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Reevaluation of Air Surveillance Station Siting

Background

DOE Technical Standard HDBK-1216-2015 (DOE 2015) recommends evaluating air-monitoring station placement using the analytical method developed by Waite (Waite, 1973). The technique utilizes wind rose and population distribution data in order to determine a weighting factor for each directional sector surrounding a nuclear facility. Based on the available resources (number of stations) and a scaling factor, this weighting factor is used to determine the number of stations recommended to be placed in each sector considered. An assessment utilizing this method was performed in 2003 to evaluate the effectiveness of the existing SRS air-monitoring program. The resulting recommended distribution of air-monitoring stations was then compared to that of the existing site perimeter surveillance program (Fledderman 2003). The assessment demonstrated that the distribution of air-monitoring stations at the time generally agreed with the results obtained using the Waite method; however at the time new stations were established in Barnwell and in Williston in order to meet requirements of DOE guidance document EH-0173T.

Using the original Waite method (Equation 1), the effect of the population distribution on the weighting factor is significantly diminished for sites with a radius larger than 10 miles, and carries very little impact on the weighting factor in comparison to the fraction of time that the sector is downwind of the source.

$$\text{Weighting Factor (W)} = \frac{\text{fraction of total population}}{\text{distance}} + \text{fraction of time sector is downwind from source}$$

Equation 1. Original Waite Method Weighting Factor

Current Study

An evaluation of the current air surveillance program at SRS was performed using a modified version of the Waite method. The model input parameters for this evaluation consist of the 2007-2011 wind rose from the H-Area meteorological tower and the population distribution obtained from the 2010 census (population data are measured from the center of site). This evaluation was performed out to a 50-mile radius from H-Area (where the release is assumed to take place), as opposed to the 10-mile radius utilized in the 2003 evaluation, as the majority of the surrounding population resides between 20 and 40 miles from the SRS center of site.

Using the original method, any population beyond the range limit of 10 miles was not factored into the placement of air monitoring stations. For smaller facilities, such as nuclear reactors, this would not be an issue as the site is small enough that a 10-mile radius would give a representative sample of the population distribution. However, for a facility on the scale of SRS, where the population distribution may not even become concentrated until close to the 10-mile range limit, maintaining this limited distance range neglects a large percentage of the population that could be affected by potential releases from the site.

A modified version of the Waite method was created for this study wherein the weighting factor is dependent only on the wind direction and frequency, and the population distribution in each sector, with the population percentage being half as important as the wind frequency. A map of the site with the directional sectors and wind rose from H-Area overlaid may be seen in Figure 1 of the appendix. The modified version of the Waite method weighting factor as applied to each sector in this evaluation is shown in Equation 2.

