DEPARTMENT OF
ECOLOGY
State of Washington

Revised Health Impact Assessment Review Document for

Microsoft Oxford Data Center
Quincy, Washington

Prepared by

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1. Executive Summary

This document presents Ecology's review and summary of the health risks from air pollutants emitted by 37 diesel engines at the Microsoft Oxford Data Center in Quincy. This document updates a previous review to reflect permit changes requested by Microsoft.

In August 2014, Ecology issued an air permit which allowed Microsoft to install and operate equipment that emits pollutants into the air at the Oxford Data Center. The permit specified limits on the emissions and operation of:

- Thirty-two (32) cooling towers
- Thirty-two (32) generators rated at 2,500 kilowatt (kW) electrical output
- Four (4) generators rated at 2,000 kW
- One (1) generator rated at 750 kW

In December 2014, Microsoft submitted an application to revise the permit to allow generators to operate over a wider range of operating loads. This wider range results in an increase in the amount of air pollution the facility could emit. Ecology required Microsoft to revise the health impact assessment (HIA) to evaluate the health risks from exposure to diesel engine exhaust particles.

Microsoft hired Landau Associates (Landau) to revise the HIA (Landau Associates, 2015). In this assessment, Landau estimated lifetime increased cancer risks associated with Microsoft's diesel particles and other toxic air pollutant (TAP) emissions.

The revised diesel particle emissions resulted in an increase lifetime cancer risk from the previous estimate of four in one million to a new estimate of about six in one million. The maximum risk was estimated at a residential location north of Oxford Data Center. This risk assumes that a person is exposed to Oxford's emissions continuously during their entire lifetime. Ecology allows an increased risk of up to10 in one million from new sources of air pollutants. The risk can also be expressed as the number of cancers that might occur in addition to those normally expected in a population of one million people. The cancer risk estimates reported here are for increases above a baseline lifetime risk of cancer of about 40 percent in the United States.

The increased cancer risk was quantified assuming that both filterable and condensable particles emitted from Oxford's diesel engines are in diesel particles. Typically, only the filterable particles are considered when estimating the risk of exposure to diesel exhaust particles. This is because the studies about the health risk from diesel exposure used measurements of respirable particles from "fresh" diesel exhaust and elemental carbon to represent diesel exhaust emissions. The increased risk estimated by Landau represents a conservatively high estimate. If emissions estimates were based on only filterable emissions (excluding the condensable particles), then the estimated risk would be about one in one million. Landau also assessed chronic and acute noncancer hazards associated with the project's emissions and determined that Oxford's emissions by themselves are not likely to result in adverse noncancer health effects.

To evaluate the cumulative effect of numerous sources of diesel particles in the area, Ecology assessed the cumulative health risk by adding estimated concentrations associated with Oxford's emissions to an estimated background concentration. The maximum cumulative cancer risk to a person who lives near Oxford is about 46 in one million. Most of the exposure to diesel particles at this location comes from vehicles travelling on State Route 28. Additionally, exposure to diesel particles in the area is not likely to result in long-term noncancer health effects.

Finally, Ecology updated a cumulative dispersion model in Quincy to evaluate short-term impacts of nitrogen dioxide (NO_2) emitted at the same time by all 195 permitted Quincy data center backup diesel generators during a system-wide power outage. This evaluation indicated that elevated NO_2 levels could occur, but the likelihood of a system-wide power outage happening at the same time winds are unfavorable is very low.

Because the increase in cancer risk associated with the new data center alone is less than the maximum risk allowed under Ecology's rules (10 in one million), and the noncancer hazard is low, the project could be approvable under WAC 173-460-090. Furthermore, the cumulative risks to residents living near Oxford Data Center are below the cumulative risk threshold established by Ecology for permitting data centers in Quincy (100 per million or 100×10^{-6}).

This summary document presents Ecology's review of the Microsoft Oxford Data Center's revised HIA and other requirements under WAC 173-460.

2. Second Tier Review Processing and Approval Criteria

2.1. Second Tier Review Processing Requirements

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

(a) The permitting authority has determined that other conditions for processing the NOC Order of Approval (NOC) have been met, and has issued a preliminary approval order.

(b) Emission controls contained in the preliminary NOC approval order represent at least best available control technology for toxics (tBACT).

(c) The applicant has developed an HIA protocol that has been approved by Ecology.

(d) The ambient impact of the emissions increase of each TAP that exceed acceptable source impact levels (ASILs) has been quantified using refined air dispersion modeling techniques as approved in the HIA protocol.

(e) The second tier review petition contains an HIA conducted in accordance with the approved HIA protocol.

Acting as the "permitting authority" for this project, Ecology's project permit engineer satisfied items (a) and (b) above on April 21, 2015.[1] Landau submitted an HIA protocol (item (c)) on December 20, 2013, and the revised final HIA (item (e)) was received by Ecology on February 19, 2015. The refined air dispersion modeling for the annual DEEP emissions (item (d)) was conducted in January 2014. The results of this modeling were scaled upward to reflect higher annual emission rates specified in the draft preliminary determination. Therefore, all five processing requirements above are satisfied.

2.2. Second Tier Review Approval Criteria

As specified in WAC 173-460-090(7), Ecology may recommend approval of a project that is likely to cause an exceedance of ASILs for one or more TAPs only if it:

(a) Determines that the emission controls for the new and modified emission units represent tBACT.

(b) 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.

(c) Ecology determines that the noncancer hazard is acceptable.

2.2.1.   tBACT Determination

Ecology's permit engineer determined that Microsoft's proposed pollution control equipment (i.e., Tier 2 engines equipped with diesel particulate filters, diesel oxidation catalysts, and selective catalytic reduction) more than satisfies the BACT and tBACT requirement for diesel engines powering backup generators at Oxford Data Center.[2]

3. HIA Review

As described above, the applicant is responsible for preparing the HIA under WAC 173-460-090. Ecology's project team consisting of an engineer, a toxicologist, and a modeler review the HIA to determine if the methods and assumptions are appropriate for assessing and quantifying surrounding community's risk from a new project.

For the Oxford project, the HIA focused mainly on health risks attributable to DEEP exposure as this was the only TAP with a modeled concentration in ambient air that exceeded an ASIL. Landau briefly described emissions and exposure to other TAPs (NO_2, benzene, carbon monoxide (CO), ammonia,[3] and acrolein) because these pollutants exceeded a small quantity

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[1] Gary Huitsing, "RE: Amendments to Oxford approval order" e-mail message with attachments, addressed to Gregory Flibbert, Kay Shirey, Gary Palcisko, Beth Mort, and Karen Wood, April 21, 2015.
[2] BACT was determined to be met through the use of EPA Tier 2 certified engines if the engines are installed and operated as emergency engines, as defined at 40 CFR§60.4219; compliance with the operation and maintenance restrictions of 40 CFR Part 60, Subpart IIII; and use of ultra-low sulfur diesel fuel containing no more than 15 parts per million by weight of sulfur.
[3] Some ammonia is released from the selective catalytic reduction equipment designed to reduce NO_X emissions.

emission rate (SQER), and Ecology requested that health hazards from exposure to these
pollutants be quantified.

3.1. DEEP Health Effects Summary

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 HIA prepared by Landau quantifies the noncancer hazards and increased cancer risks
attributable to the proposed Oxford Data Center's DEEP emissions.

