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

[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.

APPENDIX A: DETAILS OF MODELING RESULTS

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.

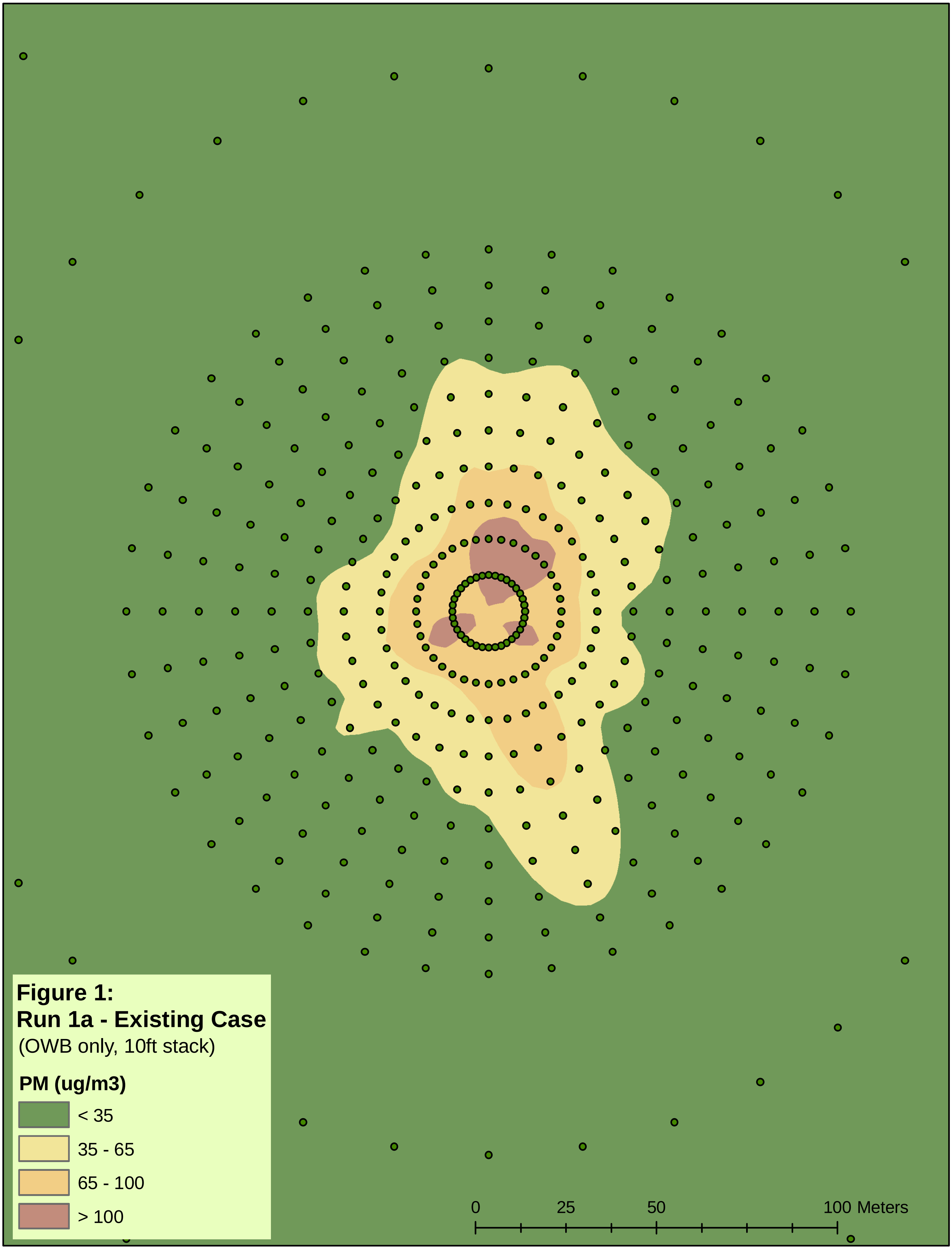


Figure 1:
Run 1a - Existing Case
(OWB only, 10ft stack)