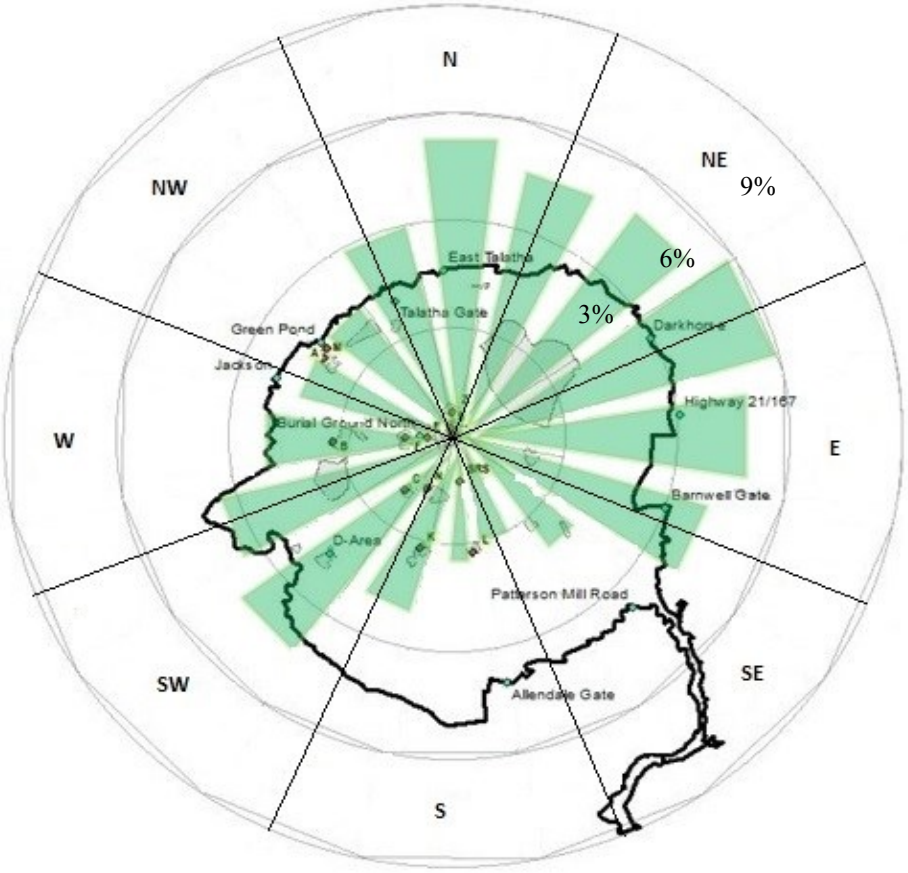

Figure 1. Map of Savannah River Site with H-Area Wind Rose (In direction in which wind blows)

$$\text{Weighting Factor (W)} = \frac{\text{fraction of total population}}{2} + \text{fraction of time sector is downwind of source}$$

Equation 2. Modified Waite Method Weighting Factor

Table 1 shows a comparison between the scaled weighting factors for the 2003 study and the scale weighting factors for the 2016 study. Changes between the two generally result from changes in population distribution.

Sector	Scaled Weighting Factor (2003)		Scaled Weighting Factor (2016)		Scaled Modified Weighting Factor (2016)	
# of samplers	10	9*	10	9	10	9
NW	1.3267	N/A	1.5387	1.3848	2.0789	1.8710
N	1.5368	N/A	1.5228	1.3705	1.7525	1.5527
NE	1.5228	N/A	1.6022	1.4420	1.2906	1.1615
E	1.6061	N/A	0.7441	0.6697	1.4033	1.2629
SE	0.7481	N/A	0.7677	0.6909	0.6117	0.5885
S	0.7740	N/A	1.4533	1.3079	0.6059	0.5825
SW	1.4435	N/A	1.0474	0.9427	1.1450	1.0991
W	1.0419	N/A	1.3234	1.1910	1.1389	1.0250

* The 2003 study was only performed for 11 and 10 sampling locations

Table 1. Scaled Weighting Factor Comparison, 2003-2016 (unmodified and modified)

The second column set of Table 1 (*Scaled Weighting Factor (2016)*) was generated using the original version of the Waite method, and may be used as an exact comparison to the 2003 data. However, the data generated over greater than 10-mile areas did not fit well with existing population distributions, and as part of the purpose of this re-evaluation was the inclusion of the population at a 50-mile radius, only the *Scaled Modified Weighting Factor (2016)* column will be referred to in this memo from this point forward.

The modified Waite method was determined to be acceptable for use in this evaluation based on its response to the population distribution in a 50-mile radius from the center of site, as opposed to the 10-mile limit imposed with the original Waite method. Table 2 displays the basic population and recommended number of air monitoring stations for each sector, assuming 11 air-monitoring stations. Various directional sectors will show fewer or more recommended samplers based on the population; this trend shows agreement between the number of samplers recommended and the population distribution surrounding the site.