3.2. DEEP Toxicity Reference Values

To quantify noncancer hazards and cancer risk from exposure to DEEP, quantitative toxicity
values must be identified. Landau identified toxicity values for DEEP from two agencies: the
U.S. Environmental Protection Agency (EPA) (EPA, 2002; EPA, 2003), and California EPA's
Office of Environmental Health Hazard Assessment (OEHHA) (CalEPA, 1998). These toxicity
values are derived from studies of animals that were exposed to a known amount (concentration)
of DEEP, or from epidemiological studies of exposed humans, and are intended to represent a
level at or below which adverse noncancer health effects are not expected, and a metric by which
to quantify increased risk from exposure to a carcinogen. Table 1 shows the appropriate DEEP
noncancer and cancer toxicity values identified by Landau.

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

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

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. In these studies, DEEP exposure was estimated from
measurements of elemental carbon and respirable particulate representing fresh diesel exhaust.
The URF is expressed as the estimate of the plausible upper limit (i.e., the 95th percentile upper

confidence interval) of cancer risk, assuming continuous lifetime exposure to a substance at a concentration of one microgram per cubic meter (1 µg/m^3). It is expressed in units of inverse concentration [i.e., (µg/m^3)$^{-1}$]. OEHHA's URF for DEEP is 0.0003 (µg/m^3)$^{-1}$ meaning that a lifetime of exposure to 1 µg/m^3 of DEEP results in an increased individual cancer risk of 0.03 percent or a population cancer risk of 300 excess cancer cases per million people exposed.

Table 1. Toxicity Values Used to Assess and Quantify Noncancer Hazard and Cancer Risk			
Pollutant	**Agency**	**Noncancer**	**Cancer**
DEEP	U.S. Environmental Protection Agency	RfC = 5 µg/m3	NA[1]
	California EPA–Office of Environmental Health Hazard Assessment	Chronic REL = 5 µg/m^3	URF = 0.0003 per µg/m^3
[1] EPA considers DEEP to be a probable human carcinogen, but has not established a cancer slope factor or unit risk factor.			

3.3. Affected Community/Receptors

While Oxford Data Center is located in an industrially zoned area and surrounded largely by agricultural land uses, air dispersion modeling indicated that proposed DEEP emissions, assuming DEEP is represented by both condensable and filterable particulate, could result in concentrations in excess of the ASIL at roughly 123 parcels with residential land use codes (Figure 1) [Ecology 2013, Grant County 2013]. U.S. Census data show that approximately 509 people live in the Census Blocks intersected by the area in which DEEP concentrations are estimated to exceed the ASIL (U.S. Census Bureau, 2010). When assuming that only filterable particulate is DEEP, three parcels with residential land use codes and approximately sixteen people could be impacted at levels in excess of the ASIL.

For the purposes of assessing increased cancer risk and noncancer hazards, Landau identified receptor locations where the highest exposure to project-related air pollutants could occur: at the project boundary, a nearby residence, and off-site commercial areas. They also identified and evaluated exposures at other areas with sensitive populations such as schools and a hospital. Landau calculated both noncancer hazards and cancer risks for each of these receptors, and estimated long-term cumulative risks attributable to other known sources of DEEP.[4]

Ecology's review of the HIA found that Landau identified appropriate receptors to capture the highest exposures for residential, commercial, and fence line receptors. Landau also identified other potential sensitive receptor areas such as students at Monument Elementary and Quincy Valley Schools, and patients at Quincy Valley Hospital (Figure 2 and Figure 3).

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[4] Landau and Ecology modeled cumulative emissions from existing data centers, railway, and highways. Results were incorporated into the review of proposed emissions from Oxford Data Center.

3.4. Increased Cancer Risk

3.4.1.   Cancer Risk Attributable to Oxford's DEEP and Other TAP Emissions

Table 2, adapted from the HIA, shows the estimated Oxford Data Center-specific and cumulative cancer risk per million at each of the receptors evaluated. The highest increase in risks attributable to Oxford Data Center's emissions is 5.7 per million[5] and occurs at residential property north of Oxford. Landau also calculated risks posed by other carcinogenic TAPs (i.e., acetaldehyde, benzene, formaldehyde, 1,3-butadiene, and carcinogenic polycyclic aromatic hydrocarbons). They estimated a negligible increased risk attributable to these other TAPs of about 0.01 per million. When estimating exposure to DEEP, Landau assumed that both filterable and condensable particulate matter make up DEEP resulting in an estimated risk that errs on the side of overestimating risk.[6] Additionally, Landau chose a receptor location to represent a residence that was approximately 200 ft south of a residential property and 400 ft south of the actual house (closer to Oxford's emission sources) and therefore, the risk reported for a residential receptor at this location represents a conservatively high estimate of risk.

The highest estimated increased risk for a residential receptor near Oxford assuming only filterable particulate represents DEEP is approximately 1.4 per million. For non-residential exposure scenarios, workers at nearby commercial facilities may have increased risks of about 1.5 per million (or 0.3 per million assuming only filterable). Increased cancer risks to potential bystanders exposed near the point of maximum impact (i.e., fence line receptor) may be about 0.2 to 0.8 per million.

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[5] # per million represents an upper-bound theoretical estimate of the number of excess cancers that might result in an exposed population of one million people compared to an unexposed population of one million people. Alternatively, an individual's increase in risk of one in one million means a person's chance of getting cancer in their lifetime increases by one in one-million or 0.0001 percent.

[6] California Air Resources Board considers the front half (filterable) PM emissions to be consistent with the techniques used to establish diesel PM as a toxic air contaminant.

Table 2. Estimated Increased Cancer Risk for Residential, Occupations, and Student Scenarios Attributable to Oxford's DEEP Emissions						
Risk Per Million from DEEP Exposure at Various Receptor Locations						
Attributable to:	**Fence Line Receptor[1]**	**R-1 North Residence (MIRR)[2]**	**C-1 Industrial Building (MICR)[3]**	**Monument Elementary School**		**Patients at Quincy Valley Medical Center[6]**	**Maximally Cumulatively Impacted Residence in Modeling Domain[2]**
				Students[4]	**Teachers[5]**		
Oxford (assumes filterable and condensable particulate are DEEP)	0.8	5.7	1.5	<0.1	0.2	<0.1	2.0
Oxford (assumes filterable only Is DEEP)	0.2	1.4	0.3	<0.1	<0.1	<0.1	0.5

[1] Fence line scenario assumes intermittent exposure 250 days per year, two hours per day for 30 years.

[2] Residential scenarios assume continuous lifetime exposure.

[3] Workplace scenarios assume exposure occurs 250 days per year, eight hours per day for 40 years.

[4] Student scenario assumes exposure occurs 180 days per year, eight hours per day for seven years.

[5] Teacher scenario assumes exposure occurs 200 days per year, eight hours per day for 40 years.

[6] Patient scenario assumes a patient is present at the hospital 365 days per year, 24 hours per day for one year.

Note: Landau also calculated risks posed by other carcinogenic TAPs (i.e., acetaldehyde, benzene, formaldehyde, 1,3-butadiene, and carcinogenic polycyclic aromatic hydrocarbons). They estimated a negligible increased risk attributable to these TAPs of about 0.003 per million at the north residence (R-1).

