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Laboratory Studies on Surface Sampling of *Bacillus anthracis* Contamination: Summary, Gaps, and Recommendations

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November 2011

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Executive Summary

This report summarizes previous laboratory studies to characterize the performance of methods for collecting, storing/transporting, processing, and analyzing samples from surfaces contaminated by *Bacillus anthracis* or related surrogates. The focus is on plate culture and count estimates of surface contamination for swab, wipe, and vacuum samples of porous and nonporous surfaces. Summaries of the previous studies and their results were assessed to identify gaps in information needed as inputs to calculate key parameters critical to risk management in biothreat incidents. One key parameter is the number of samples needed to make characterization or clearance decisions with specified statistical confidence. Other key parameters include the ability to calculate, following contamination incidents, the 1) estimates of *Bacillus anthracis* contamination, as well as the bias and uncertainties in the estimates, and 2) confidence in characterization and clearance decisions for contaminated or decontaminated buildings. Gaps in knowledge and understanding identified during the summary of the studies are discussed. Recommendations are given for future evaluations of data from existing studies and possible new studies.

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Acronyms and Abbreviations

%RSD	percent relative standard deviation
BA	*Bacillus anthracis*
CDC	Centers for Disease Control and Prevention
CFU	colony forming unit
DHS	U.S. Department of Homeland Security
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FBI	Federal Bureau of Investigation
FNR	false negative rate
FPR	false positive rate
GAO	Government Accountability Office
LOD	limit of detection
NIST	National Institute of Standards and Technology
PNNL	Pacific Northwest National Laboratory
RE	recovery efficiency
SD	standard deviation
S&T	Science and Technology Directorate
SNL	Sandia National Laboratories
U.S.	United States
VSP	Visual Sample Plan

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1.0 Introduction

In 2001, letters containing *Bacillus anthracis* (BA) contaminated areas of the Hart Senate office building in Washington, DC and postal facilities that processed the letters. A congressional inquiry and Government Accountability Office (GAO) investigation (GAO 2005a, 2005b) identified two main concerns regarding the methods used to characterize and clear buildings. One main concern was the reliance on sampling specific locations where it was thought BA would be found. This type of sampling approach is referred to as *judgmental (or targeted) sampling*. The GAO reports identified the need to use *statistical (or probabilistic) sampling* so that when all results are negative, a building (or area within a building) can be cleared with a known level of statistical confidence. The second main concern was that methods used in the *sampling and analysis process* (i.e., sample collection, storage/transportation, processing/extraction, and analytical) were not validated. The lack of validated methods raised questions about the reliability of the negative sampling results obtained.

Several organizations are working to address the GAO concerns, including the U.S. Department of Homeland Security (DHS), U.S. Environmental Protection Agency (EPA), Centers for Disease Control and Prevention (CDC), National Institute of Standards and Technology (NIST), U.S. Department of Defense (DoD), Federal Bureau of Investigation (FBI), Pacific Northwest National Laboratory (PNNL), and Sandia National Laboratories (SNL). Some key activities to address the GAO's main concerns are:

A. developing a sampling-strategy document that describes appropriate uses of judgmental and statistical sampling approaches

B. validating methods associated with the sampling and analysis processes

C. developing formulas to estimate the BA contamination, quantify the bias and uncertainty of the estimate, calculate the confidence in characterization and clearance decisions, and calculate the number of samples necessary to achieve the desired uncertainty and confidence in such decisions.

For conciseness in subsequent discussions, these are referred to as Activities A, B, and C.

Activities B and C require quantitative information on the performance of sampling and analysis methods for indoor surface samples. Such information can be obtained from laboratory and field studies, although laboratory studies are best suited for certain performance measures because the level of contamination can be better controlled. Hence, we identified previous laboratory studies that were conducted to assess the performance of swab, wipe, and vacuum sample collection methods and subsequent sample storage/transportation, processing/extraction, and analysis methods for surfaces contaminated by BA or surrogates. The test conditions and results of the studies were summarized and assessed to determine whether there were any substantive gaps. The summary information, gaps and needs that were found, and recommendations made to address the gaps and needs, are presented and discussed in this report. Edmonds (2009) also reviewed the literature and discusses some needs and perspectives for future work. However, this report is more comprehensive and is based on tabular summaries of previous studies that make gaps and needs easier to identify.

The following section discusses how Activities B and C motivated the work discussed in this report. The two subsequent sections 1) identify the previous laboratory studies that were considered in this effort

and summarize their characteristics and results, and 2) discuss the gaps and needs identified, and make several recommendations to address the gaps and needs. The final section summarizes the work.

2.0 Motivation for Summarizing and Assessing the Gaps of Previous Anthrax Laboratory Studies

Activities A and C involve developing sampling strategies, approaches, and formulas that will provide high confidence in the results of characterizing building contamination, and 2) clearing an uncontaminated or decontaminated building for reoccupation. Statistical and combined judgmental and random sampling (Sego et al. 2010) approaches provide for calculating the number of samples necessary to achieve the desired confidence for detecting contamination and clearing uncontaminated or decontaminated buildings. These approaches also provide for calculating the confidence in characterization or clearance decisions based on sampling results following contamination incidents. The Visual Sample Plan (VSP) software (VSP Development Team 2010) implements many approaches and methods for environmental sampling. Judgmental sampling provides for using the situational knowledge and experience of a field sampler in many situations where statistical samples may not be necessary to detect contamination.

Activity B involves validating methods in the sampling and analysis process for BA contamination in buildings. Validating a method consists of several actions (ISO/IEC 2005), two of which include 1) quantifying the uncertainty (repeatability and reproducibility) and accuracy of results obtained by the method, and 2) quantifying relevant performance metrics, such as recovery efficiency (RE), false negative rate (FNR), false positive rate (FPR), and limit of detection (LOD). Hence, it is important to understand how much of this type of information exists for the previous laboratory studies that investigated sampling of surfaces contaminated with BA or surrogates. This report summarizes estimates of the above performance metrics and corresponding uncertainties reported in the references that document the studies.

The FNR plays an important role in Activity C, because a higher FNR will reduce the confidence in contamination detection and clearance decisions, which can be offset by taking more samples. Further, the overall RE of a sampling process contributes to determining the overall FNR. Here "overall" means over all steps in the sampling process: sample collection, storage/transportation, processing/extraction, and analysis (e.g., culturing and counting). Having sufficient experimental data to determine the overall RE and FNR (and their uncertainties) for swab, wipe, and vacuum samples on various surfaces at various levels of contamination (and any other influencing factors), is important in assessing risks (of failing to detect spores or erroneously clearing an area) and in developing sampling strategies and approaches.

Standard statistical formulas assume that the overall FNR = 0 when calculating 1) the number of samples required to achieve the desired confidence for a characterization or clearance sampling goal, and 2) the uncertainty and confidence associated with a characterization or clearance decision using a specific sampling approach implemented following a contamination incident. When FNR = 0, the formulas account only for the uncertainty in results associated with the specific type of statistical or hybrid sampling approach being used. However, the overall FNR is affected by anything in the sampling process that might yield a false negative, including (i) the RE of a sampling method (e.g., swab, wipe, or vacuum), (ii) the RE of storage or transportation steps, if applicable, (iii) the RE of the processing/ extraction step (i.e., extracting the contaminant from the sample medium), and (iv) the uncertainty of the

analytical/detection method and equipment. Hence, it is important in laboratory studies to quantify the REs and uncertainties affecting the results of a method at each step in the process, so that the overall RE and overall FNR can be determined.

Standard statistical formulas for calculating 1) and 2) in the previous paragraph can be extended to address situations in which the overall FNR > 0. The VSP software (VSP Development Team 2010) generally implements standard formulas to calculate the numbers of samples to address situations in which the overall FNR = 0. Extended formulas, applicable when the overall FNR > 0, have only been developed for a statistical, grid-sampling approach for detecting contaminated areas of specified size (so-called *hotspot sampling*). PNNL plans to develop extended formulas for calculations 1) and 2) when FNR > 0 with other statistical sampling approaches recommended in a multiagency sampling strategy (not yet completed). Adequate information on the FNR performance of sampling and analysis methods is needed as input to this work.

Previous study data indicates the overall RE and FNR may depend on the surface concentration of BA contamination, how the contamination is deposited on a surface, the surface material, the specifics of a sampling method, and possibly other factors. Hence, laboratory studies should investigate the performance of the sampling and analysis process for the most commonly used sampling methods over a range of BA (or surrogate) surface concentrations, different deposition methods, different surface materials, etc. In fact, several such studies have been performed, but important questions are whether the studies adequately 1) cover the combinations of factors that may affect results, and 2) quantify performance measures of the methods and conditions studied.

3.0 Summary of Anthrax-Related Laboratory Studies

Previous laboratory studies were identified that used 1) swab, wipe, and vacuum sampling methods to collect BA (or surrogate) contamination from various porous and nonporous surfaces, and 2) culture and count methods to quantify the contamination. Only BA/surrogate contamination and count methods were considered, to keep the scope of the effort manageable. We focused on laboratory studies (as opposed to field studies or data from BA contamination incidents) because they provide a basis for quantifying actual contamination levels, and using those values to estimate REs and other method performance metrics such as FNR. The 20 studies included in our summary and gap assessment are: Buttner et al. (2001, 2004a, 2004b), Rose et al. (2004), Hodges et al. (2006), Nellen et al. (2006), Brown et al. (2007a, 2007b, 2007c), Quizon et al. (2007), Almeida et al. (2008), Frawley et al. (2008), Montgomery and Camp (2008), Valentine et al. (2008), Edmonds et al. (2009), Estill et al. (2009), Hodges et al. (2010), Einfeld et al. (2011), Krauter et al. (2011), and Rose et al. (2011).

The characteristics and results of relevant tests in each study are summarized in four tables, each with "a" and "b" parts. The "a" part of each table summarizes the characteristics of the studies, while the "b" part summarizes the results of the studies. The "b" parts of tables are further divided into three categories of information: 1) Recovery concentration results – Mean & %RSDs, 2) Recovery efficiency (RE) – Mean & %RSDs, and 3) LOD, FNR and FPR. All percent relative standard deviation (%RSD) values are rounded to zero decimal places. Table 1 describes the study characteristics and results in the columns of the summary tables. In each table, different studies are represented by groups of rows, in which the rows correspond to the tests performed within a study. Because the four tables that summarize groups of tests

and results are long, they are included in the Appendix as Tables A.1 (swab sampling), A.2 (wipe sampling), A.3 (vacuum sampling), and A.4 (one storage/transportation study that did not involve surface sampling). Condensed summaries of Tables A.1 to A.4 are presented in Tables 2 to 5 with "a" and "b" parts as described previously. Acronyms and abbreviations used in Tables 2 to 5 and Tables A.1 to A.4 are defined in Table 6.

In reading the publications that document the studies summarized in this report, we noticed many differences in the way tests and calculations were performed and reported. The main differences are documented in Tables 2 to 5 (and Tables A.1 to A.4), but some differences were too detailed to document. A common difference was in the units used to report results. Whenever possible, we performed calculations using information in the publications to convert results reported in a given set of units to the common set of units used in the "b" parts of Tables 2 to 5 (and Tables A.1 to A.4). There were also experimental and calculational differences in the ways studies used positive controls to obtain the "actual" contamination values used as the denominator in calculating RE. These differences affect the RE values and their uncertainties, in some cases potentially making the uncertainties larger than they needed to be.

Table 7 documents key study characteristics and results from Tables 2 to 5 (and Tables A.1 to A.4). Specifically, it summarizes the numbers of the 20 laboratory studies that varied several study factors and reported various performance metrics. Table 7 shows that 13, 12, and 5 studies investigated swab, wipe, and vacuum sampling, respectively. Some studies investigated more than one type of sampling. Only Almeida et al. (2008) investigated storage/transportation effects on sampling results. An additional storage/transportation study has been completed, but the results have only been partially released (O'Connell et al. 2010, Perry et al. 2010). The information in those references was not complete enough to include the study in this report.

The "zero" entries in Table 7 denote combinations of study characteristics/results that were not addressed by the 20 studies. Table 7 shows that few of the 20 studies had results available from varying the factors: 1) agent (contaminant), 2) agent deposition method, 3) sample-collection medium, 4) wetting agent for the sampling medium (swab and wipe), 5) storage/transport conditions, and 6) processing/extraction method. Lab-to-lab uncertainties of REs were reported only by Estill et al. (2009) for swabs, wipes, and vacuum samples; Hodges et al. (2010) for swab samples; and Rose et al. (2011) for wipe samples. Run-to-run uncertainties were quantified by Estill et al. (2009) for swab, wipe, and vacuum samples; Edmonds et al. (2009) and Hodges et al. (2006) for swab samples; and Montgomery and Camp (2008) for vacuum samples. Even when uncertainties reported in some studies include lab-to-lab and/or run-to-run uncertainties, the numbers of labs and runs were typically small, indicating these sources of uncertainty are poorly estimated. Lab-to-lab and run-to-run uncertainties are expected to be substantial contributors to uncertainty and are missing from most of the studies. Hence, the uncertainties reported by many studies can be expected to underestimate the total uncertainties in surface sampling results. Also, the uncertainties may be underestimated because of smaller uncertainties when applying sampling and analysis methods in controlled laboratory environments than may occur in actual contamination incidents.

LOD and FNR/FPR results are rarely reported in the laboratory study results, as shown in Table 7. As discussed previously, the FNR and RE (each of which may be a function of contaminant concentration and other factors) play a key role in the framework for determining the number of samples necessary to achieve a characterization or clearance goal with a specified confidence. Hence, it is important to experimentally quantify how RE and FNR depend on contaminant surface concentration and other

sampling and environmental factors. Table 7 shows that only a few of the 20 studies varied the contaminant at different surface concentrations. Most of these studies investigated three or fewer concentrations, although Hodges et al. (2006) investigated six and Krauter et al. (2011) investigated eight. Montgomery and Camp (2008) [vacuum results], Estill et al. (2009), Hodges et al. (2010), Rose et al. (2011), and Krauter et al. (2011) found that RE did not depend on surface concentration for the range of concentrations tested. However, Hodges et al. (2006) and Edmonds et al. (2009) reported that RE increased as concentration increased. Of the studies that investigated different surface concentrations, only Krauter et al. (2011) presented equations for FNR as a function of surface concentration (for each of six surface materials). Estill et al. (2009) mentioned using probit regression to develop a probability-of-detection (equivalent to FNR) curve as a function of contaminant concentration, but did not present the results. The general lack of FNR data (and of FNR and RE curves as functions of surface concentration, surface material, and other influencing factors) is a significant gap in all studies except Krauter et al. (2011).

