Dispersion Modeling Assessment of Impacts of Outdoor Wood Boiler Emissions in Support of NESCAUM's Model Rule

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I. Introduction and Background.

The increasing use of outdoor wood boilers (OWBs)[a] in recent years has led to a corresponding increase in concern over the health effects of the emissions associated with these units, in addition to the fuel combustion characteristics due to proximity of these units to both the users and their neighbors. This has, in turn, led many states to consider new regulations or guidelines for these devices. One of these efforts has been undertaken by the northeast states through NESCAUM, which is preparing a model rule to assist states for use when considering emission limits and stack height and/or unit setback requirements and to create consistency among state regulations.

In order to support some of the concepts in the model rule, NESCAUM requested an air quality modeling exercise to assess the impacts of these units in a variety of situations and configurations. These simulations are meant to be representative of OWB installations currently in use, many of which do not seem to match purported "proper" locations for OWBs, as well as, in possible future configurations and emissions scenarios. The pollution metric for which the impacts were estimated is the 24-hour PM concentration, which was deemed to be the controlling threshold for the pollutants of interest from these units, as well as the averaging time of concern versus the effect of annual operations. As a threshold for comparison of the impacts, the revised National Ambient Air Quality Standard (NAAQS) for the 24 hour $PM_{2.5}$ level of 35 $\mu g/m^3$ is used.[b] However, the results allow for comparison to the 24 hour NAAQS for PM_{10} as well.

II. Modeling Assumptions and Approach.

The modeling was performed using the EPA's AERMOD model[c] which was recently promulgated as the recommended approach for a variety of source specific assessments. It incorporates the latest state-of-the-science in atmospheric transport and dispersion concepts, including a revised approach to building downwash effects. In order to assess the implications of possible wide range of conditions, a set of combinations of stack parameters, device proximity to buildings, meteorological data sites, and the influence of receptor height were tested. The results of these combinations were then scales with four emissions scenarios representing existing and proposed emission rates. The various model input parameters required for the modeling are outlined in the following sections.

1. Stack and Emissions Data: The OWBs in use currently are represented in the model as a building 4 feet by 6 feet, and 6.7 feet high ("weighted" height of the pitched roof). The stack is 10ft high along the shorter side of the unit and has a diameter of 6 inches. In addition to this stack height, another height at 18ft was tested to account for potential

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[a] Also known as outdoor wood furnaces, waterstoves or outdoor hydronic heaters,

[b] Some of the figures presented also highlight impacts at the 30 $\mu g/m^3$, which is the level supported by CASAC and the NESCAUM states.

[c] EPA's *Guideline on Air Quality Models*, Appendix W of 40 CFR Part 51

extensions of the stack to mitigate the unit's downwash effects on the plume. Other stack parameters were derived from actual data that NESCAUM obtained during stack testing. It was found that the units generally spend about 25% of the time in burn mode with the dampers open, and 75% of the time in standby mode, with the dampers closed. The stack testing measured a stack velocity of 1.98 m/s in burn mode and 0.74 m/s in standby mode. The corresponding stack temperatures were measured at 491°F in burn mode and 228°F in standby mode. These values were then weighted averaged for use in the modeling as 1.05 m/s velocity and 294°F stack temperature. All model runs were performed using a unitized emission rate of 1 g/s, and the model outputs were then scaled to four emission rates provided by NESCAUM representing the existing conditions and potential future limits. The rate for existing units was set to 161 g/hr. The stack parameter and emission rate data used in the modeling are based upon the only known field test of an in-use unit operations which was witnessed by state staff as of the writing of this report. The Phase I rates were set based on an emission rate of 0.44 lb/mmBtu heat input. This number was converted to a grams per hour number for residential units with a rated heat output of less than 350,000 Btu/hr. This number set a range of emissions from 16 g/hr to 70 g/hr with an average emission rate of 43 g/hr. For this report, emissions were modeled at the average emission rate of 43 g/hr and the maximum emission rate of 70 g/hr. The potential Phase II emission rate was set at 15 g/hr since the model rule establishes an emission limit of 0.32 lb/mmBtu heat output with no individual test run to exceed 15 grams per hour.

2. Building Downwash Parameters: One of the significant effects considered in the modeling for these units is the downwash experienced by the plume from the relatively short stack due to the flow disturbance imposed by the unit itself. In order to test the effects of raising the stack to a height which minimizes these effects, that is to Good Engineering Practice (GEP) height, another stack height of 18ft was also modeled. Rarely, however, are these units in a "stand alone" mode. The more commonplace use of these units in practice is wherein an adjacent house or another structure exists. Thus, typically these structures would impose additional downwash effects and were approximated in additional modeling as a house (6m height and 15 by 20m) or a 40ft height barn (13m high and 25 by 30m) located about 20ft from the units. This determination was based on information obtained by agency staff on unit installations. To test the effects of the distance from these structures and their orientation, a limited number of additional model runs were performed as described below. It should be noted that general GEP guidance suggest that in order to minimize structure influence on the unit's plume, these units have to be at a distance of at least 5 times the height of the nearby structures, or about 100 and 200ft away from the house and barn, respectively.

3. Receptor Locations and Heights: Due to the short stack and the high potential for building downwash, which would quickly bring the plume towards ground level, the likely impact areas were deemed to be very close to the unit. Thus, a dense receptor grid next to the unit was generated for the modeling. A polar receptor grid was chosen with receptors located at each 10-degree increment of angle. Within 100 meters of the source, receptors were spaced 10 meters apart along each radial, beginning 10 meters from the

source. Beyond 100 meters, the receptors were spaced 50 meters apart, extending out to 500 meters from the source. The initial modeling results indicated that impacts maximized close in and gradients dropped off beyond 100 meters of the source, confirming that the sparser receptor grid beyond 100 meters was justified. All receptors were assumed to be at flat terrain in most of the model runs. Given the low level plume heights and the significance of building downwash effects in determining maximum impacts, it was determined that terrain effects are not likely to be a major factor in defining the controlling concentrations for these single source simulations. Terrain effects on individual sources are most significant for elevated sources when plume impaction on terrain features is likely. Another scenario under which terrain effects could be important is the case of a well-defined valley flow with sheltering which results in periods of stagnation characterized by low wind speeds and stable conditions, resulting in accumulation of emissions. The latter scenario cannot be properly simulated by the steady state AERMOD model and any potential future simulations would have to address this issue with a proper model. However, since the purpose of the current study is to provide reasonable estimates of impacts from individual OWB under various scenarios, limited model runs with terrain heights close to plume height were tested to determine the effects on the maximum impacts for select scenarios.

4. Meteorological Data: In order for the results to have general applicability, it is necessary to test the results with multiple meteorological data sites of varying conditions. Practical limitations and time constraints, however, dictated the use of three data bases readily available in the AERMOD input format previously processed for applications in New York. Five years of data are available at these sites, but the initial modeling runs were performed with only 1 year from each site: 2002 from Jamestown, 2000 from Erie, PA and 1992 from Syracuse. Fortunately, these data are deemed to represent a range of wind patterns and conditions, as depicted in the attached figures of wind roses for the data. It is noted that there is good representation of low wind speeds conditions, which could potentially be associated with worst case impacts. It was also presumed that the downwash effects will likely dominate the worst case impacts for the 24 hour averages and the specific data base might not be as critical as in other applications. The initial modeling results generally confirmed this presumption, but additional four years of meteorological data from Syracuse, which corresponded to the maximum impact from all scenarios, were also used for assessing the year to year variability of the maxima for some of the scenarios.

   Using these input parameters, a number of model runs were made for a combination of the variables. Specifically, both stack heights were initially modeled in the stand alone and next to the house and barn situations with one year of meteorological data from two of the three meteorological data sites to determine the variability in impacts. Both stack heights were also tested with the limited terrain feature with Jamestown 2002 data, while the 10ft stack case was tested with a different stack location, building orientation and direction from the house since this was the structure resulting in the higher impacts. The worst case 24 hour impact from each model run was tabulated and used to guide further

analysis with the additional Syracuse data. The latter modeling runs were set to also provide the 8th highest impacts for comparison to the form of the 24 hour $PM_{2.5}$ standard.

III. Results and Conclusion.

The modeling analysis was carried out to answer certain general questions on the consequences of emissions from OWBs under various configurations. To the extent that refinements to the modeling assumptions could be made to determine their influence of the results due to certain regulatory requirements, these were limited to the parameters of significance. For example, to test the influence of using five years of meteorological data, as required by EPA modeling guidance, a set of such calculations were carried out with one of the data sets to deem the influence of such variability on the general conclusions. The same approach was taken in determining whether these conclusions would differ with the use of the different stack to building configuration, or the specific form of the threshold used for comparison of impacts to the revised 24 hour $PM_{2.5}$ standard, or the consideration of background levels.

Details of all modeling results are presented in Appendix A and are summarized in Table 1. Table 1 presents the maximum 24 hour impacts under various stack configurations and the four emission rates. Appendix A outlines the approach taken in the modeling and the stepwise process of addressing the specific source configurations and assumptions tested. Not all combinations of the parameters were analyzed. Rather, as combinations were tested and results summarized in Table 1, the next set of model calculations were limited to those conditions which required further reinforcement or testing. A summary of all the results are presented in the first page of Appendix A. Modeling results for one-year of meteorological data for Jamestown and Erie are presented on the next two pages of Appendix A. This Table includes the maximum and second highest impacts with a "unitized" emission rate of 1g/s which is then scaled to impacts for the existing scenario emission rate (0.045g/s). The corresponding location of the impacts, any terrain feature height and the meteorological day of the maximum are also listed for these results.

The next set of modeling results, presented in Appendix A, provide impacts for the additional one year of Syracuse data. This Table includes, in addition to the maximum 24 hour impact, the 8th highest impact for the scenarios modeled. In this case, the impacts are scaled to the four different emission rates for existing units, the average and maximum Phase I emission limits, and the maximum rate for Phase II emission limit. It should be noted that in some of these results, the maximum impact was found to be located "upwind" of the stack location due to the back circulation in the cavity imposed by the nearby structure. Although these impacts are considered valid, the maximum impacts downwind of the stack were tabulated instead to avoid any confusion. However, it was noted that the differences in these impacts were very low (i.e. about 2percent). The final two pages of Appendix A present the summary and the detailed information, respectively, of using five years of meteorological data from Syracuse for the maximum and 8th highest impacts. The purpose of the latter impact is to roughly represent the form of the 24 hour $PM_{2.5}$ standard which is the average of the 98% of the concentrations.

Appendix B provides the meteorological data associated with sample days of maximum impacts. These data can be used to address not only the question of the conditions associated with high

expected impacts, but also the likely persistence of the conditions causing the maximum over the daily period of the boiler operations cycle. These also allow the inter-site comparison of conditions to identify any potential differences which might be associated with the use of limited number of sites of meteorological data.

For the purposes of general conclusions seen in these results, the maximum 24 hour impacts under the stack and emission scenarios modeled are summarized in Table 1. It should be noted that for Syracuse data, some of the scenarios (2a,1b,2b-corresponding to Appendix A scenarios) include not only the maxima associated for the 1992 "base" year modeled, but also the overall maximum for any of the 5 years of data. For the 2a case (i.e. 10ft stack next to a house), 1992 data resulted in the overall maximum; thus there is only one impact presented per emission rate. These impacts could be viewed in the context of various thresholds for PM_{10} and $PM_{2.5}$; here we chose to compare these to the revised 24 hour $PM_{2.5}$ standard of 35 ug/m^3. Although most conclusions are based on the incremental impacts due to a single wood boiler, the considerations of 8th highest impact and of background levels are also discussed below. In addition since a number of scenarios projected impacts above the 35 ug/m^3 level, some of the results were plotted on the receptor grid to determine the areal extent of these exceedences. These results are presented in graphical form in Figures 1 to 8 and are discussed in the following observations:

1) Table 1 indicates that the impacts associated with existing emissions are above the revised 24 hour $PM_{2.5}$ standard under all conditions modeled. This includes the cases of stack extensions by 8 ft, which only has a significant effect in reducing impacts in a "stand alone" configuration. Some of these impacts are also above the PM_{10} 24 hour standard of 150 ug/m^3. The maximum impacts are associated with the configuration of the boiler stack being within the influence of a nearby house ("nearby" is generally recognized to be 5 times the height of the structure of influence). The impacts associated with a nearby barn with larger dimensions are somewhat lower, likely due to the additional dilution of the already low level plume by the structure's downwash effects.

2) The meteorological data site does not play a significant role in the determination of these maxima. That is, the meteorological conditions associated with the worst case impacts are found to be similar in all three data sets and the maxima are likely associated with the downwash influences of the boiler "structure" or other nearby structures. Even with the case of the extended stack height of 18 ft on a stand-alone boiler, where downwash effects are minimized, there is consistency in impacts from the three data bases. One exception is a unit with a 10ft stack next to a house. In this case the predicted impacts are somewhat higher with Syracuse data. The reason for this seems to be more hours of lower wind speed and directions to the specific receptor associated with this maximum, based on a review of the Appendix B meteorological data.

3) A review of the selected days of meteorological data of Appendix B indicates that the conditions associated with the maxima are generally moderate and some low wind speeds during nighttime, moderately stable conditions, but association also exists with higher wind speeds or convective conditions. It is also seen that the specific hours which transport the plume to the receptors of maxima are limited to a handful of hours, which means that it is not necessary for

prolonged persistence to occur to produce these high impacts. In addition, it is noted that the low wind speeds (less than 2m/s) seen in the data are not associated with these maxima. This could be a result of the chosen averaging time of the impacts (24 hours) which appear not to be controlled by the occurrences of these lower wind speeds in these simulations. However, for shorter averages or for the topographic setting where persistence of stable/low wind speeds are more likely, the results could be controlled by these conditions.

4) Raising the stack by 8ft does have a significant effect in reducing impacts of the unit under limited conditions. In order for the increased stack height to have this effect on ambient impacts, the boiler must be outside the influence of nearby structures; i.e. under the "stand alone" condition. Thus, when the stack is outside the influence zone of nearby or it's own structures, the stack is GEP height and the plume is not affected by downwash considerations. However, this situation does not seem to be found in current practical applications.

5) Under the two Phase I emission scenarios tabulated (average and maximum emission rates) the majority of impacts exceed the $PM_{2.5}$ standard. The exceptions are the standalone boiler or boiler next to the barn cases with an extended stack height.