3.4.2.   Cancer Risk Attributable to Cumulative DEEP Emissions

Ecology and Landau conducted separate analyses of cumulative exposure to DEEP in Quincy. Both analyses yielded similar concentrations at key receptor locations, but the key methodological discrepancy stems from the use of different modeling techniques involving line sources (i.e., roads and railways). For the purpose of incorporating the cumulative modeling results into the review of proposed emissions from Oxford Data Center, Ecology chose to report results from both analyses.

The cumulative risk of all known sources of DEEP emissions in the vicinity of Oxford Data Center (Table 3 and Figure 4) is highest for a nearby residence south of State Route 28, and southeast of the proposed project. The cumulative DEEP risk at this home is about 46 per

million.[7] The majority (~75%) of estimate DEEP exposure at this location is attributable to emissions from vehicles travelling on State Route 28.

Table 3. Estimated Increased Cancer Risk for Residential, Occupations, and Student Scenarios Attributable to All Known Sources of DEEP in Quincy							
Risk Per Million from DEEP Exposure at Various Receptor Locations							
Modeled by:	Fence Line Receptor[1]	R-1 North Residence (MIRR)[2]	C-1 Industrial Building (MICR)[3]	Monument Elementary School		Patients at Quincy Valley Medical Center[6]	Maximum Cumulatively Impacted Residence in Modeling Domain[2]
				Students[4]	Teachers[5]		
Landau	1.0	10.1	6.4	0.3	NA	0.6	46
Ecology	0.8	9.5	6.5	0.3	1.8	0.6	46

[1] Fence line scenario assumes intermittent exposure 250 days per year, two hours per day for 30 years.
[2] Residential scenarios assume continuous lifetime exposure.
[3] Workplace scenarios assume exposure occurs 250 days per year, eight hours per day for 40 years.
[4] Student scenario assumes exposure occurs 180 days per year, eight hours per day for seven years.
[5] Teacher scenario assumes exposure occurs 200 days per year, eight hours per day for 40 years.
[6] Patient scenario assumes a patient is present at the hospital 365 days per year, 24 hours per day for one year.

3.5. Noncancer Hazard

Landau evaluated chronic noncancer hazards associated with long-term exposure to DEEP emitted from Oxford Data Center and other local sources. Hazard quotients were much lower than unity (one) for all receptors' exposure to Oxford Data Center-related and cumulative DEEP.[8] In addition, Landau evaluated combined long-term exposure to DEEP, benzene, acrolein, and ammonia emitted from Oxford and determined the hazard indices were much lower than unity for all receptors' exposure to Oxford Data Center-related pollutants. This indicates that chronic noncancer hazards are not likely to occur as a result of exposure to DEEP and other project-related TAPs in the vicinity of Oxford Data Center.

Landau also evaluated acute hazards associated with short-term exposure to NO_2, CO, benzene, ammonia, and acrolein. Landau evaluated scenarios where Oxford Data Center was operating under full power outage mode because this is the time period when short-term emissions would be greatest. Hazard quotients and hazard indices for all receptors' exposures were below one

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[7] Note that residential receptors tend to be the most exposed (e.g., longest exposure duration and exposure frequency). Therefore, their risks tend to be higher than other types of receptors. For regulatory decision making purposes, Ecology assumes that a resident is continuously exposed at their residence for their entire lifetime.
[8] The highest chronic hazard quotient attributed to cumulative exposure to DEEP (0.07) occurred at the maximum impacted boundary receptor location.

indicating that acute adverse health effects are not likely to be caused solely by Oxford Data Center's emissions during a power outage.[9]

4. Other Considerations

4.1. Short-Term Exposures to DEEP

Exposure to DEEP can cause both acute and chronic health effects. However, as discussed previously, reference toxicity values specifically for DEEP exposure at short-term or intermediate intervals do not currently exist. Therefore, Landau did not quantify short-term risks from DEEP exposure. Generally, Ecology assumes that compliance with the 24-hour $PM_{2.5}$ NAAQS is an indicator of acceptable short-term health effects from DEEP exposure. Ecology's Technical Support Document (TSD) for the draft preliminary NOC approval concludes that Oxford's emissions are not expected to cause or contribute to an exceedance of any NAAQS (Ecology, 2015).

4.2. Cumulative Short-Term NO_2 Hazard

While Oxford Data Center's NO_2 emissions by themselves are not likely to result in adverse noncancer health effects, Ecology recognizes that it is possible that cumulative impacts of multiple data center's emissions during a system-wide outage could potentially cause NO_2 levels to be a health concern. Ecology evaluated the short-term NO_2 impacts that could result from emergency engine operation during a system-wide power outage. While NO_2 levels could indeed rise to levels of concern[10] at various locations across town, the outage would have to occur at a time when the dispersion conditions were optimal for concentrating NO_2 at a given location.

Ecology estimated the combined probability of a system-wide outage coinciding with unfavorable dispersion conditions. Ecology found the likelihood of this occurrence to be relatively low throughout Quincy.

To conduct this analysis, Ecology modeled emissions of:

- Simultaneous outage emissions of NO_X for all permitted and proposed data center engines, during all meteorological conditions experienced throughout 2005.

- Each engine operates at loads specified in permits (for existing data centers) or permit applications (for Oxford Data Center).

- Potential emissions from other NO_X sources in Quincy like the Celite Corporation and mobile source emissions.

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[9] The highest acute hazard index of 0.9 occurred at the fence line receptor location (i.e., maximum impacted boundary receptor). Most of the acute hazard is attributable to nitrogen dioxide exposure.

[10] The level of concern in this case is 462 μg/m^3. This represents California OEHHA's acute reference exposure level of 470 μg/m^3 minus an estimated regional background concentration of 8.3 μg/m^3.

Figure 5 shows the maximum 1-hour NO_2 concentrations that could occur in Quincy if all data centers' engines operated simultaneously under emergency conditions. Although the acute reference exposure level for NO_2 is 470 µg/m^3 (CalEPA, 2008), the figure shows only those concentrations that exceed 462 µg/m^3 because Ecology assumes that a NO_2 background concentration of 8.3 µg/m^3 exists in Quincy at any given time (NW AIRQUEST, 2014). It is important to note that the maximum 1-hour concentrations shown in Figure 5 do not all occur at the same time. The figure displays the worst-case concentration at each location in Quincy. Generally, this figure shows that concentrations of NO_2 could exceed a level of health concern in some areas of Quincy.

Ecology also analyzed the frequency (# of hours per year) meteorological conditions could result in a NO_2 concentration greater than 462 µg/m^3 at each receptor point within the Quincy modeling domain. Figure 6 shows the number of hours per year that a cumulative NO_2 concentration could exceed 462 µg/m^3 assuming data center engines operate during all combinations of meteorological conditions experienced throughout the year. If engines were run continuously during the course of a year, some areas near data centers could achieve concentrations of health concern for up to about 300 hours per year. In reality, these data centers were not permitted to continuously operate their engines; instead, they are only permitted to operate between eight and 400 hours per year under emergency outage conditions. Grant County Public Utilities District (PUD) reported that from 2003 to 2009, the average total outage time for customers that experience an outage throughout Grant County PUD's service area is about 143 minutes per year (Coe, 2010).

