year, or an average of no more than eight hours per year averaged over continuous 36-month intervals.

Hazard quotients related to acute exposure to NO_2 exceed one for people who might live, work, or be present near DIS during a full power outage. Therefore, people with asthma experience increased airway reactivity if they were present at these locations coincident with the right meteorological conditions and simultaneous power outage.

ICF analyzed the probability of meteorological conditions necessary to result in ambient NO_2 concentrations in excess of the ASIL, combined with the probability that DIS' engines operate under full power outage mode. The results of their analysis are summarized in Table 7. Generally, the likelihood that a power outage will coincide with meteorological conditions resulting in NO_2 concentrations higher than the ASIL is extremely low. The substation location has the greatest likelihood of being impacted by NO_2 above the ASIL at a five percent chance per year or once every 19 years. Given that the substation is not staffed, it is improbable that people would be exposed to NO_2 at levels above the ASIL. The frequency with which NO_2 concentrations could exceed the ASIL at Residence B and Office B could be less than one time every 100 years or so. Therefore, it is unlikely that people will be exposed to DIS-related NO_2 at levels in excess of the ASIL.

Table 7. Probability of Off-Site NO_2 Concentrations in Excess of the ASIL at Select Locations

Parameter Description	Notes	Off-Site Location		
		Substation	Residence B	Office B
Number of hours during 5-year period met conditions would produce a concentration > 470	hr/5 years	300	2	1
Number of hours per 5 years	hr/5years	43800		
Fraction of hourly meteorological conditions resulting in concentration > ASIL	unitless	0.006849	0.000046	0.000023
Maximum number of hours operating at power outage over 5-year period	hr	40		
Fraction of time engines operate – outage conditions	= 40 hr/43800 hr	0.000913		
Combined probability	Probability/hr of exceeding ASIL	$6.3x 10^{-6}$	4.2×10^{-8}	2.1×10^{-8}
Overall Probability per year of exceeding ASIL	$P=1-((1-p_{hr})^{8760})$	5%	0.037%	0.018%
Recurrence interval	$R = 1/p_{1yr}$	19 yr	>100 yr	>100 yr

ICF also considered "background" levels of NO_2 to determine the probability and frequency that an NO_2 level could exceed 470 $\mu g/m^3$ at each receptor location. ICF found that the probability impacts at levels above the ASIL, even considering "background" concentrations, remained extremely low. The estimated frequency with which NO_2 concentrations could exceed the ASIL at each receptor is once every 12 years at the substation and greater than 100 years at Residence B and Office B.

ICF's analysis concluded that coincidental worst-case meteorological and power outage conditions are extremely unlikely to occur. Although extremely improbable, we cannot completely rule out the possibility of having such a scenario. If such an event were to occur, people with asthma who might be cumulatively exposed to NO_2 and DEEP from DIS and other sources may experience respiratory symptoms such as wheezing, shortness of breath, and reduced pulmonary function with airway constriction.

5.4.2. Quantifying Cancer Risk

Cancer risk is estimated by determining the concentration of DEEP at each receptor point and multiplying it by its respective unit risk factor (URF). Because URFs are based on a continuous exposure over a 70-year lifetime, exposure duration and exposure frequency are important considerations.

The formula used to determine cancer risk is as follows:

$$\text{Risk} = \frac{\text{CAir} \times \text{URF} \times \text{EF} \times \text{ED}}{\text{AT}}$$

Where:

CAir = Concentration in air at the receptor ($\mu g/m^3$)
URF = Unit Risk Factor $(\mu g/m^3)^{-1}$
EF1 = Exposure Frequency (days per year)
EF2 = Exposure Frequency (hours per day)
ED = Exposure Duration (years)
AT = Averaging Time (days)

Current regulatory practice assumes that a very small dose of a carcinogen will give a very small cancer risk. Cancer risk estimates, therefore, do not yield absolute "yes/no" answers, but provide measures of chance (probability) that an exposed person could get cancer. Such measures, however uncertain, are useful in determining the magnitude of a cancer threat because any level of a carcinogenic contaminant carries an associated risk. The validity of this approach for all cancer-causing chemicals is not clear. Some evidence suggests that certain chemicals considered carcinogenic must exceed a threshold of tolerance before initiating cancer. For such chemicals, risk estimates are not appropriate. Recent guidelines on cancer risk from EPA reflect the potential that thresholds for some carcinogenesis exist. However, EPA still assumes no threshold unless sufficient data indicate otherwise.

