Testimony of Central Boiler, Inc.
On Outdoor Wood-Burning Furnaces (SB 126)
To the Connecticut General Assembly – Environment Committee
March 8, 2010

Good morning Mr. Chairman and members of the Committee. My name is Andrew Beaton. I am an air quality consultant at Tech Environmental, Inc. and am appearing on behalf of Central Boiler Inc. of Greenbush, Minnesota. Our firm has over 25 years of experience as air pollution consultants here in New England and our staff includes experts on wood-burning emissions.

Senate Bill 126 is not needed. Public Act 05-227 enacted in 2005 solves potential problems from smoke complaints by requiring that OWFs only be installed with proper set-back distances, a proper chimney height above the roof peaks of residences not served, and that only clean wood can be used as fuel. The existing law provides enforcement powers to the state Department of Environmental Protection and the local communities to ensure these standards are met. Enforcing the existing law ensures protection of air quality and public health.

EPA test data reveal that a properly installed OWF has the same Particulate Matter emissions as an EPA-certified wood stove for the same load of wood fuel.[1] Also, since 2007 EPA has provided testing and labeling of cleaner OWFs through its Hydronic Heaters program. The program has evolved to Phase 2, and EPA-qualified units are up to 90 percent cleaner,[2] and Phase 2 OWFs are lower-emitting than certified woodstoves. These improvements suggest Phase 2 models should be allowed to be installed in Connecticut with less restrictive setbacks and chimney heights.

An OWF installed and operated in compliance with Public Act 05-227 does not impact neighbors or adversely affect public health. It fully complies with National Ambient Air Quality Standards

[1] Guldberg, P., "Outdoor Wood Boilers – New Emissions Test Data and Future Trends," presented at the EPA 16th Annual International Emissions Inventory Conference, Raleigh, NC, May 2007. http://www.outdoorfurnacefacts.com/cms/repository/media/16th_Annual_International_Emission_Inventory_Conference_Guldberg_Paper.pdf.

[2] http://www.epa.gov/burnwise/owhhlist.html.

(NAAQS) for fine Particulate Matter ($PM_{2.5}$), established to protect public health for the most sensitive individuals with a margin of safety. Using emissions data from EPA tests on an OWF, air dispersion modeling was performed for a properly-installed Central Boiler Model 6048 furnace and operated to heat a larger-than-average (2,800 sf) home. The predicted maximum $PM_{2.5}$ concentrations are all safely in compliance with the stringent air standards **during all months of the year.** Thus, there is no factual basis for banning the use of existing OWFs that meet current law during the period of April 15 through October 15 each year.

A second air dispersion modeling study done for a Central Boiler Phase 2 OWF shows all air concentrations are insignificant, as measured by EPA criteria. And the results demonstrate that **no minimum setback distance is required so long as the chimney height is two feet above the roof peak of nearby structures.** Copies of both studies are provided with our testimony.

When properly sited and operated in accordance with Public Act 05-227, OWFs are a clean and affordable heating source for homeowners in Connecticut and they do not impact public health. I urge the Committee to reject SB 126. Thank you.

AIR QUALITY DISPERSION MODELING OF OUTDOOR WOOD HYDRONIC HEATERS

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EXECUTIVE SUMMARY

Air dispersion modeling was performed with the U.S. AERMOD model and following EPA guidance to determine the effect of a Central Boiler Outdoor Wood Hydronic Heater (OWHH) on air quality for two emission scenarios. Air dispersion modeling assumed the OWHH was located a typical distance of 50 feet from either a one-story or a two-story house and had a stack top two feet above the roof peak of the nearest structure, following the chimney height installation instructions supplied by Central Boiler with every new unit. Five years of hourly meteorological data for Burlington, Vermont were utilized in the modeling.

The principal air pollutant emitted by OWHHs is particulate matter (PM). The Central Boiler Model 6048 was assumed to emit 60 g/hr of PM using the average of U.S. EPA test data[1] for emissions from Central Boiler furnaces of 10.7 g/kg-dry and a firing rate of 5.6 kg-dry/hour,[2] corresponding to a heat input rate of approximately 99,600 Btu/hour. Thus, the emission rate for the first scenario is 1.33-lb/MMBtu heat input. With 55% efficiency, the heat output rate is 54,300 Btu/hour and satisfies the peak heating-load for January in a northern State for a larger-than-average 2,800 sf home. The new EPA Phase 1 guideline of 0.60 lb/MMBtu was assumed in the second dispersion-modeling scenario, which translates to a mass emission rate of 27 g/hr. Two stack heights (20 ft and 35 ft) were analyzed for each emission rate.

The modeling results demonstrate that maximum predicted air concentrations from operation of a Central Boiler OWHH with an emission rate of either 60 g/hour or 27 g/hour are safely in compliance with the new 24-hour National Ambient Air Quality Standards (NAAQS) for fine particulate matter ($PM_{2.5}$) of 35 $\mu g/m^3$. The NAAQS have been established by EPA to protect the most sensitive groups in the population (for PM, these are people with asthma and respiratory disease) from any adverse effects, with a margin of safety. Full compliance with the NAAQS is demonstrated both on the homeowner's property and off-site for both stack heights.

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[1] U.S. EPA, "Emissions From Outdoor Wood-Burning Residential Hot Water Furnaces," EPA-600/R-98-017, February 1998, p. 22, Table 4-1a, average of Furnace B/B-1 through B-4 test results for a Central Boiler unit.

[2] Wood firing rate of 16 lb/hr (24% moisture) = 7.4 kg/hour = 5.6 kg-dry/hour.

1.0 INTRODUCTION

Central Boiler, Inc. of Greenbush, Minnesota is the manufacturer of Outdoor Wood Hydronic Heaters (OWHH). These are freestanding units that are located outside the structure being heated and consist of a firebox, water reservoir and ancillary mechanical equipment. The combustion of wood heats water that is pumped from the furnace to a heat exchanger located inside the structure. Combustion gasses are passed over or through heating tubes before being vented to the atmosphere through a metal stack. While similar in principle to other stick wood burning devices, these units are designed to provide continuous on-demand heat from the combustion of cordwood. The design allows the unit to be placed near the location of the wood supply. The thermal outputs range from 15,000 to over 50,000 Btu/hr. Figure 1 shows a typical installation of a Central Boiler OWHH.

The purpose of this study is to evaluate the air pollutant concentrations resulting from Central Boiler OWHH units when installed and operated according to manufacturer's instructions that are shipped with every new unit. A typical setting for this equipment would be a rural area that has an available nearby supply of firewood. The unit is typically installed 50 feet from the heated structure and over 100 feet from other residences. A stack height 2 feet above any nearby roofline is recommended. The modeling was performed with the U.S. Environmental Protection Agency (EPA) AERMOD model using emissions that were obtained from EPA testing of Central Boiler equipment. The EPA also provides guidance on modeling methodology and establishes National Ambient Air Quality Standards.

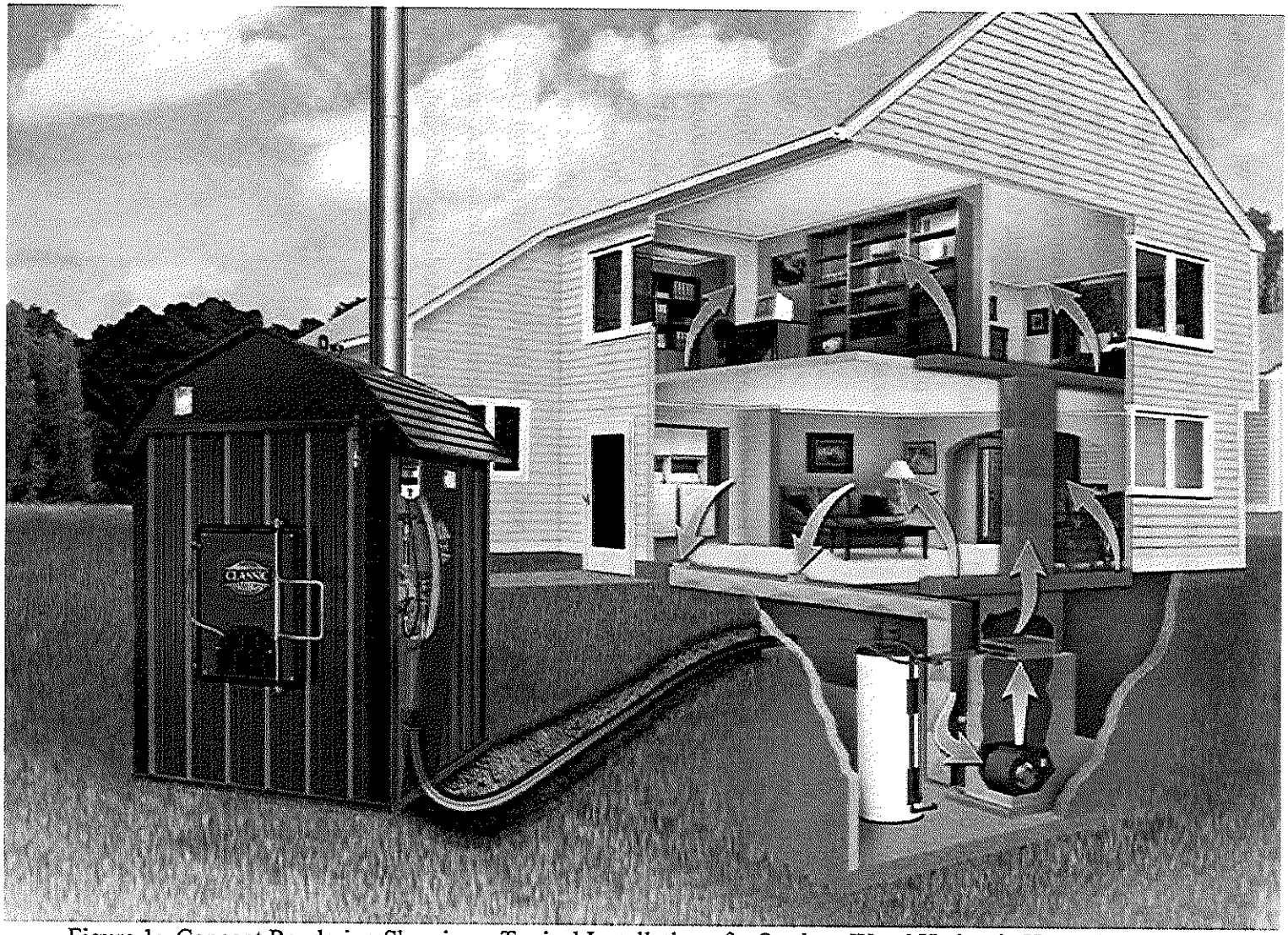


Figure 1: Concept Rendering Showing a Typical Installation of a Outdoor Wood Hydronic Heater Installation

2.0 AIR QUALITY STANDARDS

The principal air pollutant emitted by OWHHs is particulate matter (PM). EPA has established National Ambient Air Quality Standards (NAAQS) for both coarse (PM_{10}) and fine ($PM_{2.5}$) particulate matter. The PM_{10} standard applies to particles with a mass-mean diameter of 10 microns or less, while the $PM_{2.5}$ standard is keyed to particles 2.5 microns in diameter or less. While both long-term (annual) and short-term (24-hour) standards have been established, the 24-hour standards are the controlling set because of their more stringent limits. Also, the $PM_{2.5}$ standard is more stringent than the PM_{10} standard. Thus, only the 24-hour $PM_{2.5}$ levels are examined in this study.