To account for infrequent intermittent emergency outages, Ecology estimated the joint probability of a system-wide power outage coinciding with unfavorable meteorological conditions. The joint probability was estimated as:

$$P(X \cap Y) = P(X) \cdot P(Y)$$

Where:

P(X) = The number of unfavorable atmospheric condition hours[11] that occurred in a one year period[12] divided by the total number of hours in the same period, i.e., 8760 hours

P(Y) = The number of hours during which unplanned outage generator operation takes place divided by the total number of hours considered. Ecology estimated P(Y) by examining the lowest duration that Quincy data centers are permitted to operate engines under outage conditions, i.e., eight hours per year.

P(X ∩ Y) = The hourly probability that the concentration at a given receptor will exceed 462 µg/m^3.

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[11] The number of times the NO_2 concentration exceeded 462-µg/m^3 in the AERMOD simulation.
[12] Meteorology was based on 2005 year meteorology from Moses Lake.

Based on this joint probability, the estimated number of hours per year that an ambient NO_2 concentration of 462 µg/m^3 would probably occur given full use of the allowance for up to eight hours of emergency outage operation is:

Frequency (hours per year) = P(X ∩ Y) · 8760 hr/yr

The long-term recurrence intervals between hours that an ambient NO_2 concentration of 462 µg/m^3 would probably occur given full use of the allowance for up to eight hours of emergency outage operation is:

Recurrence (years) = 1/Frequency (hr/yr)

This analysis determined that the combined probability of an outage coinciding with unfavorable weather conditions results in recurrence intervals of every 100 years or more at most of the locations within the modeling domain (Figure 7). Some areas near and within the property boundaries of Yahoo!, Intuit, Sabey, and Microsoft Columbia Data Center could experience NO_2 levels > 462 µg/m^3 once every few decades to few years.

Ecology's analysis concluded that coincidental worst-case meteorological and system-wide 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 emitted from emergency engines and other sources may experience respiratory symptoms such as wheezing, shortness of breath, and reduced pulmonary function with airway constriction.

4.3. Outages Reported by Quincy Data Centers

Ecology obtained reports of unplanned generator usage at the Microsoft, Yahoo!, Dell, Intuit, and Sabey data centers in Quincy to determine if the assumed eight hours of simultaneous outage per year represents a reasonable assumption. Table 4 shows the dates of data center power outages reported to Ecology. The information received about power outages from the data centers varies in the level of detail. For example, some reports do not specify the number of engines or the duration of lost power, while others provide this information. None of the reports specify the load at which the engines operated during the outage.

The outage reports indicate that two or more data centers lost power at the same time on at least two occasions: May 29, 2013, affecting Dell and Microsoft Columbia Data Center on the west side of Quincy for a duration of about 1.3 hours; and November 16, 2013, affecting Sabey and Yahoo! on the east side of Quincy for about 1.5 hours. While these data are not comprehensive, there have been no reported instances of system-wide outages affecting the entire electrical grid in Quincy since the first data centers were permitted in 2006. According to Grant County Public Utilities District, the east and west sides of Quincy are connected to transmission lines via two different feeder lines thus reducing the likelihood of a simultaneous outage affecting all Quincy data centers (Coe, 2010).

Table 4. Summary of Power Outage Reports from Quincy-Area Data Centers (2008 to 2014)										
	Microsoft Columbia Data Center		**Yahoo!**		**Intuit**		**Dell**		**Sabey**	
# Permitted Engines	37		23		9		28		44	
Date of Reported Outage	**# Engines**	**Duration**	**# Engines**	**Duration**	**# Engines**	**Duration**	**# Engines**	**Duration**	**# Engines**	**Duration**
08/09/2008	---	---	Not specified	0.5 hr	---	---	---	---	---	---
10/25/2008	---	---	Not specified	2 hr	---	---	---	---	---	---
06/05/2009	---	---	Not specified	0.5 hr	---	---	---	---	---	---
12/2009	Not specified	Not specified	---	---	---	---	---	---	---	---
01/2010	Not specified	Not specified	---	---	---	---	---	---	---	---
01/22/2010	Not specified	Not specified	---	---	---	---	---	---	---	---
12/ 20/2011	2	0.6 hrs	---	---	---	---	---	---	---	---
03/2012	---	---	13	0.5 hr	---	---	---	---	---	---
07/06/2012	---	---	---	---	---	---	5	0.2 to 0.4 hr (avg. 0.3 hr/engine)	---	---
05/29/2013	33	0.1 to 1.3 hr (avg. 0.8 hr)	---	---	---	---	5	0.4 to 1 hr (avg. 0.8 hr)	---	---
08/2013	---	---	16	1 to 5 hours (avg. 2 hr/ engine)	---	---	---	---	---	---
11/16/2013	---	---	---	--	--	---	---	---	Not Specified	1.5 hr
11/2013	---	---	20	1 to 26 hr (avg. 3.9 hr/engine)	---	---	---	---	---	---
02/2014	---	---	9	1 hr	---	---	---	---	---	---
04/21/2014	---	---	---	---	6	0.75 hr	---	---	---	---
04/24/2014	---	---	---	---	6	0.5 hr	---	---	---	---
04/2014	---	---	22	8 to 12 hr (avg. 9.4 hr/engine)	---	---	---	---	---	---
05/2014	---	---	12	1 hr	---	---	---	---	---	---
Note: Shaded cells represent times when more than one data center reports an outage at the same time interval.										

5. Uncertainty

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 Oxford's emissions. The assumptions used in the face of uncertainty may tend to over- or underestimate the health risks estimated in the HIA. Key aspects of uncertainty in the HIA for project Oxford are exposure assumptions, emissions estimates, air dispersion modeling, and toxicity of DEEP.

5.1. Exposure

It is difficult to characterize the amount of time that people can be exposed to Oxford's DEEP emissions. For simplicity, Landau and Ecology assumed a residential receptor is at one location for 24 hours per day, 365 days per year for 70 years. These assumptions tend to overestimate exposure.

The duration and frequency of power outages is also uncertain. From 2003 to 2009, the average outage for all Grant County PUD power customers was about 2.5 hours per year. While this small amount of power outage provides some comfort that power service is relatively stable, Oxford cannot predict future outages with any degree of certainty.

5.2. Emissions

The exact amount of DEEP emitted from Oxford's diesel-powered generators is uncertain. Landau estimated emissions assuming that each engine operates at a load resulting in the highest emissions regardless of actual intended operational load. Landau also attempted to account for higher emissions that would occur during initial start-up and before control equipment was fully warmed up. Finally, the emission estimates for DEEP include adjustment factors to account for condensable particulate in addition to filterable particles. The resulting values are considered to be a conservatively high estimate of DEEP emissions.

5.3. Air Modeling

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 techniques that are more accurate 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 model used for the Oxford analysis may slightly overestimate the short-term (1-hour average) impacts and somewhat underestimate the annual concentrations.

5.4. Toxicity

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 noncancer effects in animals or humans. Agencies apply these uncertainty factors so that they derive a toxicity value that is considered protective of humans including susceptible populations. In the case of DEEP exposure, the noncancer reference values used in this assessment were generally derived from animal studies. These reference values are probably protective of the majority of the population including sensitive individuals, but in the case of EPA's DEEP RfC, EPA acknowledges (EPA, 2002):

> *"…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 (3×10^{-4} per µg/m^3) falls within this range. Regarding the range of URFs, EPA states in their health assessment document for diesel exhaust (EPA, 2002):

> *"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.