In this document, cancer risks are reported using scientific notation to quantify the increased cancer risk of an exposed person, or the number of excess cancers that might result in an exposed population. For example, a cancer risk of 1 x 10^{-6} means that if 1,000,000 people were exposed to a carcinogen, one excess cancer might occur, or a person's chance of getting cancer in their life increases by one in one million or 0.0001 percent. The reader should note that these estimates are for excess cancers that might result in addition to those normally expected in an unexposed population. Cancer risks quantified in this document are an upper-bound theoretical estimate.

5.4.2.1. Quantifying Cancer Risk Attributable to DIS

Table 8 shows ranges of estimated worst-case residential and off-site worker increased cancer risks from exposure to DEEP near the proposed DIS facility. Estimated increased cancer risks related to DIS' emissions for maximally exposed residential and workplace receptors are less than one in one hundred thousand (1 x 10^{-5}). Under WAC 173-460, Ecology may recommend approval of a project if the applicant demonstrates that the increase in emissions of TAPs is not likely to result in an increased cancer risk of more than one in one hundred thousand (1 x 10^{-5}).

Table 8. Estimated Cancer Risk Attributable to DIS' DEEP Emissions

Location/ Scenario	Pollutant	Annual DEEP Concentration Attributed to Project (μg/m^3)	URF	EF		ED (yr)	AT (days)	Risk Attributed to Project	Risk/ Million
				day/yr	hr/day				
Maximum Impacted Residence A	DEEP	0.0078	0.0003	365	24/24	70	25550	2.3 x 10^{-6}	2
Maximum Impacted Workplace A		0.011		250	8/24	40	25550	4.3 x 10^{-7}	< 1

5.4.2.2. Quantifying Cancer Risk Attributable to "Background" Near DIS

As mentioned in Section 5.2.5.1, EPA's 2002 NATA estimated a DEEP concentration of 1.2 μg/m^3 in the census tract relevant to DIS (EPA, 2009). This concentration equates to a risk of about 360 per million for a residential receptor, and 45 per million for an occupational receptor. These risk values are consistent with those estimated in ORCAA's Olympic Regional Air Modeling and Health Risk Assessment (ORCAA, 2005). ORCAA's estimate of cancer risk in the vicinity of the DIS campus ranges between 200-500 excess cancers per million for people exposed to all air toxics in the area near DIS. Assuming DEEP contributes to 80 percent of this total risk, then a residential receptor in the DIS vicinity has an increased cancer risk from DEEP exposure of about 160-400 per million.

6. UNCERTAINTY CHARACTERIZATION

Many factors of the HIA are prone to uncertainty. Uncertainty relates to the lack of exact knowledge regarding many of the assumptions used to estimate the human health impacts of DEEP emissions from DIS' emergency generators. The assumptions used in the face of uncertainty may tend to over- or underestimate the health risks estimated in the HIA.

6.1. Exposure Uncertainty

It is difficult to characterize the amount of time that people can be exposed to DIS' DEEP emissions. For simplicity, DIS assumed a person stays at one location for 24 hours per day, 365 days per year, for 70 years. These assumptions tend to overestimate exposure attributable to a single source or project.

The duration and frequency of power outages is also uncertain. DIS estimates that they will use the generators during emergency outages for an average of eight hours per year. Over the last 10 years, the outage at the substation serving DIS averaged about 45 minutes per year. While this small amount of power outage provides some comfort that power service is relatively stable, DIS cannot predict future outages with any degree of certainty. DIS accepted a limit of emergency operation for an average of eight hours per year and estimated that limit should be sufficient to meet their emergency demands.

For the purpose of estimating short-term NO_2 impacts associated with power outages, DIS assumed that power outages can occur at any time and would coincide with worst-case meteorological conditions. This scenario is not likely, so short-term exposure to NO_2 is likely overestimated.

There is also some uncertainty related to ICF's combined probability analysis to estimate the likelihood of an NO_2 impact above an ASIL (Table 8). This analysis assumed that the probability of a power outage and the probability of worst-case meteorological conditions are independent of each other. It is not clear if this assumption is true, but we also do not have enough information to the contrary. In other words, it is possible that meteorology could play a factor in power outages, but we do not know if meteorological conditions following such a weather related power outage would be more or less likely to result in maximum NO_2 impacts. For the purpose of this evaluation, ICF's analysis represents a reasonable approach to identify the likelihood of ambient 1-hr NO_2 impacts above the ASIL.