The studies summarized in Tables 2 to 5 have large ranges of mean RE values and sample-within-run uncertainty (%RSD_{RE}) values. The following ranges of RE and %RSD_{RE} exclude data from direct-inoculation tests in which surfaces were not sampled with a swab, wipe, or vacuum. For swabs, RE ranged from 0−92.7% and %RSD_{RE} ranged from 6−550. For wipes, RE ranged from 1−97% (excluding a questionable 120% value in the Estill et al. 2009 study) and %RSD_{RE} ranged from 0−316. For vacuums, RE ranged from 0.02−36% and %RSD_{RE} ranged from 10−130. These ranges of %RSD_{RE} values represent the uncertainty in RE results from replicate tests performed at the same time, generally by the same samplers and the same laboratory personnel (because that is what most studies reported). Hence, these %RSD_{RE} ranges do not include all relevant sources of variation, and can be expected to underestimate the total uncertainty.

The wide ranges of RE values summarized above are a result of the effects of several factors varied within and across the studies (e.g., contaminant surface concentration; contaminant deposition method; surface material being sampled; materials and specifics of swabs, wipes, and vacuum socks; wetting agent for swabs and wipes; specifics of sample preparation and extraction methods, and counting method) as shown in Tables 2a – 5a. Krauter et al. (2011) also indicate that FNR values can be affected by such factors. Hence, the dependence of RE, FNR, LOD, and their total uncertainties (including all sources of uncertainty in the sampling and analysis process) on such factors needs to be quantified. Ideally, all data from each of the swab, wipe, and vacuum studies would be combined and a statistical analysis performed to estimate the effects of the quantitative and qualitative test factors on RE, FNR, and LOD. However, FNR and LOD were not reported in enough studies to do this. Even for the widely reported RE, the number of test factors is large with test factors sometimes having many possible values/options. Also, there may have been interactive effects on performance metrics between some test factors in the studies. Although it was beyond the scope of this work to attempt such a combined-data statistical analysis, our initial assessment is that there are not enough data for this exercise to be successful given the large number of factor combinations and possible interactions in the swab, wipe, and vacuum studies.

4.0 Gaps, Needs, and Recommendations

This section discusses several gaps and needs identified based on the summaries of laboratory studies of swab, wipe, and vacuum sampling and analysis methods in Tables 2 to 5 (and Tables A.1 to A.4).

Recommendations are made for additional laboratory studies and other evaluations to address these gaps and needs. In what follows, "performance results" refers to RE, FNR, LOD, and their uncertainties, considering uncertainty contributions from all steps of the sampling and analysis process (i.e., sample collection, storage/transportation, processing/extraction, and analytical methods).

Realistic versus Laboratory Conditions: Price et al. (2009) emphasize the importance of quantifying the performance of methods (sample collection, storage/transportation, processing/extraction, and analysis) under realistic conditions and not just highly sanitized laboratory conditions. Some studies investigated other material added with the BA or surrogate spores: non-BA organism (Buttner et al. 2001), grime (Einfeld et al. 2011), and silicon dioxide (Brown et al. 2007a, 2007b, 2007c; Estill et al. 2009). Buttner et al. (2001) and Einfeld et al. (2011) found that material added to the BA or surrogate spores can have a significant effect on RE. Data from field studies (e.g., Amidan et al. 2007, Piepel et al. 2009) and the 2001 BA letter incident that involve realistic conditions are available, but don't provide for accurately assessing RE and FNR in the way that laboratory studies do. More work may be needed to quantify the effects on method performance results of surfaces being contaminated with other biological organisms and material in addition to BA. Ideally such studies should be performed with three levels of each other organism/material (none, low, high) to better assess the effects of such factors on sampling performance results.

Bacillus anthracis (BA) versus Surrogates: Previous laboratory studies have used BA and several surrogates (see Tables 2 to 5). However, these studies have not quantitatively addressed the relationship between performance results of swab, wipe, and vacuum methods with BA and with its surrogates. If it is not feasible to use BA and key surrogates in a new laboratory study to establish these relationships, then measurements of organism properties relevant to sampling and resuspension studies should be performed on BA and the various surrogates. The data should then be used to establish the relationships for sampling and analysis performance results between BA and its surrogates.

Deposition Method: Previous laboratory studies generally used one of two contaminant deposition methods: 1) contaminant in liquid (water, ethanol, or a mixture of the two) that was allowed to dry after deposition by wet aerosol or liquid drops, and 2) dry aerosol. Only one swab study (Edmonds et al. 2009) compared REs for different deposition methods. No wipe or vacuum studies varied the deposition method. Edmonds et al. (2009) found that for high contaminant concentrations, REs differed significantly depending on liquid vs. dry deposition, with the difference depending on the swab sampling method. More work is needed to quantify the difference in performance results of swab, wipe, and vacuum sampling and analysis methods as a function of the contaminant deposition method, as well as functions of other influencing factors (e.g., contaminant concentration).

Surface Types: A wide variety of surface materials were investigated in the swab, wipe, and vacuum sampling studies summarized in Tables 2 to 4. However, some studies investigated only stainless steel or a limited number of surface materials. Method performance results were generally reported separately for each surface material, without any attempt to develop relationships between performance results and characteristics of the surface materials. The exception was Krauter et al. (2011), who compared mean REs, FNR, and LOD to the roughness index of the surfaces investigated. More work is needed to develop equations that relate method performance to one or more surface-characteristic variables (as well as any other influencing factors). Such equations can then be used to estimate method performance for various surface materials.

Storage and Transportation of Samples: Only two previous studies have investigated the effects of storage and/or transportation conditions on method performance results. Almeida et al. (2008) investigated the effects of different additives, storage times, and storage temperatures on the stability of BA in water. However, that work is not directly relevant to surface sampling, because it would be swab, wipe, and vacuum samples that would be stored and/or transported to laboratories (which would then perform the processing/extraction and analysis steps). A second study investigated the effects of storage and transportation factors on swab samples, but only partial results have been released (O'Connell et al. 2010, Perry et al. 2010). Because this study only addresses swab samples, additional studies or evaluations are needed to quantify how sampling and analysis methods for wipe and vacuum samples are affected by storage and transportation methods.

Recovery Efficiency of Sample Collection vs. Processing: Several studies investigated the contributions of sample collection and sample processing/extraction to the overall RE of a method. For directly inoculated petri dishes, Buttner et al. (2001) reported sample collection efficiency, processing efficiency, and overall RE for two swab and one wipe sampling methods. For all three, the majority of the inefficiency came in the processing step, not the sample collection step. Results from other studies that investigated and reported REs for sample collection and processing steps were similar in some cases (Rose et al. 2004), while in other cases the sample collection inefficiency was similar to or larger than processing inefficiency (Buttner et al. 2001; Nellen et al. 2006; and Brown et al. 2007a, 2007b). In all cases, processing/extraction inefficiency is large enough that optimizing the specifics of the processing/extraction step would be very important in maximizing RE. The optimal processing conditions may depend on the sample collection material, the extraction solution, and the methods of dissociation (e.g., vortexing, sonication).

RE and FNR as Functions of Concentration and Other Influencing Factors: Few of the 20 studies reported FNR data and only Krauter et al. (2011) developed relationships between low contaminant concentrations and the FNR performance (for the sponge-stick wipe method). Similar work is needed for other surface sampling and analysis methods that may be used when BA surface concentrations are low. Quantifying the FNR-concentration relationships is critical because FNR > 0 significantly affects 1) the number of samples required to achieve desired confidences in characterization and clearance decisions, and 2) the confidence in characterization and clearance decisions made using sample and analysis data following a contamination incident. On the other hand, if surface concentrations are at levels much higher than when false negatives begin to appear, then the magnitude of RE and its dependence on surface concentration are not very important if the goal is to merely detect contamination (versus to accurately quantify the amount/concentration of contaminant).

Estimates of Main Sources of Uncertainty: Previous laboratory studies did not capture the main sources of uncertainty affecting performance results. Many of the studies investigated only short-term, within-run uncertainties (repeatability) and did not investigate run-to-run or lab-to-lab uncertainties (reproducibility). Hence, the estimates of uncertainty in performance measures for most of the studies in Tables 2–5 (and Tables A.1–A.4) can be expected to underestimate the total uncertainty. Further, in some studies that captured more than one source of uncertainty, the statistical measures of uncertainty reported may have been improperly calculated. A common error is to calculate the standard deviation (or %RSD) from a set of data subject to more than one source of uncertainty when the data provides for separately estimating the uncertainties. The correct approach is to use statistical variance-component estimation to separately estimate the standard deviation (or %RSD) for each source of uncertainty, and then properly combine the separate estimates into an estimate of total uncertainty. The studies that best met the goals of

quantifying repeatability and reproducibility uncertainties are the swab and wipe validation studies (Hodges et al. 2010 and Rose et al. 2011, respectively). If additional studies of this type are needed, they should be designed to capture repeatability and reproducibility uncertainties in the steps of the sampling and analysis process (i.e., sample collection, storage/transportation, processing/extraction, and analytical).

Control Samples: Control samples (e.g., positive, negative, sample-medium blanks, laboratory blanks) are necessary to quantify performance measures such as RE, FNR, and FPR. Although the studies summarized in this report included control samples, FNR and FPR were seldom reported. Positive controls for deposition load used to calculate RE should be co-located with each surface sample, although this was not done for some of the studies. That way, the RE for each surface sample can be calculated using the co-located positive control sample, if necessary. This approach corrects for unavoidable systematic variation in contaminant deposition in a chamber or controlled test area, so that such differences do not inflate the uncertainties of RE.

We recommend that additional experimental studies and non-experimental evaluations be performed to address the above gaps and needs. Additional experimental studies should be performed selectively, along with non-experimental evaluations, so that the combination of previous and new results provide for adequately quantifying the performance characteristics (e.g., RE, FNR, LOD, and uncertainties) of swab, wipe, and vacuum sampling methods, accounting for all the steps of the sampling and analysis process.

5.0 Summary

The GAO reports (GAO 2005a, 2005b) recommended the use of statistical sampling approaches to support making high-confidence characterization and clearance decisions for biological contamination incidents. Methodology and related data for quantifying the overall uncertainty and confidence associated with characterization and clearance decisions is needed to address the GAO concerns. This methodology must account for the performance and uncertainties of relevant statistical sampling approaches, sample collection methods, sample transportation and/or storage effects, sample processing and extraction methods, and sample analysis methods. PNNL plans to develop methodology and formulas that account for FNR > 0 when calculating 1) the number of samples needed with a given statistical sampling approach to achieve specified confidence in characterization and clearance decisions, and 2) the confidence in characterization and clearance decisions using statistical sampling data obtained following a contamination incident. For both of these, method performance data are needed to provide input values for the formulas.

The literature summarized and discussed in this report contains considerable data on the performance of swab, wipe, and vacuum surface-sampling methods for BA (or surrogates) contamination. However, that body of work does not provide for fully quantifying the performance of swab, wipe, and vacuum sampling methods while accounting for all steps of the sampling process (sample collection, transportation/storage, processing/extraction, and analytical). Additional work is needed to quantify the biases (e.g., REs), FNRs, and uncertainties associated with the steps of the sampling process over a range of contamination concentrations for relevant surface materials that are sampled/extracted/analyzed by relevant methods. Further, most of the studies summarized in this report did not capture one or more applicable sources of uncertainty. Hence, data from those studies can be expected to underestimate the overall uncertainties in the sampling process. In summary, to adequately quantify all of the sources of

bias and uncertainty in the steps of the sampling process (collection, storage/transportation, processing/extraction, and analysis), additional laboratory studies and other evaluations should be conducted to augment the data from previous studies.

6.0 References

Almeida, J.L., Harper, B. and Cole, K.D. (2008) *Bacillus anthracis* spore suspensions: determination of stability and comparison of enumeration techniques. *J Appl Microbiol* **104**, 1442-1448.

Amidan, B.G., Piepel, G.F., Matzke, B.D., Filliben, J.J. and Jones, B.J. (2007) *Experimental Design for the INL Sample Collection Operational Test*, PNNL-17129, Pacific Northwest National Laboratory, Richland, WA. http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-17129.pdf

Brown, G.S., Betty, R.G., Brockmann, J.E., Lucero, D.A., Souza, C.A., Walsh, K.S., Boucher, R.M., Tezak, M., Wilson, M.C. and Rudolph, T. (2007a) Evaluation of a wipe surface sample method for collection of *Bacillus* spores from nonporous surfaces. *Appl Environ Microbiol* **73**, 706-710.

Brown, G.S., Betty, R.G., Brockmann, J.E., Lucero, D.A., Souza, C.A., Walsh, K.S., Boucher, R.M., Tezak, M.S., Wilson, M.C., Rudolph, T., Lindquist, H.D. and Martinez, K.F. (2007b) Evaluation of rayon swab surface sample collection method for *Bacillus* spores from nonporous surfaces. *J Appl Microbiol* **103**, 1074-1080.

Brown, G.S., Betty, R.G., Brockmann, J.E., Lucero, D.A., Souza, C.A., Walsh, K.S., Boucher, R.M., Tezak, M.S. and Wilson, M.C. (2007c) Evaluation of vacuum filter sock surface sample collection method for *Bacillus* spores from porous and non-porous surfaces. *J Environ Monitor* **9**, 666-671.