Regarding the second bullet above, California EPA's Office of Environmental Health Hazard Assessment recently evaluated experimental data from several new technology diesel engine emissions reflecting emission controls similar to those proposed for Oxford's engines (CalEPA, 2012).

"These studies indicate that the reductions of some air toxics such as polycyclic aromatic hydrocarbons, benzene and 1,3- butadiene in new technology engine exhaust (often 80 – 90%) are not as great as the corresponding reductions in DEP [diesel engine particulate] *(often 95 – 99%). The resulting air toxics/DEP ratios for NTE* [new technology engine] *exhaust may be greater than or equal to similar ratios found in exhaust from older diesel engines. As an example, an analysis of data from one published review indicated that the average 3-ring PAH, 1,3-butadiene and benzene/DEP ratios increased in NTE exhaust compared to older DEE* [diesel engine emissions] *by 2-, 10- and 4-fold, respectively. These data suggest that while the absolute amount of DEP (and thus estimated cancer risk) and air toxics is much reduced in NTE exhaust, the exhaust composition has not necessarily become less hazardous. Thus, the available data do not indicate that NTE exhaust should be considered to be fundamentally different in kind compared to older DEE for risk assessment purposes and suggests the TAC cancer unit risk value for DEP can continue to be applied to NTE exhaust risk assessments."*

Table 5 presents a summary of how the uncertainty affects the quantitative estimate of risks or hazards.

| Table 5. Qualitative 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 concentrations
Air modeling methods	Possible underestimate of average long-term ambient concentrations and overestimate of short-term ambient concentration
Toxicity of DEEP at low concentrations	Possible overestimate of cancer risk, possible underestimate of noncancer hazard for sensitive individuals

6. Conclusions and Recommendation

The project review team has reviewed the HIA and determined that:

a) The TAP emissions estimates presented by Landau represent a reasonable estimate of the project's future emissions.

b) Emission controls for the new and modified emission units meet or exceed the tBACT requirement.

c) The ambient impact of the emissions increase of each TAP that exceeds ASILs has been quantified using refined air dispersion modeling techniques as approved in the HIA protocol.

d) The HIA submitted by Landau on behalf of Microsoft adequately assesses project-related increased health risk attributable to TAP emissions.

In the HIA, Landau estimated lifetime increased cancer risks attributable to Oxford's DEEP and other toxic air pollutant emissions. The revised DEEP emissions resulted in an increase from the previous risk estimate of four in one million to a new estimate of **six in one million.** The maximum risk was estimated at a residential location north of Oxford Data Center's property. This risk was quantified assuming that both filterable and condensable particulate emitted from Oxford's engines constitutes DEEP. It is important to note that diesel particulate is typically quantified as only the filterable fraction. This is because the health studies that form the basis for quantifying the health risk from diesel exposure used measurements of respirable particulate from "fresh" diesel exhaust and elemental carbon as a surrogate for diesel exhaust emissions. Therefore, the increased risk estimated by Landau represents a conservatively high estimate. Based on Oxford's filterable emissions only, an additional risk of about 1.4 in one million at that location is a more realistic estimate.

Landau also assessed chronic and acute noncancer hazards attributable to the project's emissions and determined that Oxford's emissions by themselves are not likely to result in adverse noncancer health effects.

Finally, Landau and Ecology assessed the cumulative health risk by adding estimated concentrations attributable to Microsoft's emissions to an estimated background DEEP concentration. The maximum cumulative cancer risk from resident's exposure to DEEP in the vicinity of Oxford is approximately **46 in one million**. Most of the exposure to diesel particulate at this location comes from vehicles travelling on State Route 28. Additionally, exposure to DEEP in the area is not likely to result in noncancer health effects. These DEEP-related health risks in the vicinity of Oxford Data Center are generally much lower than those estimated in urban areas of Washington.

The project review team concludes that the HIA represents an appropriate estimate of potential increased health risks posed by Oxford Data Center's TAP emissions. The risk manager may recommend approval of the revised permit because total project-related health risks are permissible under WAC 173-460-090 and the cumulative risk from DEEP emissions in Quincy is less than the cumulative additional cancer risk threshold established by Ecology for permitting data centers in Quincy (100 per million or 100×10^{-6}) [Ecology, 2010].

Additionally, Ecology's analysis of short-term impacts from simultaneous outage emissions determined a very low likelihood of a system-wide power outage coinciding with unfavorable pollutant dispersion. While existing power outage reports from each of the data centers do not indicate power outages have simultaneously affected all Quincy data centers, Ecology should track outage reports from the data centers to ensure that assumptions used in the analysis remain plausible.