6.2. Emissions Uncertainty

The exact amount of DEEP emitted from DIS' diesel-powered generators is uncertain. ICF applied EPA's Tier 2 emission factors to describe the emission rates from the diesel engines. The real amount of DEEP that DIS' engines emit on average is likely to be less than the limits set by EPA, but certified engine-specific emission rates are not available. As a result, ICF's use of EPA's Tier 2 engine particulate matter (PM) emission limit as the DEEP emission factor estimate is intended to represent worst-case emission rates.

6.3. Air Dispersion Modeling Uncertainty

The transport of pollutants through the air is a complex process. Regulatory air dispersion models are developed to estimate the transport and dispersion of pollutants as they travel through the air. The models are frequently updated as more accurate techniques become known but are written to avoid underestimating the modeled impacts. Even if all of the numerous input parameters to an air dispersion model are known, random effects found in the real atmosphere will introduce uncertainty. Typical of the class of modern steady-state Gaussian dispersion models, the AERMOD modeling for the DIS analysis will likely slightly overestimate the short-term (24-hour average) impacts and somewhat underestimate the annual concentrations. The expected magnitude of the uncertainty is probably similar to the emissions uncertainty and much lower than the toxicity uncertainty.

To estimate the conversion of DIS' NO_X emissions to ambient NO_2, ICF used the PVMRM model with an assumed background ozone concentration of 40 ppb. In reality, ozone levels would be lower during much of the year with the exception of summertime. This assumption likely overestimates the rate at which NO_X converts to NO_2 and therefore ambient impacts are likely overestimated.

6.4. Toxicity Uncertainty

One of the largest sources of uncertainty in any risk evaluation is associated with the scientific community's limited understanding of the toxicity of most chemicals in humans following exposure to the low concentrations generally encountered in the environment. To account for uncertainty when developing toxicity values (e.g., RfCs), EPA and other agencies apply "uncertainty" factors to doses or concentrations that were observed to cause adverse non-cancer effects in animals or humans. EPA applies these uncertainty factors so that they derive a toxicity value that is considered protective of humans including susceptible populations. In the case of EPA's DEEP RfC, EPA acknowledges:

> *"…the actual spectrum of the population that may have a greater susceptibility to diesel exhaust (DE) is unknown and cannot be better characterized until more information is available regarding the adverse effects of diesel particulate matter (DPM) in humans."*

Quantifying DEEP cancer risk is also uncertain. Although EPA classifies DEEP as probably carcinogenic to humans, they have not established a URF for quantifying cancer risk. In their health assessment document, EPA determined that "human exposure-response data are too uncertain to derive a confident quantitative estimate of cancer unit risk based on existing studies." However, EPA suggested that a URF based on existing DEEP toxicity studies would range from 1×10^{-5} to 1×10^{-3} per µg/m^{3}. OEHHA's DEEP URF falls within this range. Regarding the range of URFs, EPA states in their health assessment document for diesel exhaust:

> *"Lower risks are possible and one cannot rule out zero risk. The risks could be zero because (a) some individuals within the population may have a high tolerance to exposure from [diesel exhaust] and therefore not be susceptible to the cancer risk from environmental exposure, and (b) although evidence of this has not been seen, there could be a threshold of exposure below which there is no cancer risk."*

Other sources of uncertainty cited in EPA's health assessment document for diesel exhaust are:

- Lack of knowledge about the underlying mechanisms of DEEP toxicity.
- The question of whether toxicity studies of DEEP based on older engines is relevant to current diesel engines.

Table 9. Summary of How the Uncertainty Affects the Quantitative Estimate of Risks or Hazards

Source of Uncertainty	How Does it Affect Estimated Risk From This Project?
Exposure assumptions	Likely overestimate of exposure
Emissions estimates	Possible overestimate of emissions
Air modeling methods	Possible underestimate of average long-term ambient concentration and overestimate of short-term ambient concentration
Toxicity of DEEP at low concentrations	Possible overestimate of cancer risk, possible underestimate of non-cancer hazard for sensitive individuals

7. SECOND TIER RECOMMENDATION

DIS' proposed DEEP emissions could result in a cancer risk of up to 2×10^{-6} (two per million). This risk falls below Ecology's threshold of maximum acceptable risk (10 per million) as defined in Chapter 173-460 WAC.

Currently, ORCAA's preliminary determination to approve DIS' project includes a condition to limit each engine's use to a maximum of 153 hours (for engines powering the 2,500 kW generators) to 168 hours (for engines powering the 750 kW generator) averaged over three years. This condition is necessary for minimizing health risks attributable to the project and must be retained in the final NOC.