6) Under the Phase II emission scenarios, all impacts are below the standard regardless of the conditions modeled. The overall maximum is associated with the 1992 Syracuse meteorological data case with the 10ft stack next to the house, with most impacts well below the 35 ug/m^3 threshold.

7) Modeling indicates that the maximum impacts from any configurations occur 10 to 30 meters from the stack (see Appendix A). Thus, to determine the spatial extend of impact areas above the standard and the associated concentration gradients, a number of graphs were generated for the Jamestown 2002 meteorological data model results and under sample scenarios. The results are presented in Figures 1 to 4 for cases 1a, 1b, 2a and 2b, respectively, all for the existing unit emission rate scenarios. Note that the scale for Figure 2 is different than for the rest to allow the depiction of all the results to be discussed. It is seen that the spatial extent of the impacts above 35 ug/m^3 is rather limited, with a sharp drop off beyond 100m from the stack. These impacts, however, do not include background $PM_{2.5}$ levels. For the Phase I emissions scenarios, impact areas above the NAAQS are reduced, with no such areas projected for the Phase II emissions. Modeling for larger than 350,000 Btu units or several units in one geographic area was not conducted. However, these results indicate that potential for significant cumulative short term impacts due to a number of these boilers in a given area is limited to instances of "adjacent" multiple configurations. On the other hand, it is likely that for long-term or annual basis, cumulative impacts could be associated with multiple units over larger areas due to influence of wind direction frequencies.

8) The influence of nearby terrain has been modeled only to the extent of plume "impaction" on relatively small features in the vicinity of the stack. The simulation of terrain effects, especially with close in receptors and potential for impaction, is deemed problematic for these low level sources. Thus, the limited modeled impacts associated with these features are comparable to those with structure downwash effects, especially with the higher stack case

which does not really sense the terrain influence. A proper assessment of the significance of terrain effects is thought to be the instance of persistent low wind speed case in a well defined valley situation which could lead to accumulation of concentrations, but that scenario cannot be simulated for the source specific configurations considered here by the AERMOD model. It is noted that the maxima 24 hour impacts associated with the scenarios were not due to very low wind speed cases, some of which are found in the wind roses from all three sites, but this is likely due to low persistence of these winds in the data sets and the corresponding averaging time for the concentrations, as discussed above. Thus, these results are a good representation of worst-case 24 hour impacts, at least for single source simulations.

9) To test the influence of the stack configuration with respect to the nearby structure orientation, at least two additional runs were performed: one with a different horizontal house dimension facing the stack, using the 2000 data from Erie, and another with the house placed due west of the stack, instead of due east, but at the same distance and with 2002 Jamestown data. The first test resulted in somewhat higher impact of 209 ug/m^3 (case 2h of Appendix A) versus the 178 ug/m^3 for case 2c of Table 1, while the second test resulted in a comparable increased to 199 ug/m^3 (case 2r in Appendix A) versus the 159 ug/m^3 impact for case 2a of Table 1. Thus, it is important that these results be used to draw general conclusions and not for absolute demonstration of standards compliance.

10) To test the influence of meteorological year variability on the conclusions reached, five years of Syracuse data were analyzed. These data were modeled for the worst case scenario of a woodboiler next to the house with a 10ft stack height, as well as the configurations of a 18 ft stack next to a house and in a stand alone mode (GEP stack). The maximum 24 hour impacts are summarized in Tables 4 and are detailed in the two tables that follow in Appendix A for the existing emissions conditions (the corresponding 8th highest impacts are also presented in Tables 5). The use of five years of data results in a range of impacts which differ from the average by about 20 to 30%, depending on the emission scenario, but do not significantly alter the conclusions reached previously. The use of 5 years of data will likely result in higher impacts for the other two sites of meteorological data, but the results for the Phase II emission scenario are not expected to be above the 35 ug/m^3 threshold based on the variability seen.

11) The last conclusion is further supported by the testing done to determine the consequences of using the 8th highest $PM_{2.5}$ impact to represent the 98% of the 24 hour values for comparison to the form of the standard. This testing was done with the Syracuse 1992 data for all scenarios of Table 1, except the terrain cases, and for all five years of Syracuse data for the same cases modeled in the meteorological data variability runs discussed above. These results are presented in Tables 3 and in the tables on the pages which follow it in Appendix A. The general conclusion reached from these results is that the use of the 8th highest impacts would result in roughly 1/4 to 1/3 lower impacts than the use of the maxima presented previously. However, the conclusions noted above relative to the standard are not significantly affected, although the cases of exceedences of the standard under the Phase I emissions are reduced.

12) All of the above conclusions are based on the comparison of the source impacts to the standards without consideration of existing background levels. In many instances, this omission

of background levels is of no consequence to the conclusions since the source impacts alone are projected to be above the $PM_{2.5}$ standard. However, in two specific aspects a rough estimate of a background level was used to test the influence of ambient background concentrations on the conclusions of this report. These are: in the determination of the areal extent of the impacts above the standard, and in the case of Phase II emission results, which are below the standard without background levels. The consideration of a background level is important for a pollutant such as $PM_{2.5}$ that has a relatively consistent and large regional transport component. For this purpose, however, it was decided to use an average representation of 24 hour background levels that could be associated with a random day of potential high impacts from the woodboiler and not to use worst case background levels which are conservatively used in general permit modeling analysis. Thus, the average daily value of 15 ug/m^3 was used for this analysis, which represents the average yearly background levels observed in New York over the last few years. It is also believed that this level fairly represents the contribution of regional transport component to the levels of daily averages.

Using this background level, isopleths of total impacts (woodboiler plus background) for the controlling scenario of a 10ft stack next to a house are plotted in Figures 5 to 7 for the existing, the maximum Phase I, and Phase II emission rates, respectively. Figure 7 indicates that with the background concentration included, no exceedences of the 35 ug/m^3 level would occur for the Phase II emission limit. Comparing the results in Figure 5 to Figure 2 for the same worst case controlling impact scenario, it is seen that the projected maximum distance to impacts above the $PM_{2.5}$ standard is extended from 100 to about 150m with the inclusion of a background level. A simpler way to view this result on the same map is to plot an isopleth of the standard minus the background level (i.e. 20 ug/m^3) on the figure with the boiler only impacts, as depicted by the darker blue line in Figure 2 (i.e. the outline of this line corresponds exactly to the distance to the areas below the standard depicted in Figure 5). This revised estimate of distance to total impacts above the $PM_{2.5}$ standard still represents a rather localized impact zone. As Phase I and Phase II emissions are implemented, these areas will shrink or become non-existent, accordingly, as depicted in Figures 6 and 7, respectively.

An additional depiction in Figures 2 and 4 are the lighter blue lines, and in Figures 5 and 6, the "hatched" area, which show the extent of impacts above a value of 30 ug/m^3, the level supported by CASAC and NESCAUM for the 24 hour PM2.5 standard. As noted above, Figures 5 and 6 contain the regional background level in the total impacts. These areas further extend the distance to which the OWBs have an impact over the 30 ug/m^3 value, although the extended impact areas are of the same general magnitude noted previously.

In summary, the modeling analysis undertaken by NYSDEC was developed to determine the range of maximum projected impacts of various particulate matter emissions rates from OWBs under various configurations and scenarios. This data will be used to inform policy makers on the potential impacts of various emission standards. The results of the modeling demonstrate that under current emission rates, as well as the proposed Phase I emission limit, there will be localized exceedences of EPA's 24 hour $PM_{2.5}$ standard. In order to avoid exceedences of EPA's 24 hour $PM_{2.5}$ standard, units must move to emission rates proposed in Phase II of NESCAUM's model rule.

Table 1 SUMMARY OF MODELED PM IMPACTS FROM OUTDOOR WOOD BOILER EMISSIONS (ug/m^3)

Modeled Conditions (Case)	Jamestown Met Data(2002)				Erie, PA Met Data(2000)				Syracuse Met Data (1992 /Max of 5 Years			
	Existing Rate	Phase I Ave.	Phase I Max.	Phase II Rate	Existing Rate	Phase I Ave.	Phase I Max.	Phase II Rate	Existing Rate	Phase I Ave.	Phase I Max.	Phase II Rate
Stack=10ft, flat terrain, **stand alone (1a)**	123	32	53	11	120	32	52	11	119	32	50	11
Stack=10ft, flat terrain, **next to house (2a)**	159	42	69	15	178	47	77	16	246**	66	104	22
Stack=10ft, flat terrain, **next to barn (3a)**	104	27	45	10	103	27	44	10	81	22	34	7
Stack=18ft, flat terrain, **stand alone (1b)**	42	11	18	4	40	11	17	4	40/55	11/15	17/23	4/6
Stack=18ft, flat terrain, **next to house (2b)**	118	31	51	11	83	22	36	8	106/137	28/36	45/58	9/12
Stack=18ft, flat terrain, **next to barn (3b)**	69	18	30	6	64	17	28	6	65	17	27	6
Stack=10ft, terrain feature, **stand alone (1f)**	159	42	69	15	137	36	59	13	163	43	69	15
Stack=10ft, terrain feature, **next to house-2j**	156	41	67	15	168	44	72	16	223	60	94	20

NOTE: Emission rates are as follows: Existing case: 161 g/hr (0.0447g/s), Phase I: Average=43g/hr (0.0119g/s) and Maximum=70g/hr (0.0194g/s), Phase II: 15g/hr (0.00417g/s).

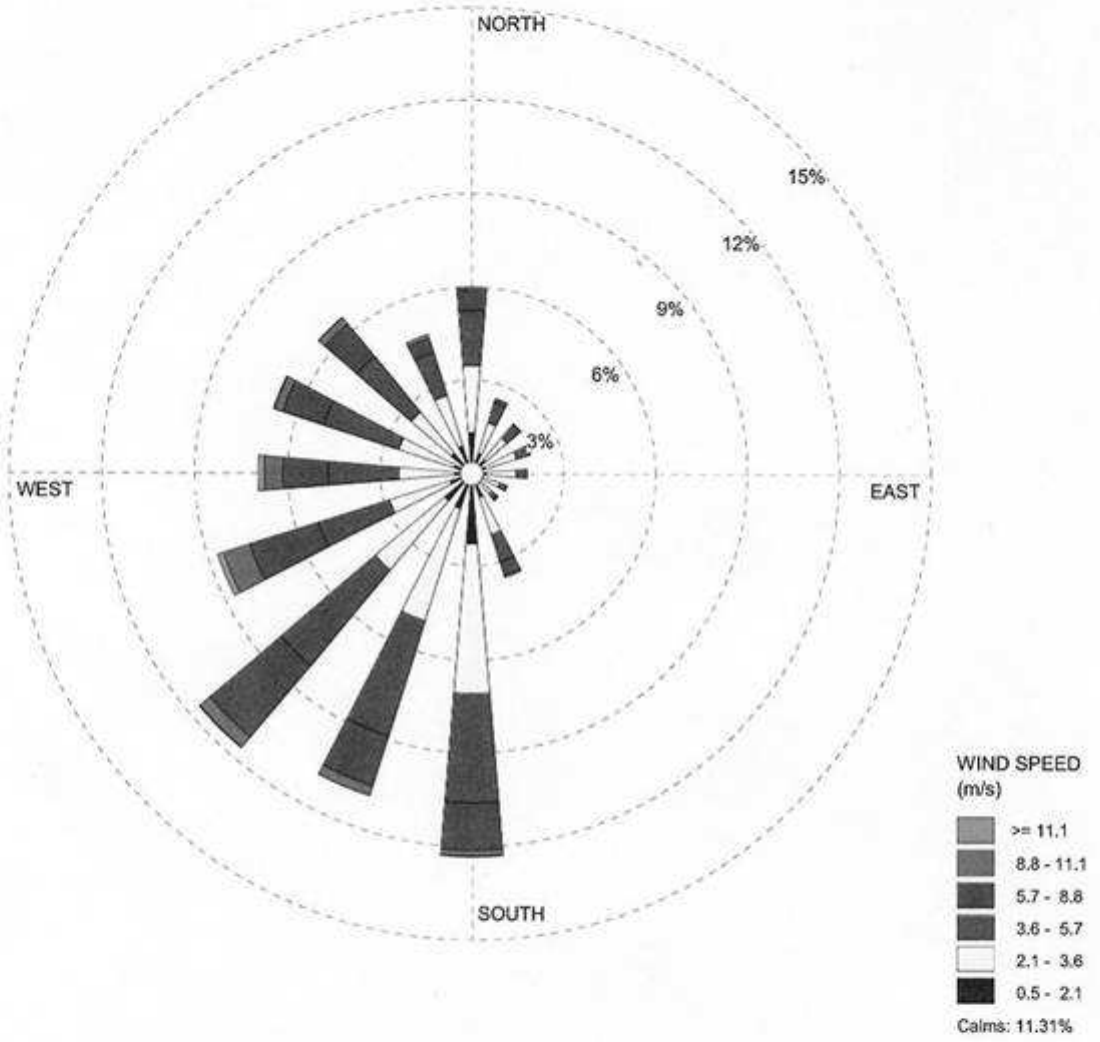
** Maximum occurred with 1992 data for the 5 years modeled.

WIND ROSE PLOT: JAMESTOWN, N.Y.