The 24-hour $PM_{2.5}$ standard is 35 $\mu g/m^3$, measured as a 3-year average of 98^{th}-percentile concentrations. In a one-year period, the 8th-highest 24-hour value represents the 98^{th}-percentile concentration. For compliance purposes, the $PM_{2.5}$ design concentration is the 3-year average of the highest, 8^{th}-highest (H8H) values in each year at any receptor location. The US EPA added special processing for $PM_{2.5}$ in the latest versions of AERMOD (versions 06341 and 07026) to predict the design concentrations for each receptor. AERMOD now calculates the N-year average H8H 24-hour average $PM_{2.5}$ concentration at each receptor over the N years of meteorological data provided. The U.S. EPA considers the five-year average of the H8H 24-hour $PM_{2.5}$ values at each receptor to be unbiased estimates of the 3-year average H8H values, since US EPA guidance requires the use of five years of meteorological data when the data are from an off-site National Weather Service meteorological station.[3] Thus, the five-year average H8H values from the AERMOD model are the design values used to establish compliance with the NAAQS.

[3] US EPA, "Addendum User's Guide for the AMS/EPA Regulatory Model – AERMOD (EPA-454/B-03-001, September 2004)", pp. 5 – 7, December 2006.

3.0 OWHH EMISSIONS AND STACK PARAMETERS

Particulate matter from a fuel combustion process contains a wide distribution of particle sizes. For wood combustion, these range from relatively larger carbon particles (soot) down to sub-micron organic compound aerosols. Research studies of OWHH emissions have used sampling methods that capture the full size distribution of PM, solid particles and condensible organics. EPA particle size distribution data for wood boilers reveal that typically 90% of the total PM mass has a diameter of 10 microns or less, and 76% has a diameter of 2.5 microns or less.[4] As a conservative assumption in this study, all PM emissions were assumed to be $PM_{2.5}$.

Air dispersion modeling assumed the OWHH was located a typical distance of 50 feet from a house having a 30-foot by 50-foot footprint. The OWHH building had dimensions of 5.4 feet by 5.8 feet and stood 6 feet high (a Central Boiler Model 6048). Four modeling cases were examined:

- Case 1: One-story house, 18-foot roof peak, 20-foot stack, PM = 60 g/hr
- Case 2: Two-story house, 33-foot roof peak, 35-foot stack, PM = 60 g/hr
- Case 3: One-story house, 18-foot roof peak, 20-foot stack, PM = 27 g/hr
- Case 4: Two-story house, 33-foot roof peak, 35-foot stack, PM = 27 g/hr

Central Boiler has recommended since 1996 that OWHH stacks be installed to a height two feet above the roof-line of the nearest structure. These chimney height installation instructions accompany every new Central Boiler OWB that is sold and are contained in the industry's Best Burn Practices guideline attached to this report.

The stack gas exit temperature and exit velocity used in this analysis represent typical values measured in Central Boiler's emissions test laboratory in Greenbush, Minnesota for the OWHHs. All stack and emission values used in this study are summarized in Table 1.

[4] EPA publication AP-42, Section 1.6.

TABLE 1

STACK PARAMETERS AND EMISSIONS FOR AIR DISPERSION MODELING

Parameter	English Units	Metric Units
Stack Height		
Case 1	20 feet	6.1 m
Case 2	35 feet	10.7 m
Stack Exit Diameter	8 inches	0.2 m
Stack Exit Velocity	7.2 feet/sec.	2.2 m/s
Stack Exit Temperature	350° F	449.9° K
$PM_{2.5}$ Emission Rate		
Existing OWHH Models	0.13 lb/hr	60.0 g/hr
Model Meeting EPA Phase 1 Limit	0.06 lb/hr	27.1 g/hr

4.0 MODELING RESULTS AND CONCLUSIONS

The air dispersion modeling reveals that the boiler operation produces $PM_{2.5}$ concentrations ranging from 2.0 to 8.4 $\mu g/m^3$ under the four modeled scenarios. The results are summarized in Tables 3 and 4, and the model output is appended to this report. The results are also shown graphically on $PM_{2.5}$ contour maps presented in four figures at the end of this section. All maximum predicted $PM_{2.5}$ concentrations are in compliance with the National Ambient Air Quality Standards (NAAQS) for all stack heights and emission rates.

The highest predicted concentration of 8.4 $\mu g/m^3$ was obtained using the 60 g/hr emission rate and 20-foot stack height. Both decreasing the emission rate and increasing the stack height reduces the expected ambient concentration. The lowest concentration was predicted under the assumed 27 g/hr emission rate and 35-foot stack height. The modeling results are presented without background levels or any assumption as to where the OWHH is located. However, since the OWHH are typically located in rural settings where abundant nearby wood is available and background levels are low, the introduction of 8.4 $\mu g/m^3$ or less from an OWHH would not adversely affect air quality and total $PM_{2.5}$ concentrations would remain well below the the $PM_{2.5}$ NAAQS of 35 $\mu g/m^3$.

TABLE 3

24-HOUR $PM_{2.5}$ AIR MODELING RESULTS FOR
CENTRAL BOILER MODEL 6048 WITH
PM EMISSIONS OF 60 G/HR
($\mu g/m^3$)

	Case 1	Case 2
Roof Height (ft) Stack Height (ft)	18 20	33 35
Assume All PM is $PM_{2.5}$		
5-Year Average of H8H	8.4	4.5
NAAQS	35.0	35.0

TABLE 4

24-HOUR $PM_{2.5}$ AIR MODELING RESULTS FOR
CENTRAL BOILER MODEL 6048 WITH
PM EMISSIONS OF 27 G/HR
($\mu g/m^3$)

	Case 3	Case 4
Roof Height (ft) Stack Height (ft)	18 20	33 35
Assume All PM is $PM_{2.5}$		
5-Year Average of H8H	3.8	2.0
NAAQS	35.0	35.0

OUTDOOR WOOD FURNACE BEST BURN PRACTICES

1. Read and follow all operating instructions supplied by the manufacturer.

2. FUEL USED: Only those listed fuels recommended by the manufacturer of your unit. Never use the following: trash, plastics, gasoline, rubber, naphtha, household garbage, material treated with petroleum products (particle board, railroad ties and pressure treated wood), leaves, paper products, and cardboard.

3. LOADING FUEL: For a more efficient burn, pay careful attention to loading times and amounts. Follow the manufacturer's written instructions for recommended loading times and amounts.

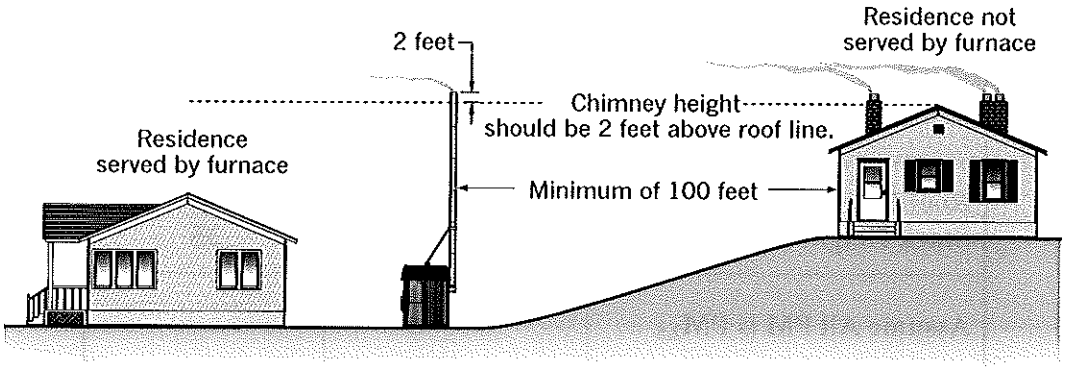
4. STARTERS: Do not use lighter fluids, gasoline, or chemicals.

5. LOCATION: It is recommended that the unit be located with due consideration to the prevailing wind direction.

   - Furnace should be located no less than 100 feet from any residence not served by the furnace.

   - If located within 100 feet to 300 feet to any residence not served by the furnace, it is recommended that the stack be at least 2 feet higher than the peak of that residence.

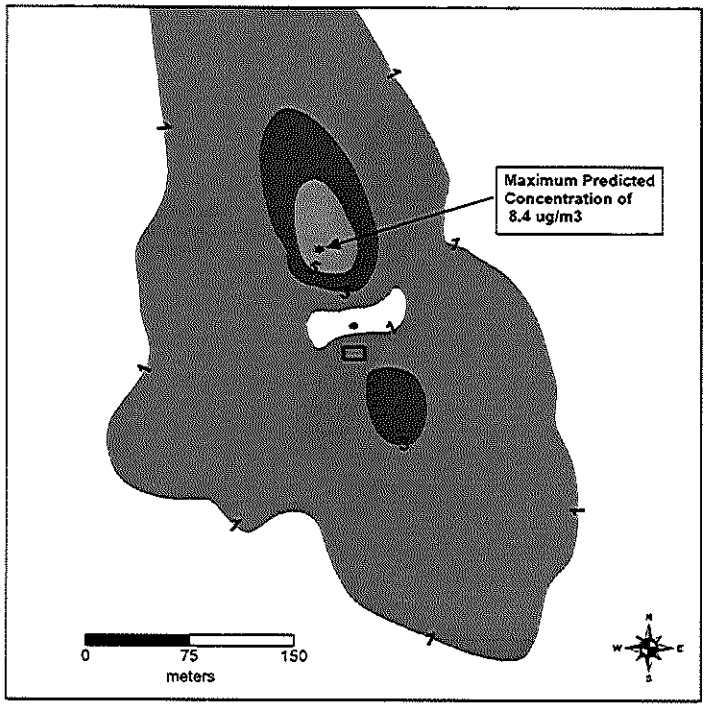
Chimney Height Installation Scenario



6. Always remember to comply with all applicable state and local codes.

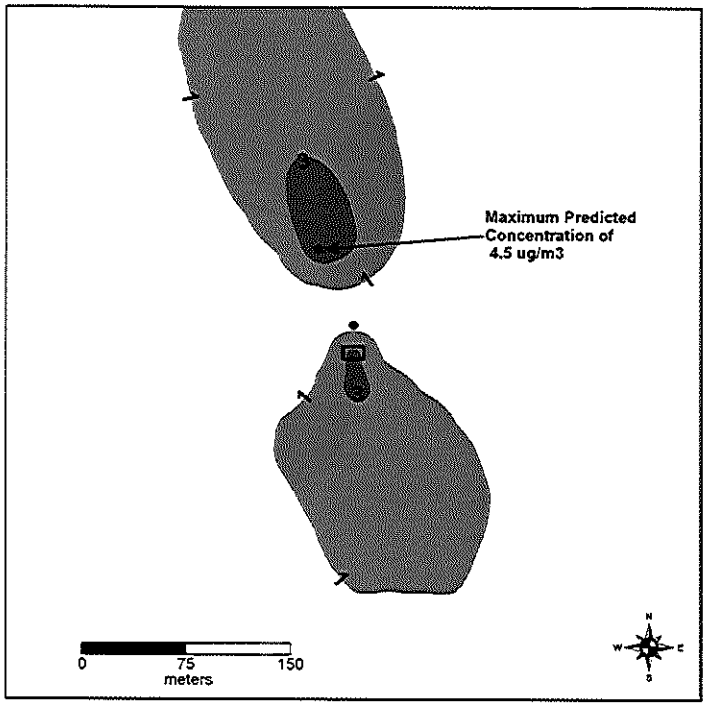
HPBA
Hearth, Patio & Barbecue Association