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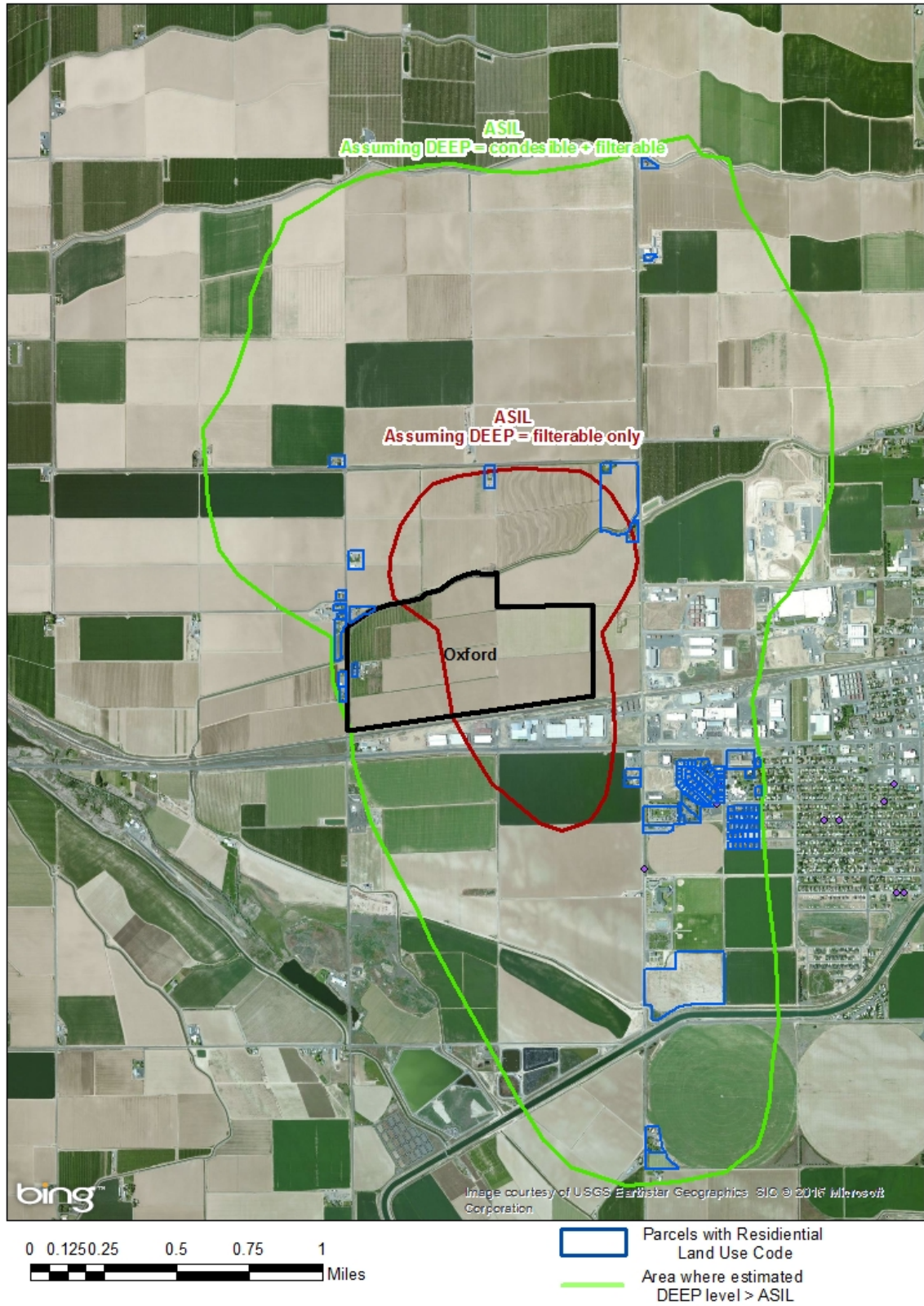
Figure 1. Residential parcels in the area where DEEP concentrations could exceed the ASIL.
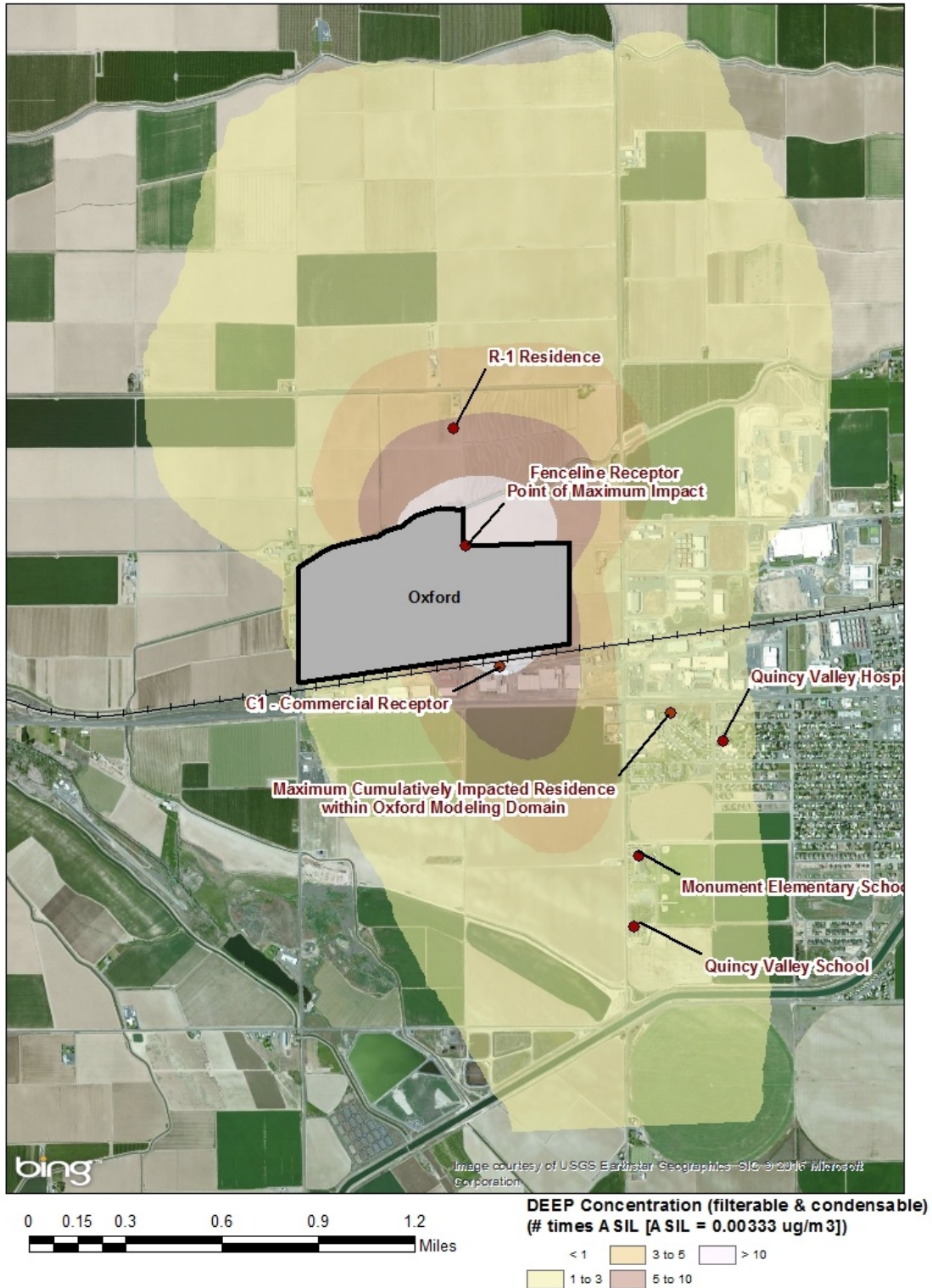
Figure 2. Receptor locations in relation to estimated DEEP concentrations (assuming both filterable and condensable fractions represent DEEP). Concentrations are reported as the number of times higher than the ASIL.
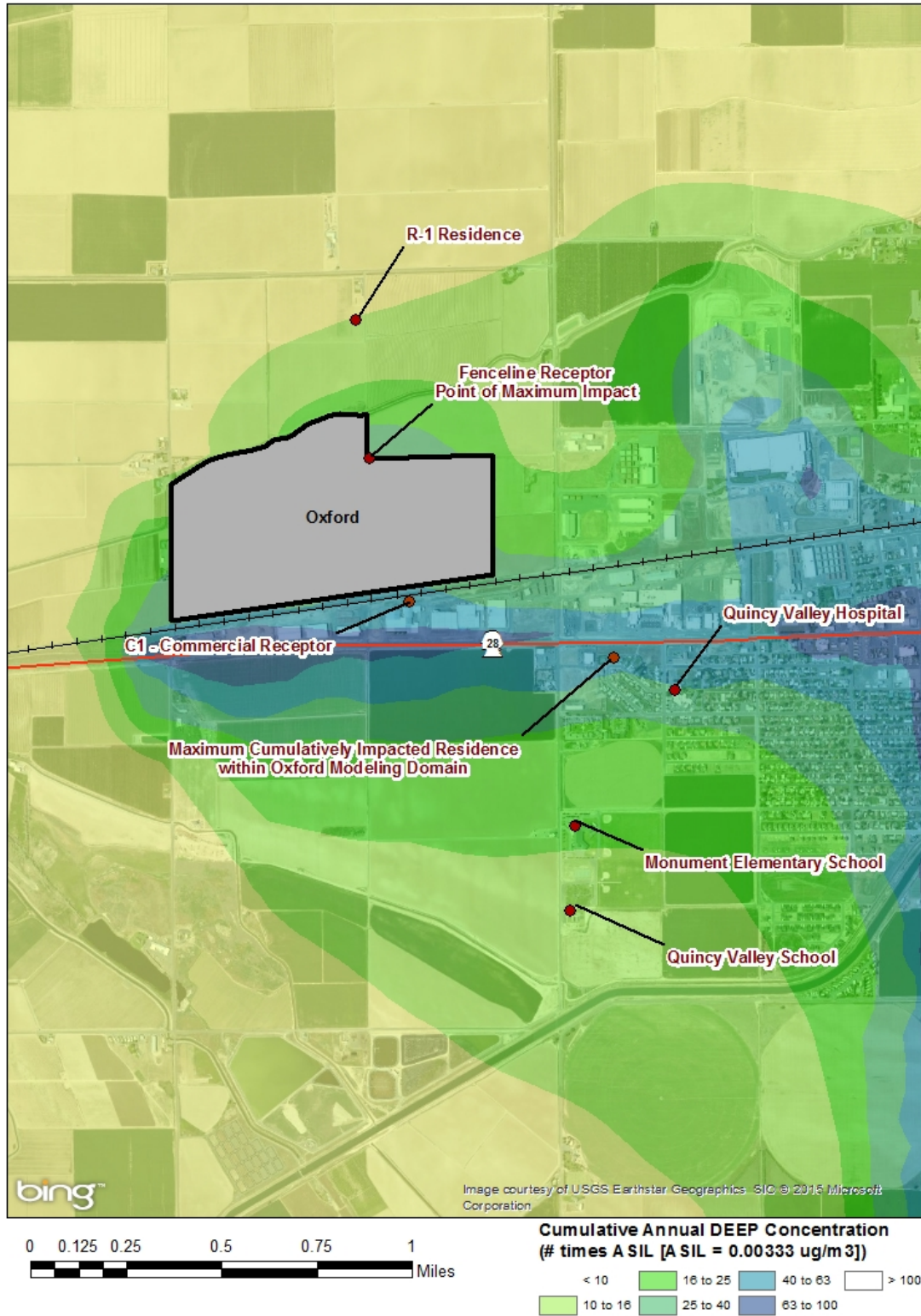
Figure 3. Receptor locations in relation to estimated DEEP concentrations (assuming only filterable fraction represents DEEP). Concentrations are reported as the number of times higher than the ASIL.