Station #72523

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2002 **Jan 1 - Dec 31** **00:00 - 23:00**		
	CALM WINDS: **11.31%**	TOTAL COUNT: **8760 hrs.**	
	AVG. WIND SPEED: **3.87 m/s**		PROJECT NO.:

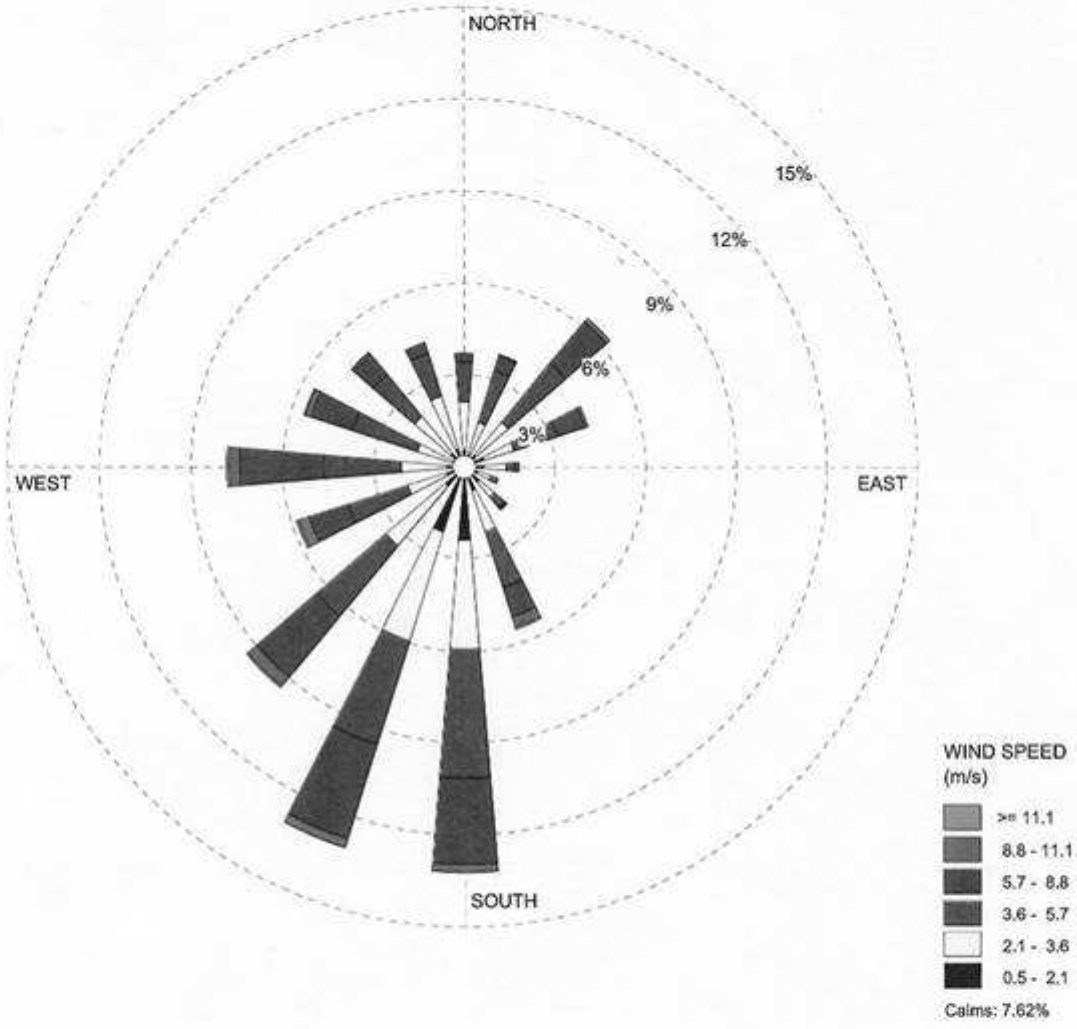
WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

Station #14860 - ERIE/INT'L ARPT, PA

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2000 **Jan 1 - Dec 31** **00:00 - 23:00**		
	CALM WINDS: **7.62%**	TOTAL COUNT: **8784 hrs.**	
	AVG. WIND SPEED: **4.24 m/s**		PROJECT NO.:

WRPLOT View - Lakes Environmental Software

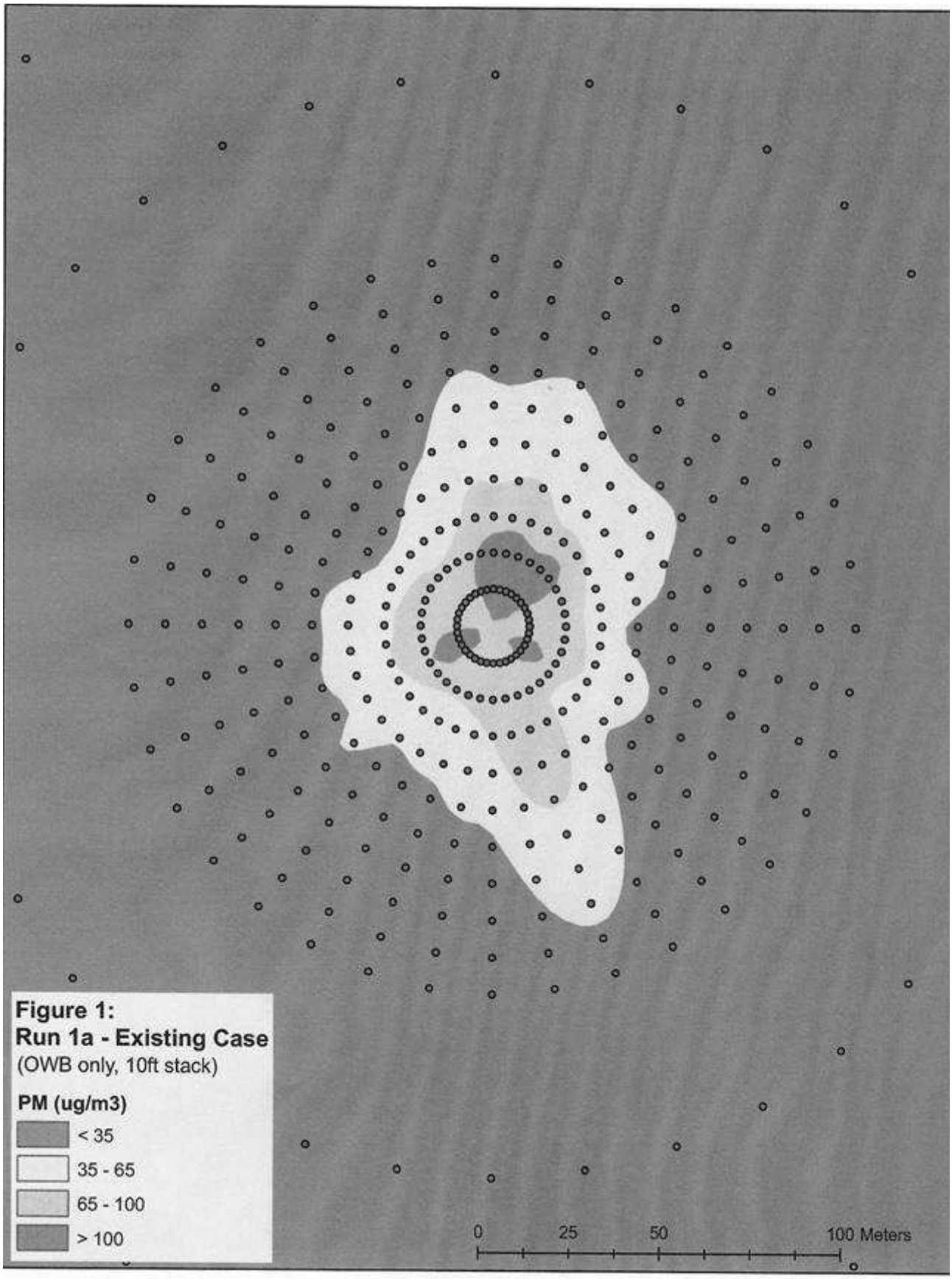


Figure 1:
Run 1a - Existing Case
(OWB only, 10ft stack)
PM (ug/m3)
< 35
35 - 65
65 - 100
> 100
0
25
50
100 Meters

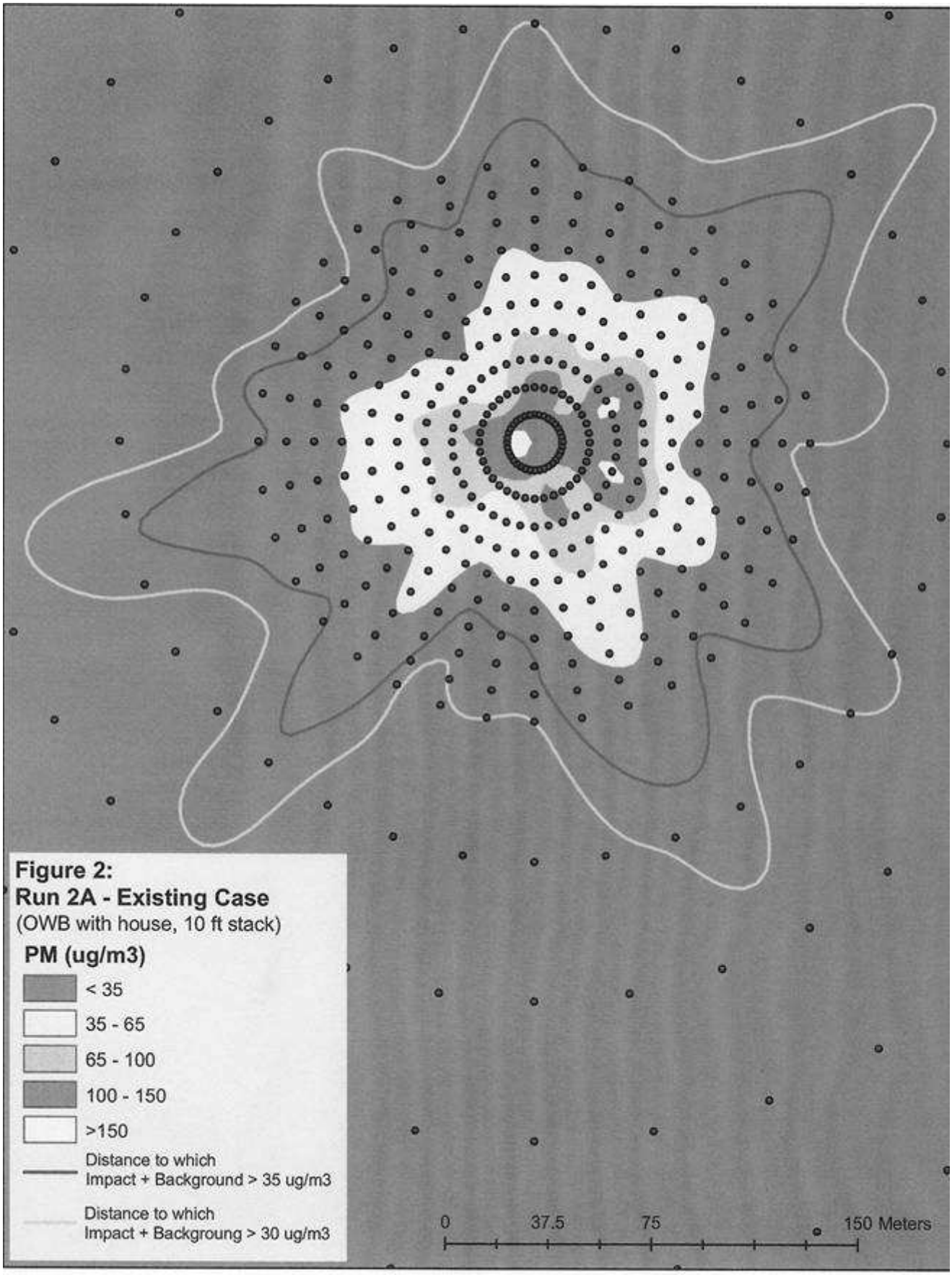


Figure 2:
Run 2A - Existing Case
(OWB with house, 10 ft stack)
PM (ug/m3)
< 35
35 - 65
65 - 100
100 - 150
>150
Distance to which
Impact + Background > 35 ug/m3
Distance to which
Impact + Backgroung > 30 ug/m3
0
37.5
75
150 Meters

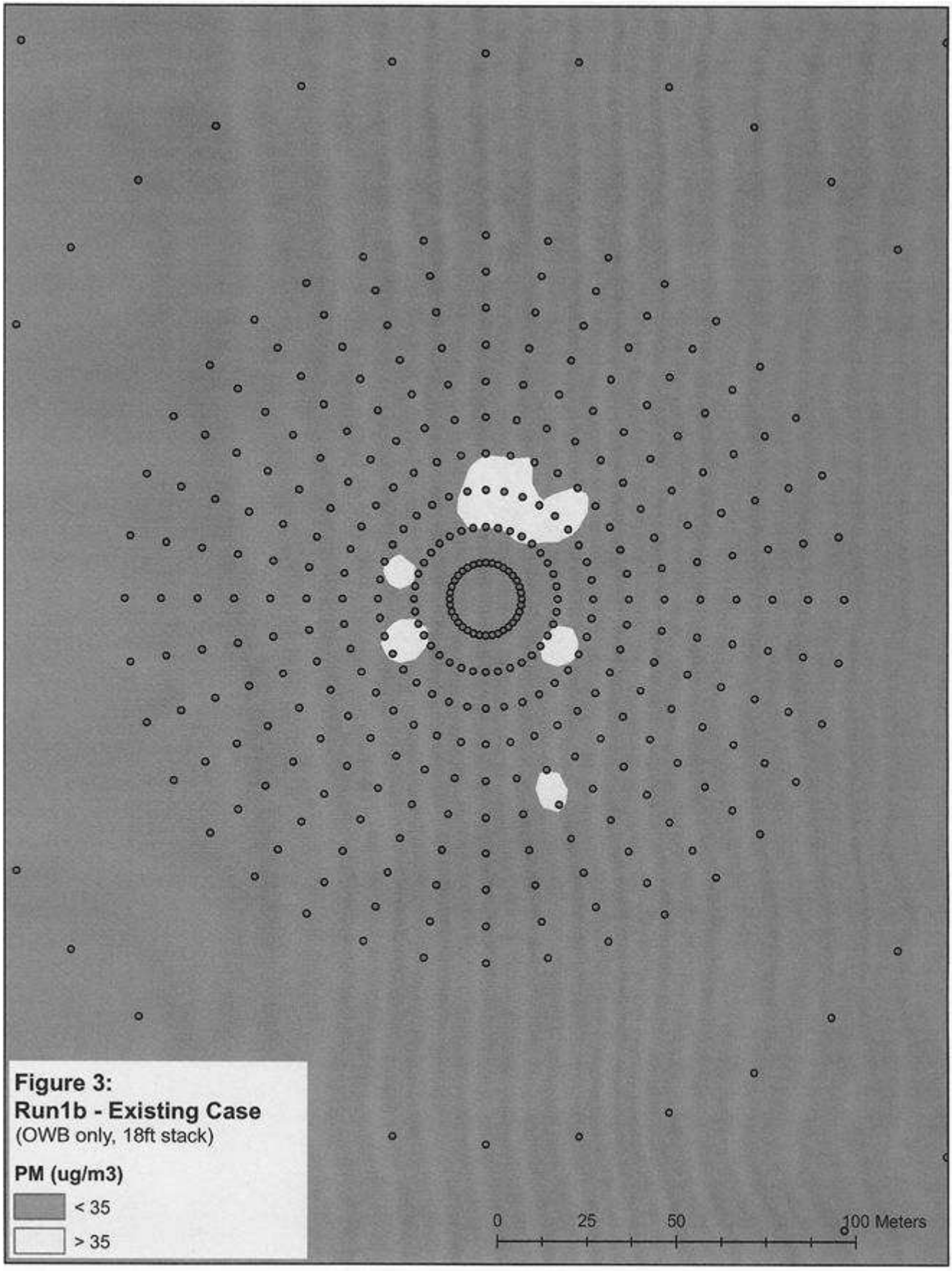


Figure 3:
Run1b - Existing Case
(OWB only, 18ft stack)
PM (ug/m3)
< 35
> 35
0
25
50
100 Meters