Buttner, M.P., Cruz-Perez, P. and Stetzenbach, L.D. (2001) Enhanced detection of surface-associated bacteria in indoor environments by quantitative PCR. *Appl Environ Microbiol* **67**, 2564-2570.

Buttner, M. P., Cruz, P., Stetzenbach, L.D., Klima-Comba, A.K., Stevens, V.L. and Cronin, T.D. (2004a) Determination of the efficacy of two building decontamination strategies by surface sampling with culture and quantitative PCR analysis. *Appl Environ Microbiol* **70**, 4740-4747.

Buttner, M.P., Cruz, P., Stetzenbach, L.D., Klima-Comba, A.K., Stevens, V.L. and Emanuel, P.A. (2004b) Evaluation of the biological sampling kit (BiSKit) for large-area surface sampling. *Appl Environ Microbiol* **70**, 7040-7045.

Edmonds, J.M. (2009) Efficient methods for large-area surface sampling of sites contaminated with pathogenic microorganisms and other hazardous agents: current state, needs, and perspectives. *Appl Microbiol Biotech* **84**, 811-816.

Edmonds, J.M., Collett, P.J., Valdes, E.R., Skowronski, E.W., Pellar, G.J. and Emanuel, P.A. (2009) Surface sampling of spores in dry-deposition aerosols. *Appl Environ Microbiol* **75**, 39-44.

Einfeld, W., Boucher, R.M., Tezak, M.S., Wilson, M.C. and Brown, G.S. (2011) *Evaluation of Surface Sampling Method Performance for Bacillus Spores on Clean and Dirty Outdoor Surfaces*, SAND2011-4085, Sandia National Laboratories, Albuquerque, NM.

Estill, C.F., Baron, P.A. Beard, J.K., Hein, M.J., Larsen, L.D., Rose, L., Schaefer III, F.W., Noble-Wang, J., Hodges, L., Lindquist, H.D.A., Deye, G.J. and Arduino, M.J. (2009) Recovery efficiency and limit of detection of aerosolized *Bacillus anthracis Sterne* from environmental surface samples. *Appl Environ Microbiol* **75**, 4297-4306.

Frawley, D.A., Samaan, M.N., Bull, R.L., Robertson, J.M., Mateczun, A.J. and Turnbull, P.C.B. (2008) Recovery efficiencies of anthrax spores and ricin from nonporous or nonabsorbent and porous or absorbent surfaces by a variety of sampling methods. *J Forensic Sciences* **53**, 1102-1107.

Government Accountability Office (GAO). (2005a) *Anthrax Detection: Agencies Need to Validate Sampling Activities in Order to Increase Confidence in Negative Results* (Report to the Chairman, Subcommittee on National Security, Emerging Threats, and International Relations, House Committee on Government Reform, House of Representatives), GAO-05-251, U.S. Government Accountability Office, Washington, DC.

Government Accountability Office (GAO). (2005b) *Anthrax Detection: Agencies Need to Validate Sampling Activities in Order to Increase Confidence in Negative Results*, (Testimony before the Chairman, Subcommittee on National Security, Emerging Threats, and International Relations, House Committee on Government Reform, House of Representatives), GAO-05-493T, U.S. Government Accountability Office, Washington, DC.

Hodges, L.R., Rose, L.J., Peterson, A., Noble-Wang, A.J. and Arduino, M.J. (2006) Evaluation of a macrofoam swab protocol for the recovery of *Bacillus anthracis* spores from a steel surface. *Appl Environ Microbiol* **72**, 4429-30.

Hodges, L.R., Rose, L.J., O'Connell, H. and Arduino, M.J. (2010) National validation study of a swab protocol for the recovery of *Bacillus anthracis* spores from surfaces. *J Microbiol Meth* **81**, 141-146.

ISO/IEC (2005) Validation of Methods, Section 5.4.5, in International Standard 17025: General Requirements for the Competence of Testing and Calibration Laboratories, Second Edition, ISO/IEC 17025:2005(E), Geneva, Switzerland.

Krauter, P.A., Piepel, G.F., Boucher, R., Tezak, M., Amidan, B.G. and Einfeld, W. (2011) *False Negative Rate and Other Performance Measures of a Sponge-Wipe Surface Sampling Method for Low Contaminant Concentrations*, SAND2011-3395, Sandia National Laboratories, Albuquerque, NM.

Montgomery, N.K. and Camp, D.W. (2008) *The Efficiency of Collecting Bacillus anthracis Spores from HVAC Filters and Carpet by Vacuum, Wipe, and Bulk Sampling Methods*, LLNL-PRES-408494. Lawrence Livermore National Laboratory, Livermore, CA.

Nellen, J., Rettberg, P., Horneck, G. and Streit, W.R. (2006) Planetary protection − approaching uncultivable microorganisms. *Adv Space Res 38*, 1266-1270.

O'Connell, H., Rose, L., Perry, A., Noble-Wang, J. and Arduino, M. (2010) Shipping integrity of *Bacillus anthracis* swab samples, poster presented at the American Society for Microbiology Biodefense Conference, New Orleans, LA, Feb. 2010, Centers for Disease Control and Prevention, Atlanta, GA.

Perry, A., O'Connell, H., Rose, L. and Noble-Wang, J. (2010) Storage effects on sample integrity of environmental surface sampling specimens with *Bacillus anthracis*, primary and secondary containment, Poster presented at the American Society for Microbiology Biodefense Conference, New Orleans, LA, Feb. 2010, Centers for Disease Control and Prevention, Atlanta, GA.

Piepel, G.F., Amidan, B.G., and Matzke, B.D. (2009) *Experimental and Sampling Design for the INL-2 Sample Collection Operational Test*, PNNL-18187, Pacific Northwest National Laboratory, Richland, WA. http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-18187.pdf

Price, P.N., Sohn, M.D., Lacommare, K.S.H. and McWilliams, J.A. (2009) Framework for evaluating anthrax risk in buildings. *Environ Sci Technol* **43**, 1783-1787.

Quizon, R., Quizon, J., Proescher, A., Bare, C., Goodenow, B., Wagner, M. and Van Gieson, E. (2007) *Test and Evaluation of Surface Sampling Approaches Before and After Small-Scale Fumigation-Based Decontamination Events*, NSTD-07-0592. Applied Physics Laboratory, National Security Technology Department, John Hopkins University, Laurel, MD.

Rose, L., Jensen, B., Peterson, A., Banerjee, S.N. and Arduino, M.J. (2004) Swab materials and *Bacillus anthracis* spore recovery from nonporous surfaces. *Emerg Infect Dis* **10**, 1023-1029.

Rose, L.J., Hodges, L., O'Connell, H. and Noble-Wang, J. (2011) National validation study of a cellulose sponge-wipe processing method for use after sampling *Bacillus anthracis* spores from surfaces. *Appl Environ Microbiol*, doi:10.1128/AEM.05377-11.

Valentine, N.B., Butcher, M.G., Su, Y.F., Jarman, K.H., Matzke, M., Webb-Robertson, B.J., Panisko, E.A., Seiders, B.A.B. and Wahl, KL. (2008) Evaluation of sampling tools for environmental sampling of bacterial endospores from porous and nonporous surfaces. *J Appl Microbiol* **105**, 1107-1113.

VSP Development Team (2010) *Visual Sample Plan: A Tool for Design and Analysis of Environmental Sampling*. Version 6.0. Pacific Northwest National Laboratory, Richland, WA. http://vsp.pnl.gov.

Table 1. Descriptions of columns in tables summarizing the characteristics and results of laboratory studies on surface sampling of *Bacillus anthracis* and surrogates.

Study Characteristics (in Tables 2a, 3a, 4a, and 5a)	
Reference	Author (Year) citation of publication that documents the study
Test #	A number of the form x.y where x is 1, 2, 3, … for each study, and y = 1, 2, 3, … for the tests within a study
Agent	*B. anthracis* or related surrogate
Agent deposition	Method used to deposit agent on test material
Agent concentration	Concentration or amount of agent on surface
Swab/Wipe/Vacuum type	Type or material of sample collection medium
Wetting agent	Swab or Wipe: Liquid, if any, used to wet or premoisten the sampling material
Vacuum technique	Vacuum: Technique in vacuuming (e.g., pattern, pressure applied)
Relative humidity	Percent relative humidity in chamber or laboratory during testing
Surface type	Material type of surface sampled
Surface area sampled	Area of surface sampled
Extraction liquid	Liquid used to extract spores from the sample
Extraction method	Method used to prepare a sample and extract the contaminant
Culture method/medium	Method/medium used to culture samples
# labs	The number of labs that participated in a study
# test runs	The number of test runs (set up and performed separately at different times)
Total # test samples	Total number of samples tested (i.e., over labs, runs, and samples within runs)
Study Results (in Tables 2b, 3b, 4b, and 5b)	
Recovery Concentration Results - Mean & %RSDs	
Reference	Same as for "Study characteristics" tables (see above)
Test #	Same as for "Study characteristics" tables (see above)
Mean (CFU/cm^2)	Mean surface concentration recovered
Lab %RSD	Lab-to-lab percent relative standard deviation, which includes the variation from preparing the samples, extraction, and analysis.
Run %RSD	Percent relative standard deviation from replicate runs of a test performed at different times.
Sample-within-run %RSD	Percent relative standard deviation from replicate tests performed at the same time (in one run)
Total %RSD	Total percent relative standard deviation (including Lab, Run, and Sample-within-run)
Recovery Efficiency (RE) – Mean & %RSDs	
RE mean (%)	Mean recovery efficiency
RE lab %RSD	Lab-to-lab percent relative standard deviation of RE
RE run %RSD	Run percent relative standard deviation of RE
RE sample-within-run %RSD	Sample-within-run percent relative standard deviation of RE
RE total %RSD	Total percent relative standard deviation of RE (including Lab, Run, and Sample-within-run)
LOD, FNR, and FPR	
Positive result	How a positive result (detection) was defined (e.g., CFU ≥ 1)
LOD definition	How the limit of detection (LOD) is defined
LOD	Value of the limit of detection
LOD SD or 95% CI (CFU/cm^2)	Standard deviation or 95% confidence interval for the LOD
FNR	False negative rate (FNR) based on controlled tests where the sampled surface was known to be contaminated but yielded a negative result
FPR	False positive rate (FPR) based on controlled tests where the sampled surface was known to be uncontaminated but yielded a positive result

Table 2a. Summary of test conditions for swab sampling studies. Acronyms and abbreviations are defined in Table 6 and the footnotes.

Reference (lead author and year)	# tests	Agent	Agent depo-sition	Agent concentration(s) #	Agent concentration(s) Range (CFU/cm^2)	Swab types	Wetting agent	Surface types	Surface area sampled (cm^2)	Extract -ion liquid	Extraction method	Culture method, medium	# Labs	# test runs	# samples /test
Estill 2009	6	BA-S	DA	3	0.03 – 2	MF	BBT	SS, Cpt	103	BBT	V+S	FP, TSAB	3	2 – 4	24 – 36
Hodges 2006	6	BA-S	LD	6	0.4 – 6000	MF	PBST	SS	10	PBST	V	Plate/FP, TSAB	2[(a)]	NR	15 – 45
Rose 2004	24	BA-S	LD	1	1937.5	Ct, P, R, MF	Dry, PBST	SS	25.8	PBST	U, V, S	Plate, TSAB	1	NR	10
	4	BA-S	LI	1	1E+4 CFU/swab	DI: Ct, PE, R, MF	NA	None	NA	PBST	V	Plate, TSAB	1	NR	10
Frawley 2008	6	BA-S	LD	1	1E+2 – 1E+5 CFU/sample	PE	Dry, PBST/Tr	P, W, Cl	1, NR	PBST	V	Plate, SBA	1	NR	12 – 24
	7	BA (4)	LD	1	50 CFU/sample	Ct	PBST/Tr	P, G, F, M, Cpt, B, Ct Cloth	NR	NR	NR	Plate, NR	1	NR	11
Brown 2007b	4	BAtr	DA	2	10^2–10^3, 10^5–10^6	R	DW	SS	25	BBT	S, H, V	Plate, PF	1	NR	20
	1	BAtr	LI	1	1E+6 CFU/swab	DI: R	NA	None	NA	BBT	S, H, V	Plate, PF	1	NR	20
	1	BAtr	LD	1	2.0E+5	NA	NA	DI: SS	6.25	BBT	S, H	Plate, BHIA	1	NR	24
Edmonds 2009	16	BAtr	LD	1	1.0E+5	Ct, DP, R, MF	DW	G	10	PBSTr	V, S	SprP, NR	1	3 – 4	28 – 40
	16	BAtr	DA	1	1.0E+9	Ct, DP, R, MF	DW	G, SS, PC, VL	10	PBSTr	V, S	SprP, NR	1	3	24 – 30
	4	BAtr	LD	4	4.77E+3 – 2.52E+6	DP	DW	G	10	PBSTr	V, S	SprP, NR	1	3	30
Valentine 2008	16	BS	LD	2	9.03E+4, 2.82E+5	Ct, PF, PE, DP	PBST	P, O, PEUF, Cpt	104.04	PBST	V	Plate, TSA	1	10	10
	4	BS	LD	2	9.03E+4, 2.82E+5	Ct, PF, PE, DP	PBST	Monitor	25	PBST	V	Plate, TSA	1	10	10
Buttner 2001	2	BS	LD	1	1.48E+6	SK	PBST	G	5	PBT	V	Plate, TSAC	1	3	3
	8	BS	DA	1	100 – 1000	SK, Ct	PBST	VL, Cpt(3)	32.49	PBT	V	Plate, TSAC	1	3	3
	8	BS+PC2	DA	1	100 – 1000	SK	PBST	VL, Cpt(3)	32.49	PBT	V	Plate, TSAC	1	2	2
Buttner 2004a	6	BAtr	DA	1	107.6 – 1076.4	SSPK	NR	VL, W, M	929	NR	HM	Plate, TSA	1	3	3
	3	BAtr	DA	1	107.6 – 1076.4	SSPK	NR	VL, W, M	929	NR	HM	Plate, TSA	1	1	2
Buttner 2004b	4	BAtr	DA	1	NR	SSPK, Ct	NR	M, W	100, 317	NR	HM, Shake	Plate, TSA	1	NR	4, 8
Quizon 2007	4	BAtr	WA	1	NR	PEUF	PBST	PWB, SS, VL, W	100	PBST	V, S	SP/FP, TSA	1	4	4, 10
Nellen 2006	2	BS-168	LD	1	1000 CFU/swab	DI: Ct, R	NA	NA	NA	PBS	Untreated	Plate, TSA	1	3	15
	6	BS-168	LD	1	1000 CFU/swab	DI: Ct, R	NA	NA	NA	PBS	V, S, V+S	Plate, TSA	1	3	15
	4	BS-168	LD	1	4	Ct, R	DW	PD	25	PBS	NR, H+V+S	Plate, TSA	1	3	15
	10	BS-168	LD	1	16	R	DW	(b)	25	PBS	NR, H+V+S	Plate, TSA	1	3	3
Hodges 2010	6	BA-S	LD	3	1.4, 15.3, 1607.2	MF	PBST, PBST+	SS	26	PBST	V	FP, TSAB	12	1	118 – 120
	6	BA-S	LI	3	36–33300 CFU/swab	DI: MF	NA, PBST+	NA	NA	PBST	V	FP, TSAB	12	1	24 – 48

(a) Five analysts total from two laboratories.
(b) Aluminum, V2A steel, MLI foil, Kapton®, Teflon®.