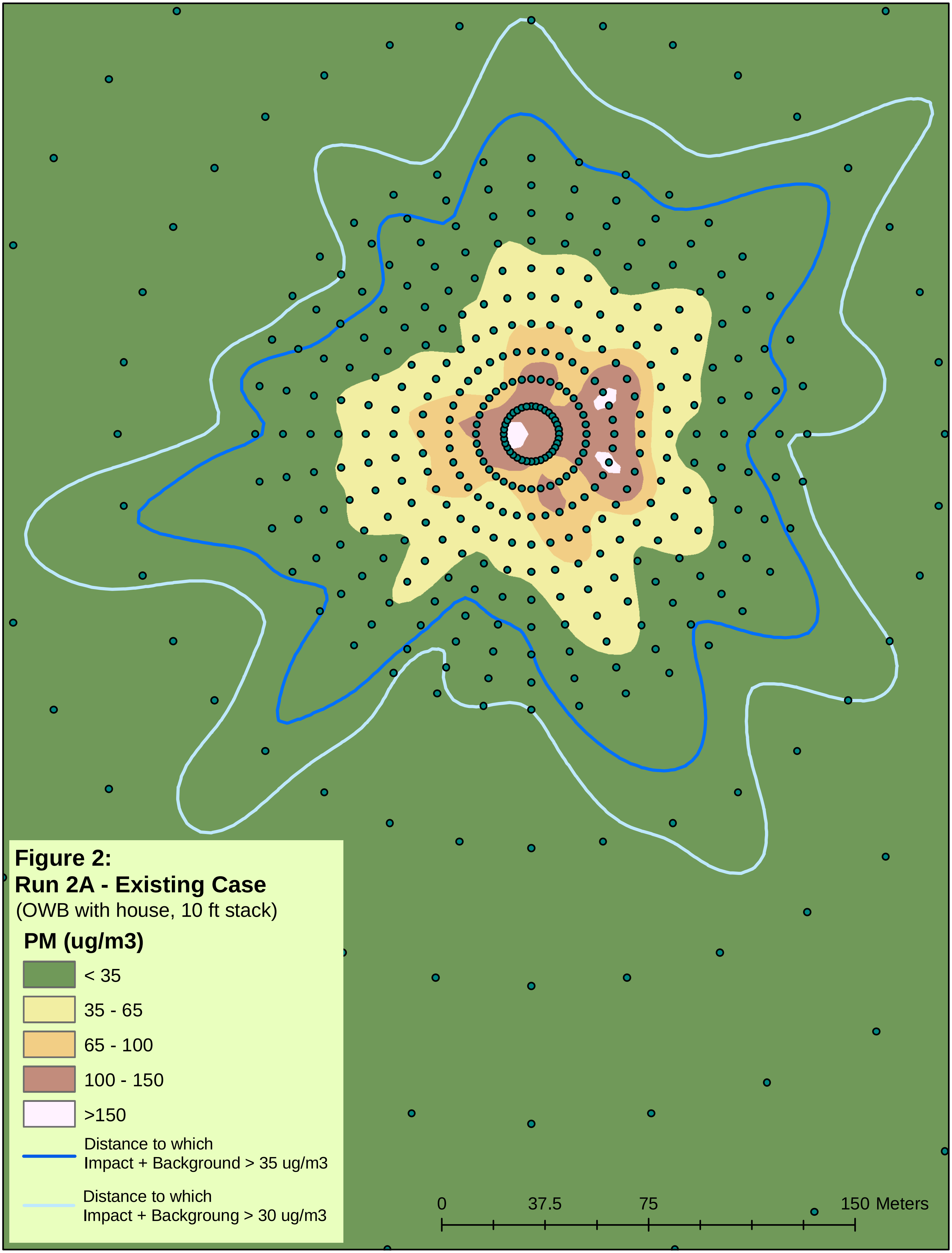


Figure 2:
Run 2A - Existing Case
(OWB with house, 10 ft stack)