For example, the N and E sectors initially have more samplers assigned to them within the 10-mile radius; this corresponds to the population areas of New Ellenton, Jackson, Snelling, and Barnwell. Within the 20 and 30-mile radii, more samplers are recommended corresponding to the Aiken population, and the trend is seen again strongly in the NW sector around the 40-mile radius mark, where Augusta, Grovetown, and North Augusta are all located (the largest population center surrounding the site). Figure 2 shows the population distribution from the 2010 census over a 50-mile range, corroborating these trends.

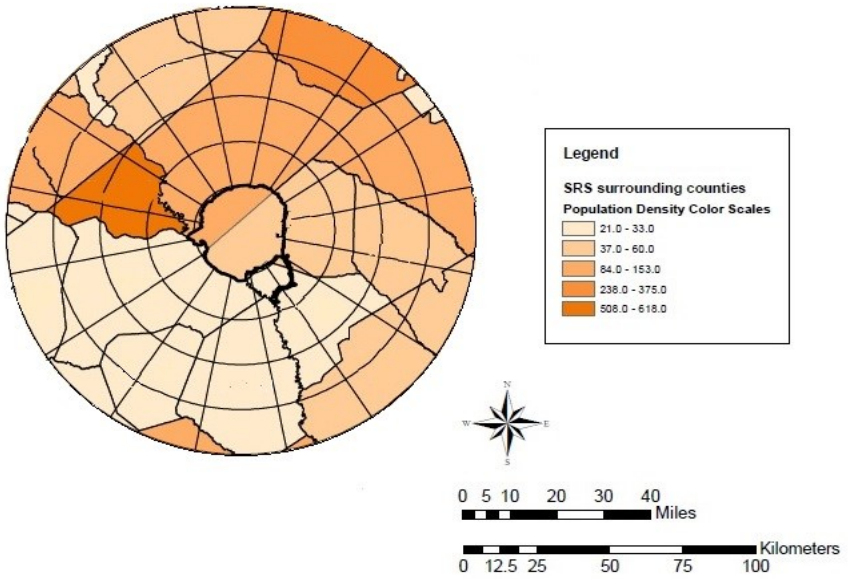

Figure 3. Population Density – 50 miles
(Average persons per square mile)

There are 11 sampler sites available in the current air surveillance program for placement on and around the perimeter of the site; evaluating the system could lead to maintaining that number, increasing it to maximize detection potential, or even reducing the number of samplers. In addition, currently one of the 11 sites is located onsite (Burial Ground North) and, therefore, the number of perimeter sites may be taken as only 10 (ASER 2014). Table 3 contains data for the number of recommended samplers for each sector assuming a reduction in the available perimeter sampler sites assuming 10 sites and 9 sites.

	10 Mile Range		20 Mile Range		30 Mile Range		40 Mile Range		50 Mile Range	
Sectors	**Pop (2010)**	**# of Samplers**	**Pop (2010)**	**# of Samplers**	**Pop (2010)**	**# of Samplers**	**Pop (2010)**	**# of Samplers**	**Pop (2010)**	**# of Samplers**
N	426	2	35839	3	67955	2	79842	1	108841	1
NE	0	1	7155	2	12045	1	26276	1	79073	2
E	99	2	11053	2	22879	1	33571	1	73252	2
SE	13	1	1190	1	8490	1	15250	1	30846	1
S	3	1	977	1	3724	1	12675	1	18900	1
SW	45	1	2244	1	13027	1	19234	1	23729	1
W	47	1	4281	1	83959	2	88193	1	111775	1
NW	600	2	16421	1	191214	2	322729	3	334632	2
Total		11		12*		11		10*		11

*Rounding errors encountered while converting the scaled weighting factor associated with each sector into the recommended number of stations (an integer) resulted in more stations recommended than were available. The model results from sectors containing multiple air-monitoring sites may be modified eliminating stations in the sector with the smallest scaled weighting factor.