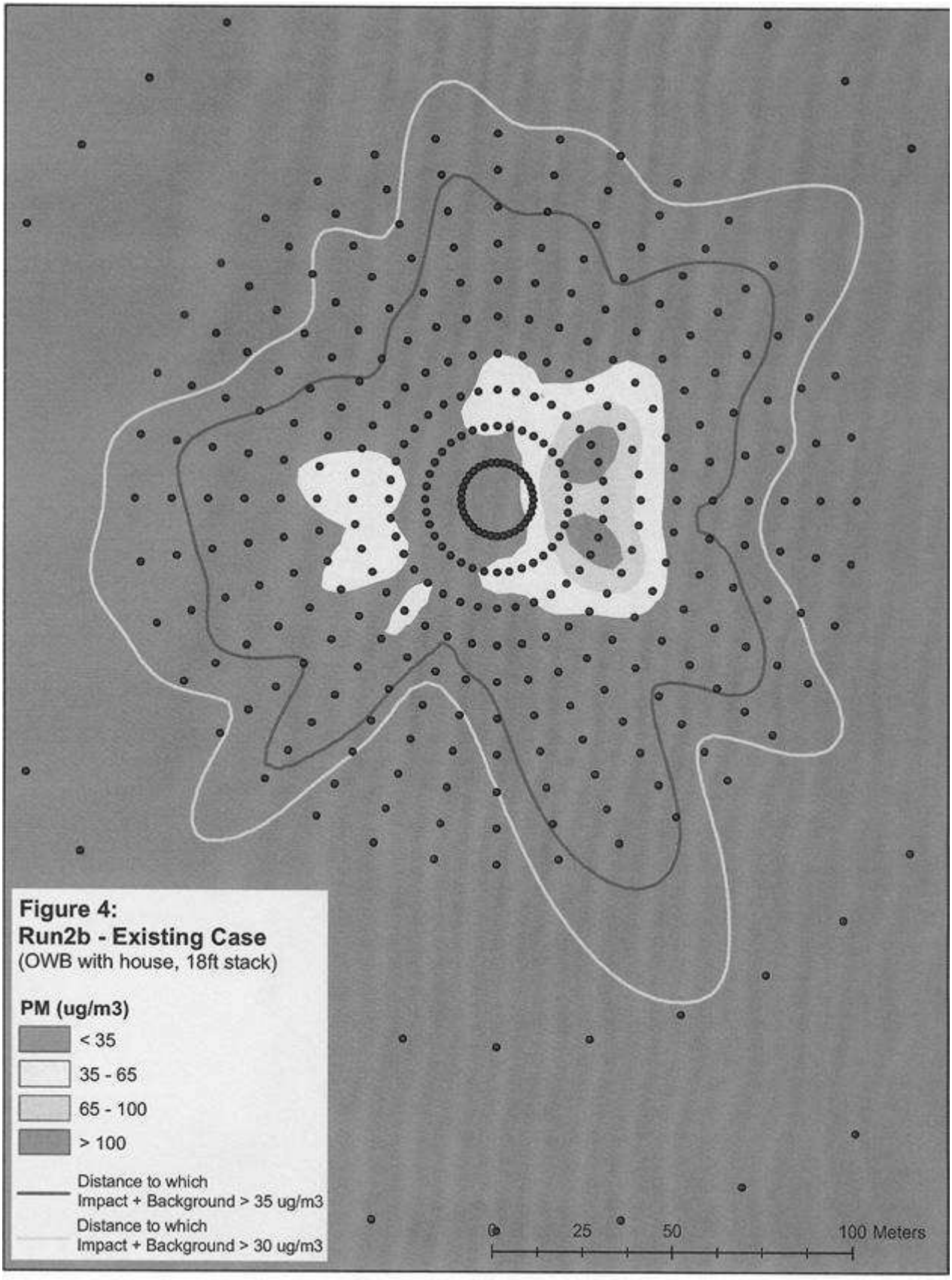


Figure 4:
Run2b - Existing Case
(OWB with house, 18ft stack)
PM (ug/m3)
< 35
35 - 65
65 - 100
> 100
Distance to which
Impact + Background > 35 ug/m3
Distance to which
Impact + Background > 30 ug/m3
0
25
50
100 Meters

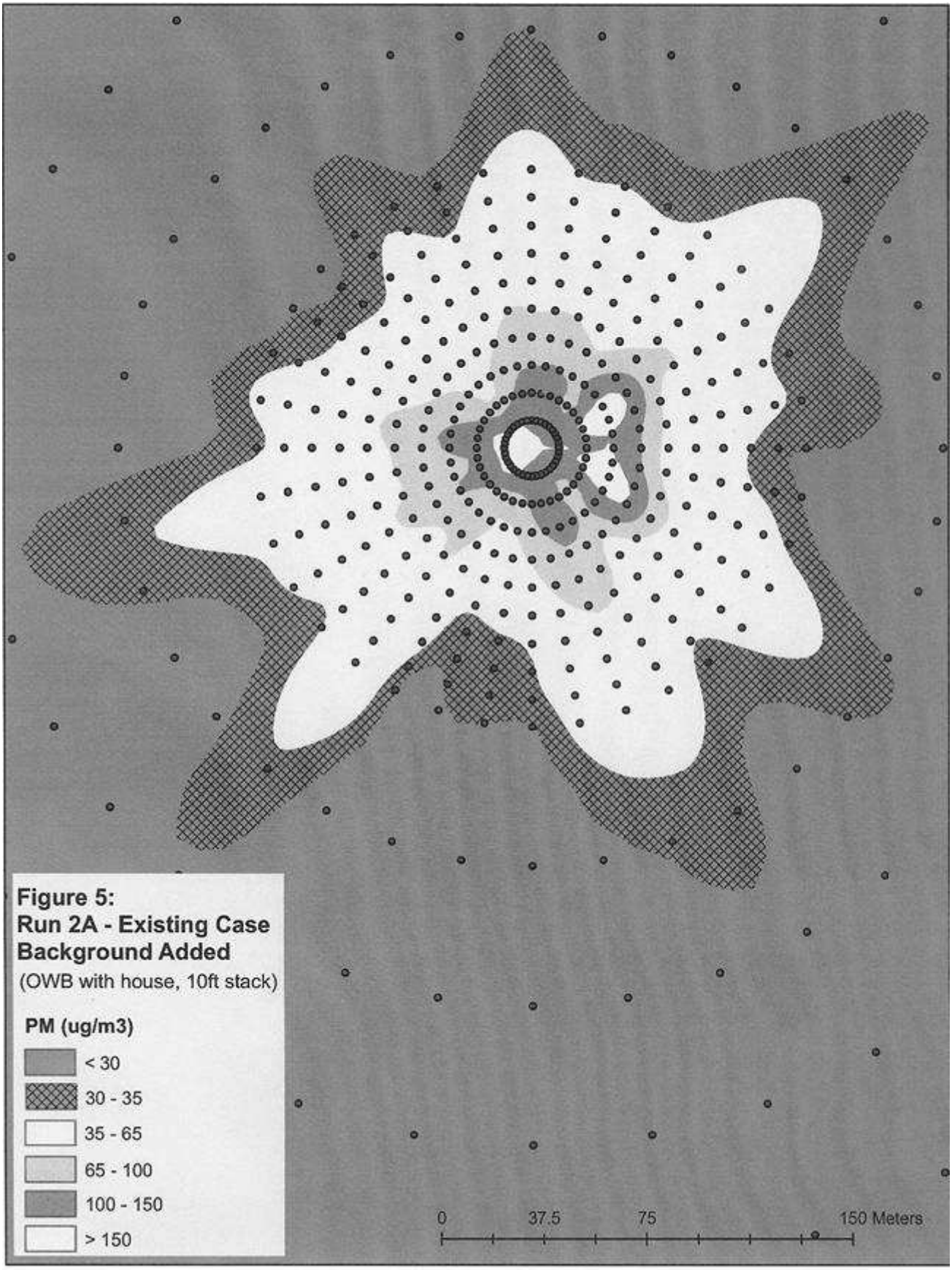


Figure 5:
Run 2A - Existing Case
Background Added
(OWB with house, 10ft stack)
PM (ug/m3)
< 30
30 - 35
35 - 65
65 - 100
100 - 150
> 150
0
37.5
75
150 Meters

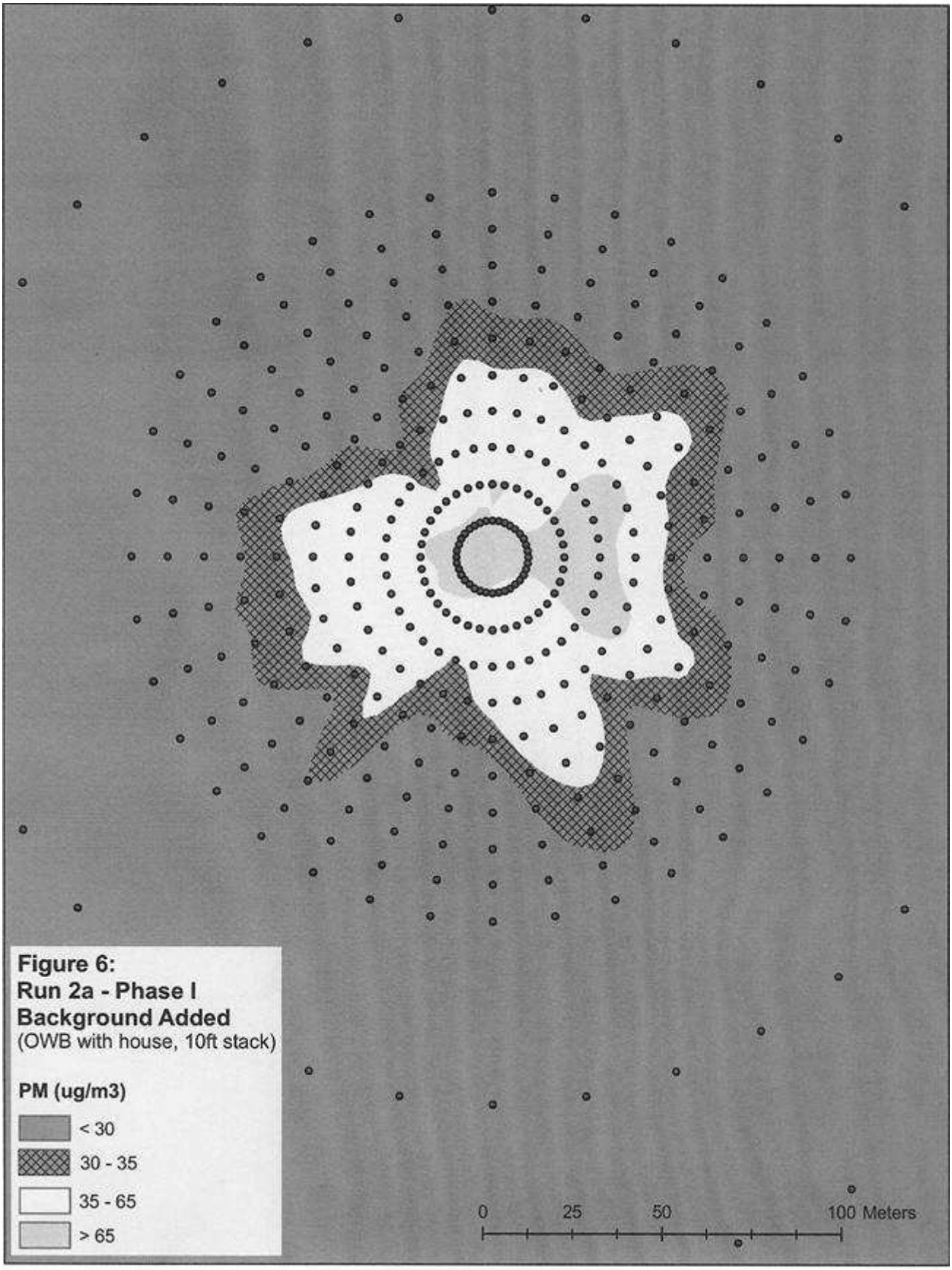


Figure 6:
Run 2a - Phase I
Background Added
(OWB with house, 10ft stack)
PM (ug/m3)
< 30
30 - 35
35 - 65
> 65
0
25
50
100 Meters