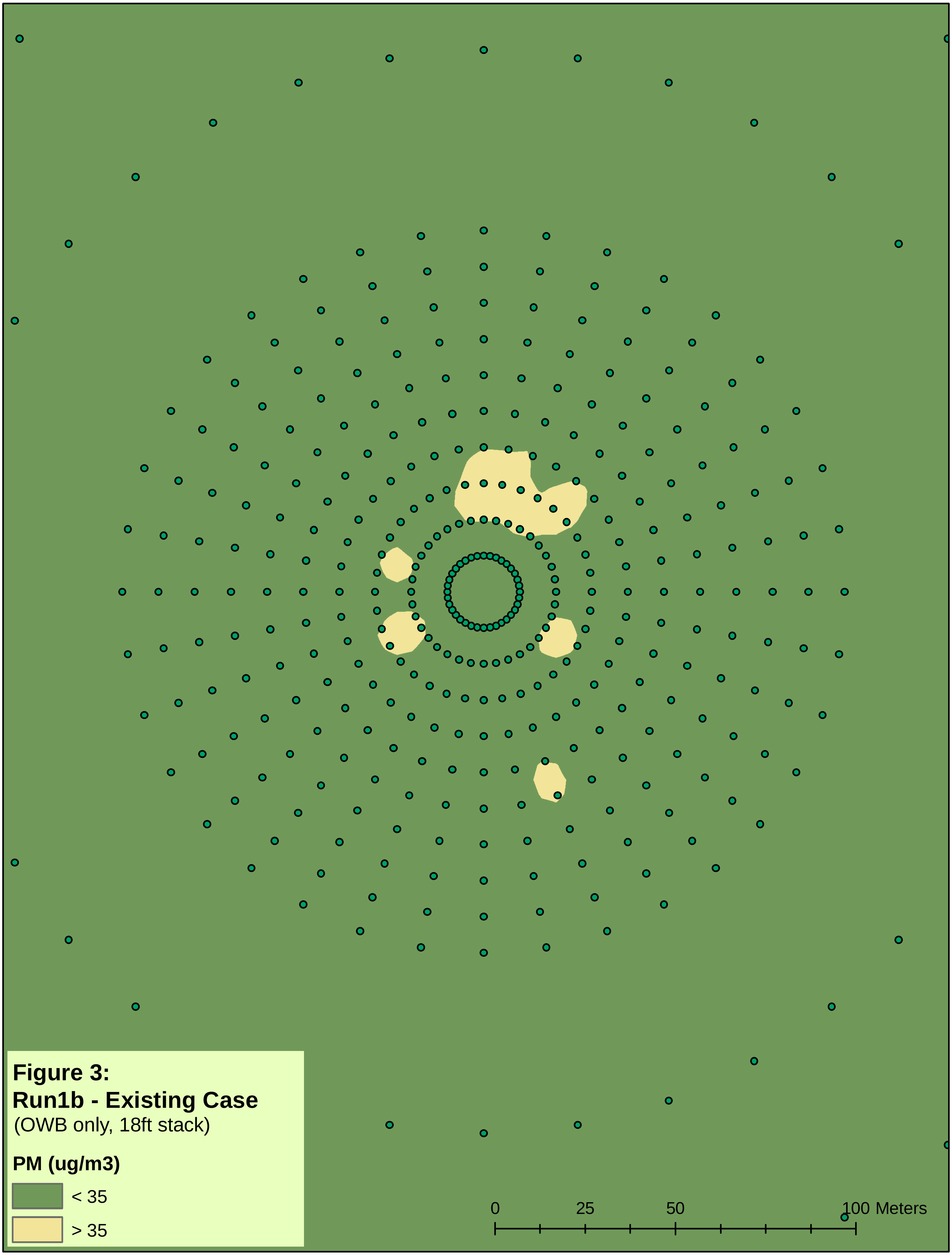


Figure 3:
Run1b - Existing Case
(OWB only, 18ft stack)

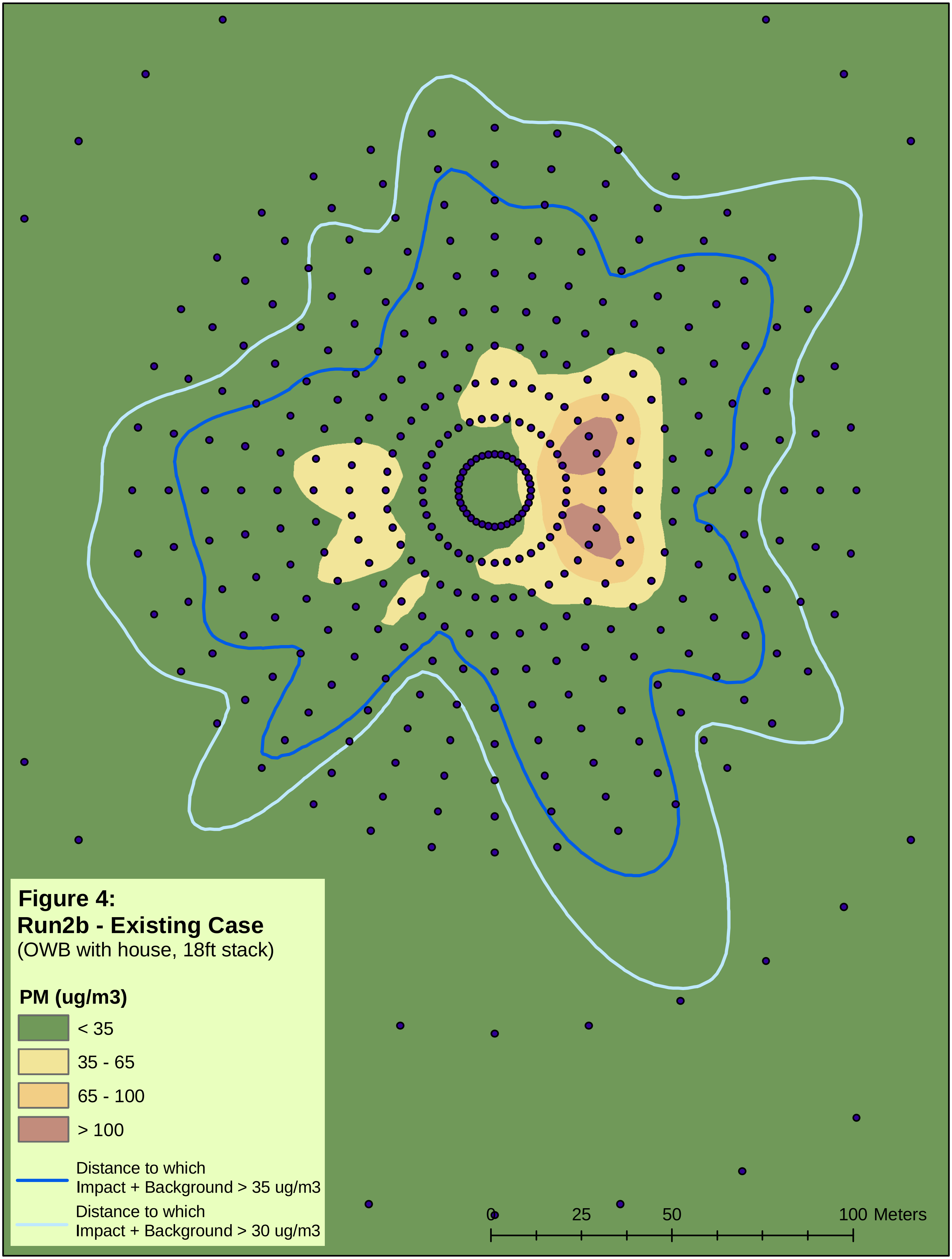


Figure 4:
Run2b - Existing Case
(OWB with house, 18ft stack)
PM (ug/m3)
< 35
35 - 65
65 - 100
> 100
Distance to which
Impact + Background > 35 ug/m3
Distance to which
Impact + Background > 30 ug/m3
0
25
50
100 Meters