Table 2. Modeled Number of Samplers per Sector, 11 sites

	Number of Available Air-Monitoring Stations									
	10-Mile Range		20-Mile Range		30-Mile Range		40-Mile Range		50-Mile Range	
	10	**9**	**10**	**9**	**10**	**9**	**10**	**9**	**10**	**9**
N	2	2	2	2	1	1	1	1	1	1
NE	1	1	1	1	1	1	1	1	1	1
E	1	1	2	1	1	1	1	1	1	1
SE	1	1	1	1	1	1	1	1	1	1
S	1	1	1	1	1	1	1	1	1	1
SW	1	1	1	1	1	1	1	1	1	1
W	1	1	1	1	1	1	1	1	1	1
NW	2	2	1	1	2	2	2	2	2	2
Total	10	10	10	9	9	9	9	9	9	9

Table 3. Comparison of Air-Monitoring Stations Available

As shown in Table 3, seven out of the 10 iterations of the method performed while varying the number of available samplers, only nine sampler locations were recommended, even if 10 or 11 samplers were marked as available for that iteration. This further supports the idea that some sites could be removed from the program without losing precision of detection. The results of the evaluation are presented in Table 4, along with a comparison of the existing sites that agreed with the 2003 version of the study, compared with the model results from 2016, and the actual sites decided on in 2016.

Sector	Existing Sites (2003-2016)	Recommended Sites (2016)	*Alternative (2016)*
N	2	2	*2*
NE	1	1	*1*
E	2	1	*1*
SE	1	1	*1*
S	1	1	*0*
SW	1	1	*1*
W	1	1	*1*
NW	1	2	*2*
Total	10	10	*9*

Table 4. Comparison of 2003 Model and 2016 Model Results

Maintaining the same number of available air-monitoring stations, the 2016 results involve moving one of the stations from the E sector to the NW sector. It should be noted that while the 2016 results are based off of the average sampler distribution over 50 miles, this change from the E sector to the NW sector is also present in the 10-mile range only for the 2016 evaluation, making it an equivalent comparison to the 2003 evaluation.

In the event that a reduction in the number of samplers is desired for financial or other reasons, the sampler with the lowest scaled weighting factor may be eliminated (in this study, the SE and S sectors), or sectors with similarly small scaled weighting factors may be combined (SE and S). Examples of the calculations of weighting factors in Microsoft Excel can be seen in Figure 3 (below).

This report does not recommend any action at present based on the results of this re-evaluation. Further examination of the air-monitoring system and individual sampler response will be conducted, and recommendations for moving or eliminating any air-monitoring stations will be presented in a future report.

10 miles
11 samplers

	Pop (2010)	Pop frac	Wind frac	WF	SF	W*SF	# samplers
N	426	0.34549878	0.1347	0.30744939	7.333822	2.254779	2
NE	0	0	0.1675	0.1675	7.333822	1.228415	1
E	99	0.08029197	0.1682	0.20834599	7.333822	1.527972	2
SE	13	0.01054339	0.0808	0.0860717	7.333822	0.631235	1
S	3	0.00243309	0.0842	0.08541655	7.333822	0.62643	1
SW	45	0.03649635	0.1562	0.17444818	7.333822	1.279372	1
W	47	0.03811841	0.1114	0.13045921	7.333822	0.956765	1
NW	600	0.486618	0.0969	0.340209	7.333822	2.495032	2
	Total Pop:	1233	sum of WF:	1.4999			11

Figure 3. Example Waite Calculation in Excel – 10 Miles

References:

DOE (2015). DOE Handbook: Environmental Radiological Effluent Monitoring and Environmental Surveillance. DOE-HDBK-1216-2015. U.S. Department of Energy, Washington, DC.

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Fledderman, P.D. (2003). Evaluation of Air Surveillance Station Siting. ESH-EMS-03-00623. Memorandum to J.D. Heffner, G.R. Whitney, August 28, 2003.

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Thanks to Kelsey Moore for the creation of the population density map of the counties surrounding SRS