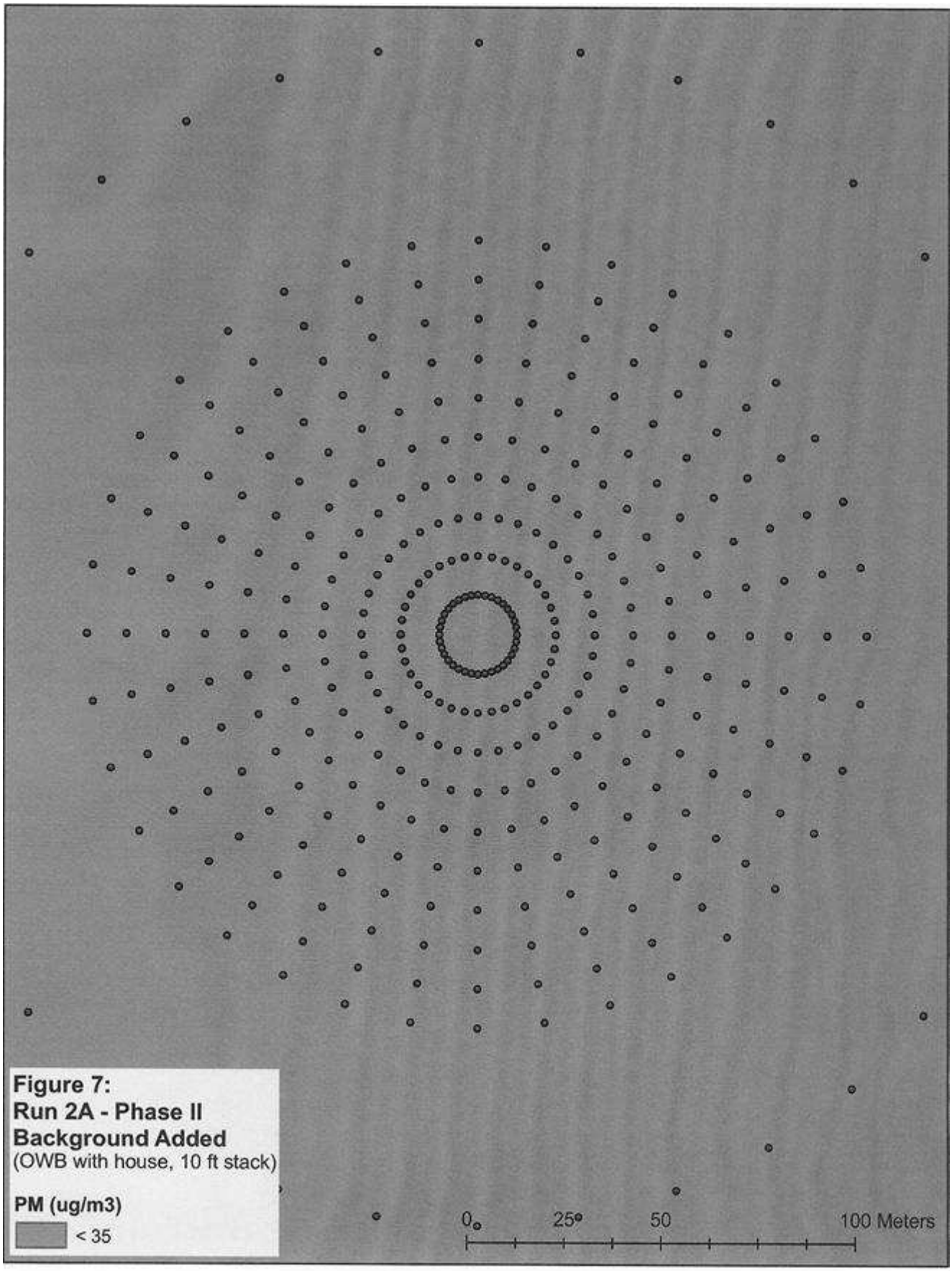


Figure 7:
Run 2A - Phase II
Background Added
(OWB with house, 10 ft stack)
PM (ug/m3)
< 35
0
25
50
100 Meters

APPENDIX A: DETAILS OF MODELING RESULTS

Summary of Results-Outdoor wood boiler impact assessment using AERMOD

OWB dimensions: 4 ft x 6 ft x 6.7 ft hgt., stack diameter 6 inches
House dimensions: 15m x 20m x 6m hgt., located 7m from stack
Barn dimensions: 25m x 30m x 13m hgt., located 7m from stack
Stack velocity = 1.05 m/s (weighted average of 0.74 m/s 75% of time and 1.98 m/s 25% of time)
Stack temperature = 294°F (weighted average of 226°F 75% of time and 491°F 25% of time)

All model runs done with unitized emission rate of 1 g/s, then scaled to various rates as follows:
Existing: 0.045 g/s Phase I average: 0.012 g/s Phase I max: 0.019 g/s Phase II: 0.004 g/s

Meteorology data:
Jamestown, NY 2002 w/Buffalo NY upper-air (JHW)
Erie, PA 2000 w/Buffalo NY upper-air (ERI)
Syracuse, NY 1988-1992 w/Buffalo NY upper-air (SYR)

All impact concentrations in µg/m³

Table 1 - Flat terrain, rural, max 24-hour impacts based on existing emission rate (.045 g/s)

	ERI met 10' stack	ERI met 18' stack	JHW met 10' stack	JHW met 18' stack	SYR met 10' stack	SYR met 18' stack
OWB only	120	41	123	42	119	40
OWB w/house	178	83	159	118	246	106
OWB w/barn	103	64	104	69	81	65

Run IDs	ERI met 10' stack	ERI met 18' stack	JHW met 10' stack	JHW met 18' stack	SYR met 10' stack	SYR met 18' stack
OWB only	1c	1d	1a	1b	1j	1k
OWB w/house	2c	2d	2a	2b	2o	2p
OWB w/barn	3c	3d	3a	3b	3g	3h

Table 2 - Slightly hilly terrain, rural, max 24-hour impacts based on existing emission rate (.045 g/s)

	ERI met 10' stack	ERI met 18' stack	JHW met 10' stack	JHW met 18' stack	SYR met 10' stack
OWB only	137	40	159	41	163
OWB w/house	168	81	156	115	223

Run IDs	ERI met 10' stack	ERI met 18' stack	JHW met 10' stack	JHW met 18' stack
OWB only	1i	1h	1f	1g
OWB w/house	2j	2n	2l	2m

Table 3 - Comparison of 1st and 8th max 24-hour impacts (all with SYR 92 met)

Emission rates>	Existing	Existing	Ph. I avg	Ph. I avg	Ph. I Max	Ph. I Max	Phase II	Phase II
Bldgs/stack heights	1st Max	8th Max	1st Max	8th Max	1st Max	8th Max	1st Max	8th Max
1j - OWB only/10'	119	90	32	24	50	38	11	8
2o - OWB/house/10'	246	185	66	49	104	78	22	16
3g - OWB/barn/10'	81	63	22	17	34	27	7	6
1k - OWB only/18'	40	31	11	8	17	13	4	3
2p - OWB/house/18'	106	66	28	18	45	28	9	6
3h - OWB/barn/18'	65	53	17	14	27	23	6	5

Table 4 - Comparison of 1st max 24-hour impacts based on 5 years of met data (SYR 1988-1992)

all based on existing emission rate (.045 g/s)

SYR met year >	1988	1989	1990	1991	1992
OWB/house/10'	217*	203*	228*	176	246*
OWB/house/18'	136	137	98	84	106
OWB only/18'	45	55	41	36	40

*max downwind impact

Table 5 - Comparison of 8th max 24-hour impacts based on 5 years of met data (SYR 1988-1992)

all based on existing emission rate (.045 g/s)

SYR met year >	1988	1989	1990	1991	1992
OWB/house/10'	148	165	157	159	185
OWB/house/18'	102	81	76	67	66
OWB only/18'	32	36	33	28	31

Details of Model run results - Outdoor wood boiler impact assessment using AERMOD
First round of modeling, testing various building, terrain, and stack height configurations

OWB dimensions: 4 ft x 6 ft x 6.7 ft hgt., stack diameter 6 inches
House dimensions: 15m x 20m x 6m hgt.
Barn dimensions: 25m x 30m x 13m hgt.
Stack velocity = 1.05 m/s (weighted average of 0.74 m/s 75% of time and 1.98 m/s 25% of time)
Stack temperature = 294°F (weighted average of 228°F 75% of time and 491°F 25% of time)
All model runs done with unitized emission rate of 1 g/s, then scaled to existing emission rate of 0.045 g/s

Meteorology data:
Jamestown, NY 2002 w/Buffalo NY upper-air (JHW)
Erie, PA 2000 w/Buffalo NY upper-air (ERI)

Table lists 1st and 2nd max 24-hour impacts in $\mu g/m^3$

Model Run Description	Rank	Model Output PM2.5 Conc	Scaled Impact Conc*0.045	Location East(X)	Location North(Y)	Source-receptor elev diff (m)	Date
1a - OWB only, flat terrain, rural, 10 ft stack, JHW met							
base case							
	1ST	2729.3	122.8	12.86	15.32		12/27/2002
	2ND	2518.9	113.4	0.00	10.00		9/19/2002
1b - OWB only, flat terrain, rural, 18 ft stack, JHW met							
compare to 1a to test effect of stack height extension							
	1ST	922.0	41.5	0.00	30.00		2/19/2002
	2ND	812.2	36.5	5.21	29.54		1/28/2002
1c - OWB only, flat terrain, rural, 10 ft stack, ERI met							
compare to 1a to test effect of different met							
	1ST	2666.9	120.0	0.00	20.00		1/1/2000
	2ND	2332.2	104.9	0.00	20.00		11/24/2000
1d - OWB only, flat terrain, rural, 18 ft stack, ERI met							
compare to 1b to test effect of different met							
	1ST	899.8	40.5	-5.21	29.54		11/24/2000
	2ND	813.9	36.6	0.00	30.00		11/24/2000
1f - OWB only, slightly hilly terrain, rural, 10 ft stack, JHW met							
compare to 1a to test effect of terrain							
	1ST	3542.1	159.4	-8.66	-5.00	1.6	11/16/2002
	2ND	2686.5	120.9	-9.85	1.74	1.6	10/29/2002
1g - OWB only, slightly hilly terrain, rural, 18 ft stack, JHW met							
compare to 1b to test effect of terrain							
	1ST	918.4	41.3	0.00	30.00	0.6	2/19/2002
	2ND	812.4	36.6	5.21	29.54	0.6	1/28/2002
1i - OWB only, slightly hilly terrain, rural, 10 ft stack, ERI met							
compare to 1c to test effect of terrain							
	1ST	3037.5	136.7	-8.66	-5.00	1.6	6/5/2000
	2ND	2692.1	121.1	-9.40	-3.42	1.6	1/22/2000
2a - OWB with house (15m x 20m x 6m hgt.) 7m away, flat terrain, rural, 10 ft stack, JHW met							
compare to 1a to test effect of downwash from house							
	1ST	3538.3	159.2	28.19	-10.26		4/5/2002
	2ND	3355.8	151.0	28.19	-10.26		4/23/2002
2b - OWB with house 7m away, flat terrain, rural, 18 ft stack, JHW met							
compare to 2a to test effect of stack height extension							
	1ST	2622.5	118.0	25.98	15.00		12/4/2002
	2ND	2489.7	112.0	28.19	-10.26		4/23/2002

2c - OWB with house 7m away, flat terrain, rural, 10 ft stack, ERI met							
compare to 2a to test effect of different met							
	1ST	3946.9	177.6	-6.43	-7.66		6/5/2000
	2ND	3820.6	171.9	-7.66	-6.43		10/22/2000
2d - OWB with house 7m away, flat terrain, rural, 18 ft stack, ERI met							
compare to 2b to test effect of different met							
	1ST	1851.6	83.3	28.19	10.26		7/4/2000
	2ND	1837.2	82.7	25.98	15.00		7/17/2000
2g - OWB with house 15m away, flat terrain, rural, 10 ft stack, ERI met							
compare to 2c to test effect of moving OWB further from house							
	1ST	3304.2	148.7	-29.54	-5.21		10/22/2000
	2ND	2332.2	104.9	0.00	20.00		11/24/2000
2h - OWB with house 7m away and turned lengthwise, flat terrain, rural, 10 ft stack, ERI met							
compare to 2c to test effect of turning house lengthwise							
	1ST	4651.1	209.3	-5.00	-8.66		6/5/2000
	2ND	3968.8	178.6	-3.42	-9.40		5/19/2000
2j - OWB with house 7m away, slightly hilly terrain, rural, 10 ft stack, ERI met							
compare to 2c to test effect of terrain							
	1ST	3740.4	168.3	-5.00	-8.66	0.6	6/5/2000
	2ND	3363.2	151.3	-5.00	-8.66	0.6	10/22/2000
2l - OWB with house 7m away, slightly hilly terrain, rural, 10 ft stack, JHW met							
compare to 2a to test effect of terrain							
	1ST	3470.4	156.2	28.19	-10.26	-0.4	4/5/2002
	2ND	3295.8	148.3	28.19	-10.26	-0.4	4/23/2002
3a - OWB with barn (25m x 30m x 13m hgt.) 7m away, flat terrain, rural, 10 ft stack, JHW met							
compare to 2a to test effect of larger building							
	1ST	2299.2	103.5	-3.42	9.40		9/1/2002
	2ND	2187.9	98.5	0.00	10.00		9/2/2002
3b - OWB with barn 7m away, flat terrain, rural, 18 ft stack, JHW met							
compare to 3a to test effect of stack height extension							
	1ST	1530.0	68.8	-9.85	1.74		10/29/2002
	2ND	1450.1	65.3	8.66	5.00		10/29/2002
3c - OWB with barn 7m away, flat terrain, rural, 10 ft stack, ERI met							
compare to 3a to test effect of different met							
	1ST	2291.4	103.1	0.00	20.00		12/3/2000
	2ND	2060.5	92.7	-1.74	9.85		11/24/2000
3d - OWB with barn 7m away, flat terrain, rural, 18 ft stack, ERI met							
compare to 3b to test effect of different met							
	1ST	1424.9	64.1	-6.43	-7.66		10/22/2000
	2ND	1094.4	49.2	5.00	-8.66		10/5/2000
2r - OWB & house west of source, 10 ft stack, flat terrain, JHW 2002 met							
Compare to 2a to test effect of moving house to west of source (same distance)							
	1ST	4428.1	199.3	9.85	-1.74		2/22/2002
	8TH	3015.2	135.7	-10.00	0.00		1/11/2002

Modeling round #2 - Additional met data set from Syracuse, and comparing 8th max impacts with 1st max