OUTDOOR FURNACE MANUFACTURERS CAUCUS



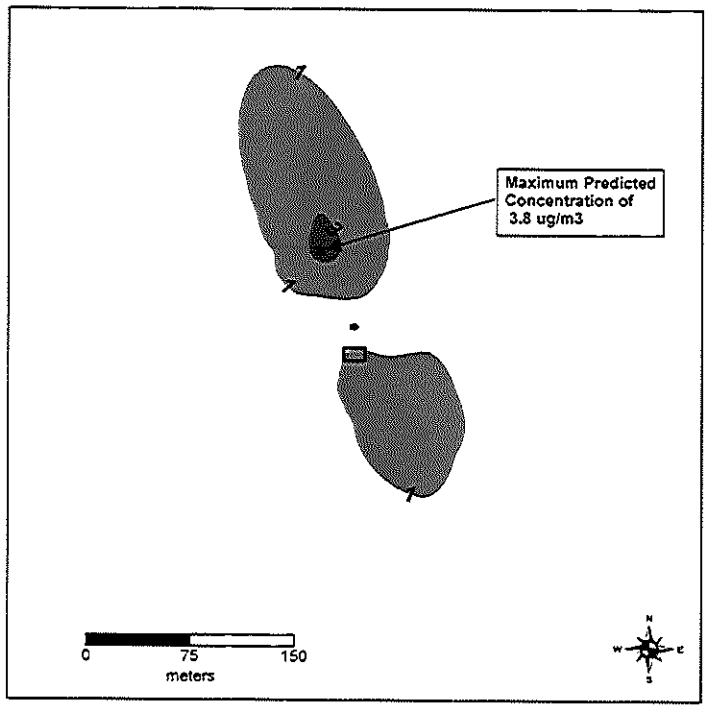
20-FOOT WOOD BOILER STACK (CASE 1)

Five-Year Average 24-Hour H8H Concentations for 60 grams/hour (ug/m3)



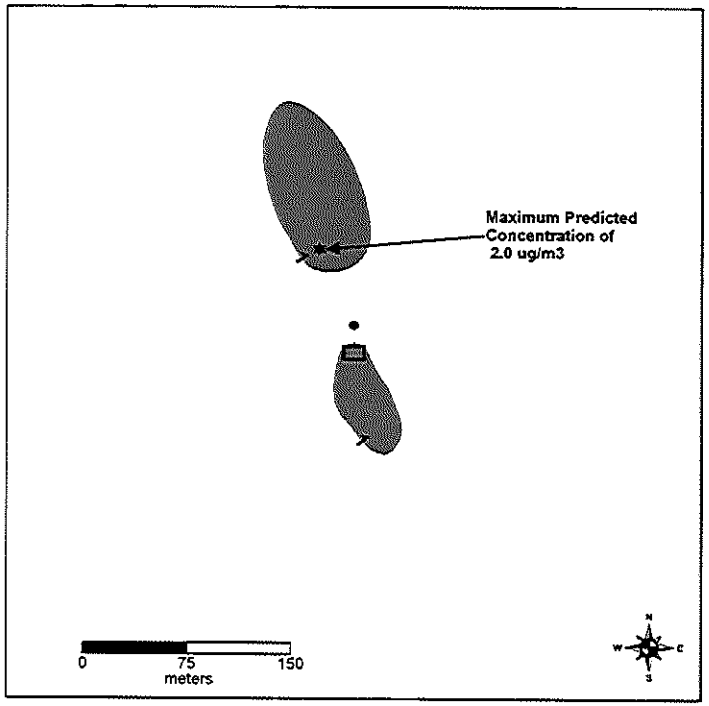
35-FOOT WOOD BOILER STACK (CASE 2)

Five-Year Average 24-Hour H8H Concentations for 60 grams/hour (ug/m3)



35-FOOT WOOD BOILER STACK (CASE 3)

Five-Year Average 24-Hour H8H Concentations for 27.1 grams/hour (ug/m3)



35-FOOT WOOD BOILER STACK (CASE 4)

Five-Year Average 24-Hour H8H Concentations for 27.1 grams/hour (ug/m3)

AIR QUALITY DISPERSION MODELING OF THE E-CLASSIC 2300 OUTDOOR WOOD HYDRONIC HEATER

June 2009

tech environmental
FOCUSED KNOWLEDGE. REAL SOLUTIONS.

AIR QUALITY DISPERSION MODELING OF THE E-CLASSIC 2300 OUTDOOR WOOD HYDRONIC HEATER

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TABLE OF CONTENTS

Section		Page
EXECUTIVE SUMMARY		1
1.0	INTRODUCTION	3
2.0	AIR QUALITY STANDARDS	5
3.0	AIR DISPERSION MODELING METHODOLOGY	7
4.0	MODELING RESULTS AND CONCLUSIONS	10

APPENDIX A – BEST BURN PRACTICES

APPENDIX B – AIR MODELING SUMMARY OUTPUTS

LIST OF TABLES AND FIGURES

List of Tables

Table	Description	Page
1	Central Boiler E- CLASSIC 2300 Model Modeling Scenarios	8
2	Stack Parameters and Emissions for Air Dispersion Modeling	9
3	24-Hour PM2.5 Air Modeling Results for Central Boiler E-Classic 2300 Model	11

List of Figures

Figure	Description	Page
1	Concept Rendering Showing a Typical Installation of an Outdoor Wood Hydronic Heater Installation	3
2	Maximum 24-Hour $PM_{2.5}$ Concentration vs. Stack Distance from House	12
3	Case 1A-10 – 20-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 10 Feet from House	13
4	Case 1A-20 – 20-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 20 Feet from House	14
5	Case 1A-30 – 20-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 30 Feet from House	15
6	Case 1A-40 – 20-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 40 Feet from House	16
7	Case 1A-50 – 20-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 50 Feet from House	17
8	Case 1B-10 – 20-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 10 Feet from House	18
9	Case 1B-20 – 20-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 20 Feet from House	19

10 Case 1B-30 – 20-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 30 Feet from House 20

11 Case 1B-40 – 20-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 40 Feet from House 21

12 Case 1B-50 – 20-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 50 Feet from House 22

13 Case 2A-10 – 35-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 10 Feet from House 23

14 Case 2A-20 – 35-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 20 Feet from House 24

15 Case 2A-30 – 35-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 30 Feet from House 25

16 Case 2A-40 – 35-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 40 Feet from House 26

17 Case 2A-50 – 35-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 50 Feet from House 27

18 Case 2B-10 – 35-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 10 Feet from House 28

19 Case 2B-20 – 35-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 20 Feet from House 29

20 Case 2B-30 – 35-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 30 Feet from House 30

21 Case 2B-40 – 35-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 40 Feet from House 31

22 Case 2B-50 – 35-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 50 Feet from House 32

EXECUTIVE SUMMARY

Air dispersion modeling was performed with the U.S. AERMOD model and following EPA guidance to determine the effect of a Central Boiler Outdoor Wood Hydronic Heater (OWHH) E-Classic Model 2300 on air quality. Air dispersion modeling assumed the OWHH was located at one of five distances (10, 20, 30, 40, or 50 feet) from either a one-story or a two-story house and had a stack height of two-feet above the roof peak, as recommended by Central Boiler's installation recommendations and Best Burn Practices for Phase 2 stick wood models (see Appendix A). Five years of hourly meteorological data for Burlington, Vermont were utilized in the modeling.

The principal air pollutant emitted by OWHHs is particulate matter (PM). The E-Classic 2300 was assumed to emit a maximum of 17.6 grams per hour (g/hr) of PM based on the highest individual test run result from the certification test for the U.S. Environmental Protection Agency (EPA) "List of Cleaner Hydronic Heaters, Phase 2 White Tag Models" table.[1] The EPA-certified annual average emissions level of 6.4 g/hr for the E-Classic 2300 was also modeled. As a conservative assumption in this study, all PM emissions were assumed to be $PM_{2.5}$.

The modeling results demonstrate that maximum predicted 24-hour $PM_{2.5}$ concentrations from operation of a Central Boiler E-Classic 2300 model are in the range of 0.5 to 2.9 $\mu g/m^3$, and therefore, are safely in compliance with the 24-hour National Ambient Air Quality Standards (NAAQS) for fine particulate matter ($PM_{2.5}$) of 35 $\mu g/m^3$. The NAAQS have been established by EPA to protect the most sensitive individuals[2] in the population from any adverse effects, with a margin of safety.

The highest predicted concentrations were obtained using the maximum 17.6 g/hr emission rate and a 20-foot stack height next to a one-story house. For this combination, the $PM_{2.5}$ level was 2.47 ug/m^3 for a stack-house distance of 50 feet, and rose slightly as the stack was moved closer to the house, to a maximum level of 2.86 ug/m^3 for a stack-house distance of 10 feet. Figure 2

[1] (http://www.epa.gov/woodheaters/models.htm) downloaded March 21, 2009.

[2] For Particulate Matter, these are people with asthma and respiratory disease.

illustrates how predicted $PM_{2.5}$ concentrations vary only slightly as the stack-house distance changes. Thus, no minimum stack-to-house distance is required so long as the stack height is two feet above the roof peak, per Central Boiler's installation recommendations and Best Burn Practices for Phase 2 wood stick models.

EPA has also established Significant Impact Levels (SIL) under the New Source Review (NSR)/Prevention of Significant Deterioration (PSD) Rule. The 24-hour SIL for particulate matter (PM) is 5 $\mu g/m^3$. Air concentrations below the SIL are considered "insignificant" by EPA and can be ignored, even in cases where existing air quality does not comply with the standard. For all of the cases analyzed, the maximum $PM_{2.5}$ concentrations, both on the homeowner's property and off-site, are below the SIL (i.e., are insignificant).