Table 2b. Summary of test results for swab sampling. Acronyms and abbreviations are defined in Table 6.

Reference (lead author and year)	# tests	Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR				
		Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD defi-nition	LOD (CFU/cm^2)	FNR	FPR
Estill 2009	6	0.0012 – 0.18	0 – 110	0 – 98	57 – 460	73 – 473	3.4 – 14.0	0 – 110	0 – 110	76 – 550	81 – 560	≥1	LOD_{95}	0.4 (SS) 1.9 (Cpt)	NR	0.037
Hodges 2006	6	0.1 – 2900	NR	NR	27 – 100	NR	31.7 – 49.1	NA	NA, 28 – 33	21 – 91	NA	≥1	LOD_{90}	1.2	0 – 0.27	NR
Rose 2004	24	NR	NA	NR	NR	NA	0.1 – 43.6	NA	NR	18 – 200	NA	NR	NR	NR	NR	NR
	4	NR	NA	NR	NR	NA	83.8 – 93.9	NA	NR	7 – 12	NA	NR	NR	NR	NR	NR
Frawley 2008	6	NR	NA	NR	NR	NA	0.2 – 5.5	NA	NR	30 – 63	NA	NR	NR	NR	NR	NR
	7	NR	NA	NR	NR	NA	0 – 15	NA	NR	28 – 144	NA	NR	NR	NR	NR	NR
Brown 2007b	4	NR	NA	NR	NR	NA	35.5 – 45.6	NA	NR	34 – 67	NA	≥1	NR	1	NR	NR
	1	NR	NA	NR	NR	NA	75.6	NA	NR	16	NA	NR	NR	NR	NR	NR
	1	NR	NA	NR	NR	NA	99.9	NA	NR	0.1	NA	NR	NR	NR	NR	NR
Edmonds 2009	16	NR	NA	NR	NR	NA	42.5 – 89.1	NA	11 – 33	8 – 16	NA	NR	NR	NR	NR	NR
	16	NR	NA	NR	NR	NA	51.5 – 75.5	NA	10 – 35	8 – 20	NA	NR	NR	NR	NR	NR
	4	2.0E+2 – 2.4E+6	NA	19 – 29[a]	(a)	NA	42.1 – 92.7	NA	NR	19 – 29	NA	NR	NR	NR	NR	NR
Valentine 2008	16	NR	NA	NR	NR	NA	0.6 – 6.6	NA	NR	25 – 150	NA	NR	NR	NR	NR	NR
	4	NR	NA	NR	NR	NA	0.5 – 2.7	NA	NR	18 – 84	NA	NR	NR	NR	NR	NR
Buttner 2001	2	NR	NA	NR	NR	NA	68.6 – 73.5	NA	NR	6 – 7	NA	NR	NR	NR	NR	NR
	8	82 – 748	NA	7 – 107[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
	8	84 – 1264	NA	18 – 85[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
Buttner 2004a	6	340 – 711	NA	24 – 92[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
	3	523 – 704	NA	NR	8 – 55	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
Buttner 2004b	4	840 – 1200	NA	NR	11 – 28	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
Quizon 2007	4	4170 – 5670	NA	17 – 36[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
Nellen 2006	2	0.29	NA	17[a]	(a)	NA	13.4	NA	17 – 18[a]	(a)	NA	NR	NR	NR	NR	NR
	6	1.42 – 2.04	NA	1 – 6[a]	(a)	NA	65.8 – 94.5	NA	3 – 7[a]	(a)	NA	NR	NR	NR	NR	NR
	4	0.95 – 1.75	NA	25 – 33[a]	(a)	NA	35.9 – 66.1	NA	27 – 34[a]	(a)	NA	NR	NR	NR	NR	NR
	10	0.73 – 2.72	NA	24 – 56[a]	(a)	NA	19.8 – 73.7	NA	26 – 52[a]	(a)	NA	NR	NR	NR	NR	NR
Hodges 2010	6	0.48 – 1064.32	NR	NR	NR	NR	15.8 – 83.1	12.1 – 24.2	(b)	9 – 57[b]	15 – 59	(c)	NR	0.8	0	0 – 0.083
	6	0.71 – 87.27	NR	NR	NR	NR	27.9 – 73.9	26.7 – 46.8	(b)	15 – 40[b]	32 – 57	(c)	NR	NR	0 – 0.17	0 – 0.146

(a) Combined estimate of "run" and "sample-within-run" uncertainties.
(b) The precision (variance within laboratories) reported by Hodges et al. (2010) is listed in this table as sample-within-run uncertainty.
(c) ≥ 1 CFU/ml

Table 3a. Summary of test conditions for wipe sampling studies. Acronyms and abbreviations are defined in Table 6 and the footnotes.

Reference (lead author and year)	# tests	Agent	Agent depo-sition	Agent concentration(s) #	Agent concentration(s) Range (CFU/cm^2)	Wipe types	Wetting agent	Surface types	Surface area sampled (cm^2)	Extract -ion liquid	Extraction method	Culture method, medium	# labs	# test runs	# samples /test
Estill 2009	3	BA-S	DA	3	0.03 – 2	Sponge	BBT	SS	929	BBT	A+C+V+S	FP, TSAB	3	3	27
	3	BA-S	DA	3	0.03 – 2	Sponge	BBT	Cpt	929	BBT	A+C+V+S	FP, TSAB	3	2 – 4	18 – 36
Brown 2007a	4	BA	DA	2	10^2–10^3, 10^4–10^5	PR gauze	DW	SS, PWB	25	BBT	S+H+V	Plate, PF	1	NR	20
	1	BA	LI	1	NR	DI: PR gauze	DW	None	NA	BBT	S+H+V	Plate, PF	1	NR	40
	1	BA	LD	1	2.0E+5	NA	NA	DI: SS	25	BBT	S+H	Plate, BHIA	1	NR	24
Buttner 2001	1	BS	LD	1	1.48E+7	Sponge	PBST	Glass	32.49	PBST	HS	Plate, TSAC	1	3	3
	12	BS[(a)] BS+PC2 BS+PC4	DA	1	1E+2 – 1E+3	Sponge	PBST	VL, Cpt-R, Cpt-S, Cpt-C	32.49	PBST	HS	Plate, TSAC	1	2, 3	2, 3
Valentine 2008	12	BS	LD	1	90349.9	Ct, HCW,PR	PBST	P, O, PEUF, Cpt	104.04	PBST	V+C	Plate, TSAC	1	10	10
	3	BS	LD	1	282,000	Ct, HCW,PR	PBST	Monitor	25	PBST	V+C	Plate, TSAC	1	10	10
Buttner 2004a	12	BAtr	DA	1	107.6 – 1076.4	Swipe, HW	PBST	VL, W, M	929	NR	HM	Plate, TSA	1	3	3
	6	BAtr	DA	1	107.6 – 1076.4	Swipe, HW	PBST	VL W, M	929	NR	HM	Plate, TSA	1	1	1, 2
Buttner 2004b	4	BAtr	LI	2	10, 18.2	BiSKit	Dry, PBST	M	10,000	PBST	BiSKit	Plate, TSA	1	NR	4, 8
	6	BAtr	DA	1	NR	BiSKit	Dry, PBST, NR	M, W	10,000	PBST	BiSKit	Plate, TSA	1	NR	4, 8
Frawley 2008	6	BA-S	LD	1	1E+2–1E+5/sample	Gauze	Dry, PBST/Tr	P, W, Ct Cloth	1, NR	PBST	V	Plate, SBA	1	NR	12, 24
Einfeld 2011	10	BAtr BAtr+ Grime	DA	1	9,55E+0 – 6.81E+4	PR	DW RH = 10-15, 82-90	SS, G, Marble	100	BBT	S+H+V	Plate, PF	1	2, 3, 5	24 – 60
Quizon 2007	4	BAtr	WA	1	NR	PR	PBST	PWB, SS, VL, W	900	PBST	C+V+S	SP/FP, TSA	1	4	4, 10
Krauter 2011	27	BAtr	LD	8	0.00248 – 1.85380	Sponge stick	NB	SS, CerT, VL	645.16	PBST	St+C+V+S	(b)	1	1	9, 10
	27	BAtr	LD	8	0.00775 – 0.15371	Sponge stick	NB	FL, PW, PLCP	645.16	PBST	St+C+V+S	(b)	1	1	9, 10
Rose 2011	3	BA-S	LS	3	0.01349 – 17.123	DI: Sp. stick	NB+ATD	SS	645.16	PBST	St+C	SP/FP, TSAB	9	1	17 –18
	3	BA-S	LS	3	0.04046 – 51.367	Sponge stick	NB+ATD	SS	645.16	PBST	St+C	SP/FP, TSAB	9	1	54 – 63
	1	BA-S	LS	1	15.5	Rayon gauze	PBST	SS	645.16	PBST	St+C	SP/FP, TSAB	1	1	10
	1	BA-S	LS	1	15.5	Sponge wipe	DE broth	SS	645.16	PBST	St+C	SP/FP, TSAB	1	1	10
	1	BA-S	LS	1	15.5	Sponge wipe	BB	SS	645.16	PBST	St+C	SP/FP, TSAB	1	1	10
	1	BA-S	LS	1	15.5	Sponge stick	PBST	SS	645.16	PBST	St+C	SP/FP, TSAB	1	1	10
	3	BA-S	LS	3	0.0155, 0.155, 15.5	PEF sponge	PBST	SS	645.16	PBST	St+C	SP/FP, TSAB	1	3	15
Montgomery 2008	4	BA-S	EWD	1	NR	PR gauze, pad 2 wipe tech's	PBSTr	HVAC filter	100	PBSTr	Shake+C	Plate, NR	1	2, 3	2 – 5

(a) PC2 and PC4 = *Penicillium chrysogenum* at 10^2 and 10^4 CFU/cm^2 on test coupons.
(b) Plate with growth medium, or filter plate with TSA.

Table 3b. Summary of test results for wipe sampling. Acronyms and abbreviations are defined in Table 6.

Reference (lead author and year)	# tests	Recovery concentration results – Mean & %RSDs: Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	Recovery efficiency (RE) – Mean & %RSDs: RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	LOD, FNR, and FPR: Positive result (CFU)	LOD defi-nition	LOD (CFU/cm^2)	FNR	FPR
Estill 2009	3	0.017 – 0.350	9 – 27	0 – 45	61 – 200	80 – 200	18 – 31	14 – 29	0 – 13	53 – 160	57 – 160	≥3	LOD_{95}	0.15	NR	0.133
	3	0.084 – 0.500	9 – 26	0 – 52	37 – 180	60 – 182	21 – 120	0 – 11	0 – 63	40 – 220	75 – 220	≥1	LOD_{95}	0.009	NR	0.0
Brown 2007a	4	NR	NA	NR	NR	NA	25.2 – 39.2	NA	NR	32 – 59	NA	≥1 CFU/ml	NR	3.6 – 4.2	NR	NR
	1	NR	NA	NR	NR	NA	93.2	NA	NR	9	NA	≥1 CFU/ml	NR	NR	NR	NR
	1	NR	NA	NR	NR	NA	99.9	NA	NR	0.1	NA	≥1 CFU/ml	NR	NR	NR	NR
Buttner 2001	1	NR	NA	NR	NR	NA	74.3	NA	NR	7	NA	NR	NR	NR	NR	NR
	12	127 – 1283	NA	0.6 – 101[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
Valentine 2008	12	NR	NA	NR	NR	NA	1.4 – 7.9	NA	NR	18 – 84	NA	NR	NR	NR	NR	NR
	3	NR	NA	NR	NR	NA	2.6 – 4.2	NA	NR	22 – 38	NA	NR	NR	NR	NR	NR
Buttner 2004a	12	711 – 6950	NA	0 – 44[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
	6	506 – 883	NA	NA	3 – 95	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
Buttner 2004b	4	2.05 – 3.35	NA	NR	NR	NA	11.3 – 18.4	NA	NR	NR	NA	≥1 CFU/ml	NR	0.0042 – 0.01	NR	NR
	6	115 – 590	NA	14 – 84	NR	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
Frawley 2008	6	NR	NA	NR	NR	NA	0.2 – 6.6	NA	NR	46 – 70	NA	NR	NR	NR	NR	NR
Einfeld 2011	10	NR	NA	NR	NR	NA	18.0 – 96.8	NA	29 – 96[(a)]	(a)	NA	NR	NR	NR	NR	NR
Quizon 2007	4	6670 – 14615	NA	8 – 20[(a)]	(a)	NA	39.5, NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
Krauter 2011	27	0.0003 – 0.994	NA	NR	6.6 – 316	NA	12.5 – 75.5	NA	NR	6.6 – 316	NA	≥1	LOD_{95} LOD_{90}	0.013 – 0.038	0 – 0.933	0.0
	27	0.0 – 0.084	NA	NR	0 – 316	NA	4.0 – 76.9	NA	NR	0 – 316	NA	≥1	LOD_{95} LOD_{90}	0.015 – 0.051	0 – 1.0	0.0
Rose 2011	3	0.0064 – 13.34	NR	NR	NR	NR	46.1 – 77.9	14 – 48	NA	11 – 54	18 – 72	≥1	NR	NR	0 – 0.159	0 – 0.056
	3	0.013 – 15.48	NR	NR	NR	NR	24.4 – 32.4	20 – 31	NA	20 – 69	28 – 76	≥1	NR	0.031	NR	NR
	1	NR	NR	NR	NR	NR	30.8	NA	NA	50	NA	NR	NR	NR	NR	NR
	1	NR	NR	NR	NR	NR	32.3	NA	NA	30	NA	NR	NR	NR	NR	NR
	1	NR	NR	NR	NR	NR	26.8	NA	NA	21	NA	NR	NR	NR	NR	NR
	1	NR	NR	NR	NR	NR	36.3	NA	NA	25	NA	NR	NR	NR	NR	NR
	3	NR	NR	NR	NR	NR	26.0	NA	NA	38	NA	NR	NR	NR	NR	NR
Montgomery 2008	4	NR	NA	NR	NR	NA	14.5 – 19.9	NA	10 – 37	0 – 27	NA	NR	NR	NR	NR	NR

(a) Combined estimate of "run" and "sample-within-run" uncertainties. In cases where the data supported estimating each source of uncertainty and combining them, it was not possible to tell whether these calculations were correctly implemented. A common, but incorrect, method is to calculate a single standard deviation from data including two or more sources of uncertainty.