In summary, DIS' emissions are unlikely to result in excessive cancer risk or in any significant adverse non-cancer health problems to people at nearby residences or commercial locations. The increased risks from the proposed project are permissible because they fall within the limits defined in WAC 173-460-090(7). Based on our analysis, the Washington State Department of Ecology finds that the applicant, DIS, has satisfied all requirements for approval of the second tier petition. The project review team recommends approval of the proposed project in accordance with WAC 173-460-090(7).

8. PROJECT REVIEW TEAM

Richard (Rich) B. Hibbard, P.E.
Washington State Department of Ecology
Air Quality Program
P.O. Box 47600
Olympia, WA 98504-7600
360-407-6896/Phone
360-407-7534/Fax
richard.hibbard@ecy.wa.gov

Gary Palcisko
Washington State Department of Ecology
Air Quality Program
P.O. Box 47600
Olympia, WA 98504-7600
360-407-7338/Phone
360-407-7534/Fax
gary.palcisko@ecy.wa.gov

Clint Bowman
Washington State Department of Ecology
Air Quality Program
P.O. Box 47600
Olympia, WA 98504-7600
360-407-6815
clint.bowman@ecy.wa.gov

9. LIST OF ACRONYMNS AND ABBREVIATIONS

AERMOD	Air dispersion model
AEGL	Acute Exposure Guidance Level
AT	Averaging Time (days)
ASIL	Acceptable Source Impact Level
B5	5% Biodiesel Blend
BACT	Best Available Control Technology
CAir	Concentration in air
CalEPA	California Environmental Protection Agency
CAS #	Chemical Abstracts Service Number
DEEP	Diesel engine exhaust, particulate
DIS	Washington State Department of Information Services
DOC	Diesel Oxidation Catalysts
ED	Exposure Duration (years)
EF	Exposure Frequency
EF1	Exposure Frequency (days per year)
EF2	Exposure Frequency (hours per day)
Ecology	Washington State Department of Ecology, Headquarters Office
EPA	United States Environmental Protection Agency
HQ	Hazard Quotient
HIA	Health Impacts Assessment
hr	Hour
ICF	ICF International
I-5	Interstate–5
kWe	kilowatt, electrical
$\mu g/m^3$	Micrograms per Cubic Meter
μm	Micron or micrometer
NAAQS	National Ambient Air Quality Standards
NAS	National Academies of Science
NATA	National Air Toxics Assessment
NO_2	Nitrogen dioxide
NO_X	Oxides of Nitrogen
NOC	Notice of Construction Order of Approval
OAC	Order of Approval to Construct
OEHHA	California's Office of Environmental Health Hazard Assessment
ORCAA	Olympic Region Clean Air Agency
$PM_{2.5}$	Particulate Matter less than 2.5 micrometers in diameter
PRIME	Plume Rise Model Enhancements
PVNRM	Plume Volume Molar Ratio Method
REL	OEHHA Reference Exposure Level
RBC	Risk Based Concentration
RfC	Reference Concentration

SQER	Small Quaintly Emission Rate
TAP	Toxic Air Pollutants
tBACT	Best Available Control Technology for Toxics
WAC	Washington Administrative Code
UF	Uncertainty Factor
URF	Unit Risk Factor

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APPENDIX A. California's Air Toxics Hotspots Risk Assessment Guidance on Specific Pathways to be Analyzed for Each Multipathway Substance

Substance	Soil Ingestion	Dermal	Meat, Milk & Egg Ingestion	Fish Ingestion	Exposed Vegetable Ingestion	Leafy Vegetable Ingestion	Protected Vegetable Ingestion	Root Vegetable Ingestion	Water Ingestion	Breast Milk Ingestion
4,4'-Methylene dianiline	X	X		X	X	X	X	X	X	
Creosotes	X	X	X	X	X	X			X	
Diethylhexylphthalate	X	X		X	X	X	X	X	X	
Hexachlorocyclohexanes	X	X		X	X	X			X	
PAHs	X	X	X	X	X	X			X	
PCBs	X	X	X	X	X	X	X	X	X	X
Cadmium & compounds	X	X	X	X	X	X	X	X	X	
Chromium VI & compounds	X	X	X	X	X	X	X	X	X	
Inorganic arsenic & compounds	X	X	X	X	X	X	X	X	X	
Beryllium & compounds	X	X	X	X	X	X	X	X	X	
Lead & compounds	X	X	X	X	X	X	X	X	X	
Mercury & compounds	X	X	X	X	X	X	X	X	X	
Nickel	X	X	X		X	X	X	X	X	
Fluorides (Including hydrogen fluoride)	To be determined									
Dioxins & furans	X	X	X	X	X	X	X		X	X