In conclusion, operation of a Central Boiler E-Classic 2300 OWHH with a stack height two feet above the roof peak does not adversely affect air quality or public health, either on the homeowner's property or off-site. For all 20 configurations of stack and building heights, the maximum $PM_{2.5}$ concentrations from the E-Classic 2300 fully comply with the NAAQS. In addition, all maximum predicted $PM_{2.5}$ concentrations are below the EPA PM SIL of 5 $\mu g/m^3$ and are therefore insignificant.

1.0 INTRODUCTION

Central Boiler, Inc. of Greenbush, Minnesota is the manufacturer of Outdoor Wood Hydronic Heaters (OWHH) E-Classic 2300 model. These are freestanding units that are located outside the structure being heated and consist of a firebox, water reservoir and ancillary mechanical equipment. The combustion of wood heats water that is pumped from the furnace to a heat exchanger located inside the structure. Combustion gasses are passed over or through heating tubes before being vented to the atmosphere through a metal stack. While similar in principle to other stick wood burning devices, these units are designed to provide continuous on-demand heat and very low stack emissions. The design allows the unit to be placed near the location of the wood supply. The thermal output for an E-Classic 2300 model is listed by EPA as 160,001 Btu/hr. Figure 1 shows a typical installation of a Central Boiler OWHH.

The purpose of this study is to evaluate the air pollutant concentrations resulting from Central Boiler E-Classic 2300 units when installed and operated according to manufacturer's instructions that are shipped with every new unit. The unit is typically installed within 50 feet of the residence served. A stack height 2 feet above the peak of the residence served is recommended. Both a one-story house (roof peak 18 feet and stack height 20 feet) and a two-story house (roof peak 33 feet, stack height 35 feet) were studied, along with five different distances for the OWHH from the side of the house (10, 20, 30, 40 and 50 feet). The modeling analysis was performed using the EPA AERMOD model for PM emission rates of 17.6 (maximum) and 6.4 (annual average) grams per hour (g/hr). These emissions rates were obtained from the certification test results given in the EPA "List of Cleaner Hydronic Heaters, Phase 2 White Tag Models" table for the Central Boiler E-Classic 2300 unit.

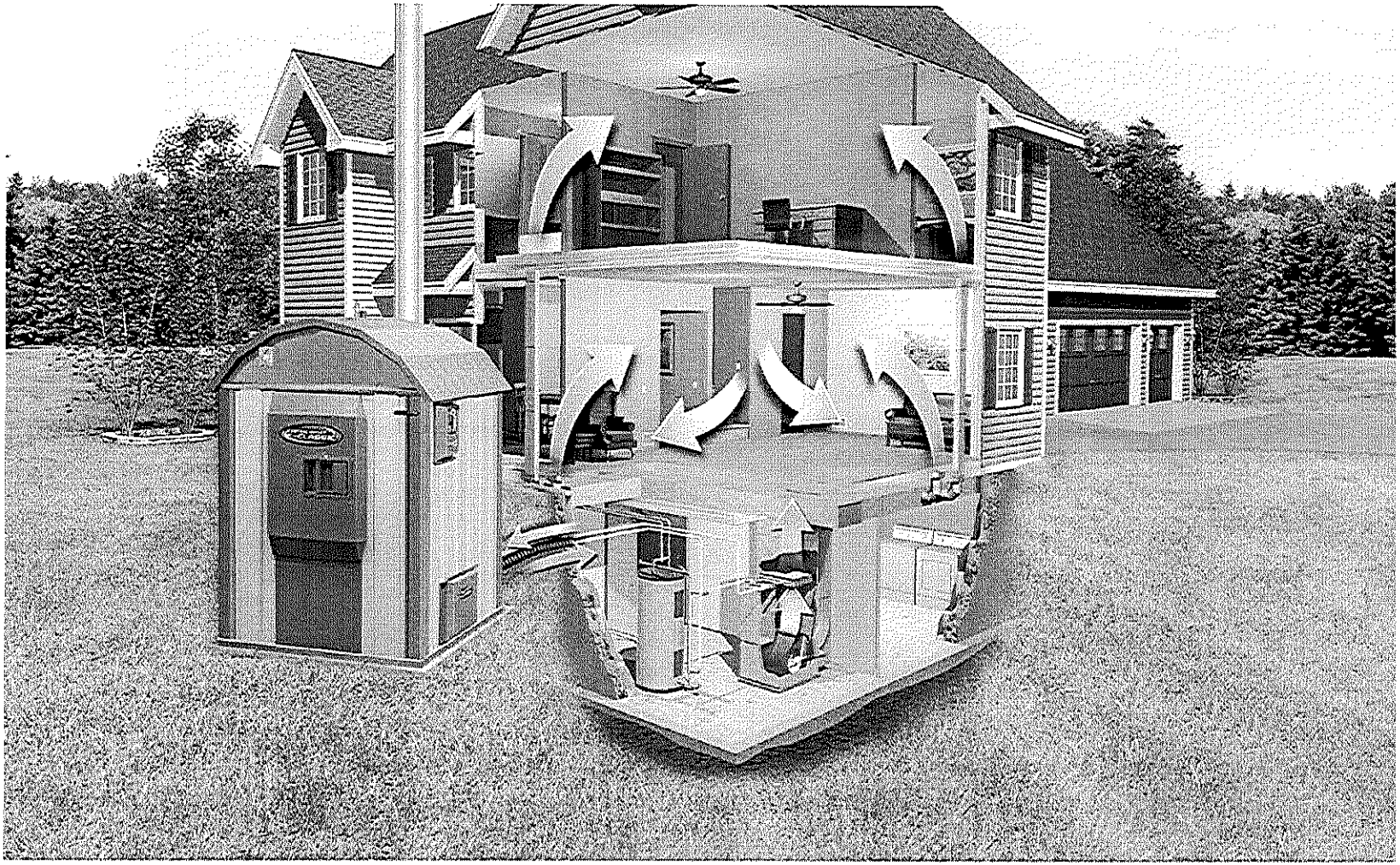


Figure 1: Concept Rendering Showing a Typical Installation of an Outdoor Wood Hydronic Heater Installation

2.0 AIR QUALITY STANDARDS

The principal air pollutant emitted by OWHHs is particulate matter (PM). EPA has established National Ambient Air Quality Standards (NAAQS) for both coarse (PM_{10}) and fine ($PM_{2.5}$) particulate matter. The PM_{10} standard applies to particles with a mass-mean diameter of 10 microns or less, while the $PM_{2.5}$ standard is keyed to particles 2.5 microns in diameter or less. While both long-term (annual) and short-term (24-hour) standards have been established, the 24-hour standards are the controlling set because of their more stringent limits. Also, the $PM_{2.5}$ standard is more stringent than the PM_{10} standard. Thus, only the 24-hour $PM_{2.5}$ levels are examined in this study.

The 24-hour $PM_{2.5}$ standard is 35 $\mu g/m^3$, measured as a 3-year average of 98^{th}-percentile concentrations. In a one-year period, the 8th-highest 24-hour value represents the 98^{th}-percentile concentration. For compliance purposes, the $PM_{2.5}$ design concentration is the 3-year average of the highest, 8^{th}-highest (H8H) values in each year at any receptor location. EPA has also established Significant Impact Levels (SILs) under the New Source Review (NSR)/Prevention of Significant Deterioration (PSD) Rule. Air concentrations below the SIL are considered "insignificant" by EPA and can be ignored, even in cases where existing air quality does not comply with the standard. Currently, EPA is working towards establishing a 24-hour SIL for $PM_{2.5}$. Until EPA does adopt a 24-hour SIL for $PM_{2.5}$, their policy is to use the existing 24-hour PM_{10} SIL of 5 $\mu g/m^3$ (PM SIL) as a surrogate for $PM_{2.5}$. Some Northeast states are working towards establishing their own $PM_{2.5}$ SILs, which may be lower. For the purposes of this modeling analysis, the EPA 5-$\mu g/m^3$ threshold was used.

The EPA added special processing for $PM_{2.5}$ in the latest versions of AERMOD (versions 06341 and 07026) to predict the design concentrations for each receptor. AERMOD now calculates the N-year average H8H 24-hour average $PM_{2.5}$ concentration at each receptor over the N years of meteorological data provided. EPA considers the five-year average of the H8H 24-hour $PM_{2.5}$ values at each receptor to be unbiased estimates of the 3-year average H8H values, since EPA guidance requires the use of five years of meteorological data when the data are from an off-site

National Weather Service meteorological station.[3] Thus, the five-year average H8H values from the AERMOD model are the design values used to establish compliance with the NAAQS and SIL.

[3] US EPA, "Addendum User's Guide for the AMS/EPA Regulatory Model – AERMOD (EPA-454/B-03-001, September 2004)", pp. 5 – 7, December 2006.

3.0 AIR DISPERSION MODELING METHODOLOGY

Particulate matter from a fuel combustion process contains a wide distribution of particle sizes. For wood combustion, these range from relatively larger carbon particles (soot) down to sub-micron organic compound aerosols. Research studies of OWHH emissions have used sampling methods that capture the full size distribution of PM, solid particles and condensible organics. EPA particle size distribution data for wood boilers reveal that typically 90% of the total PM mass has a diameter of 10 microns or less, and 76% has a diameter of 2.5 microns or less.[4] As a conservative assumption in this study, all PM emissions were assumed to be $PM_{2.5}$.

Air dispersion modeling assumed the OWHH was located near a one-story (Case 1) or two-story (Case 2) house having a 30-foot by 50-foot footprint. The OWHH building had dimensions of approximately 5.0 feet by 5.3 feet and stood 7.3 feet high (a Central Boiler Model E-Classic 2300). Both the maximum emission rate (Case A) and annual average emission rate (Case B) were examined, for five different stack distances from the house (10, 20, 30, 40 or 50 feet). The EPA AERMOD dispersion model calculated the aerodynamic downwash effects of the house near the OWHH stack.. Twenty modeling cases were examined as described in Table 1.

The stack gas exit temperature and exit velocity used in this analysis represent typical values measured in Central Boiler's emissions test laboratory in Greenbush, Minnesota for the OWHHs. All stack and emission values used in this study are summarized in Table 2.

[4] EPA publication AP-42, Section 1.6.