Table 4a. Summary of test conditions for vacuum sampling studies. Acronyms and abbreviations are defined in Table 6 and the footnotes.

Reference (lead author and year)	# tests	Agent	Agent depo-sition	Agent concentration(s) #	Agent concentration(s) Range (CFU/cm^2)	Vacuum filter type	Vacuum technique (a)	Relative humidity (%)	Surface Types	Surface area sampled (cm^2)	Extract -ion liquid	Extraction method	Culture method, medium	# labs	# test runs	# samples /test
Estill 2009	3	BA-S	DA	3	0.03 – 2	HEPA sock	P2D	NR	SS	929	BBT	A+C+V+S	FP, TSAB	1	3	27
	3	BA-S	DA	3	0.03 – 2	HEPA sock	P2D	NR	Cpt	929	BBT	A+C+V+S	FP, TSAB	1	2 – 4	18 – 36
Brown 2007c	8	BA	DA	2	1E+2 – 1E+3 1E+4 – 1E+5	HEPA filter	PP2D	NR	SS, PWB, Cpt, Concrete	100	BBT	S+H+V	Plate, PF	1	NR	13 – 24
Einfeld 2011	6	BAtr, BAtr +grime	DA	1	1.31E+3 – 8.78E+4	PE filter	NR	36 – 48, 77 – 90	Marble, Concrete	100	BBT	S+H+V	Plate, PF	1	3 – 5	33 – 59
Quizon 2007	6	BAtr	WA	1	NR	HEPA sock	SVH	NR	CelT, PWB, SS, VL, W	900	PBST	C+V+S	SP/FP, TSA	1	4	4 – 10
Montgomery 2008	1	BA-S	EWD	1	7.98E+2	HEPA sock	R	NR	HVAC filter	309.68	PBSTr	Shake+C	NR, NR	1	3	NR
	4	BA-S	EWD	3	7.98E+2, 9.0E+4, 9.1E+6	TECF	G, R	NR	HVAC filter	400	PBSTr	Shake+C	NR, NR	1	3	9, NR
	3	BA-S	EWD	2	167, 201	TECF	VS, TD	NR	Cpt	400	PBSTr	Shake+C	NR, NR	1	1	3, 6
	2	BA-S	WD	1	111	TECF	VS, TP	NR	Cpt	400	PBSTr	Shake+C	NR, NR	1	1	3

(a) R = rough, G = gentle, VS = vertical slide, TD = tilt drag, TP = tilt push. See Table 6 for remaining acronyms.

Table 4b. Summary of test results for vacuum sampling. Acronyms and abbreviations are defined in Table 6.

Reference (lead author and year)	# tests	Recovery concentration results – Mean & %RSDs: Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	Recovery efficiency (RE) – Mean & %RSDs: RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	LOD, FNR, and FPR: Positive result (CFU)	LOD defi-nition	LOD (CFU/cm^2)	FNR	FPR
Estill 2009	3	0.0043 – 0.1	18 – 38	0 – 50	82 – 98	84 – 116	3.7 – 5.5	16 – 31	0 – 5	73 – 90	79 – 92	≥3	LOD_{95}	0.44	NR	0.267
	3	0.0011 – 0.062	0 – 30	0 – 57	44 – 170	65 – 170	3.7 – 6.3	0 – 18	0 – 89	50 – 130	100 – 130	≥3	LOD_{95}	0.28	NR	0.067
Brown 2007c	8	NR	NA	NR	NR	NA	16.4 – 36.1	NA	NR	28 – 90	NA	≥1 CFU/ml	NR	NR	NR	NR
Einfeld 2011	6	NR	NA	NR	NR	NA	10.0 – 19.7	NA	NR	50 – 129	NA	NR	NR	NR	NR	NR
Quizon 2007	6	890 – 5200	NA	9 – 20[(a)]	(a)	NA	4.4, NR	NA	NR	NR	NA	NR	NR	NR	NR	NR
Montgomery 2008	1	NR	NA	NR	NR	NA	2.42	NA	1.3	24	NA	NR	NR	NR	NR	NR
	4	NR	NA	NR	NR	NA	1.16 – 3.52	NA	16 – 28	13 – 25	NA	NR	NR	NR	NR	NR
	3	NR	NA	NR	NR	NA	0.20 – 0.48	NA	NA	10 – 60	NA	NR	NR	NR	NR	NR
	2	NR	NA	NR	NR	NA	2.26, 1.69	NA	NA	18, 32	NA	NR	NR	NR	NR	NR

(a) Combined estimate of "run" and "sample-within-run" uncertainties.

Table 5a. Summary of test conditions for storage and stability tests. Acronyms and abbreviations are defined in Table 6.

Reference (lead author and year)	# tests	Agent (a)	Agent deposition (b)	Agent concen-tration (CFU/ml)	Sampling medium type (b)	Wetting agent (b)	Relative humidity	Surface type & area sampled (b)	Storage conditions			Extract-ion liquid (a)	Extract-ion method (a)	Culture method, medium	# labs	# test runs	Total # test samples
									Additive (c)	Temp. (°C)	# days						
Almeida 2008	1	BA Sterne	Liquid	NR	NA	NA	NR	NA	None	4	0	NA	NA	Plate, LBA	NR	3 lots	19
	15	BA Sterne	Liquid	NR	NA	NA	NR	NA	None, Phenol, EDTA. Ethanol, PBSTr	4	0, 182, 279	NA	NA	Plate, LBA	NR	1	3
	4	BA Sterne	Liquid	NR	NA	NA	NR	NA	None	-20, -80	182, 279	NA	NA	Plate, LBA	NR	1	3

(a) The BA Sterne spores were diluted with PBS (10 mmol/L phosphate, 138 mmol/L NaCl, and 2.7 mmol/L KCl, pH 7.4) containing 0.01% Triton® X-100, and vigorously mixed by vortexing.
(b) This study used only liquid samples containing the agent, so neither deposition onto surfaces nor sampling of surfaces was involved.
(c) Additives to sterile water: Ethanol = ethanol 20% (v⁄v), EDTA = ethylendediaminetetraacetic acid, 10 mmol/L, pH 8.0, Phenol = phenol 1% (v⁄v), PBSTr = PBS containing 0.01% (v⁄v) Triton × 100.

Table 5b. Summary of results for storage and stability tests. Acronyms and abbreviations are defined in Table 6.

Reference (lead author and year)	# tests	Recovery concentration results – Mean & %RSDs					Recovery Efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR				
		Mean (CFU/ml)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD defi-nition	LOD (CFU/cm^2)	FNR	FPR
Almeida 2008	1	6.19E+9	NA	174	25	NA	111	NA	22	24	NA	NR	NR	NR	NR	NR
	15	1.00E+8 – 1.95E+8	NA	NA	4 – 86	NA	71 – 86	NA	22	24	NA	NR	NR	NR	NR	NR
	4	1.20E+8 – 1.61E+8	NA	NA	7 – 84	NA	NA	NA	6 – 55	NA	NA	NR	NR	NR	NR	NR

(a) Combined estimate of "run" and "sample-within-run" uncertainties.

Table 6. List of acronyms and abbreviations

A	agitation (during processing/extraction)
Alum	aluminum
ATD	Arizona Test Dust
B	brick
BA	*Bacillus anthracis*
BA (4)	four strains of *Bacillus anthracis*
BA-S	*Bacillus anthracis Sterne*
BAtr	*Bacillus atrophaeus*
BAtr + grime	*Bacillus atrophaeus* + "standard grime" (Arizona test dust + diesel carbon + oil + biologicals)
BB	Butterfield buffer
BBT	Butterfield buffer with Tween
BHIA	brain heart infusion agar
BiSKit™	Biological Sampling Kit
BS	*Bacillus subtilis*
BS + PC2	*Bacillus subtilis* with 10^2 or 10^4 CFU/cm^2 *P.*
BS + PC4	*chrysogenum* background contamination
C	centrifuging (during processing/extraction)
CelT	ceiling tile
CerT	ceramic tile
CFU	colony forming unit
CI	confidence interval
Cpt	carpet
Cpt-C	carpet, commercial loop
Cpt-R	carpet, residential cut-pile
Cpt-S	carpet, soiled residential cut-pile
Cpt(3)	Cpt-C, Cpt-R, Cpt-S
Ct	cotton
Ct cloth	cotton cloth
DA	dry aerosol
DE broth	Dey Engley broth
DI	directly inoculated
DP	Dacron® polyester
DW	de-ionized, distilled, or sterile water
EWD	drops of agent in 50% ethanol, 50% water
EtOH	Ethyl alcohol, enthanol
F	Formica®
FL	faux leather
FNR	false negative rate
FP	filter plate
FPR	false positive rate
G	glass
H	heat treatment (extraction/processing)
HCW	HS II Cleanroom Wiper
HEPA	high efficiency particulate air
HM	hand mixed
HS	hand stomached
HVAC	heating, ventilation, and air conditioning
HW	heavy wipe
LBA	luria broth agar
LD	liquid drops
LI	liquid immersion
LOD	limit of detection
LOD_{90}	lowest concentration with 90% or 95%
LOD_{95}	probability of detection
LS	liquid spread
M	metal
MF, Mfoam	macrofoam
MLI foil	multilayer insulation foil (aluminized Kapton)
NA	not applicable
NB	neutralizing buffer
NB+ATD	sponge wipe pre-moistened with neutralizing buffer, wipe samples collected, then inoculated with Arizona Test Dust
NR	not reported
O	oak wood
P	Plastic
P2D	Pulled one direction & perpendicular direction
PBS	phosphate buffered saline
PBST	PBS with Tween
PBST+	PBST + Arizona Test Dust + *Bacillus atrophaeus* + *Staphylococcus epidermidis*
PBSTr	PBS-TritonX-100
PBST/Tr	PBS with 0.1% Tween (PBST) or 0.1% Triton-X (PBSTr)
PBT	potassium phosphate buffer w/ Tween
PC	Polycarbonate
PD	petri dish
PE	polyester
PE filter	polyethylene filter
PEF	polyester foam
PEUF	polyester upholstery fabric
PF	Petrifilm™
PLCP	plastic light cover panel
PP2D	push-pull one direction, then other
PR	polyester-rayon blend
PR gauze	polyester-rayon blend gauze
PU foam	polyurethane foam
PW	painted wood
PWB	painted wallboard
R	Rayon
RE	recovery efficiency
RH	relative humidity
%RSD	percent relative standard deviation
S	Sonication
SBA	sheep blood agar
SD	standard deviation
SE	standard error
SK	swab kit
SP	spread plate
Sp. stick	sponge stick
Sp. wipe	sponge wipe
SP/FP	spread plate for higher concentrations, filter plate for lower concentrations
SprP	spiral plate
SS	stainless steel
SSPK	swab sample processing kit
St	Stomached
SVH	S strokes, vertical then horizontal
TECF	3M Trace Evidence Collection Filter
TSA	trypticase soy agar
TSAB	trypticase soy agar with 5% sheep blood (also referred to as TSAII)
TSAC	trypticase soy agar + 100µg cycloheximide/ml
U	Untreated
V	vortexing (during processing/extraction)
VL	vinyl or vinyl tile
W	Wood
WA	wet aerosol
WD	drops of agent dispersed in water

Table 7. Numbers of the 20 surface sampling studies that investigated various factors and reported specific results

Number of Studies that Varied the . . .	Swabs (13)[a]						Wipes (12)[a]						Vacuums (5)[a]					
	Rec[b]		RE[c]				Rec[b]		RE[c]				Rec[b]		RE[c]			
	Mean/%RSD[d]	Lab/Run %RSD[e]	Mean/%RSD[d]	Lab/Run %RSD[e]	LOD[f]	FNR/FPR[g]	Mean/%RSD[d]	Lab/Run %RSD[e]	Mean/%RSD[d]	Lab/Run %RSD[e]	LOD[f]	FNR/FPR[g]	Mean/%RSD[d]	Lab/Run %RSD[e]	Mean/%RSD[d]	Lab/Run %RSD[e]	LOD[f]	FNR/FPR[g]
Agent (contaminant)	1	0	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0
Agent deposition	1	0	4	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0
Agent concentration	5	1	9	2	3	3	4	1	5	2	5	3	1	1	3	1	1	1
Sample collection medium type	3	0	5	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0
Wetting agent	1	0	3	1	0	1	1	0	3	0	1	0	NA	NA	NA	NA	NA	NA
Surface type	5	1	4	1	1	1	6	1	7	1	3	2	2	1	5	1	1	1
Surface area sampled	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Storage/transport conditions[h]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Processing/extraction method	4	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of labs	3	1	3	2	2	3	2	1	2	2	2	2	0	0	0	0	0	0

(a) Number in parentheses is the number of studies summarized.
(b) "Rec" denotes the agent recovered by surface sampling.
(c) RE denotes recovery efficiency.
(d) Mean/%RSD denotes the mean and within-run %RSD.
(e) Lab/Run %RSD means lab-to-lab %RSD and run-to-run %RSD.
(f) LOD denotes limit of detection
(g) FNR/FPR denotes false negative and/or false positive rate.
(h) Storage results are available in Almeida et al. (2008), but sampling media were not part of that study.