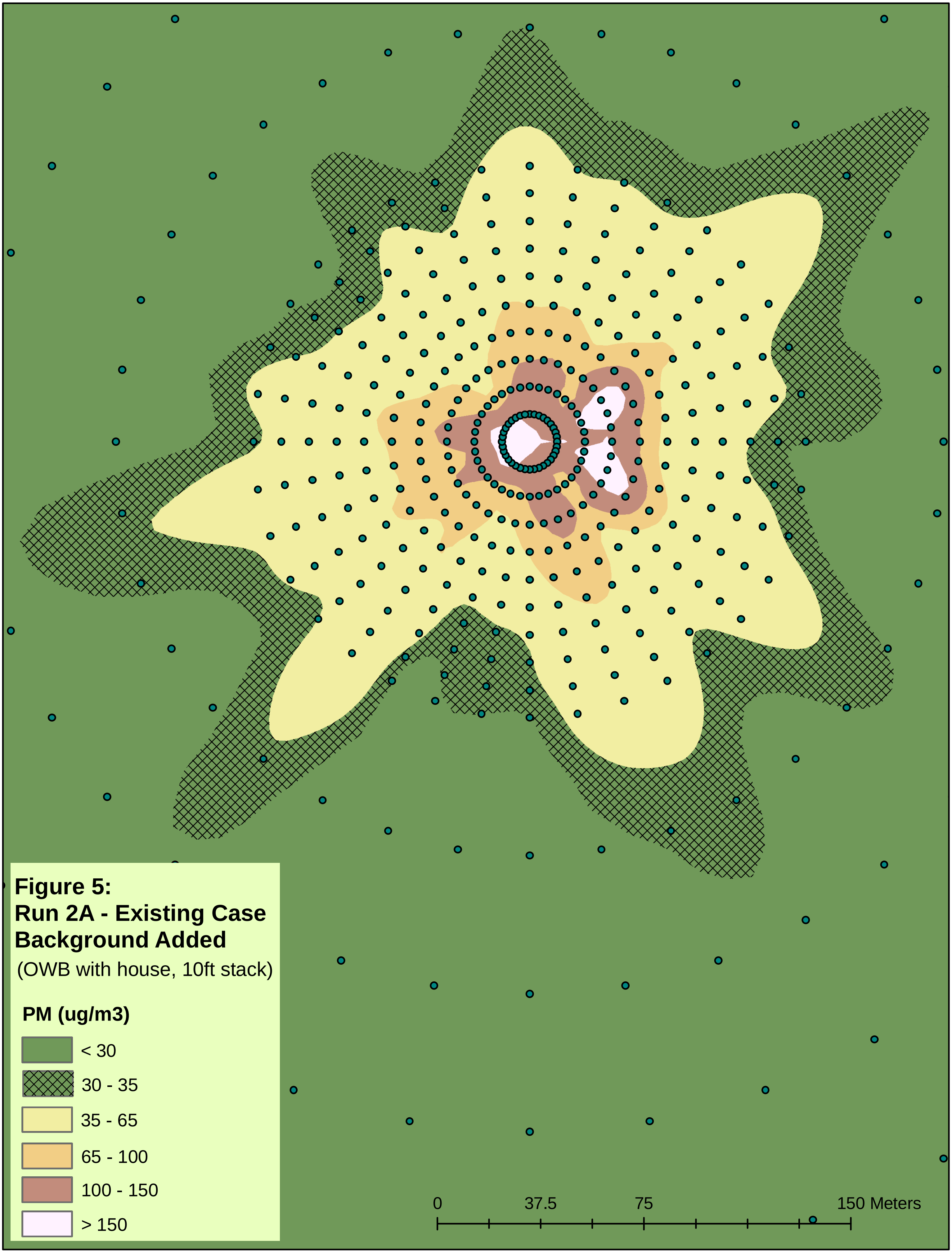


Figure 5:
Run 2A - Existing Case
Background Added
(OWB with house, 10ft stack)
PM (ug/m3)
< 30
30 - 35
35 - 65
65 - 100
100 - 150
> 150
0
37.5
75
150 Meters