Figure 4. Cumulative DEEP concentrations (estimated by Ecology) in the Oxford vicinity. Concentrations are reported as the number of times higher than the ASIL.
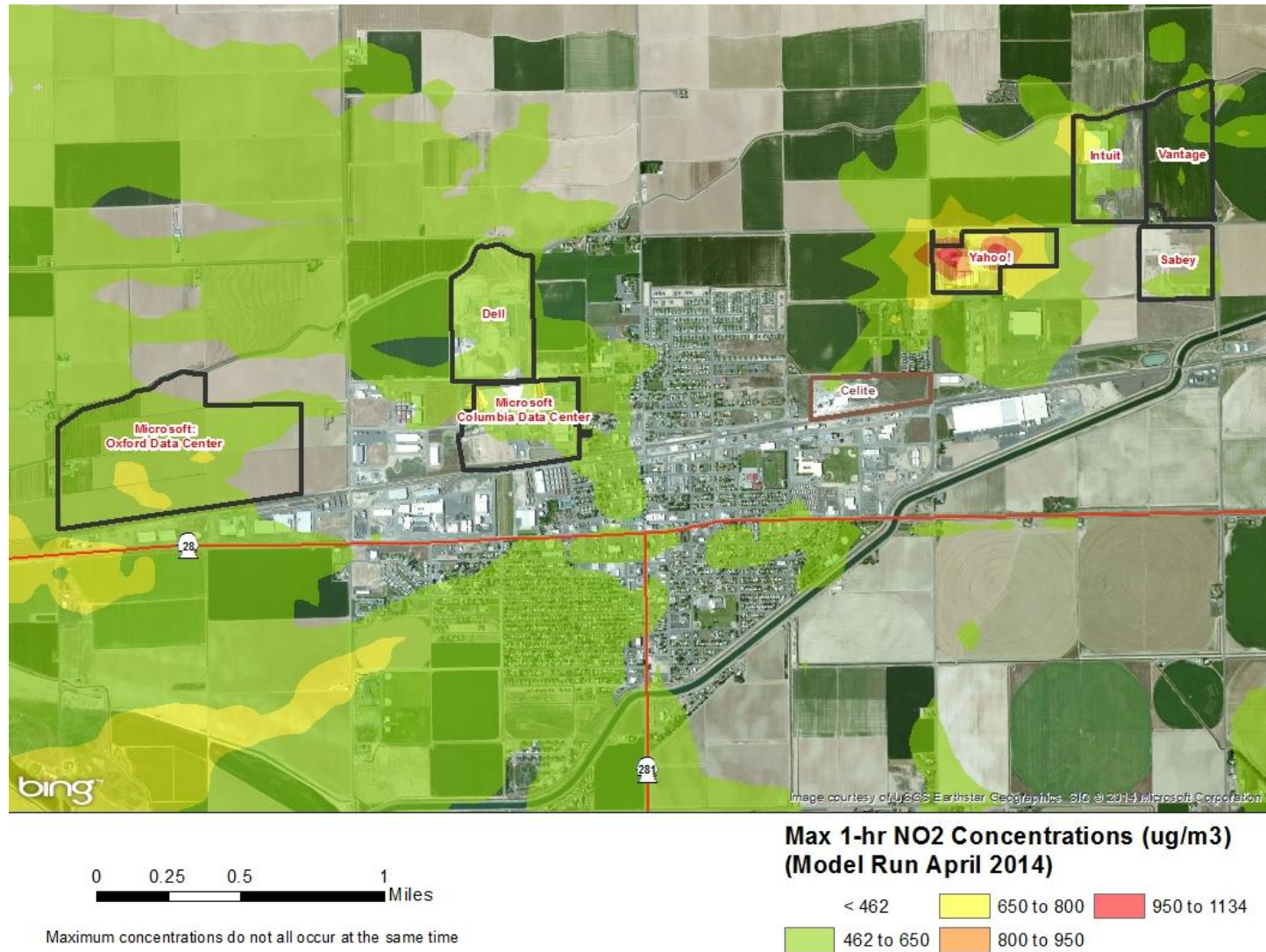
Figure 5. Estimated maximum 1-hr NO₂ concentrations resulting from cumulative NOₓ emissions of all permitted and proposed data center engines during a simultaneous outage in Quincy. These maximum concentrations do not all occur at the same time.