TABLE 1

CENTRAL BOILER E- CLASSIC 2300 MODEL
MODELING SCENARIOS

Case No.	No. of Stories on House	Roof Peak (ft)	Stack Height (ft)	PM Emissions (grams/hr)	Stack Distance from House (ft)
1A-10	1	18	20	17.6	10
1A-20	1	18	20	17.6	20
1A-30	1	18	20	17.6	30
1A-40	1	18	20	17.6	40
1A-50	1	18	20	17.6	50
1B-10	1	18	20	6.4	10
1B-20	1	18	20	6.4	20
1B-30	1	18	20	6.4	30
1B-40	1	18	20	6.4	40
1B-50	1	18	20	6.4	50
2A-10	2	33	35	17.6	10
2A-20	2	33	35	17.6	20
2A-30	2	33	35	17.6	30
2A-40	2	33	35	17.6	40
2A-50	2	33	35	17.6	50
2B-10	2	33	35	6.4	10
2B-20	2	33	35	6.4	20
2B-30	2	33	35	6.4	30
2B-40	2	33	35	6.4	40
2B-50	2	33	35	6.4	50

TABLE 2

STACK PARAMETERS AND EMISSIONS FOR
AIR DISPERSION MODELING

Parameter	English Units	Metric Units
Stack Height Case 1 Case 2	 20 feet 35 feet	 6.1 meters 10.7 meters
Stack Exit Diameter	8 inches	0.2 m
Stack Exit Velocity	7.2 feet/sec.	2.2 m/s
Stack Exit Temperature	350° F	449.9° K
$PM_{2.5}$ Emission Rate E-Classic 2300 Model EPA Phase 1 Limit E-Classic 2300 Model Highest Test Run	 0.014 lb/hr 0.039 lb/hr	 6.4 g/hr 17.6 g/hr

4.0 MODELING RESULTS AND CONCLUSIONS

The air dispersion modeling reveals that OWHH operation produces $PM_{2.5}$ concentrations ranging from 0.48 to 2.86 $\mu g/m^3$ under the 20 modeled scenarios. The results are summarized in Table 3, and the model output is presented in Appendix B of this report. The results are also shown graphically on $PM_{2.5}$ contour maps presented in Figures 3 through 22. All maximum predicted $PM_{2.5}$ concentrations are in compliance with the NAAQS and all are below the SIL.

The highest predicted concentration of 2.86 $\mu g/m^3$ was obtained using the 17.6 g/hr emission rate and a 20-foot stack height, 10 feet from a one-story house (Case No. 1A-10). As shown in Figure 2, for each additional 10 feet the stack was moved from the one-story house, the predicted maximum concentration changed only slightly. Thus, no minimum stack-to-house distance is required so long as the stack height is two feet above the roof peak.

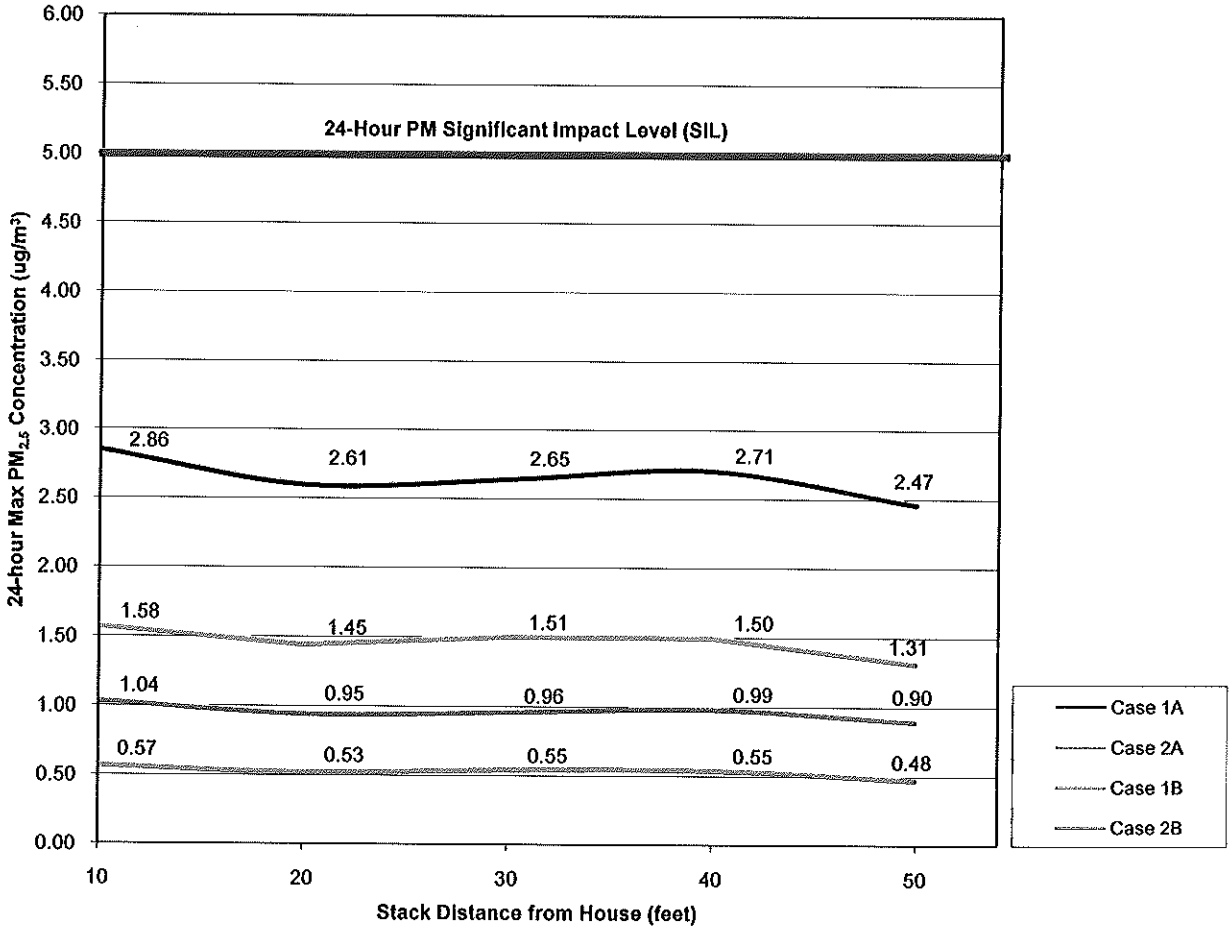
The results reveal that increasing the stack height and increasing the stack distance from the residence served both reduce the expected $PM_{2.5}$ concentration. The lowest concentration was predicted assuming the 6.4 g/hr annual average emission rate and a 35-foot stack height, 50 feet from a two-story house. The modeling results are presented without background levels. The introduction of 2.86 $\mu g/m^3$ or less from an OWHH (an amount classified as insignificant) would not adversely affect air quality, and total $PM_{2.5}$ concentrations would remain safely in compliance with the $PM_{2.5}$ NAAQS of 35 $\mu g/m^3$.

TABLE 3

24-HOUR $PM_{2.5}$ AIR MODELING RESULTS FOR
CENTRAL BOILER E- CLASSIC 2300 MODEL
($\mu g/m^3$)

Case No.	No. of Stories on House	Roof Peak (ft)	Stack Height (ft)	PM Emissions (grams/hr)	5-Year Average of H8H	24-hr NAAQS	24-hr PM SIL
1A-10	1	18	20	17.6	2.86	35	5
1A-20	1	18	20	17.6	2.61	35	5
1A-30	1	18	20	17.6	2.65	35	5
1A-40	1	18	20	17.6	2.71	35	5
1A-50	1	18	20	17.6	2.47	35	5
1B-10	1	18	20	6.4	1.04	35	5
1B-20	1	18	20	6.4	0.95	35	5
1B-30	1	18	20	6.4	0.96	35	5
1B-40	1	18	20	6.4	0.99	35	5
1B-50	1	18	20	6.4	0.90	35	5
2A-10	2	33	35	17.6	1.58	35	5
2A-20	2	33	35	17.6	1.45	35	5
2A-30	2	33	35	17.6	1.51	35	5
2A-40	2	33	35	17.6	1.50	35	5
2A-50	2	33	35	17.6	1.31	35	5
2B-10	2	33	35	6.4	0.57	35	5
2B-20	2	33	35	6.4	0.53	35	5
2B-30	2	33	35	6.4	0.55	35	5
2B-40	2	33	35	6.4	0.55	35	5
2B-50	2	33	35	6.4	0.48	35	5

Figure 2
Maximum 24-Hour $PM_{2.5}$ Concentration vs. Stack Distance from House



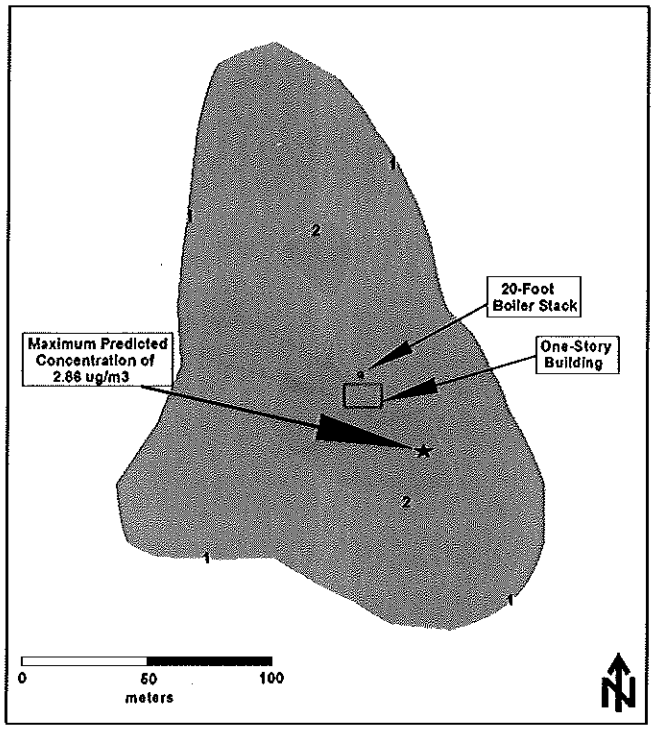


Figure 3
Case 1A-10 - 20-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 10 Feet from House

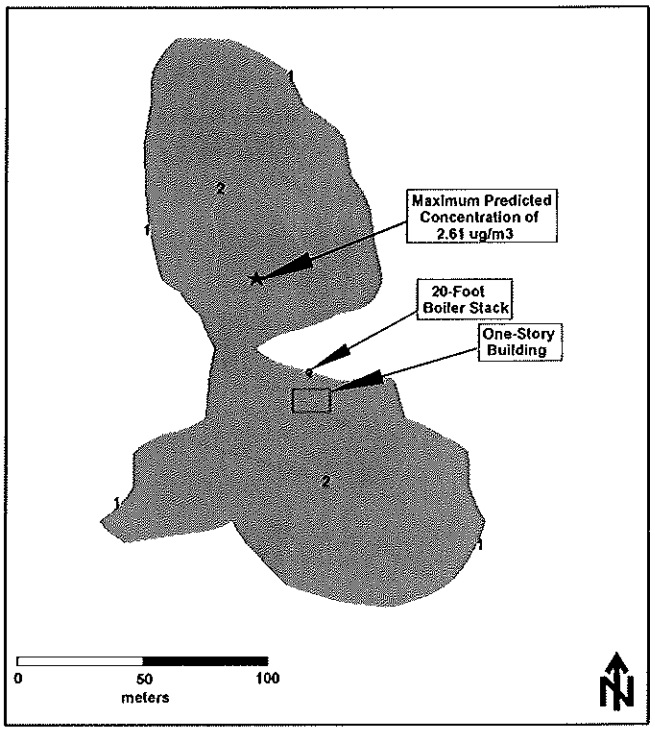


Figure 4
Case 1A-20 - 20-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 20 Feet from House