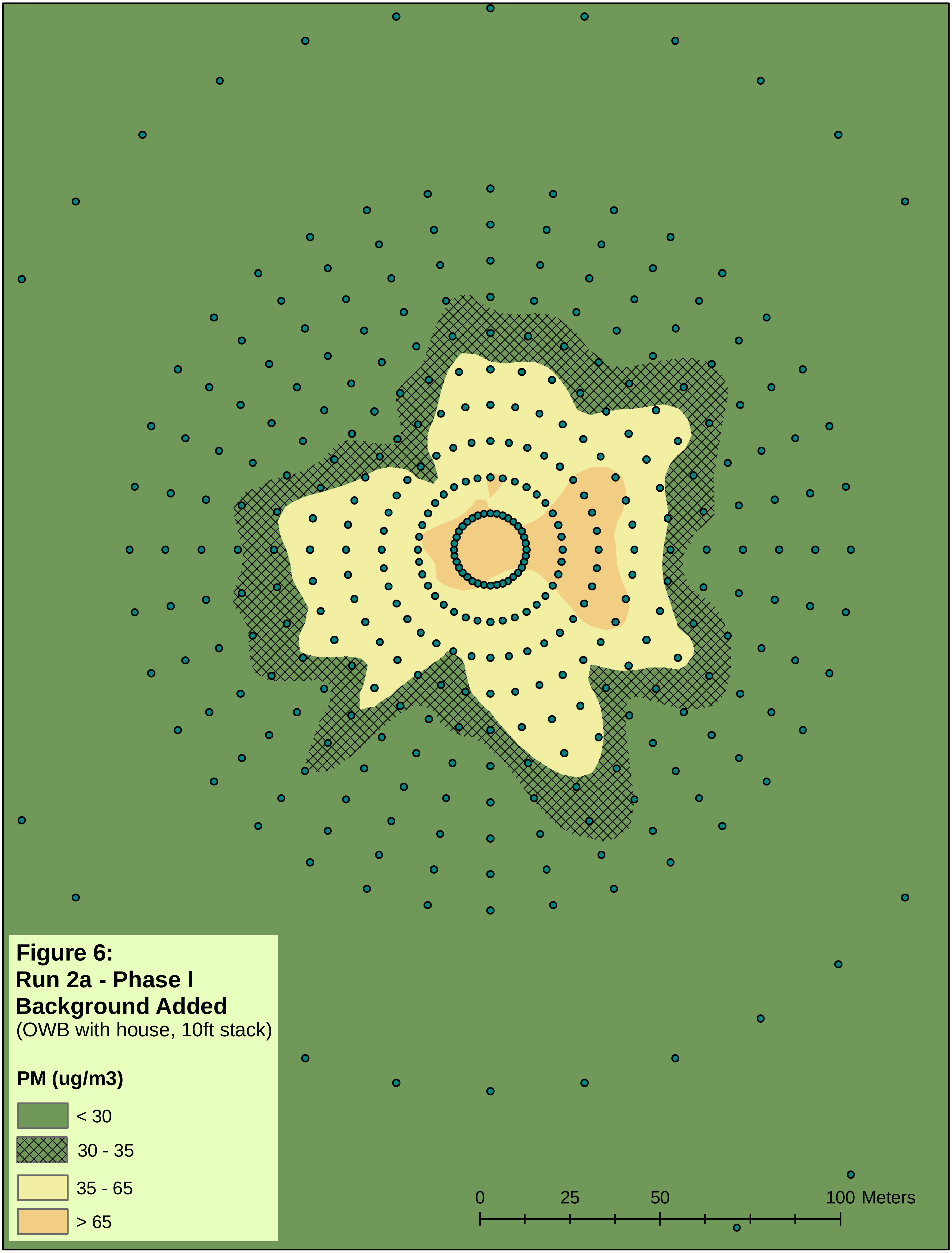


Figure 6:
Run 2a - Phase I
Background Added
(OWB with house, 10ft stack)

PM (ug/m3)