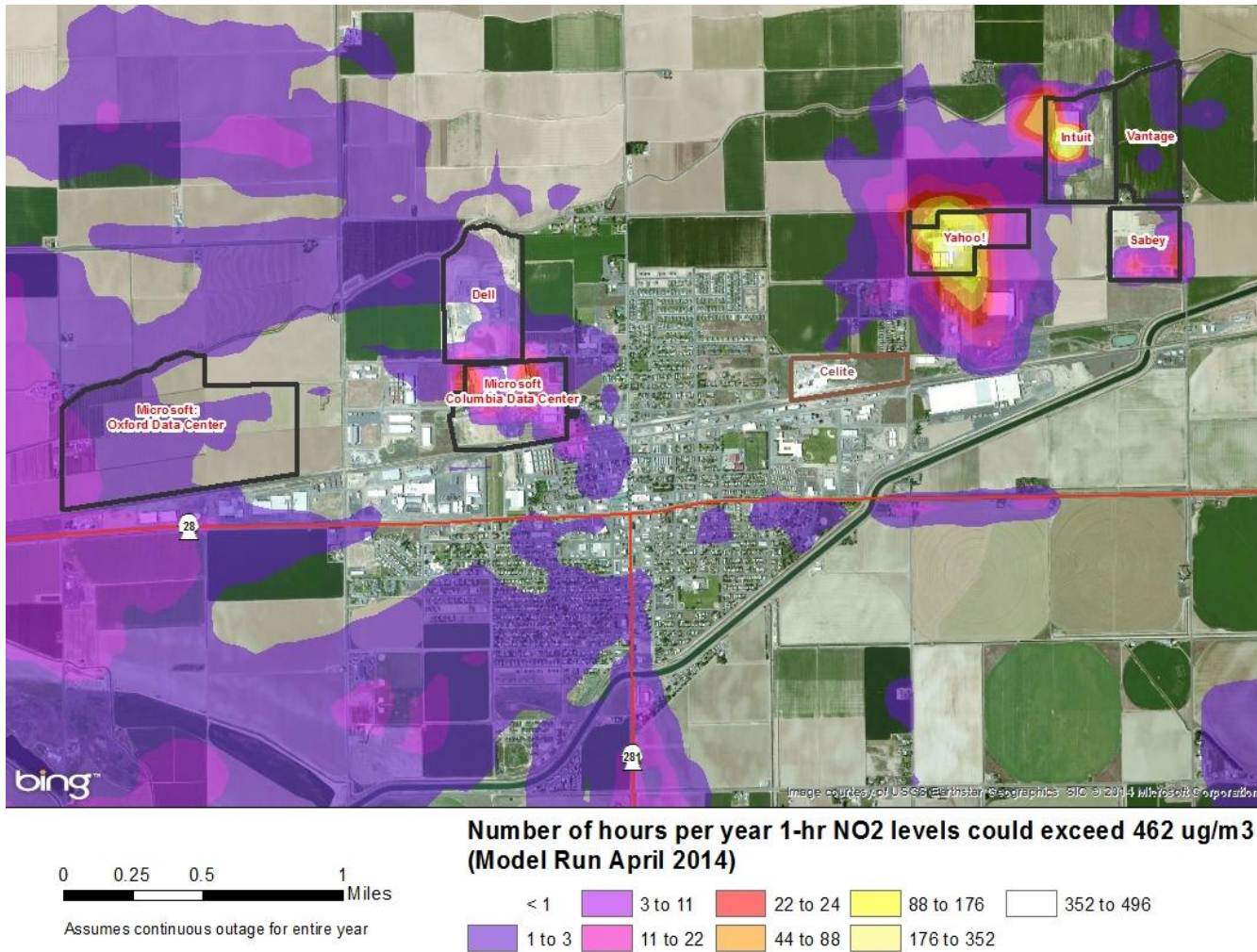
Figure 6. Estimated number of times per year that 1-hr NO$_2$ concentrations could exceed 462 ug/m^3 assuming continuous outage emissions for an entire year.
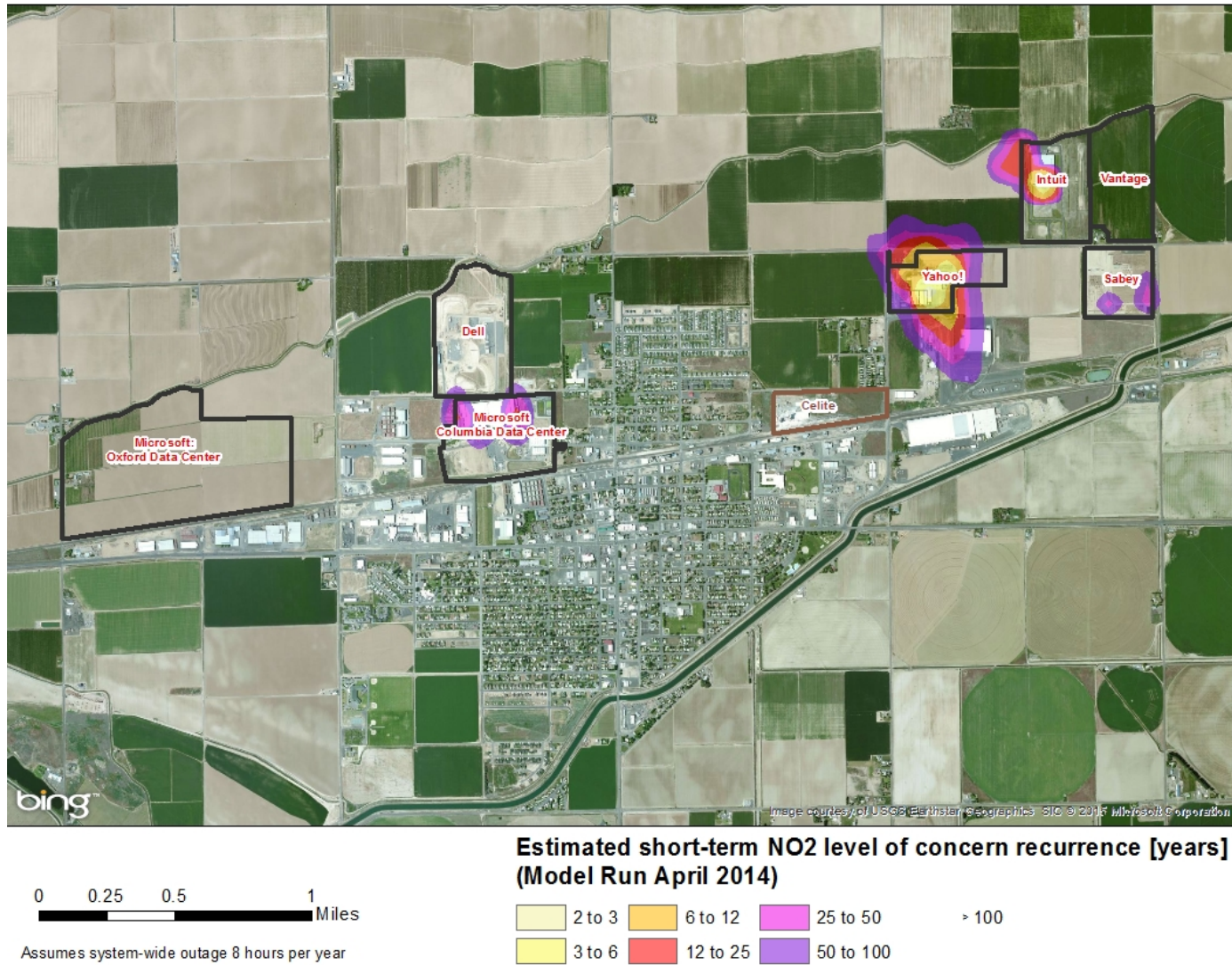
Figure 7. Estimated interval between occurrences of 1-hr NO$_2$ concentrations greater than 462 ug/m^3 assuming eight hours of simultaneous Quincy data center emergency engine outage emissions per year.