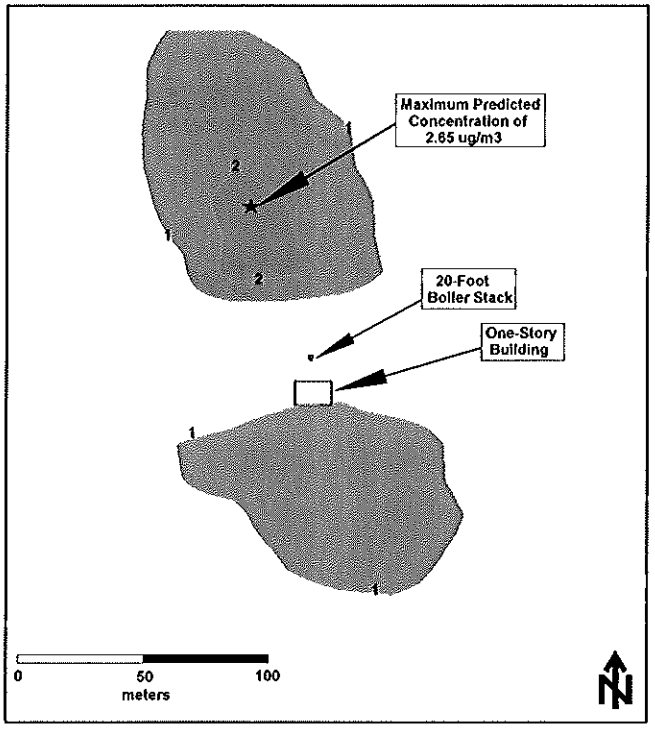


Figure 5
Case 1A-30 - 20-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 30 Feet from House

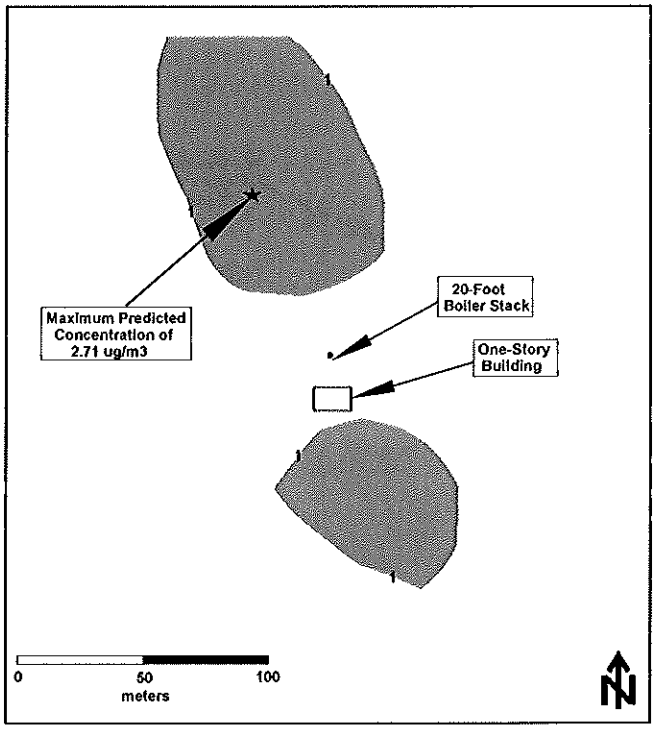


Figure 6
Case 1A-40 - 20-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 40 Feet from House

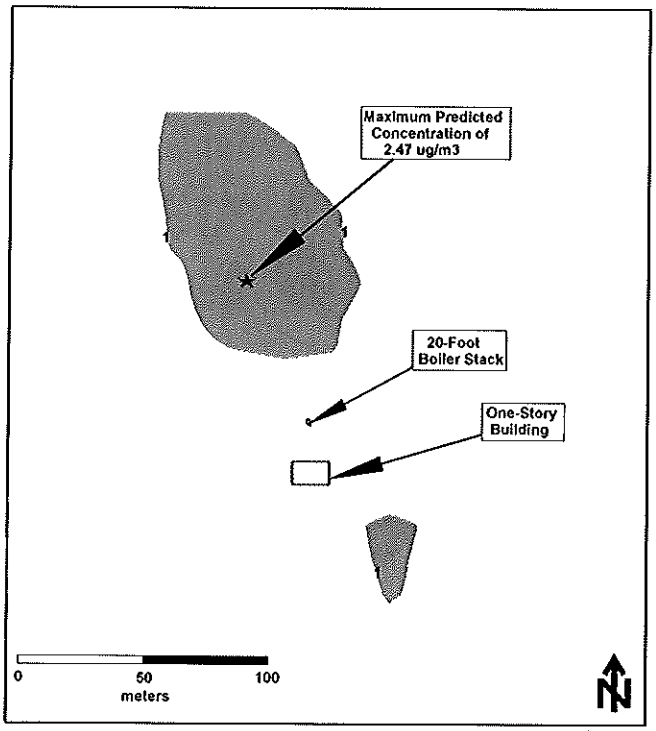


Figure 7
Case 1A-50 - 20-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 50 Feet from House

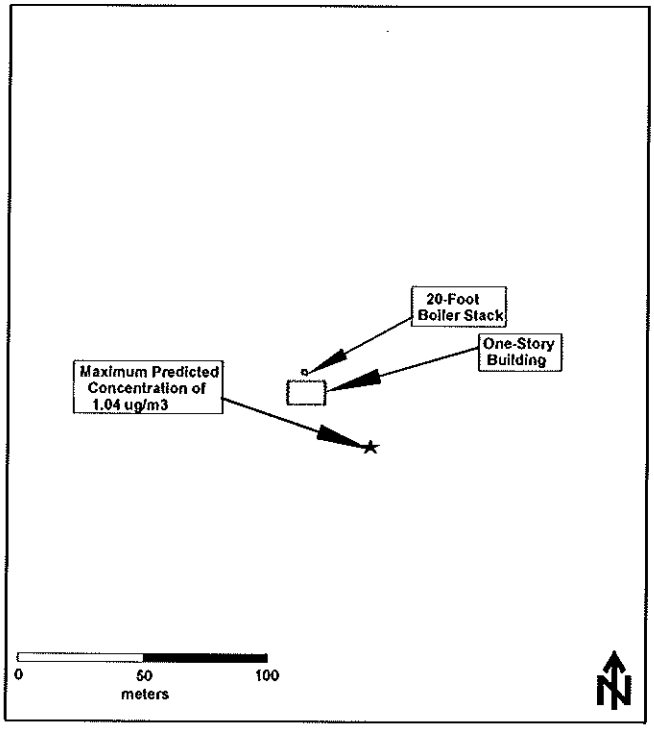


Figure 8
Case 1B-10 - 20-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 10 Feet from House

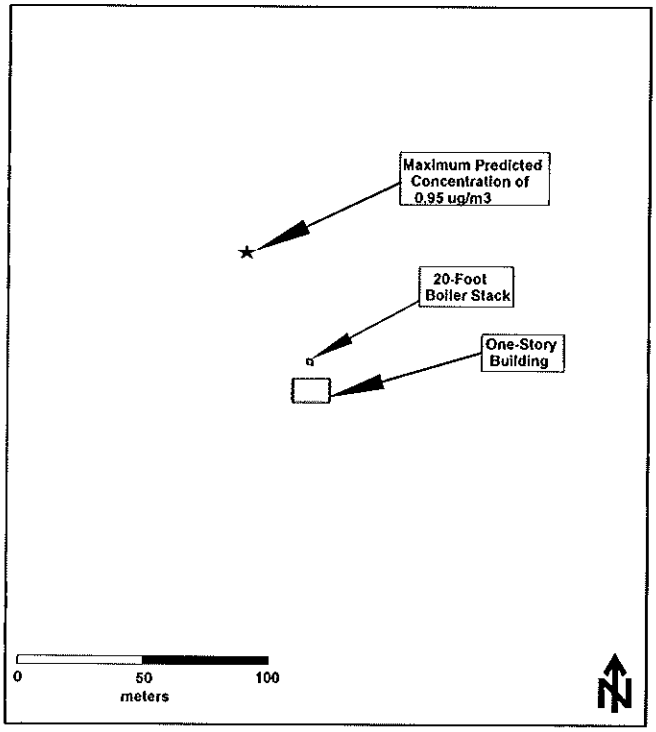


Figure 9
Case 1B-20 - 20-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 20 Feet from House

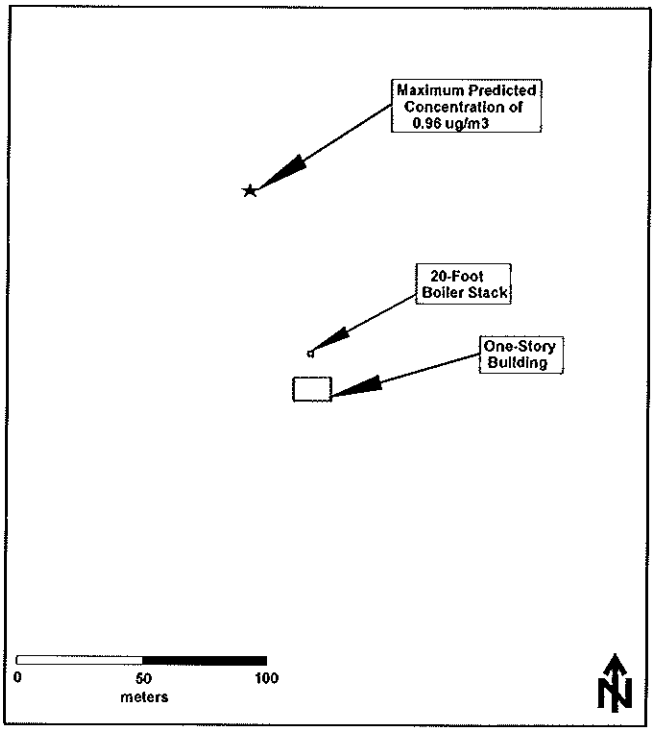


Figure 10
Case 1B-30 - 20-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 30 Feet from House