Only 1st & 8th max 24-hour impacts modeled with 1992 Syracuse data

Model Run Description	Rank	Model Output PM2.5 Conc	Scaled to 0.045 (Existing)	Scaled to 0.012 (Ph 1 avg)	Scaled to 0.019 (Ph 1 max)	Scaled to 0.004 (Ph II)	Location East(X)	Location North(Y)	Source-receptor elev diff (m)	Date
1j - OWB only, 10 ft stack, flat terrain, SYR 1992 met										
Compare to 1a to test effect of different met										
	1ST	2641.7	118.9	31.7	50.2	10.6	-9.40	3.42		8/16/1992
	8TH	2002.4	90.1	24.0	38.0	8.0	-10.00	0.00		11/2/1992
2o - OWB & house, 10 ft stack, flat terrain, SYR 1992 met										
Compare to 2a to test effect of different met										
	1ST*	5475.7	246.4	65.7	104.0	21.9	-9.40	3.42		1/27/1992
	8TH	4109.1	184.9	49.3	78.1	16.4	-8.66	5.00		2/18/1992
*1st max impact from model was upwind of source and "inside" house - replaced it with highest downwind receptor, which had max impact on same date										
3g - OWB & barn, 10 ft stack, flat terrain, SYR 1992 met										
Compare to 3a to test effect of different met										
	1ST	1809.0	81.4	21.7	34.4	7.2	0.00	-10.00		11/1/1992
	8TH	1399.2	63.0	16.8	26.6	5.6	-1.74	-9.85		8/17/1992
1k - OWB only, 18 ft stack, flat terrain, SYR 1992 met										
Compare to 1b to test effect of different met										
	1ST	879.3	39.6	10.6	16.7	3.5	-29.54	5.21		1/27/1992
	8TH	684.7	30.8	8.2	13.0	2.7	-29.54	5.21		10/8/1992
2p - OWB & house, 18 ft stack, flat terrain, SYR 1992 met										
Compare to 2b to test effect of different met										
	1ST	2349.5	105.7	28.2	44.6	9.4	29.54	5.21		11/28/1992
	8TH	1474.8	66.4	17.7	28.0	5.9	30.00	0.00		9/28/1992
3h - OWB & barn, 18 ft stack, flat terrain, SYR 1992 met										
Compare to 3b to test effect of different met										
	1ST	1436.6	64.6	17.2	27.3	5.7	-9.40	3.42		1/27/1992
	8TH	1182.7	53.2	14.2	22.5	4.7	-9.85	1.74		10/15/1992
1l - OWB only, 10 ft stack, slightly hilly terrain, SYR 1992 met										
Compare to 1f to test effect of different met										
	1ST	3613.7	162.6	43.4	68.7	14.5	-9.85	1.74	1.6	1/27/1992
	8TH	2894.1	130.2	34.7	55.0	11.6	-9.85	1.74	1.6	2/18/1992
2q - OWB & house, 10 ft stack, slightly hilly terrain, SYR 1992 met										
Compare to 2j to test effect of different met										
	1ST	4965.4	223.4	59.6	94.3	19.9	-9.85	1.74	0.6	1/27/1992
	8TH	3899.7	175.5	46.8	74.1	15.6	10.00	0.00	0.6	8/16/1992
*1ST max impact from model was upwind of source and "inside" house - replaced it with highest downwind receptor, which had max impact on same date										

5-year met data sensitivity tests

Syracuse 1988-1992 met data used to test interannual variability of impacts

1st & 8th max 24-hour impacts (μg/m³) based on existing emission rate (.045 g/s)

Run 2s - Test 5 years of SYR met data with 2a setup (OWB & house, 10 ft stack, flat terrain)					
	1988	1989	1990	1991	1992
1st Max	217*	203*	228*	176	246*
8th Max	148	165	157	159	185
*1st downwind max - 1st max was upwind and "inside" house					

Run 2t - Test 5 years of SYR met data with 2b setup (OWB & house, 18 ft stack, flat terrain)					
	1988	1989	1990	1991	1992
1st Max	136	137	98	84	106
8th Max	102	81	76	67	66

Run 1m - Test 5 years of SYR met data with 1b setup (OWB only, 18 ft stack, flat terrain)					
	1988	1989	1990	1991	1992
1st Max	45	55	41	36	40
8th Max	32	36	33	28	31

Detailed output from 5-year met tests

File	Pol	Average	Group	Rank	Conc.	Scaled conc (.045)	East(X)	North(Y)	Time	Met File
2s_88_PM2.5	PM2.5	24-HR	ALL	1ST*	4817	217	-9.85	1.74	88010824	SYR88.SFC
2s_88_PM2.5	PM2.5	24-HR	ALL	8TH	3300	148	30.00	0.00	88091024	SYR88.SFC
2s_89_PM2.5	PM2.5	24-HR	ALL	1ST*	4515	203	-10.00	0.00	89032424	SYR89.SFC
2s_89_PM2.5	PM2.5	24-HR	ALL	8TH	3675	165	-9.85	1.74	89022624	SYR89.SFC
2s_90_PM2.5	PM2.5	24-HR	ALL	1ST*	5077	228	-9.85	1.74	90033124	SYR90.SFC
2s_90_PM2.5	PM2.5	24-HR	ALL	8TH	3497	157	-9.40	3.42	90082124	SYR90.SFC
2s_91_PM2.5	PM2.5	24-HR	ALL	1ST	3915	176	-7.66	6.43	91021824	SYR91.SFC
2s_91_PM2.5	PM2.5	24-HR	ALL	8TH	3547	160	-8.66	5.00	91042824	SYR91.SFC
2s_92_PM2.5	PM2.5	24-HR	ALL	1ST*	5573	246	-9.40	3.42	92012724	SYR92.SFC
2s_92_PM2.5	PM2.5	24-HR	ALL	8TH	4109	185	-8.66	5.00	92021824	SYR92.SFC

File	Pol	Average	Group	Rank	Conc.	Scaled Conc (.045)	East(X)	North(Y)	Time	Met File
2t_88_PM2.5	PM2.5	24-HR	ALL	1ST	3029	136	25.98	15	88102524	SYR88.SFC
2t_88_PM2.5	PM2.5	24-HR	ALL	8TH	2274	102	30	0	88061124	SYR88.SFC
2t_89_PM2.5	PM2.5	24-HR	ALL	1ST	3055	137	30	0	89080324	SYR89.SFC
2t_89_PM2.5	PM2.5	24-HR	ALL	8TH	1799	81	30	0	89100624	SYR89.SFC
2t_90_PM2.5	PM2.5	24-HR	ALL	1ST	2185	98	30	0	90062524	SYR90.SFC
2t_90_PM2.5	PM2.5	24-HR	ALL	8TH	1694	76	29.54	-5.21	90082724	SYR90.SFC
2t_91_PM2.5	PM2.5	24-HR	ALL	1ST	1874	84	30	0	91061124	SYR91.SFC
2t_91_PM2.5	PM2.5	24-HR	ALL	8TH	1495	67	30	0	91111224	SYR91.SFC
2t_92_PM2.5	PM2.5	24-HR	ALL	1ST	2349	106	29.54	5.21	92112824	SYR92.SFC
2t_92_PM2.5	PM2.5	24-HR	ALL	8TH	1475	66	30	0	92092824	SYR92.SFC

File	Pol	Average	Group	Rank	Conc.	Scaled Conc (.045)	East(X)	North(Y)	Time	Met File
1m_88_PM2.5	PM2.5	24-HR	ALL	1ST	1006	45	-30	0	88051924	SYR88.SFC
1m_88_PM2.5	PM2.5	24-HR	ALL	8TH	703	32	-28.19	10.26	88051924	SYR88.SFC
1m_89_PM2.5	PM2.5	24-HR	ALL	1ST	1225	55	-29.54	5.21	89091624	SYR89.SFC
1m_89_PM2.5	PM2.5	24-HR	ALL	8TH	807	36	-29.54	5.21	89121524	SYR89.SFC
1m_90_PM2.5	PM2.5	24-HR	ALL	1ST	909	41	-18.79	6.84	90082124	SYR90.SFC
1m_90_PM2.5	PM2.5	24-HR	ALL	8TH	734	33	-29.54	5.21	90101024	SYR90.SFC
1m_91_PM2.5	PM2.5	24-HR	ALL	1ST	804	36	-19.7	3.47	91070224	SYR91.SFC
1m_91_PM2.5	PM2.5	24-HR	ALL	8TH	618	28	-29.54	5.21	91090924	SYR91.SFC
1m_92_PM2.5	PM2.5	24-HR	ALL	1ST	879	40	-29.54	5.21	92012724	SYR92.SFC
1m_92_PM2.5	PM2.5	24-HR	ALL	8TH	685	31	-29.54	5.21	92100824	SYR92.SFC

APPENDIX B: METEOROLOGICAL DATA FOR SELECT DAYS ASSOCIATED WITH MAXIMUM IMPACTS

Met for max 24-hr impact, case 1a (hs=10ft, JHW) - max impact was 12.86 E, 15.32 N

Jamestown 2002 **impacting wind direction = 220**

Y	M	D	H	ht flux	fric vel	conv vel	ptg	conv mix	mech mix	M-O	rough	Bowen	albedo	spd	dir	hgt	t(K)	hgt					
2	12	27	1	-30.3	0.535	-9	-9	-999	900	433.6	0.361	1.5	1	4.6	240	10	267	2	0	-9	86	961	10
2	12	27	2	-30.3	0.535	-9	-9	-999	901	433.6	0.361	1.5	1	4.6	232	10	267	2	0	-9	86	961	10
2	12	27	3	-26.9	0.473	-9	-9	-999	751	336.5	0.361	1.5	1	4.1	234	10	265.9	2	0	-9	93	961	10
2	12	27	4	-19.6	0.344	-9	-9	-999	475	178.6	0.361	1.5	1	3.1	215	10	265.9	2	0	-9	93	961	10
2	12	27	5	-19.6	0.344	-9	-9	-999	465	178.6	0.361	1.5	1	3.1	221	10	265.9	2	0	-9	93	961	10
2	12	27	6	-26.9	0.473	-9	-9	-999	747	336.5	0.361	1.5	1	4.1	225	10	265.9	2	0	-9	93	961	10
2	12	27	7	-26.9	0.473	-9	-9	-999	747	336.5	0.361	1.5	1	4.1	216	10	265.9	2	0	-9	93	961	10
2	12	27	8	-26.9	0.473	-9	-9	-999	747	335.6	0.361	1.5	1	4.1	241	10	265.4	2	0	-9	93	961	10
2	12	27	9	-18.7	0.414	-9	-9	-999	616	326.3	0.361	1.5	0.76	3.6	214	10	265.4	2	0	-9	93	961	10
2	12	27	10	0.1	0.434	-9	-9	-999	656	-8888	0.361	1.5	0.64	3.6	222	10	265.4	2	0	-9	90	961	10
2	12	27	11	0.1	0.373	-9	-9	-999	527	-8888	0.361	1.5	0.59	3.1	231	10	265.4	2	22	-9	86	961	10
2	12	27	12	1.5	0.375	-9	-9	-999	528	-3011.8	0.361	1.5	0.57	3.1	238	10	265.9	2	0	-9	73	960	10
2	12	27	13	2.4	0.375	-9	-9	-999	529	-1921.2	0.361	1.5	0.57	3.1	243	10	265.9	2	0	-9	79	959	10
2	12	27	14	0.4	0.434	-9	-9	-999	657	-8888	0.361	1.5	0.57	3.6	232	10	265.9	2	0	-9	86	958	10
2	12	27	15	4.4	0.556	-9	-9	-999	952	-3355.5	0.361	1.5	0.6	4.6	252	10	267	2	0	-9	80	958	9
2	12	27	16	-5.6	0.366	-9	-9	-999	537	751.1	0.361	1.5	0.67	3.1	230	10	267	2	0	-9	80	958	9
2	12	27	17	-22.1	0.34	-9	-9	-999	456	151.6	0.361	1.5	0.86	3.1	246	10	265.9	2	0	-9	86	958	9
2	12	27	18	-27.3	0.404	-9	-9	-999	591	206.7	0.361	1.5	1	3.6	241	10	265.9	2	0	-9	86	958	9
2	12	27	19	-31.6	0.318	-9	-9	-999	417	87	0.361	1.5	1	3.1	211	10	265.4	2	0	-9	86	958	5
2	12	27	20	-41.6	0.384	-9	-9	-999	546	115.8	0.361	1.5	1	3.6	210	10	265.4	2	0	-9	90	957	3
2	12	27	21	-43.2	0.381	-9	-9	-999	541	109.1	0.361	1.5	1	3.6	198	10	265.4	2	0	-9	93	957	0
2	12	27	22	-45.2	0.455	-9	-9	-999	706	178	0.361	1.5	1	4.1	210	10	265.4	2	0	-9	93	957	5
2	12	27	23	-31.6	0.468	-9	-9	-999	737	277	0.361	1.5	1	4.1	207	10	265.4	2	0	-9	93	956	9
2	12	27	24	-24.9	0.23	-9	-9	-999	305	41.6	0.361	1.5	1	2.6	220	10	265.4	2	0	-9	93	956	3