APPENDIX

Detailed Summary Tables of Test Conditions and Results from Laboratory Studies of Swab, Wipe, and Vacuum Sampling of Surfaces Contaminated with *Bacillus anthracis* or Surrogates

Tables A.1, A.2, and A.3 summarize the characteristics and results of laboratory studies from the literature (individual tests or groups of tests conducted in a laboratory or chamber) to investigate the performance of swab, wipe, and vacuum surface sampling and analysis methods when 1) the surfaces are contaminated with *Bacillus anthracis* or surrogates, and 2) culturing/counting is used to quantify results. Table A.4 summarizes the characteristics and results of one study (which did not involve surface sampling) to investigate the effects of storage/transportation factors. The contents of Tables A.1 to A.4 are explained in the section "Summary of Anthrax-Related Laboratory Studies." Also, the column headings of Tables A.1 to A.4 are described in Table 1, while the acronyms and abbreviations used in the tables are defined in Table 6.

Table A.1a Expanded summary of test conditions for swab sampling. Acronyms and abbreviations are defined in Table 6.

Reference	Test #	Agent	Agent deposition	Agent concentration (CFU/cm^2)	Swab type	Wetting agent	Relative humidity (%)	Surface type	Surface area sampled (cm^2)	Extraction liquid	Extraction method	Culture method, medium	# labs	# test runs	Total # test samples
Estill et al. 2009	1.1	BA Sterne	Dry aerosol	0.03	Macrofoam	BBT	NR	SS	103	BBT	V+S	FP, TSAB	3	3	36
	1.2	BA Sterne	Dry aerosol	0.3	Macrofoam	BBT	NR	SS	103	BBT	V+S	FP, TSAB	3	3	36
	1.3	BA Sterne	Dry aerosol	2	Macrofoam	BBT	NR	SS	103	BBT	V+S	FP, TSAB	3	3	35
	1.4	BA Sterne	Dry aerosol	0.03	Macrofoam	BBT	NR	Carpet	103	BBT	V+S	FP, TSAB	3	2	24
	1.5	BA Sterne	Dry aerosol	0.3	Macrofoam	BBT	NR	Carpet	103	BBT	V+S	FP, TSAB	3	4	48
	1.6	BA Sterne	Dry aerosol	2	Macrofoam	BBT	NR	Carpet	103	BBT	V+S	FP, TSAB	3	3	36
Hodges et al. 2006	2.1	BA Sterne	Liquid drops	0.4	Macrofoam	PBST	NR	SS	10	PBST	V	Plate, TSAB	2[(a)]	NR	15
	2.2	BA Sterne	Liquid drops	0.6	Macrofoam	PBST	NR	SS	10	PBST	V	Plate, TSAB	2[(a)]	NR	15
	2.3	BA Sterne	Liquid drops	1.2	Macrofoam	PBST	NR	SS	10	PBST	V	Plate, TSAB	2[(a)]	NR	15
	2.4	BA Sterne	Liquid drops	3.8	Macrofoam	PBST	NR	SS	10	PBST	V	Plate, TSAB	2[(a)]	NR	15
	2.5	BA Sterne	Liquid drops	59	Macrofoam	PBST	NR	SS	10	PBST	V	Plate, TSAB	2[(a)]	NR	45
	2.6	BA Sterne	Liquid drops	6000	Macrofoam	PBST	NR	SS	10	PBST	V	FP, TSAB	2[(a)]	NR	45
Rose et al. 2004	3.1	BA Sterne	Liquid drops	1937.5	Cotton	Dry	NR	SS	25.8	PBST	None	Plate, TSAB	1	NR	10
	3.2	BA Sterne	Liquid drops	1937.5	Cotton	PBST	NR	SS	25.8	PBST	None	Plate, TSAB	1	NR	10
	3.3	BA Sterne	Liquid drops	1937.5	Cotton	Dry	NR	SS	25.8	PBST	V	Plate, TSAB	1	NR	10
	3.4	BA Sterne	Liquid drops	1937.5	Cotton	PBST	NR	SS	25.8	PBST	V	Plate, TSAB	1	NR	10
	3.5	BA Sterne	Liquid drops	1937.5	Cotton	Dry	NR	SS	25.8	PBST	S	Plate, TSAB	1	NR	10
	3.6	BA Sterne	Liquid drops	1937.5	Cotton	PBST	NR	SS	25.8	PBST	S	Plate, TSAB	1	NR	10
	3.7	BA Sterne	Liquid drops	1937.5	Polyester	Dry	NR	SS	25.8	PBST	None	Plate, TSAB	1	NR	10
	3.8	BA Sterne	Liquid drops	1937.5	Polyester	PBST	NR	SS	25.8	PBST	None	Plate, TSAB	1	NR	10
	3.9	BA Sterne	Liquid drops	1937.5	Polyester	Dry	NR	SS	25.8	PBST	V	Plate, TSAB	1	NR	10
	3.10	BA Sterne	Liquid drops	1937.5	Polyester	PBST	NR	SS	25.8	PBST	V	Plate, TSAB	1	NR	10
	3.11	BA Sterne	Liquid drops	1937.5	Polyester	Dry	NR	SS	25.8	PBST	S	Plate, TSAB	1	NR	10
	3.12	BA Sterne	Liquid drops	1937.5	Polyester	PBST	NR	SS	25.8	PBST	S	Plate, TSAB	1	NR	10
	3.13	BA Sterne	Liquid drops	1937.5	Rayon	Dry	NR	SS	25.8	PBST	None	Plate, TSAB	1	NR	10
	3.14	BA Sterne	Liquid drops	1937.5	Rayon	PBST	NR	SS	25.8	PBST	None	Plate, TSAB	1	NR	10
	3.15	BA Sterne	Liquid drops	1937.5	Rayon	Dry	NR	SS	25.8	PBST	V	Plate, TSAB	1	NR	10
	3.16	BA Sterne	Liquid drops	1937.5	Rayon	PBST	NR	SS	25.8	PBST	V	Plate, TSAB	1	NR	10
	3.17	BA Sterne	Liquid drops	1937.5	Rayon	Dry	NR	SS	25.8	PBST	S	Plate, TSAB	1	NR	10
	3.18	BA Sterne	Liquid drops	1937.5	Rayon	PBST	NR	SS	25.8	PBST	S	Plate, TSAB	1	NR	10
	3.19	BA Sterne	Liquid drops	1937.5	Macrofoam	Dry	NR	SS	25.8	PBST	None	Plate, TSAB	1	NR	10
	3.20	BA Sterne	Liquid drops	1937.5	Macrofoam	PBST	NR	SS	25.8	PBST	None	Plate, TSAB	1	NR	10
	3.21	BA Sterne	Liquid drops	1937.5	Macrofoam	Dry	NR	SS	25.8	PBST	V	Plate, TSAB	1	NR	10
	3.22	BA Sterne	Liquid drops	1937.5	Macrofoam	PBST	NR	SS	25.8	PBST	V	Plate, TSAB	1	NR	10
	3.23	BA Sterne	Liquid drops	1937.5	Macrofoam	Dry	NR	SS	25.8	PBST	S	Plate, TSAB	1	NR	10
	3.24	BA Sterne	Liquid drops	1937.5	Macrofoam	PBST	NR	SS	25.8	PBST	S	Plate, TSAB	1	NR	10
	3.25	BA Sterne	Liquid imm.	1E+4 CFU/swab	Cotton, DI	NA	NR	None	NA	PBST	V	Plate, TSAB	1	NR	10
	3.26	BA Sterne	Liquid imm.	1E+4 CFU/swab	Polyester	NR	NR	None	NA	PBST	V	Plate, TSAB	1	NR	10
	3.27	BA Sterne	Liquid imm.	1E+4 CFU/swab	Rayon	NR	NR	None	NA	PBST	V	Plate, TSAB	1	NR	10
	3.28	BA Sterne	Liquid imm.	1E+4 CFU/swab	Macrofoam	NR	NR	None	NA	PBST	V	Plate, TSAB	1	NR	10

Table A.1a Expanded summary of test conditions for swab sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

Reference	Test #	Agent	Agent deposition	Agent concentration (CFU/cm^2)	Swab type	Wetting agent	Relative humidity (%)	Surface type	Surface area sampled (cm^2)	Extraction liquid	Extraction method	Culture method, medium	# labs	# test runs	Total # test samples
Frawley et al. 2008	4.1	BA Sterne	Liquid drops	1E+2 – 1E+5	Polyester	Dry	NR	Plastic	1	PBST	V	Plate, SBA	1	NR	12
	4.2	BA Sterne	Liquid drops	(b)	Polyester	Dry	NR	Wood	NR	PBST	V	Plate, SBA	1	NR	12
	4.3	BA Sterne	Liquid drops	(b)	Polyester	Dry	NR	Ct Cloth	NR	PBST	V	Plate, SBA	1	NR	12
	4.4	BA Sterne	Liquid drops	1E+2 – 1E+5	Polyester	PBST/Tr	NR	Plastic	1	PBST	V	Plate, SBA	1	NR	24
	4.5	BA Sterne	Liquid drops	(b)	Polyester	PBST/Tr	NR	Wood	NR	PBST	V	Plate, SBA	1	NR	24
	4.6	BA Sterne	Liquid drops	(b)	Polyester	PBST/Tr	NR	Ct Cloth	NR	PBST	V	Plate, SBA	1	NR	24
	4.7	BA (4)	Liquid drops	50 CFU/sample	Cotton	PBST/Tr	NR	Plastic	NR	NR	NR	Plate, NR	1	NR	11
	4.8	BA (4)	Liquid drops	50 CFU/sample	Cotton	PBST/Tr	NR	Glass	NR	NR	NR	Plate, NR	1	NR	11
	4.9	BA (4)	Liquid drops	50 CFU/sample	Cotton	PBST/Tr	NR	Formica	NR	NR	NR	Plate, NR	1	NR	11
	4.10	BA (4)	Liquid drops	50 CFU/sample	Cotton	PBST/Tr	NR	Metal	NR	NR	NR	Plate, NR	1	NR	11
	4.11	BA (4)	Liquid drops	50 CFU/sample	Cotton	PBST/Tr	NR	Carpet	NR	NR	NR	Plate, NR	1	NR	11
	4.12	BA (4)	Liquid drops	50 CFU/sample	Cotton	PBST/Tr	NR	Brick	NR	NR	NR	Plate, NR	1	NR	11
	4.13	BA, 1 strain	Liquid drops	50 CFU/sample	Cotton	PBST/Tr	NR	Ct Cloth	NR	NR	NR	Plate, NR	1	NR	11
Brown et al. 2007b	5.1	BAtr	Dry aerosol	1E+2 – 1E+3	Rayon	DW	NR	SS	25	BBT	S+H+V	Plate, PF	1	NR	20
	5.2	BAtr	Dry aerosol	1E+4 – 1E+5	Rayon	DW	NR	SS	25	BBT	S+H+V	Plate, PF	1	NR	20
	5.3	BAtr	Dry aerosol	1E+2 – 1E+3	Rayon	DW	NR	PWB	25	BBT	S+H+V	Plate, PF	1	NR	20
	5.4	BAtr	Dry aerosol	1E+4 – 1E+5	Rayon	DW	NR	PWB	25	BBT	S+H+V	Plate, PF	1	NR	20
	5.5	BAtr	Liquid imm.	1E+6 CFU/swab	Rayon, DI	NA	NR	None	NA	BBT	S+H+V	Plate, PF	1	NR	20
	5.6	BAtr	Liquid drops	2.0E+5	NA	NA	NR	SS, DI	6.25	BBT	S+H	Plate, BHIA	1	NR	24
Edmonds et al. 2009	6.1	BAtr	Liquid drops	1.0E+5	Cotton	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	4	40
	6.2	BAtr	Liquid drops	1.0E+5	Dacron	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	4	40
	6.3	BAtr	Liquid drops	1.0E+5	Rayon	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	4	38
	6.4	BAtr	Liquid drops	1.0E+5	Macrofoam	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	4	39
	6.5	BAtr	Liquid drops	1.0E+5	Cotton	DW	NR	SS	10	PBSTr	V+S	SprP, NR	1	3	28
	6.6	BAtr	Liquid drops	1.0E+5	Dacron	DW	NR	SS	10	PBSTr	V+S	SprP, NR	1	3	30
	6.7	BAtr	Liquid drops	1.0E+5	Rayon	DW	NR	SS	10	PBSTr	V+S	SprP, NR	1	3	30
	6.8	BAtr	Liquid drops	1.0E+5	Macrofoam	DW	NR	SS	10	PBSTr	V+S	SprP, NR	1	3	29
	6.9	BAtr	Liquid drops	1.0E+5	Cotton	DW	NR	PC	10	PBSTr	V+S	SprP, NR	1	3	30
	6.10	Batr	Liquid drops	1.0E+5	Dacron	DW	NR	PC	10	PBSTr	V+S	SprP, NR	1	3	30
	6.11	Batr	Liquid drops	1.0E+5	Rayon	DW	NR	PC	10	PBSTr	V+S	SprP, NR	1	3	30
	6.12	BAtr	Liquid drops	1.0E+5	Macrofoam	DW	NR	PC	10	PBSTr	V+S	SprP, NR	1	3	30
	6.13	BAtr	Liquid drops	1.0E+5	Cotton	DW	NR	Vinyl	10	PBSTr	V+S	SprP, NR	1	3	29
	6.14	BAtr	Liquid drops	1.0E+5	Dacron	DW	NR	Vinyl	10	PBSTr	V+S	SprP, NR	1	3	30
	6.15	BAtr	Liquid drops	1.0E+5	Rayon	DW	NR	Vinyl	10	PBSTr	V+S	SprP, NR	1	3	29
	6.16	BAtr	Liquid drops	1.0E+5	Macrofoam	DW	NR	Vinyl	10	PBSTr	V+S	SprP, NR	1	3	29
	6.17	BAtr	Dry aerosol	1.0E+9	Cotton	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	3	30
	6.18	BAtr	Dry aerosol	1.0E+9	Dacron	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	3	30
	6.19	BAtr	Dry aerosol	1.0E+9	Rayon	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	3	29
	6.20	BAtr	Dry aerosol	1.0E+9	Macrofoam	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	3	29