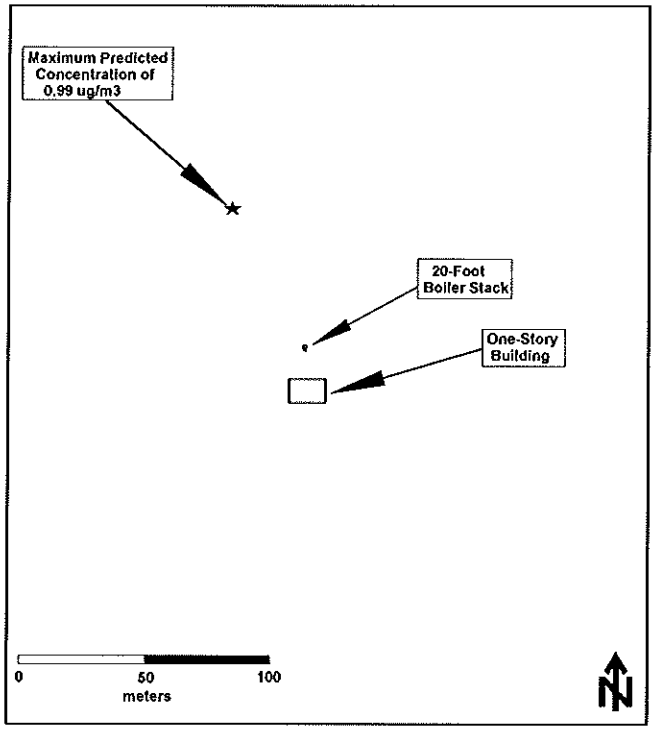


Figure 11
Case 1B-40 - 20-Foot Wood Boiler Stack
with Emission Rate of 6.4 g/hour and 40
Feet from House

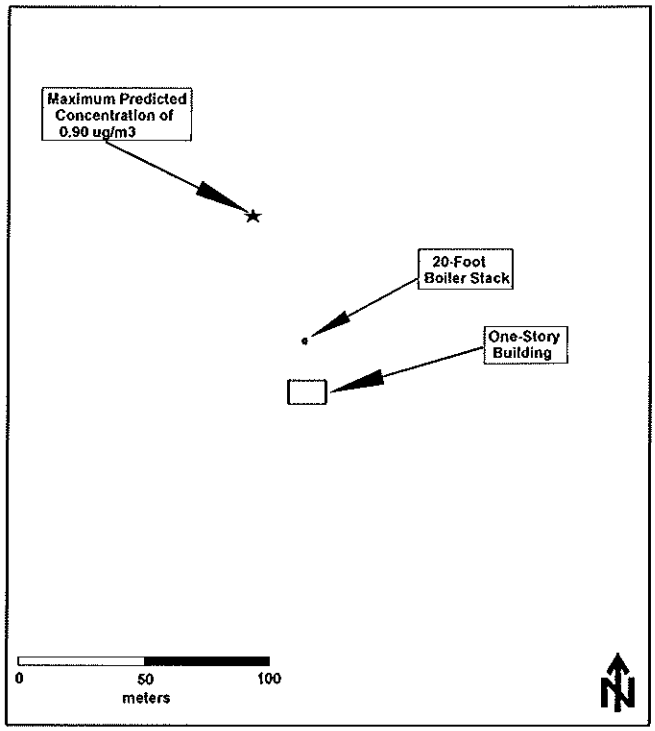


Figure 12
Case 1B-50 - 20-Foot Wood Boiler Stack
with Emission Rate of 6.4 g/hour and 40
Feet from House

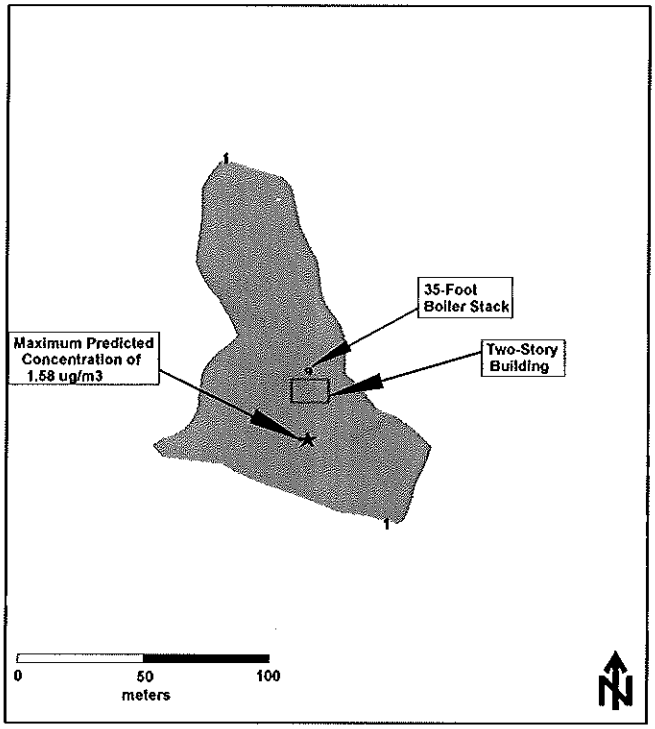


Figure 13
Case 2A-10 - 35-Foot Wood Boiler Stack
with Emission Rate of 17.6 g/hour and 10
Feet from House

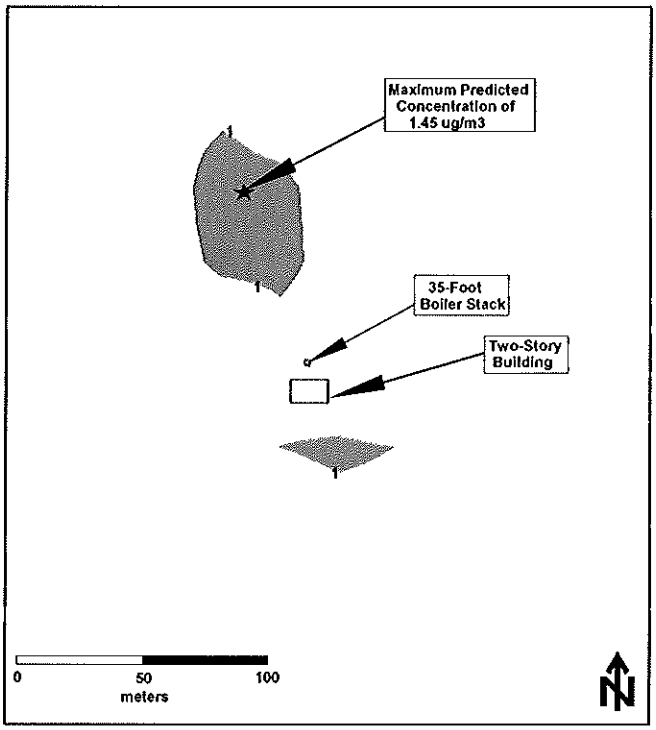


Figure 14
Case 2A-20 - 35-Foot Wood Boiler Stack
with Emission Rate of 17.6 g/hour and 20
Feet from House

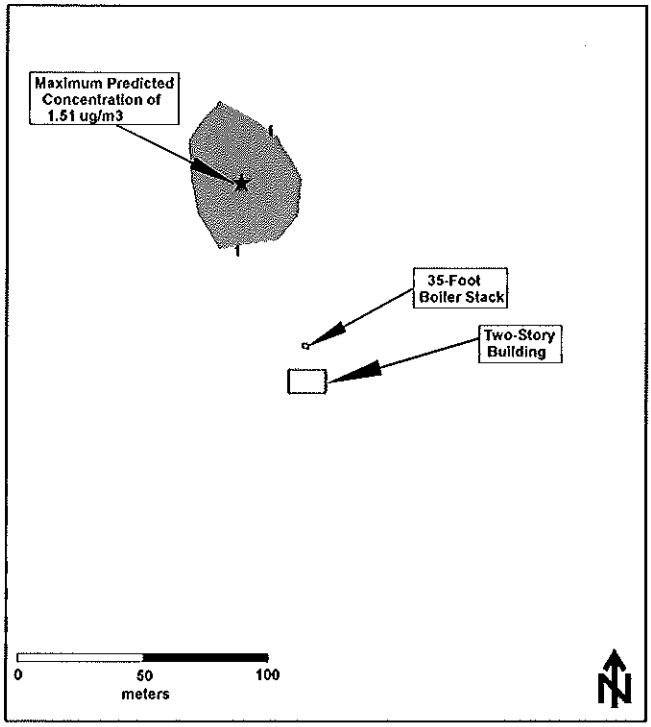


Figure 15
Case 2A-30 - 35-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 30 Feet from House

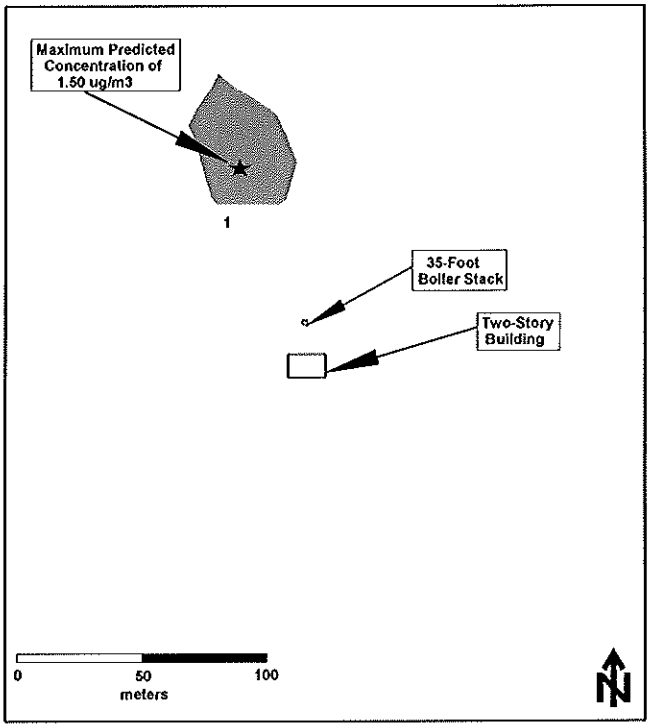


Figure 16
Case 2A-40 - 35-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 40 Feet from House

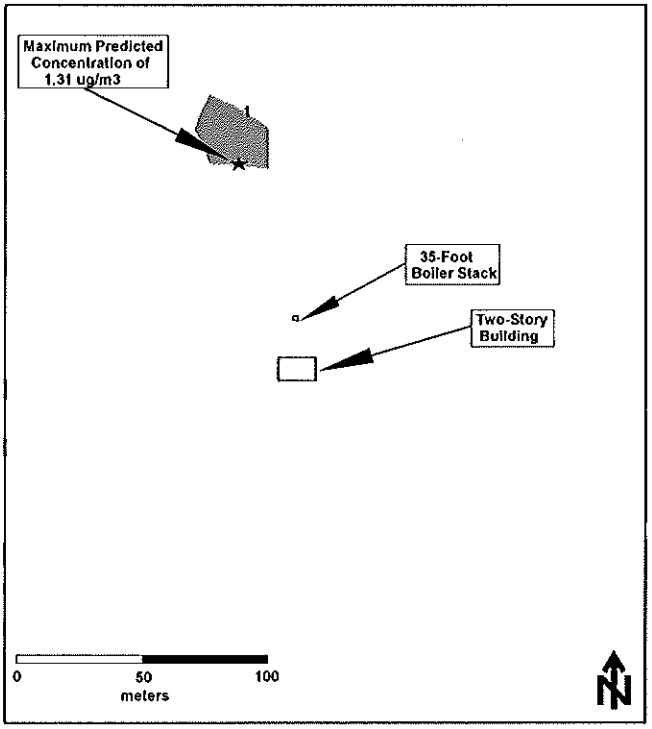


Figure 17
Case 2A-50 - 35-Foot Wood Boiler Stack with Emission Rate of 17.6 g/hour and 50 Feet from House