< 30
30 - 35
35 - 65
> 65

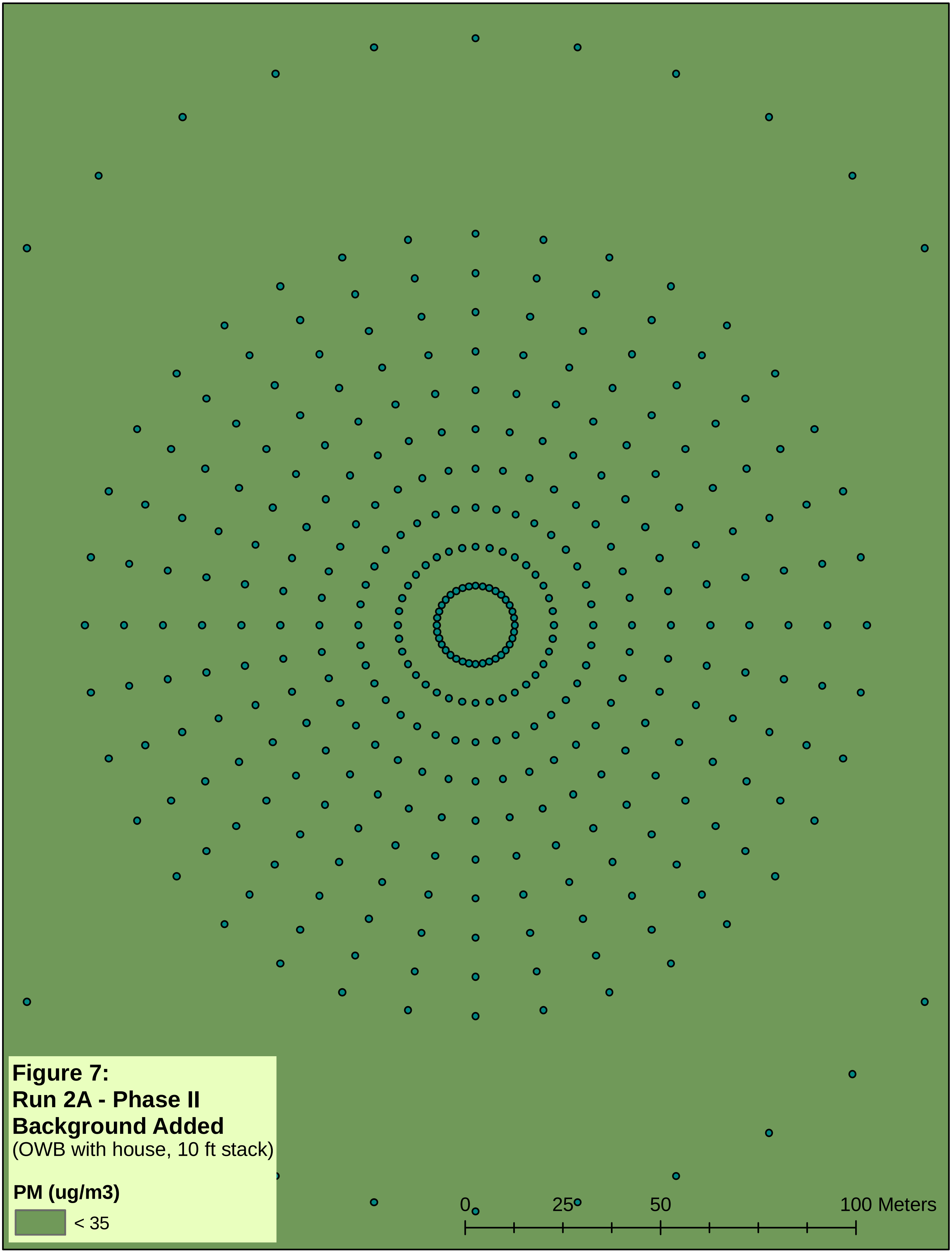


Figure 7:
Run 2A - Phase II
Background Added
(OWB with house, 10 ft stack)

APPENDIX B:

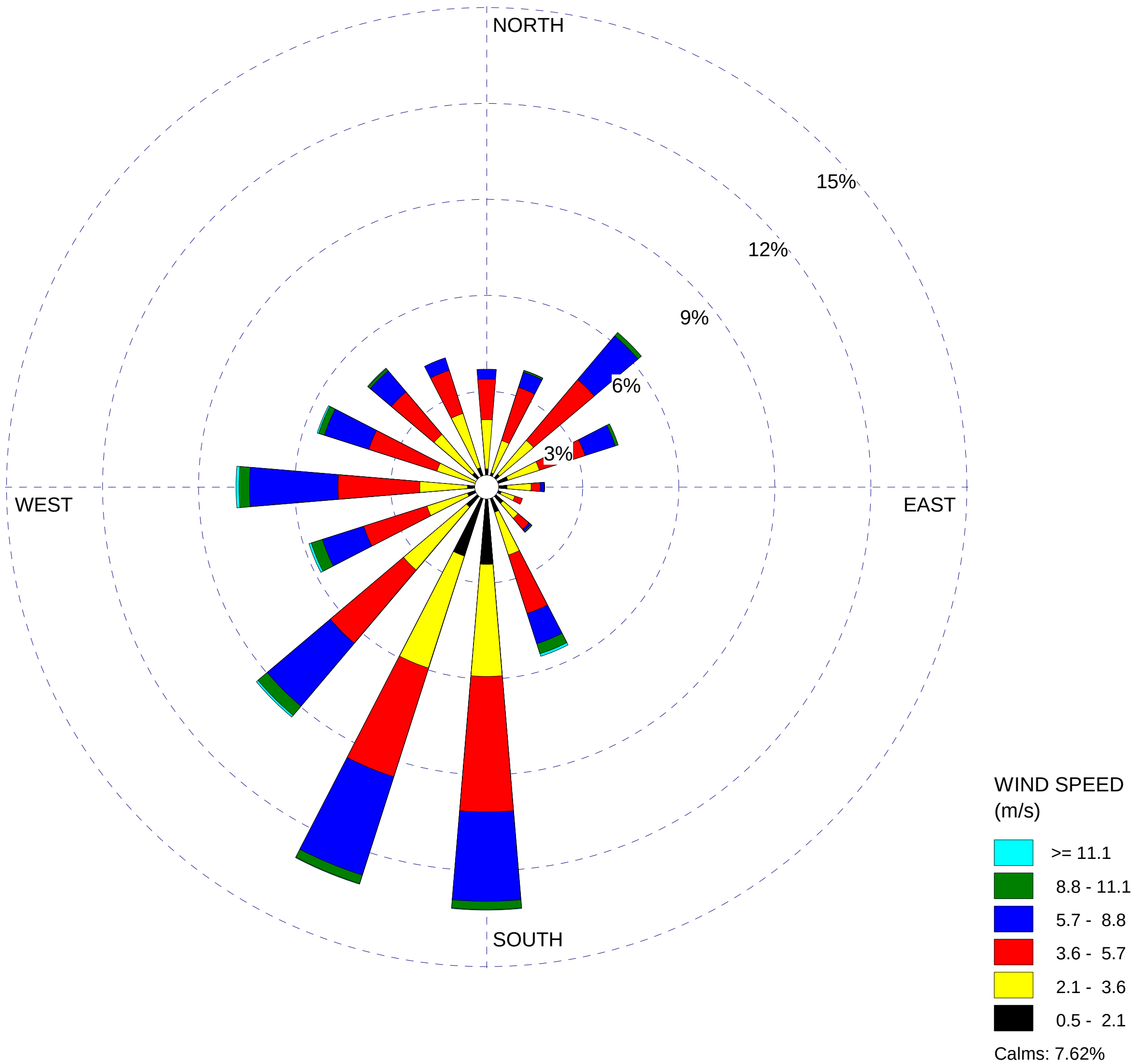
METEOROLOGICAL DATA FOR SELECT DAYS ASSOCIATED WITH MAXIMUM IMPACTS

WIND ROSE PLOT:

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

DISPLAY:

Wind Speed
Direction (blowing from)



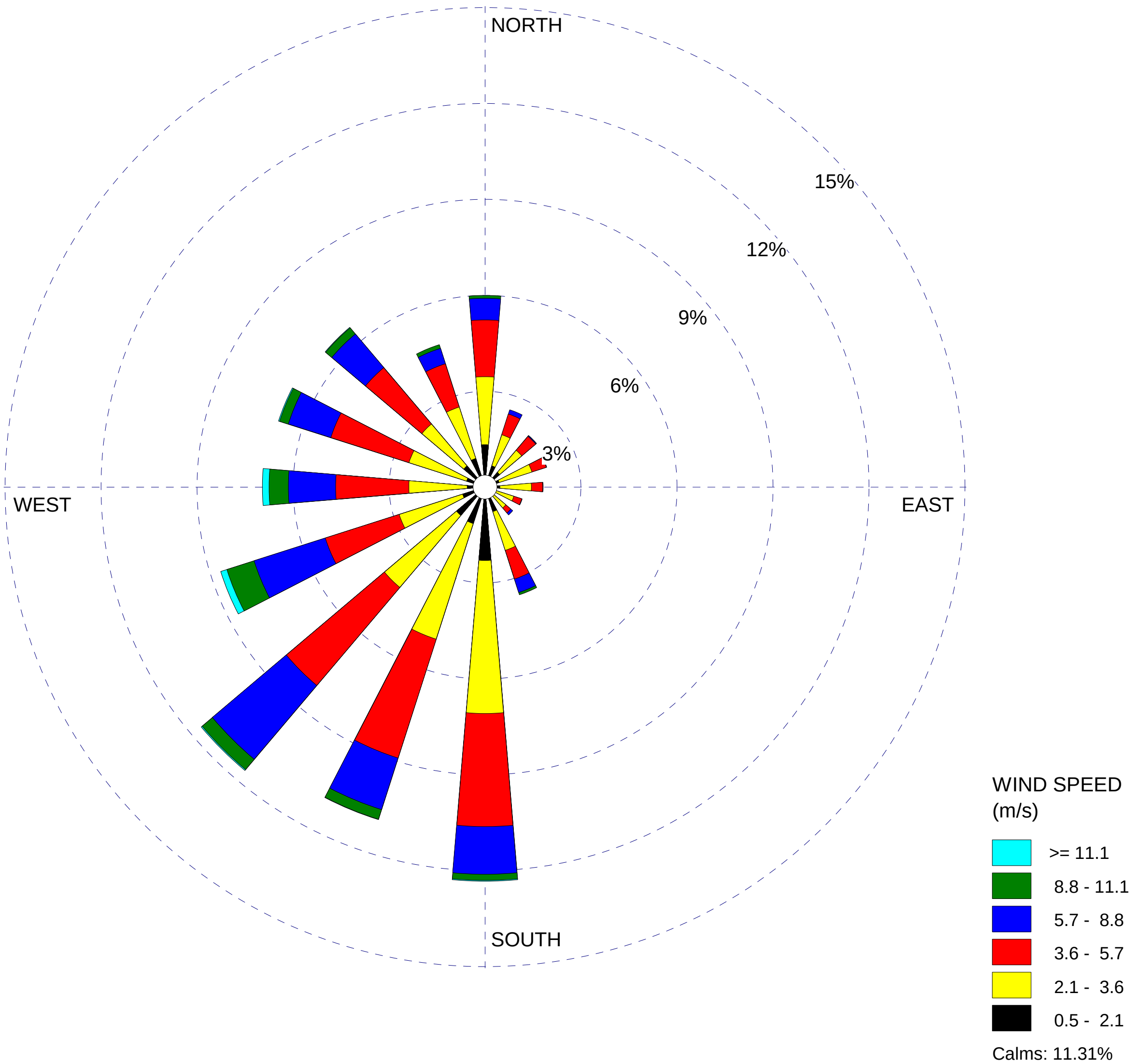
COMMENTS:	DATA PERIOD:	COMPANY NAME:	
	2000 **Jan 1 - Dec 31** **00:00 - 23:00**		
	CALM WINDS: **7.62%**	TOTAL COUNT: **8784 hrs.**	
	AVG. WIND SPEED: **4.24 m/s**		PROJECT NO.:

WIND ROSE PLOT: JAMESTOWN, N.Y.