Table A.1a Expanded summary of test conditions for swab sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

Reference	Test #	Agent	Agent deposition	Agent concentration (CFU/cm^2)	Swab type	Wetting agent	Relative humidity (%)	Surface type	Surface area sampled (cm^2)	Extraction liquid	Extraction method	Culture method, medium	# labs	# test runs	Total # test samples
Edmonds et al. 2009 (cont.)	6.21	BAtr	Dry aerosol	1.0E+9	Cotton	DW	NR	SS	10	PBSTr	V+S	SprP, NR	1	3	30
	6.22	BAtr	Dry aerosol	1.0E+9	Dacron	DW	NR	SS	10	PBSTr	V+S	SprP, NR	1	3	30
	6.23	BAtr	Dry aerosol	1.0E+9	Rayon	DW	NR	SS	10	PBSTr	V+S	SprP, NR	1	3	30
	6.24	BAtr	Dry aerosol	1.0E+9	Macrofoam	DW	NR	SS	10	PBSTr	V+S	SprP, NR	1	3	30
	6.25	BAtr	Dry aerosol	1.0E+9	Cotton	DW	NR	PC	10	PBSTr	V+S	SprP, NR	1	3	30
	6.26	BAtr	Dry aerosol	1.0E+9	Dacron	DW	NR	PC	10	PBSTr	V+S	SprP, NR	1	3	30
	6.27	BAtr	Dry aerosol	1.0E+9	Rayon	DW	NR	PC	10	PBSTr	V+S	SprP, NR	1	3	30
	6.28	BAtr	Dry aerosol	1.0E+9	Macrofoam	DW	NR	PC	10	PBSTr	V+S	SprP, NR	1	3	30
	6.29	BAtr	Dry aerosol	1.0E+9	Cotton	DW	NR	Vinyl	10	PBSTr	V+S	SprP, NR	1	3	24
	6.30	BAtr	Dry aerosol	1.0E+9	Dacron	DW	NR	Vinyl	10	PBSTr	V+S	SprP, NR	1	3	30
	6.31	BAtr	Dry aerosol	1.0E+9	Rayon	DW	NR	Vinyl	10	PBSTr	V+S	SprP, NR	1	3	29
	6.32	BAtr	Dry aerosol	1.0E+9	Macrofoam	DW	NR	Vinyl	10	PBSTr	V+S	SprP, NR	1	3	30
	6.33	BAtr	Liquid drops	4774.35	Dacron	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	3	30
	6.34	BAtr	Liquid drops	30114.6	Dacron	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	3	30
	6.35	BAtr	Liquid drops	2.916E+5	Dacron	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	3	30
	6.36	BAtr	Liquid drops	2.524E+6	Dacron	DW	NR	Glass	10	PBSTr	V+S	SprP, NR	1	3	30
Valentine et al. 2008	7.1	BS	Liquid drops	90349.9	Cotton	PBST	NR	Plastic	104.04	PBST	V	Plate, TSA	1	10	10
	7.2	BS	Liquid drops	90349.9	PU foam	PBST	NR	Plastic	104.04	PBST	V	Plate, TSA	1	10	10
	7.3	BS	Liquid drops	90349.9	Polyester	PBST	NR	Plastic	104.04	PBST	V	Plate, TSA	1	10	10
	7.4	BS	Liquid drops	90349.9	Dacron	PBST	NR	Plastic	104.04	PBST	V	Plate, TSA	1	10	10
	7.5	BS	Liquid drops	90349.9	Cotton	PBST	NR	Oak	104.04	PBST	V	Plate, TSA	1	10	10
	7.6	BS	Liquid drops	90349.9	PU foam	PBST	NR	Oak	104.04	PBST	V	Plate, TSA	1	10	10
	7.7	BS	Liquid drops	90349.9	Polyester	PBST	NR	Oak	104.04	PBST	V	Plate, TSA	1	10	10
	7.8	BS	Liquid drops	90349.9	Dacron	PBST	NR	Oak	104.04	PBST	V	Plate, TSA	1	10	10
	7.9	BS	Liquid drops	282000	Cotton	PBST	NR	Monitor	25	PBST	V	Plate, TSA	1	10	10
	7.10	BS	Liquid drops	282000	PU foam	PBST	NR	Monitor	25	PBST	V	Plate, TSA	1	10	10
	7.11	BS	Liquid drops	282000	Polyester	PBST	NR	Monitor	25	PBST	V	Plate, TSA	1	10	10
	7.12	BS	Liquid drops	282000	Dacron	PBST	NR	Monitor	25	PBST	V	Plate, TSA	1	10	10
	7.13	BS	Liquid drops	90349.9	Cotton	PBST	NR	PEUF	104.04	PBST	V	Plate, TSA	1	10	10
	7.14	BS	Liquid drops	90349.9	PU foam	PBST	NR	PEUF	104.04	PBST	V	Plate, TSA	1	10	10
	7.15	BS	Liquid drops	90349.9	Polyester	PBST	NR	PEUF	104.04	PBST	V	Plate, TSA	1	10	10
	7.16	BS	Liquid drops	90349.9	Dacron	PBST	NR	PEUF	104.04	PBST	V	Plate, TSA	1	10	10
	7.17	BS	Liquid drops	90349.9	Cotton	PBST	NR	Carpet	104.04	PBST	V	Plate, TSA	1	10	10
	7.18	BS	Liquid drops	90349.9	PU foam	PBST	NR	Carpet	104.04	PBST	V	Plate, TSA	1	10	10
	7.19	BS	Liquid drops	90349.9	Polyester	PBST	NR	Carpet	104.04	PBST	V	Plate, TSA	1	10	10
	7.20	BS	Liquid drops	90349.9	Dacron	PBST	NR	Carpet	104.04	PBST	V	Plate, TSA	1	10	10
Buttner et al. 2001	8.1	BS	Liquid drops	1.48E+6	Swab kit	PBST	NR	Glass	5	PBT	V	Plate, TSAC	1	3	3
	8.2	BS	Liquid drops	1.48E+6	Cotton	PBST	NR	Glass	5	PBT	V	Plate, TSAC	1	3	3
	8.3	BS	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Vinyl	32.49	PBT	V	Plate, TSAC	1	3	3
	8.4	BS	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Cpt-R	32.49	PBT	V	Plate, TSAC	1	3	3

Table A.1a Expanded summary of test conditions for swab sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

Reference	Test #	Agent	Agent deposition	Agent concentration (CFU/cm^2)	Swab type	Wetting agent	Relative humidity (%)	Surface type	Surface area sampled (cm^2)	Extraction liquid	Extraction method	Culture method, medium	# labs	# test runs	Total # test samples
Buttner et al. 2001 (cont.)	8.5	BS	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Cpt-S	32.49	PBT	V	Plate, TSAC	1	3	3
	8.6	BS	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Cpt-C	32.49	PBT	V	Plate, TSAC	1	3	3
	8.7	BS	Dry aerosol	100 – 1000	Cotton	PBST	NR	Vinyl	32.49	PBT	V	Plate, TSAC	1	3	3
	8.8	BS	Dry aerosol	100 – 1000	Cotton	PBST	NR	Cpt-R	32.49	PBT	V	Plate, TSAC	1	3	3
	8.9	BS	Dry aerosol	100 – 1000	Cotton	PBST	NR	Cpt-S	32.49	PBT	V	Plate, TSAC	1	3	3
	8.10	BS	Dry aerosol	100 – 1000	Cotton	PBST	NR	Cpt-C	32.49	PBT	V	Plate, TSAC	1	3	3
	8.11	BS + PC2	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Vinyl	32.49	PBT	V	Plate, TSAC	1	2	2
	8.12	BS + PC2	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Cpt-R	32.49	PBT	V	Plate, TSAC	1	2	2
	8.13	BS + PC2	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Cpt-S	32.49	PBT	V	Plate, TSAC	1	2	2
	8.14	BS + PC2	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Cpt-C	32.49	PBT	V	Plate, TSAC	1	2	2
	8.15	BS + PC4	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Vinyl	32.49	PBT	V	Plate, TSAC	1	2	2
	8.16	BS + PC4	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Cpt-R	32.49	PBT	V	Plate, TSAC	1	2	2
	8.17	BS + PC4	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Cpt-S	32.49	PBT	V	Plate, TSAC	1	2	2
	8.18	BS + PC4	Dry aerosol	100 – 1000	Swab kit	PBST	NR	Cpt-C	32.49	PBT	V	Plate, TSAC	1	2	2
Buttner et al. 2004a	9.1	BAtr	Dry aerosol	107.6 – 1076.4	SSPK	NR	NR	Vinyl	929	NR	HM	Plate, TSA	1	3	3
	9.2	BAtr	Dry aerosol	107.6 – 1076.4	SSPK	NR	NR	Wood	929	NR	HM	Plate, TSA	1	3	3
	9.3	BAtr	Dry aerosol	107.6 – 1076.4	SSPK	NR	NR	Metal	929	NR	HM	Plate, TSA	1	3	3
	9.4	BAtr	Dry aerosol	107.6 – 1076.4	SSPK	NR	NR	Vinyl	929	NR	HM	Plate, TSA	1	3	3
	9.5	BAtr	Dry aerosol	107.6 – 1076.4	SSPK	NR	NR	Wood	929	NR	HM	Plate, TSA	1	3	3
	9.6	BAtr	Dry aerosol	107.6 – 1076.4	SSPK	NR	NR	Metal	929	NR	HM	Plate, TSA	1	3	3
	9.7	BAtr	Dry aerosol	107.6 – 1076.4	SSPK	NR	NR	Vinyl	929	NR	HM	Plate, TSA	1	1	2
	9.8	BAtr	Dry aerosol	107.6 – 1076.4	SSPK	NR	NR	Wood	929	NR	HM	Plate, TSA	1	1	2
	9.9	BAtr	Dry aerosol	107.6 – 1076.4	SSPK	NR	NR	Metal	929	NR	HM	Plate, TSA	1	1	2
Buttner et al. 2004b	10.1	BAtr	Dry aerosol	NR	SSPK	NR	NR	Metal	317	NR	HM	Plate, TSA	1	NR	4
	10.2	BAtr	Dry aerosol	NR	SSPK	NR	NR	Wood	317	NR	HM	Plate, TSA	1	NR	8
	10.3	BAtr	Dry aerosol	NR	Cotton	NR	NR	Metal	100	NR	Shake	Plate, TSA	1	NR	4
	10.4	BAtr	Dry aerosol	NR	Cotton	NR	NR	Wood	100	NR	Shake	Plate, TSA	1	NR	8
Quizon et al. 2007	11.1	BAtr	Wet aerosol	NR	PU foam	PBST	NR	PWB	100	PBST	V+S	SP/FP, TSA	1	4	4
	11.2	BAtr	Wet aerosol	NR	PU foam	PBST	NR	SS	100	PBST	V+S	SP/FP, TSA	1	4	10
	11.3	BAtr	Wet aerosol	NR	PU foam	PBST	NR	Vinyl	100	PBST	V+S	SP/FP, TSA	1	4	4
	11.4	BAtr	Wet aerosol	NR	PU foam	PBST	NR	Wood	100	PBST	V+S	SP/FP, TSA	1	4	4
Nellen et al. 2006	12.1	BS 168	Liquid drops	1000 CFU/swab	Cotton, DI	NA	NR	NA	NA	PBS	Untreated	Plate, TSA	1	3	15
	12.2	BS 168	Liquid drops	1000 CFU/swab	Rayon, DI	NA	NR	NA	NA	PBS	Untreated	Plate, TSA	1	3	15
	12.3	BS 168	Liquid drops	1000 CFU/swab	Cotton, DI	NA	NR	NA	NA	PBS	V	Plate, TSA	1	3	15
	12.4	BS 168	Liquid drops	1000 CFU/swab	Rayon, DI	NA	NR	NA	NA	PBS	V	Plate, TSA	1	3	15
	12.5	BS 168	Liquid drops	1000 CFU/swab	Cotton, DI	NA	NR	NA	NA	PBS	S	Plate, TSA	1	3	15
	12.6	BS 168	Liquid drops	1000 CFU/swab	Rayon, DI	NA	NR	NA	NA	PBS	S	Plate, TSA	1	3	15
	12.7	BS 168	Liquid drops	1000 CFU/swab	Cotton, DI	NA	NR	NA	NA	PBS	V+S	Plate, TSA	1	3	15
	12.8	BS 168	Liquid drops	1000 CFU/swab	Rayon, DI	NA	NR	NA	NA	PBS	V+S	Plate, TSA	1	3	15
	12.9	BS 168	Liquid drops	4	Cotton	DW	NR	Petri dish	25	PBS	NR (c)	Plate, TSA	1	3	15

Table A.1a Expanded summary of test conditions for swab sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