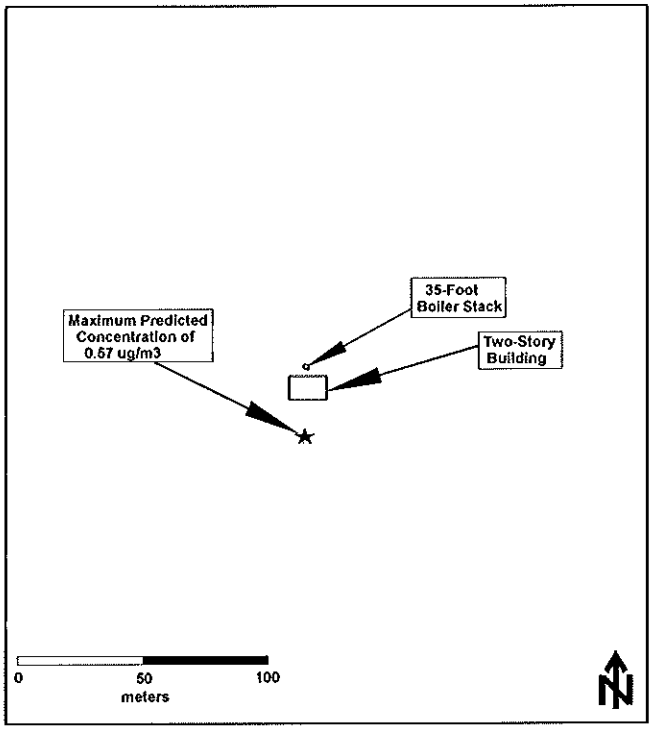


Figure 18
Case 2B-10 - 35-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 10 Feet from House

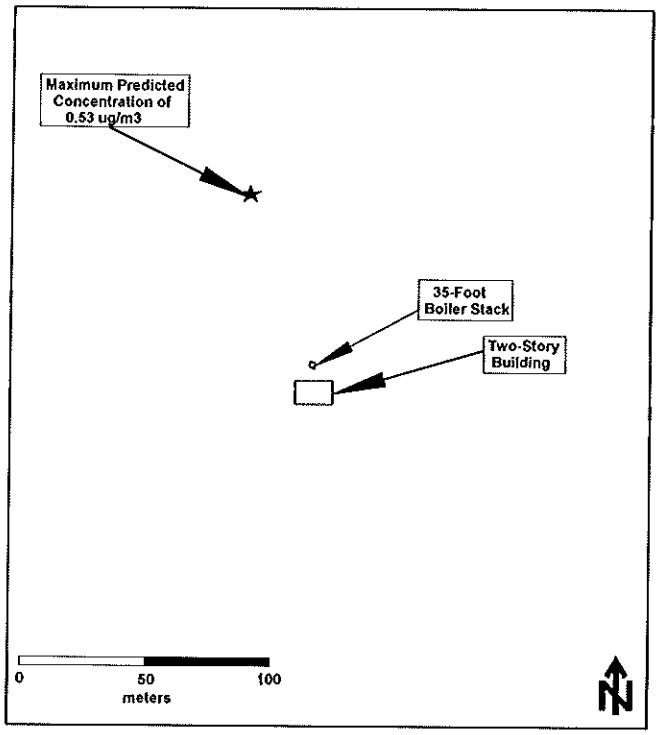


Figure 19
Case 2B-20 - 35-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 20 Feet from House

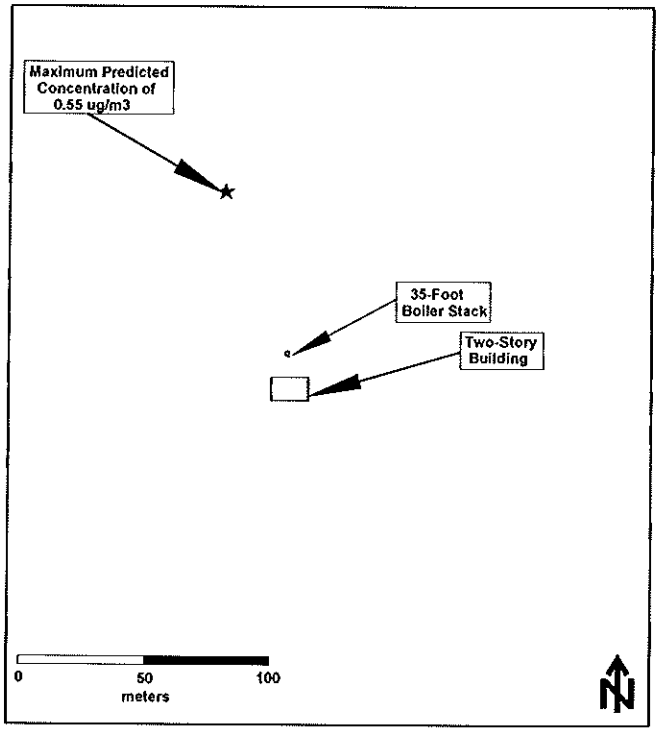


Figure 20
Case 2B-30 - 35-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 30 Feet from House

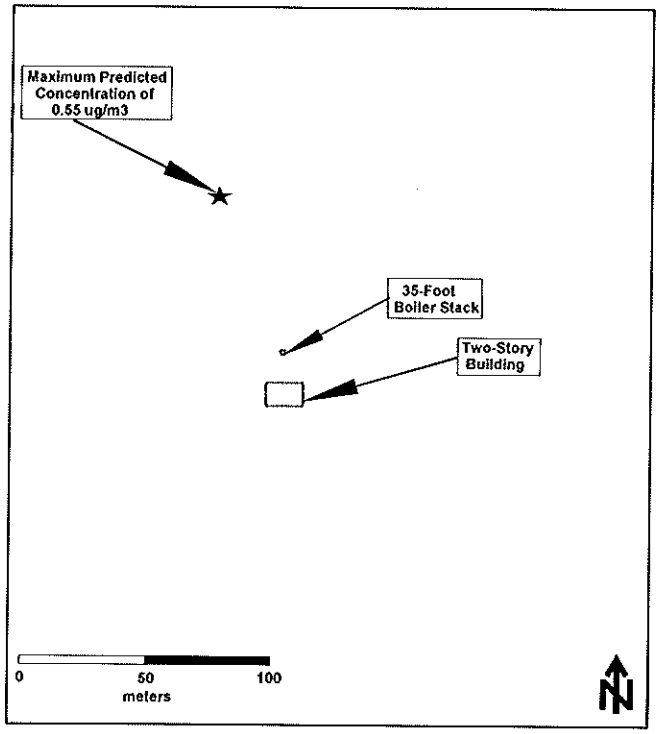


Figure 21
Case 2B-40 - 35-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 40 Feet from House

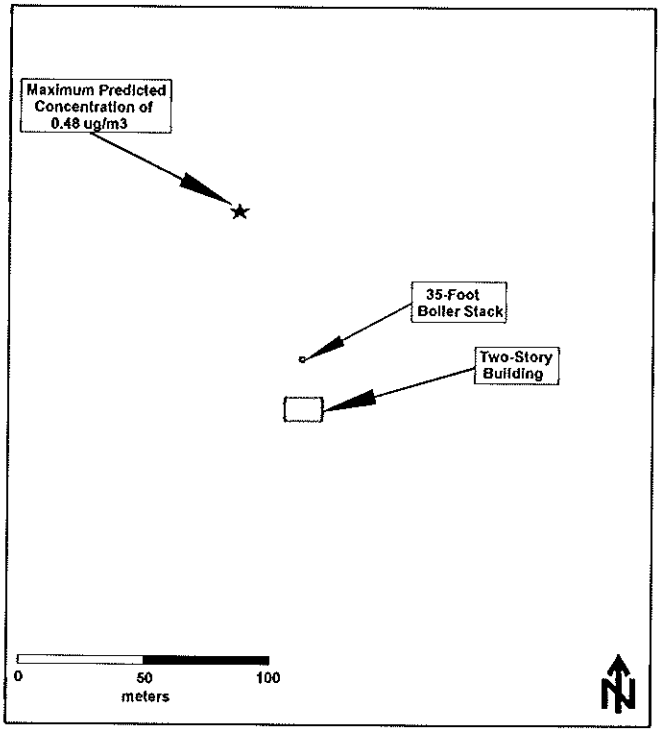


Figure 22
Case 2B-50 - 35-Foot Wood Boiler Stack with Emission Rate of 6.4 g/hour and 50 Feet from House

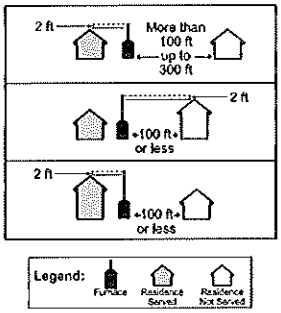
APPENDIX A

BEST BURN PRACTICES

OUTDOOR WOOD FURNACE
BEST BURN PRACTICES EPA HH PHASE 2
(0.32 LBS/MM BTU OUTPUT)

1. Read and follow all operating instructions supplied by the manufacturer.
2. FUEL USED: Only those listed fuels recommended by the manufacturer of your unit. Never use the following: trash, plastics, gasoline, rubber, naphtha, household garbage, material treated with petroleum products (particle board, railroad ties and pressure treated wood), leaves, paper products, and cardboard.
3. LOADING FUEL: For a more efficient burn, pay careful attention to loading times and amounts. Follow the manufacturer's written instructions for recommended loading times and amounts.
4. STARTERS: Do not use lighter fluids, gasoline, or chemicals.
5. LOCATION: It is recommended that the unit be located with due consideration to the prevailing wind direction.
   - If located within 300 feet to any residence not served by the furnace, it is recommended that the chimney be at least 2 feet higher than the peak of the residence served.
   - If located within 100 feet to any residence not served by the furnace, the chimney must be 2 feet higher than the peak of the residence served or not served, whichever is higher.

Chimney Height Installation Scenario



6. Always remember to comply with all applicable state and local codes.

Be considerate of neighbors when operating your furnace. If you use your furnace in the summer months, be certain your chimney exhaust is not adversely affecting neighbors with open windows.