Met for 2nd max 24-hr impact, case 1a (hs=10ft,JHW) - max impact was at 0E, 10N

impacting wind direction = 180

Y	M	D	H	ht flux	fric vel	conv vel	ptg	conv mix	mech mix	M-O	rough	Bowen	albedo	spd	dir	hgt	t(K)	hgt					
2	9	19	1	-38.4	0.373	-9	-9	-999	523	114.4	0.555	2	1	3.1	182	10	290.9	2	0	-9	78	954	0
2	9	19	2	-38.5	0.372	-9	-9	-999	523	114.1	0.555	2	1	3.1	171	10	290.4	2	0	-9	83	953	0
2	9	19	3	-38.5	0.372	-9	-9	-999	523	114.1	0.555	2	1	3.1	180	10	290.4	2	0	-9	83	953	0
2	9	19	4	-54.5	0.527	-9	-9	-999	881	228.8	0.555	2	1	4.1	194	10	290.4	2	0	-9	83	954	0
2	9	19	5	-46.9	0.451	-9	-9	-999	702	166.9	0.555	2	1	3.6	185	10	289.2	2	0	-9	88	954	0
2	9	19	6	-54.7	0.527	-9	-9	-999	880	227.8	0.555	2	1	4.1	182	10	289.2	2	0	-9	88	954	0
2	9	19	7	-37.7	0.689	-9	-9	-999	1315	739	0.555	2	0.51	5.1	187	10	290.4	2	0	-9	88	954	5
2	9	19	8	29.4	0.647	0.326	0	40	1199	-783.7	0.555	2	0.27	4.6	192	10	292	2	0	-9	83	955	9
2	9	19	9	69.9	0.658	0.654	0	136	1228	-347	0.555	2	0.19	4.6	188	10	293.1	2	0	-9	83	955	9
2	9	19	10	50.8	0.72	0.676	0	206	1401	-623.6	0.555	2	0.16	5.1	194	10	294.2	2	0	-9	83	954	10
2	9	19	11	63	0.803	0.816	0	293	1650	-698.2	0.555	2	0.15	5.7	188	10	294.2	2	0	-9	83	955	10
2	9	19	12	69.7	0.804	0.927	0	389	1658	-633.7	0.555	2	0.15	5.7	193	10	294.2	2	0	-9	83	954	10
2	9	19	13	143.3	1.231	1.424	0	686	3136	-1107.6	0.555	2	0.15	8.8	167	10	297	2	0	-9	74	953	9
2	9	19	14	134.3	1.082	1.581	0	1002	2634	-801.1	0.555	2	0.15	7.7	177	10	297	2	0	-9	74	953	9
2	9	19	15	114.7	0.879	1.603	0	1222	1961	-502.1	0.555	2	0.16	6.2	185	10	297	2	0	-9	74	952	9
2	9	19	16	164.9	0.821	1.877	0	1365	1723	-284.9	0.555	2	0.17	5.7	174	10	297	2	0	-9	74	952	5
2	9	19	17	91	0.729	1.563	0	1426	1444	-361	0.555	2	0.23	5.1	179	10	297	2	0	-9	74	952	5
2	9	19	18	5.6	0.928	0.619	0	1428	2050	-8888	0.555	2	0.39	6.7	186	10	295.9	2	0	-9	74	952	9
2	9	19	19	-40.7	0.459	-9	-9	-999	981	201.1	0.555	2	1	3.6	195	10	295.4	2	0	-9	78	952	5
2	9	19	20	-54	0.607	-9	-9	-999	1085	350.4	0.555	2	1	4.6	167	10	294.2	2	0	-9	83	952	5
2	9	19	21	-64	0.983	-9	-9	-999	2239	1259.1	0.555	2	1	7.2	180	10	293.1	2	0	-9	88	952	0
2	9	19	22	-64	0.839	-9	-9	-999	1800	784.8	0.555	2	1	6.2	185	10	292.5	2	0	-9	91	953	2
2	9	19	23	-59.2	0.603	-9	-9	-999	1143	315.4	0.555	2	1	4.6	181	10	292	2	0	-9	94	953	3
2	9	19	24	-59.2	0.603	-9	-9	-999	1079	315.4	0.555	2	1	4.6	183	10	292	2	0	-9	94	953	3

met for max 24-hr impact for case 1b (hs=18ft,JHW) - max impact was at 0E, 30N

Jamestown 2002 **impacting wind direction = 180**

Y	M	D	H	ht flux	fric vel	conv vel	ptg	conv mix	mech mix	M-O	rough	Bowen	albedo	spd	dir	hgt	t(K)	hgt					
2	2	19	1	-42.7	0.382	-9	-9	-999	555	111.8	0.361	1.5	1	3.6	179	10	270.4	2	0	-9	54	960	0
2	2	19	2	-42.7	0.382	-9	-9	-999	543	111.8	0.361	1.5	1	3.6	189	10	270.4	2	0	-9	54	960	0
2	2	19	3	-34.7	0.31	-9	-9	-999	399	73.1	0.361	1.5	1	3.1	188	10	269.2	2	0	-9	59	960	0
2	2	19	4	-41.1	0.385	-9	-9	-999	549	118.7	0.361	1.5	1	3.6	186	10	270.4	2	0	-9	54	960	3
2	2	19	5	-34.7	0.31	-9	-9	-999	399	73.1	0.361	1.5	1	3.1	169	10	269.2	2	0	-9	59	959	0
2	2	19	6	-27	0.404	-9	-9	-999	591	209.7	0.361	1.5	1	3.6	178	10	269.2	2	0	-9	59	959	9
2	2	19	7	-31.3	0.319	-9	-9	-999	418	88.8	0.361	1.5	1	3.1	180	10	269.2	2	0	-9	59	959	5
2	2	19	8	-41.7	0.384	-9	-9	-999	546	115.6	0.361	1.5	0.85	3.6	167	10	269.2	2	0	-9	59	959	0
2	2	19	9	-16.9	0.416	-9	-9	-999	617	364	0.361	1.5	0.64	3.6	184	10	270.9	2	0	-9	51	959	0
2	2	19	10	33.4	0.509	0.35	0.009	44	834	-337.8	0.361	1.5	0.58	4.1	181	10	274.2	2	0	-9	44	959	5
2	2	19	11	27.5	0.565	0.402	0.008	80	975	-559.7	0.361	1.5	0.55	4.6	200	10	277	2	0	-9	39	958	9
2	2	19	12	36.4	0.453	0.517	0.009	130	712	-218.7	0.361	1.5	0.54	3.6	183	10	279.2	2	0	-9	36	957	9
2	2	19	13	39.5	0.511	0.593	0.009	180	840	-288.5	0.361	1.5	0.54	4.1	192	10	280.4	2	0	-9	34	957	9
2	2	19	14	36.8	0.51	0.62	0.009	221	839	-307.7	0.361	1.5	0.54	4.1	202	10	280.4	2	0	-9	34	956	9
2	2	19	15	28.6	0.507	0.596	0.009	253	831	-388.8	0.361	1.5	0.55	4.1	197	10	280.4	2	0	-9	37	957	9
2	2	19	16	15.1	0.329	0.493	0.013	270	456	-199.8	0.361	1.5	0.57	2.6	197	10	280.4	2	0	-9	37	956	9
2	2	19	17	0.1	0.313	0.093	0.013	270	404	-8888	0.361	1.5	0.64	2.6	194	10	280.4	2	0	-9	39	957	9
2	2	19	18	-4.7	0.09	-9	-9	-999	131	13.3	0.361	1.5	0.84	1.5	197	10	280.4	2	0	-9	37	957	9
2	2	19	19	-999	-9	-9	-9	-999	-999	-99999	0.361	1.5	1	0	0	10	280.4	2	0	-9	39	956	9
2	2	19	20	-21.8	0.34	-9	-9	-999	456	153.7	0.361	1.5	1	3.1	170	10	279.2	2	0	-9	42	955	9
2	2	19	21	-25.9	0.406	-9	-9	-999	594	219.7	0.361	1.5	1	3.6	168	10	280.4	2	0	-9	39	955	9
2	2	19	22	-26	0.405	-9	-9	-999	594	217.7	0.361	1.5	1	3.6	169	10	278.1	2	0	-9	57	954	9
2	2	19	23	-28.9	0.536	-9	-9	-999	902	452.9	0.361	1.5	1	4.6	167	10	278.1	2	0	-9	57	954	10
2	2	19	24	-14.9	0.279	-9	-9	-999	400	123.7	0.361	1.5	1	2.6	178	10	280.4	2	0	-9	39	953	10

met for max 24-hr impact for case 1c(hs=10ft, ERI) - max impact was at 0E, 20N

Erie 2000 **impacting wind direction = 180**

Y	M	D	H	ht flux	fric vel	conv vel	ptg	conv mix	mech mix	M-O	rough	Bowen	albedo	spd	dir	hgt	t(K)	hgt					
0	1	1	1	-24.1	0.212	-9	-9	-999	224	34.8	0.31	1.5	1	2.6	181	10	272.5	2	0	-9	92	992	1
0	1	1	2	-41.8	0.363	-9	-9	-999	503	101.3	0.31	1.5	1	3.6	188	10	271.4	2	0	-9	89	992	0
0	1	1	3	-33.8	0.293	-9	-9	-999	367	66.1	0.31	1.5	1	3.1	184	10	271.4	2	0	-9	89	993	0
0	1	1	4	-56.6	0.492	-9	-9	-999	793	185.8	0.31	1.5	1	4.6	193	10	271.4	2	0	-9	89	992	0
0	1	1	5	-63.5	0.554	-9	-9	-999	946	236.1	0.31	1.5	1	5.1	183	10	272	2	0	-9	85	992	0
0	1	1	6	-64	0.617	-9	-9	-999	1114	325.1	0.31	1.5	1	5.6	182	10	272.5	2	0	-9	82	991	0
0	1	1	7	-63.4	0.554	-9	-9	-999	952	236.6	0.31	1.5	1	5.1	215	10	272.5	2	0	-9	79	992	0
0	1	1	8	-63.2	0.554	-9	-9	-999	948	237.8	0.31	1.5	1	5.1	193	10	273.8	2	0	-9	75	992	0
0	1	1	9	-61.9	0.619	-9	-9	-999	1117	338.3	0.31	1.5	0.77	5.6	177	10	275.4	2	0	-9	70	992	0
0	1	1	10	-22.9	0.706	-9	-9	-999	1363	1365	0.31	1.5	0.63	6.2	191	10	277.5	2	0	-9	58	992	0
0	1	1	11	15.2	0.775	-9	-9	-999	1565	-2708	0.31	1.5	0.58	6.7	194	10	279.2	2	0	-9	53	992	0
0	1	1	12	31	0.721	-9	-9	-999	1414	-1071	0.31	1.5	0.56	6.2	196	10	280.9	2	0	-9	44	992	0
0	1	1	13	35.4	0.779	-9	-9	-999	1577	-1177	0.31	1.5	0.56	6.7	223	10	282.5	2	0	-9	38	991	0
0	1	1	14	27.9	0.653	-9	-9	-999	1231	-881.7	0.31	1.5	0.57	5.6	219	10	282.5	2	0	-9	39	991	0
0	1	1	15	9.4	0.591	-9	-9	-999	1050	-1933	0.31	1.5	0.59	5.1	212	10	283.1	2	0	-9	39	991	0
0	1	1	16	-27.7	0.513	-9	-9	-999	850	430.6	0.31	1.5	0.66	4.6	194	10	283.1	2	0	-9	39	992	0
0	1	1	17	-39.5	0.367	-9	-9	-999	526	110.5	0.31	1.5	0.84	3.6	181	10	280.9	2	0	-9	47	991	0
0	1	1	18	-47.8	0.43	-9	-9	-999	648	146.8	0.31	1.5	1	4.1	167	10	280.4	2	0	-9	49	991	0
0	1	1	19	-47.9	0.43	-9	-9	-999	648	146.8	0.31	1.5	1	4.1	184	10	280.4	2	0	-9	52	992	0
0	1	1	20	-54.9	0.493	-9	-9	-999	795	192.9	0.31	1.5	1	4.6	177	10	280.4	2	0	-9	52	992	0
0	1	1	21	-64	0.618	-9	-9	-999	1115	325.5	0.31	1.5	1	5.6	170	10	280.4	2	0	-9	52	992	0
0	1	1	22	-61.7	0.555	-9	-9	-999	954	244.2	0.31	1.5	1	5.1	172	10	280.4	2	0	-9	52	991	0
0	1	1	23	-64	0.617	-9	-9	-999	1114	325.1	0.31	1.5	1	5.6	170	10	280.4	2	0	-9	52	991	0
0	1	1	24	-47.8	0.43	-9	-9	-999	677	146.8	0.31	1.5	1	4.1	180	10	280.4	2	0	-9	56	990	0

met for max 24-hour impact for case 2a(hs=10ft, house,JHW) - max impact was at 28.19E, -10.26N

Jamestown 2002 — **impacting wind direction = 300**

Y	M	D	H	ht flux	fric vel	conv vel	ptg	conv mix	mech mix	M-O	rough	Bowen	albedo	spd	dir	hgt	t(K)	hgt					
2	4	5	1	-15	0.267	-9	-9	-999	318	109.5	0.683	0.55	1	2.1	285	10	270.4	2	0	-9	80	963	10
2	4	5	2	-34.7	0.308	-9	-9	-999	393	72.4	0.683	0.55	1	2.6	291	10	269.2	2	0	-9	74	962	0
2	4	5	3	-23.1	0.345	-9	-9	-999	467	152.9	0.683	0.55	1	2.6	302	10	269.2	2	0	-9	74	962	9
2	4	5	4	-19.9	0.353	-9	-9	-999	482	188.9	0.683	0.55	1	2.6	304	10	268.1	2	0	-9	80	962	10
2	4	5	5	-15	0.267	-9	-9	-999	321	108.9	0.683	0.55	1	2.1	311	10	269.2	2	0	-9	69	962	10
2	4	5	6	-999	-9	-9	-9	-999	-999	-99999	0.683	0.55	1	0	0	10	269.2	2	0	-9	69	962	10
2	4	5	7	-16.8	0.258	-9	-9	-999	302	88.1	0.683	0.55	0.47	2.1	305	10	269.2	2	0	-9	74	962	3
2	4	5	8	14.4	0.4	0.511	0.005	317	582	-382.4	0.683	0.55	0.25	2.6	300	10	270.4	2	0	-9	69	962	9
2	4	5	9	36.3	0.483	0.894	0.005	674	772	-266.4	0.683	0.55	0.17	3.1	288	10	270.4	2	0	-9	64	962	9
2	4	5	10	54.6	0.56	1.098	0.005	831	964	-276.5	0.683	0.55	0.15	3.6	334	10	270.9	2	0	-9	64	962	9
2	4	5	11	67.9	0.635	1.267	0.005	1029	1161	-322.8	0.683	0.55	0.14	4.1	295	10	272	2	0	-9	59	961	9
2	4	5	12	75.7	0.865	1.403	0.009	1251	1846	-731.6	0.683	0.55	0.14	5.7	292	10	273.1	2	0	-9	51	960	9
2	4	5	13	36.8	0.415	1.124	0.005	1319	858	-165.6	0.683	0.55	0.14	2.6	283	10	272	2	0	-9	55	960	10
2	4	5	14	34.8	0.413	1.12	0.007	1380	619	-173.8	0.683	0.55	0.14	2.6	335	10	272	2	0	-9	64	959	10
2	4	5	15	29.7	0.48	1.076	0.009	1433	764	-317.9	0.683	0.55	0.14	3.1	266	10	272	2	0	-9	75	959	10
2	4	5	16	21.8	0.476	0.979	0.01	1469	755	-421.9	0.683	0.55	0.15	3.1	300	10	270.9	2	22	-9	86	958	10
2	4	5	17	11.5	0.616	0.794	0.01	1490	1110	-1737.7	0.683	0.55	0.19	4.1	332	10	270.9	2	0	-9	80	958	10
2	4	5	18	-8.4	-9	-9	-9	-999	-999	-99999	0.683	0.55	0.29	0	0	10	270.9	2	22	-9	86	958	10
2	4	5	19	-28.4	0.513	-9	-9	-999	845	406.4	0.683	0.55	0.62	3.6	312	10	270.4	2	22	-9	86	958	10
2	4	5	20	-37.2	0.667	-9	-9	-999	1252	681.8	0.683	0.55	1	4.6	314	10	270.4	2	22	-9	93	959	10
2	4	5	21	-39	0.586	-9	-9	-999	1040	442.3	0.683	0.55	1	4.1	304	10	270.4	2	0	-9	80	959	9
2	4	5	22	-24.3	0.434	-9	-9	-999	676	287	0.683	0.55	1	3.1	299	10	269.2	2	22	-9	86	959	10
2	4	5	23	-49.4	0.74	-9	-9	-999	1465	702.5	0.683	0.55	1	5.1	301	10	269.2	2	0	-9	86	959	9
2	4	5	24	-28.5	0.428	-9	-9	-999	744	234.8	0.683	0.55	1	3.1	314	10	269.2	2	0	-9	86	958	9

met for max downwind 24-hr impact, run 2r (hs=10ft, house west, JHW) - max impact was at 9.85E, -1.74N