Station #72523

DISPLAY:

Wind Speed
Direction (blowing from)



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

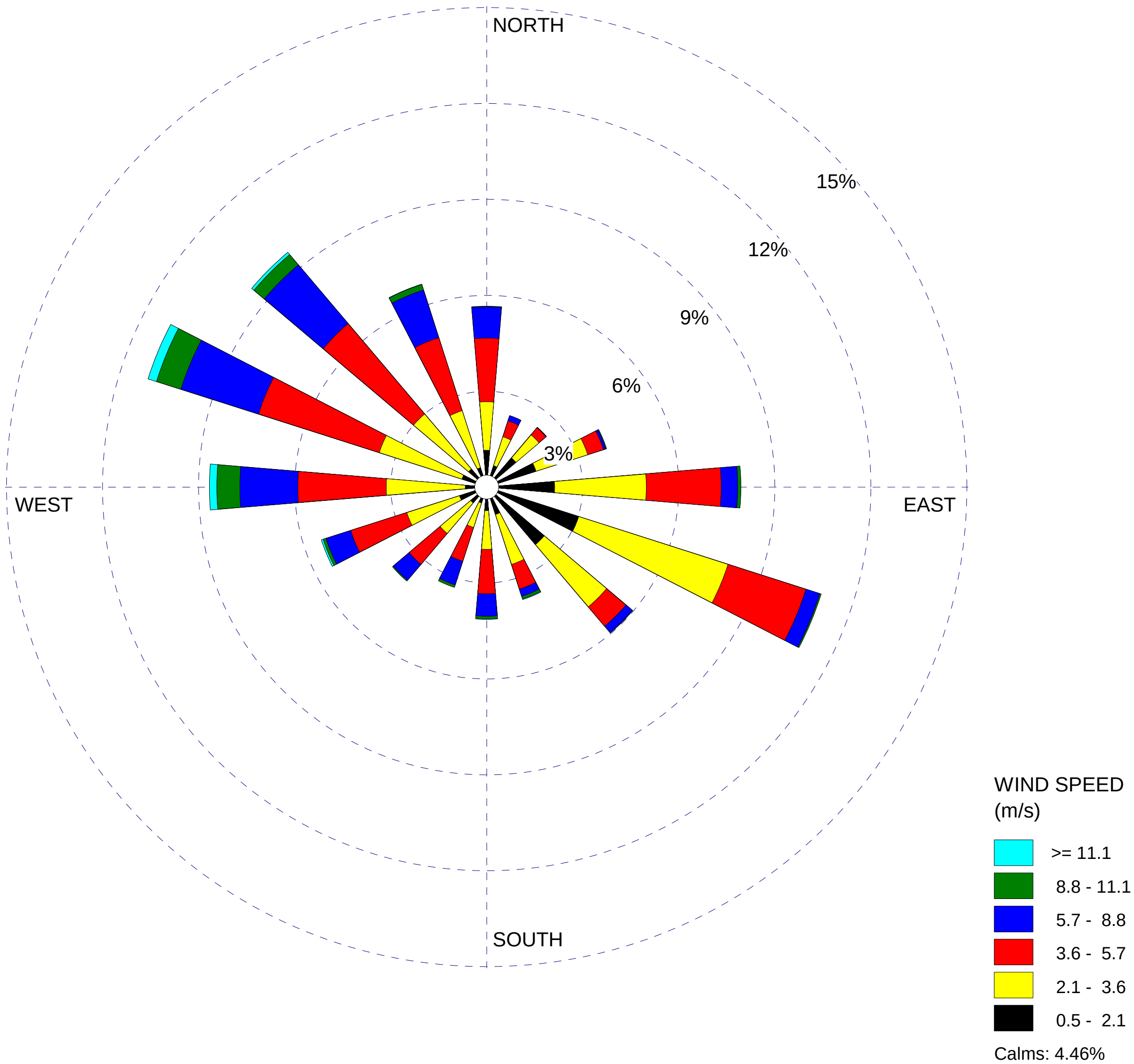
WRPLOT View - Lakes Environmental Software

WIND ROSE PLOT:

Station #14771 - SYRACUSE/HANCOCK INT'L ARPT, NY

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:

DATA PERIOD:

1992
Jan 1 - Dec 31
00:00 - 23:00

COMPANY NAME:

CALM WINDS:

4.46%

TOTAL COUNT:

8784 hrs.

AVG. WIND SPEED:

3.97 m/s

PROJECT NO.:

WRPLOT View - Lakes Environmental Software