Jamestown 2002 — **impacting wind direction = 280**

Y	M	D	H	ht flux	fric vel	conv vel	ptg	conv mix	mech mix	M-O	rough	Bowen	albedo	spd	dir	hgt	t(K)	hgt					
2	2	#	1	-29.5	0.536	-9	-9	-999	902	440.3	0.361	1.5	1	4.6	266	10	270.9	2	0	-9	93	948	10
2	2	#	2	-40.4	0.733	-9	-9	-999	1442	825.2	0.361	1.5	1	6.2	250	10	270.9	2	0	-9	93	948	10
2	2	#	3	-37	0.672	-9	-9	-999	1273	692.7	0.361	1.5	1	5.7	250	10	270.9	2	0	-9	93	948	10
2	2	#	4	-40.4	0.733	-9	-9	-999	1441	825.2	0.361	1.5	1	6.2	266	10	270.9	2	0	-9	86	948	10
2	2	#	5	-37	0.672	-9	-9	-999	1272	692.7	0.361	1.5	1	5.7	254	10	270.9	2	0	-9	86	949	10
2	2	#	6	-33	0.598	-9	-9	-999	1070	548.4	0.361	1.5	1	5.1	260	10	270.9	2	0	-9	86	950	10
2	2	#	7	-29.6	0.536	-9	-9	-999	906	440.3	0.361	1.5	1	4.6	265	10	270.9	2	0	-9	86	950	10
2	2	#	8	-37.4	0.734	-9	-9	-999	1446	897.4	0.361	1.5	0.82	6.2	280	10	270.9	2	0	-9	93	951	10
2	2	#	9	0.1	0.554	0.011	0.005	0	980	-8888	0.361	1.5	0.63	4.6	274	10	270.9	2	22	-9	93	951	10
2	2	#	10	1.2	0.494	0.058	0.005	5	804	-8496.4	0.361	1.5	0.57	4.1	277	10	270.9	2	22	-9	86	952	10
2	2	#	11	8.3	0.557	0.215	0.005	40	956	-1764.8	0.361	1.5	0.55	4.6	284	10	270.4	2	22	-9	93	952	10
2	2	#	12	12.8	0.75	0.328	0.01	93	1491	-2804.8	0.361	1.5	0.54	6.2	276	10	270.4	2	22	-9	93	953	10
2	2	#	13	14.3	0.81	0.401	0.009	153	1672	-3159.9	0.361	1.5	0.54	6.7	279	10	270.4	2	22	-9	80	953	10
2	2	#	14	12.8	0.5	0.428	0.005	206	913	-828.5	0.361	1.5	0.54	4.1	284	10	270.4	2	22	-9	80	953	10
2	2	#	15	8.4	0.617	0.391	0.005	241	1113	-2364.1	0.361	1.5	0.55	5.1	274	10	269.2	2	22	-9	86	953	10
2	2	#	16	1.4	0.434	0.214	0.006	246	686	-5160.1	0.361	1.5	0.57	3.6	292	10	269.2	2	22	-9	86	953	10
2	2	#	17	0.1	0.614	0.09	0.005	246	1106	-8888	0.361	1.5	0.63	5.1	293	10	269.2	2	22	-9	80	954	10
2	2	#	18	-24.1	0.475	-9	-9	-999	769	378.1	0.361	1.5	0.81	4.1	301	10	269.2	2	22	-9	86	955	10
2	2	#	19	-22.9	0.409	-9	-9	-999	606	255.7	0.361	1.5	1	3.6	308	10	269.2	2	22	-9	80	955	10
2	2	#	20	-22.9	0.409	-9	-9	-999	603	255.7	0.361	1.5	1	3.6	286	10	269.2	2	0	-9	86	956	10
2	2	#	21	-29.9	0.535	-9	-9	-999	901	437.4	0.361	1.5	1	4.6	296	10	269.2	2	22	-9	80	956	10
2	2	#	22	-26.4	0.473	-9	-9	-999	751	341	0.361	1.5	1	4.1	269	10	269.2	2	22	-9	86	956	10
2	2	#	23	-30.1	0.535	-9	-9	-999	900	435.5	0.361	1.5	1	4.6	275	10	268.1	2	0	-9	86	956	10
2	2	#	24	-26.6	0.473	-9	-9	-999	751	338	0.361	1.5	1	4.1	257	10	267	2	0	-9	86	956	10

met for max downwind 24-hr impact, run 2o(hs=10ft,house,SYR) - max impact was at -9.4E, 3.42N

Syracuse 1992 **impacting wind direction = 110**

Y	M	D	H	ht flux	fric vel	conv vel	ptg	conv mix	mech mix	M-O	rough	Bowen	albedo	spd	dir	hgt	t(K)	hgt				
92	1	27	1	-9.7	0.157	-9	-9	-999	146	36	0.34	1.54	1	1.5	111	6.4	258.1	2	0	-9	999	1013	10
92	1	27	2	-24.9	0.404	-9	-9	-999	591	239.3	0.34	1.54	1	3.1	112	6.4	258.8	2	0	-9	999	1013	10
92	1	27	3	-15.8	0.257	-9	-9	-999	313	97.3	0.34	1.54	1	2.1	91	6.4	259.2	2	0	-9	999	1013	10
92	1	27	4	-31.8	0.316	-9	-9	-999	408	89.6	0.34	1.54	1	2.6	111	6.4	259.9	2	0	-9	999	1013	6
92	1	27	5	-33.2	0.357	-9	-9	-999	491	124	0.45	1.5	1	2.6	88	6.4	259.2	2	0	-9	999	1013	7
92	1	27	6	-33.1	0.397	-9	-9	-999	575	171.1	0.34	1.54	1	3.1	111	6.4	260.4	2	0	-9	999	1013	8
92	1	27	7	-29.1	0.401	-9	-9	-999	583	199.3	0.34	1.54	1	3.1	97	6.4	260.9	2	0	-9	999	1013	9
92	1	27	8	-20.2	0.332	-9	-9	-999	443	163.9	0.34	1.54	1	2.6	100	6.4	262	2	0	-9	999	1013	10
92	1	27	9	-17.4	0.482	-9	-9	-999	768	578.3	0.34	1.54	0.71	3.6	111	6.4	262.5	2	0	-9	999	1013	10
92	1	27	10	0.1	0.559	0.012	0.018	1	960	-8888	0.34	1.54	0.6	4.1	112	6.4	264.9	2	0	-9	999	1013	10
92	1	27	11	1.1	0.559	0.063	0.018	8	961	-8888	0.34	1.54	0.56	4.1	103	6.4	266.4	2	0	-9	999	1013	10
92	1	27	12	6.1	0.769	0.198	0.005	46	1550	-6769.9	0.45	1.5	0.53	5.1	80	6.4	267.5	2	0	-9	999	1013	10
92	1	27	13	59.3	0.704	0.74	0.006	246	1367	-531.8	0.45	1.5	0.53	4.6	76	6.4	268.8	2	0	-9	999	1013	5
92	1	27	14	51.9	0.865	0.815	0.005	377	1847	-1128.1	0.45	1.5	0.53	5.7	77	6.4	269.9	2	0	-9	999	1013	3
92	1	27	15	0.1	0.559	0.102	0.009	378	1061	-8888	0.34	1.54	0.57	4.1	94	6.4	270.4	2	0	-9	999	1013	10
92	1	27	16	7.1	0.62	0.426	0.008	395	1121	-3047.4	0.45	1.5	0.6	4.1	86	6.4	269.9	2	0	-9	999	1013	5
92	1	27	17	-34.9	0.472	-9	-9	-999	763	272	0.34	1.54	0.75	3.6	98	6.4	269.9	2	0	-9	999	1013	6
92	1	27	18	-32.4	0.546	-9	-9	-999	926	453.3	0.34	1.54	1	4.1	111	6.4	268.8	2	0	-9	999	1013	10
92	1	27	19	-26.7	0.449	-9	-9	-999	700	307.6	0.45	1.5	1	3.1	76	6.4	268.8	2	0	-9	999	1013	10
92	1	27	20	-19.8	0.333	-9	-9	-999	450	168.6	0.34	1.54	1	2.6	96	6.4	268.8	2	0	-9	999	1013	10
92	1	27	21	-24	0.405	-9	-9	-999	592	249.5	0.34	1.54	1	3.1	108	6.4	268.8	2	0	-9	999	1013	10
92	1	27	22	-19.8	0.333	-9	-9	-999	444	168.6	0.34	1.54	1	2.6	91	6.4	268.8	2	0	-9	999	1013	10
92	1	27	23	-19.8	0.333	-9	-9	-999	442	168.6	0.34	1.54	1	2.6	96	6.4	268.8	2	0	-9	999	1013	10
92	1	27	24	-22	0.37	-9	-9	-999	518	208.8	0.45	1.5	1	2.6	76	6.4	268.8	2	0	-9	999	1013	10

met for max 24-hr impact for case 3a (hs=10ft, barn, JHW) - max impact was at -3.42E, 9.4N

Jamestown 2002 **impacting wind direction = 160**

Y	M	D	H	ht flux	fric vel	conv vel	ptg	conv mix	mech mix	M-O	rough	Bowen	albedo	spd	dir	hgt	t(K)	hgt				
2	9	1	1	-47.5	0.451	-9	-9	-999	730	166.9	0.555	2	1	3.6	170	10	289.2	2	0	-9	72	967	0
2	9	1	2	-55.7	0.527	-9	-9	-999	879	226.7	0.555	2	1	4.1	184	10	288.1	2	0	-9	77	966	0
2	9	1	3	-47.8	0.451	-9	-9	-999	701	165.3	0.555	2	1	3.6	168	10	287	2	0	-9	82	966	0
2	9	1	4	-15.3	0.145	-9	-9	-999	256	17.2	0.555	2	1	2.1	168	10	287	2	0	-9	82	966	0
2	9	1	5	-7.8	0.104	-9	-9	-999	87	12.3	0.555	2	1	1.5	154	10	285.9	2	0	-9	94	966	0
2	9	1	6	-15.4	0.145	-9	-9	-999	127	17.2	0.555	2	1	2.1	168	10	285.9	2	0	-9	94	966	0
2	9	1	7	-11	0.341	-9	-9	-999	458	310.7	0.555	2	0.41	2.6	174	10	287	2	0	-9	94	966	0
2	9	1	8	84.2	0.727	0.834	0.005	237	1425	-393.1	0.555	2	0.23	5.1	166	10	289.2	2	0	-9	83	966	3
2	9	1	9	168	0.743	1.304	0.005	455	1473	-210.6	0.555	2	0.17	5.1	184	10	290.4	2	0	-9	77	966	3
2	9	1	10	237.2	0.691	1.751	0.005	781	1327	-119.8	0.555	2	0.16	4.6	186	10	292	2	0	-9	68	966	3
2	9	1	11	274.6	0.697	2.048	0.005	1078	1338	-106	0.555	2	0.15	4.6	202	10	293.1	2	0	-9	64	965	5
2	9	1	12	154.3	0.551	1.749	0.007	1195	960	-93	0.555	2	0.15	3.6	144	10	294.2	2	0	-9	64	964	9
2	9	1	13	157.7	0.678	1.799	0.006	1271	1281	-169.5	0.555	2	0.15	4.6	161	10	294.9	2	0	-9	63	964	9
2	9	1	14	150.5	0.818	1.804	0.005	1343	1698	-312.7	0.555	2	0.15	5.7	183	10	295.4	2	0	-9	61	963	9
2	9	1	15	132.4	0.881	1.755	0.005	1404	1897	-443.3	0.555	2	0.15	6.2	178	10	295.4	2	0	-9	61	962	9
2	9	1	16	104.5	0.944	1.64	0.008	1448	2102	-689.3	0.555	2	0.16	6.7	188	10	295.4	2	0	-9	61	962	9
2	9	1	17	66.7	0.464	1.419	0.005	1471	1007	-128.2	0.555	2	0.19	3.1	168	10	293.1	2	0	-9	69	962	9
2	9	1	18	49.7	0.587	1.293	0.005	1492	1033	-347.8	0.555	2	0.28	4.1	171	10	293.1	2	0	-9	69	961	5
2	9	1	19	-999	-9	-9	-9	-999	-999	-99999	0.555	2	0.57	0	0	10	290.9	2	0	-9	78	961	0
2	9	1	20	-999	-9	-9	-9	-999	-999	-99999	0.555	2	1	0	0	10	290.4	2	0	-9	83	961	0
2	9	1	21	-47.1	0.452	-9	-9	-999	698	167.7	0.555	2	1	3.6	159	10	290.4	2	0	-9	83	961	0
2	9	1	22	-52.9	0.529	-9	-9	-999	885	240.2	0.555	2	1	4.1	183	10	289.2	2	0	-9	88	961	3
2	9	1	23	-29.3	0.471	-9	-9	-999	748	306.1	0.555	2	1	3.6	182	10	289.2	2	0	-9	88	961	9
2	9	1	24	-36.1	0.69	-9	-9	-999	1319	780.9	0.555	2	1	5.1	166	10	289.2	2	0	-9	88	960	10