Reference	Test #	Agent	Agent deposition	Agent concentration (CFU/cm^2)	Swab type	Wetting agent	Relative humidity (%)	Surface type	Surface area sampled (cm^2)	Extraction liquid	Extraction method	Culture method, medium	# labs	# test runs	Total # test samples
Nellen et al. 2006 (cont.)	12.10	BS 168	Liquid drops	4	Rayon	DW	NR	Petri dish	25	PBS	NR (c)	Plate, TSA	1	3	15
	12.11	BS 168	Liquid drops	4	Cotton	DW	NR	Petri dish	25	PBS	H+V+S	Plate, TSA	1	3	15
	12.12	BS 168	Liquid drops	4	Rayon	DW	NR	Petri dish	25	PBS	H+V+S	Plate, TSA	1	3	15
	12.13	BS 168	Liquid drops	16	Rayon	DW	NR	Alum	25	PBS	NR (c)	Plate, TSA	1	3	3
	12.14	BS 168	Liquid drops	16	Rayon	DW	NR	V2A steel	25	PBS	NR (c)	Plate, TSA	1	3	3
	12.15	BS 168	Liquid drops	16	Rayon	DW	NR	MLI foil	25	PBS	NR (c)	Plate, TSA	1	3	3
	12.16	BS 168	Liquid drops	16	Rayon	DW	NR	Kapton	25	PBS	NR (c)	Plate, TSA	1	3	3
	12.17	BS 168	Liquid drops	16	Rayon	DW	NR	Teflon	25	PBS	NR (c)	Plate, TSA	1	3	3
	12.18	BS 168	Liquid drops	16	Rayon	DW	NR	Alum	25	PBS	H+V+S	Plate, TSA	1	3	3
	12.19	BS 168	Liquid drops	16	Rayon	DW	NR	V2A steel	25	PBS	H+V+S	Plate, TSA	1	3	3
	12.20	BS 168	Liquid drops	16	Rayon	DW	NR	MLI foil	25	PBS	H+V+S	Plate, TSA	1	3	3
	12.21	BS 168	Liquid drops	16	Rayon	DW	NR	Kapton	25	PBS	H+V+S	Plate, TSA	1	3	3
	12.22	BS 168	Liquid drops	16	Rayon	DW	NR	Teflon	25	PBS	H+V+S	Plate, TSA	1	3	3
Hodges et al. 2010	13.1	BA Sterne	Liquid drops	1.88	Macrofoam	PBST	NR	SS	26	PBST	V	FP, TSAB	12	1	118
	13.2	BA Sterne	Liquid drops	19.46	Macrofoam	PBST	NR	SS	26	PBST	V	FP, TSAB	12	1	120
	13.3	BA Sterne	Liquid drops	1607.2	Macrofoam	PBST	NR	SS	26	PBST	V	FP, TSAB	12	1	116
	13.4	BA Sterne	Liquid imm.	42 CFU/swab	Mfoam, DI	NA	NR	NA	NA	PBST	V	FP, TSAB	10/12	1	30/24[f]
	13.5	BA Sterne	Liquid imm.	373 CFU/swab	Mfoam, DI	NA	NR	NA	NA	PBST	V	FP, TSAB	10/12	1	30/24[f]
	13.6	BA Sterne	Liquid imm.	33300 CFU/swab	Mfoam, DI	NA	NR	NA	NA	PBST	V	FP, TSAB	10/10	1	30/20[f]
	13.7	BA Sterne	Liquid drops	1.38	Macrofoam	(d)	NR	SS	26	PBST	V	FP, TSAB	12	1	120
	13.8	BA Sterne	Liquid drops	15.27	Macrofoam	(d)	NR	SS	26	PBST	V	FP, TSAB	12	1	120
	13.9	BA Sterne	Liquid drops	1188.5	Macrofoam	(d)	NR	SS	26	PBST	V	FP, TSAB	12	1	120
	13.10	BA Sterne	Liquid imm.	36 CFU/swab	Mfoam, DI	(d)	NR	NA	26	PBST	V	FP, TSAB	12	1	24/48[e]
	13.11	BA Sterne	Liquid imm.	397 CFU/swab	Mfoam, DI	(d)	NR	NA	26	PBST	V	FP, TSAB	12	1	24/48[e]
	13.12	BA Sterne	Liquid imm.	30900 CFU/swab	Mfoam, DI	(d)	NR	NA	26	PBST	V	FP, TSAB	12	1	24/48[e]

(a) Five analysts from two laboratories each analyzed samples with each contaminant concentration.
(b) 1E+2 – 1E+5/sample, sample surface area not reported.
(c) These tests investigated the spores detached from the surface by swabbing, although the method used to quantify spore detachment independent of extraction and processing was not described by Nellen et al. (2006).
(d) PBST + Arizona Test Dust + *Bacillus atrophaeus* + *Staphylococcus epidermidis*.
(e) xx/yy = # positive control samples/# negative control samples.

Table A.1b Expanded summary of test results for swab sampling. Acronyms and abbreviations are defined in Table 6.

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive Result (CFU)	LOD defin-ition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Estill et al. 2009	1.1	0.0012	110	0	460	473	3.4	68	0	550	560						
	1.2	0.025	0	27	82	86	6.5	0	12	80	81	≥1	LOD_{95}	1.9	95% CI: 0.74 – 37	NR	1/27 = 0.037
	1.3	0.15	19	87	75	116	5.1	21	67	78	100						
	1.4	0.0018	85	0	220	236	12.0	110	0	230	260						
	1.5	0.023	0	98	73	122	14.0	0	110	76	130	≥1	LOD_{95}	0.4	95% CI: 0.16 - 5.6	NR	1/27 = 0.037
	1.6	0.18	21	40	57	73	12.0	19	71	76	110						
Hodges et al. 2006	2.1	0.1	NR	NR	100	NR	31.7	NA	NA	82	NA	≥1				0.267	NR
	2.2	0.2	NR	NR	100	NR	37.8	NA	NA	91	NA	≥1				0.133	NR
	2.3	0.4	NR	NR	75	NR	37.2	NA	NA	58	NA	≥1	LOD_{90}	1.2	NR	0	NR
	2.4	1.5	NR	NR	27	NR	40.1	NA	32	23	NA	≥1				0	NR
	2.5	22	NR	NR	30	NR	38.0	NA	28	21	NA	≥1				0	NR
	2.6	2900	NR	NR	30	NR	49.1	NA	33	27	NA	≥1				0	NR
Rose et al. 2004	3.1	NR	NA	NR	NR	NA	0.5	NA	NR	80	NA	NR	NR	NR	NR	NR	NR
	3.2	NR	NA	NR	NR	NA	4.7	NA	NR	47	NA	NR	NR	NR	NR	NR	NR
	3.3	NR	NA	NR	NR	NA	8.0	NA	NR	18	NA	NR	NR	NR	NR	NR	NR
	3.4	NR	NA	NR	NR	NA	41.7	NA	NR	35	NA	NR	NR	NR	NR	NR	NR
	3.5	NR	NA	NR	NR	NA	6.9	NA	NR	44	NA	NR	NR	NR	NR	NR	NR
	3.6	NR	NA	NR	NR	NA	13.6	NA	NR	24	NA	NR	NR	NR	NR	NR	NR
	3.7	NR	NA	NR	NR	NA	0.1	NA	NR	200	NA	NR	NR	NR	NR	NR	NR
	3.8	NR	NA	NR	NR	NA	2.0	NA	NR	50	NA	NR	NR	NR	NR	NR	NR
	3.9	NR	NA	NR	NR	NA	2.1	NA	NR	43	NA	NR	NR	NR	NR	NR	NR
	3.10	NR	NA	NR	NR	NA	9.9	NA	NR	38	NA	NR	NR	NR	NR	NR	NR
	3.11	NR	NA	NR	NR	NA	1.4	NA	NR	36	NA	NR	NR	NR	NR	NR	NR
	3.12	NR	NA	NR	NR	NA	11.2	NA	NR	39	NA	NR	NR	NR	NR	NR	NR
	3.13	NR	NA	NR	NR	NA	0.1	NA	NR	200	NA	NR	NR	NR	NR	NR	NR
	3.14	NR	NA	NR	NR	NA	1.0	NA	NR	80	NA	NR	NR	NR	NR	NR	NR
	3.15	NR	NA	NR	NR	NA	4.4	NA	NR	23	NA	NR	NR	NR	NR	NR	NR
	3.16	NR	NA	NR	NR	NA	11.5	NA	NR	69	NA	NR	NR	NR	NR	NR	NR
	3.17	NR	NA	NR	NR	NA	4.5	NA	NR	22	NA	NR	NR	NR	NR	NR	NR
	3.18	NR	NA	NR	NR	NA	8.5	NA	NR	52	NA	NR	NR	NR	NR	NR	NR
	3.19	NR	NA	NR	NR	NA	0.7	NA	NR	157	NA	NR	NR	NR	NR	NR	NR
	3.20	NR	NA	NR	NR	NA	6.3	NA	NR	62	NA	NR	NR	NR	NR	NR	NR
	3.21	NR	NA	NR	NR	NA	11.9	NA	NR	26	NA	NR	NR	NR	NR	NR	NR
	3.22	NR	NA	NR	NR	NA	43.6	NA	NR	26	NA	NR	NR	NR	NR	NR	NR
	3.23	NR	NA	NR	NR	NA	12.7	NA	NR	27	NA	NR	NR	NR	NR	NR	NR
	3.24	NR	NA	NR	NR	NA	17.7	NA	NR	33	NA	NR	NR	NR	NR	NR	NR
	3.25	NR	NA	NR	NR	NA	93.9	NA	NR	11	NA	NR	NR	NR	NR	NR	NR

Table A.1b Expanded summary of test results for swab sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD defin-ition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Rose et. al. 2004 (cont.)	3.26	NR	NA	NR	NR	NA	83.8	NA	NR	9	NA	NR	NR	NR	NR	NR	NR
	3.27	NR	NA	NR	NR	NA	91.7	NA	NR	7	NA	NR	NR	NR	NR	NR	NR
	3.28	NR	NA	NR	NR	NA	93.4	NA	NR	12	NA	NR	NR	NR	NR	NR	NR
Frawley et al. 2008	4.1	NR	NA	NR	NR	NA	2.3	NA	NR	30	NA	NR	NR	NR	NR	NR	NR
	4.2	NR	NA	NR	NR	NA	0.2	NA	NR	56	NA	NR	NR	NR	NR	NR	NR
	4.3	NR	NA	NR	NR	NA	0.6	NA	NR	71	NA	NR	NR	NR	NR	NR	NR
	4.4	NR	NA	NR	NR	NA	5.5	NA	NR	42	NA	NR	NR	NR	NR	NR	NR
	4.5	NR	NA	NR	NR	NA	2.5	NA	NR	63	NA	NR	NR	NR	NR	NR	NR
	4.6	NR	NA	NR	NR	NA	2.0	NA	NR	61	NA	NR	NR	NR	NR	NR	NR
	4.7	NR	NA	NR	NR	NA	8.0	NA	NR	45	NA	NR	NR	NR	NR	NR	NR
	4.8	NR	NA	NR	NR	NA	15.0	NA	NR	39	NA	NR	NR	NR	NR	NR	NR
	4.9	NR	NA	NR	NR	NA	15.0	NA	NR	37	NA	NR	NR	NR	NR	NR	NR
	4.10	NR	NA	NR	NR	NA	14.0	NA	NR	28	NA	NR	NR	NR	NR	NR	NR
	4.11	NR	NA	NR	NR	NA	2.0	NA	NR	95	NA	NR	NR	NR	NR	NR	NR
	4.12	NR	NA	NR	NR	NA	2.0	NA	NR	144	NA	NR	NR	NR	NR	NR	NR
	4.13	NR	NA	NR	NR	NA	0.0	NA	NR	NA	NA	NR	NR	NR	NR	NR	NR
Brown et al. 2007b	5.1	NR	NA	NR	NR	NA	39.5	NA	NR	50	NA	≥1 CFU/ml	NR	1	NR	NR	NR
	5.2	NR	NA	NR	NR	NA	42.9	NA	NR	34	NA	≥1 CFU/ml	NR	1	NR	NR	NR
	5.3	NR	NA	NR	NR	NA	35.5	NA	NR	67	NA	≥1 CFU/ml	NR	1	NR	NR	NR
	5.4	NR	NA	NR	NR	NA	45.6	NA	NR	48	NA	≥1 CFU/ml	NR	1	NR	NR	NR
	5.5	NR	NA	NR	NR	NA	75.6	NA	NR	16	NA	NR	NR	NR	NR	NR	NR
	5.6	NR	NA	NR	NR	NA	99.9	NA	NR	0.1	NA	NR	NR	NR	NR	NR	NR
Edmonds et al. 2009	6.1	NR	NA	NR	NR	NA	88.7	NA	11	9	NA	NR	NR	NR	NR	NR	NR
	6.2	NR	NA	NR	NR	NA	82.1	NA	14	11	NA	NR	NR	NR	NR	NR	NR
	6.3	NR	NA	NR	NR	NA	87.5	NA	14	13	NA	NR	NR	NR	NR	NR	NR
	6.4	NR	NA	NR	NR	NA	89.1	NA	19	10	NA	NR	NR	NR	NR	NR	NR
	6.5	NR	NA	NR	NR	NA	47.0	NA	20	15	NA	NR	NR	NR	NR	NR	NR
	6.6	NR	NA	NR	NR	NA	42.5	NA	21	16	NA	NR	NR	NR	NR	NR	NR
	6.7	NR	NA	NR	NR	NA	43.6	NA	33	16	NA	NR	NR	NR	NR	NR	NR
	6.8	NR	NA	NR	NR	NA	55.7	NA	19	15	NA	NR	NR	NR	NR	NR	NR
	6.9	NR	NA	NR	NR	NA	74.9	NA	16	10	NA	NR	NR	NR	NR	NR	NR
	6.10	NR	NA	NR	NR	NA	83.4	NA	17	10	NA	NR	NR	NR	NR	NR	NR
	6.11	NR	NA	NR	NR	NA	75.4	NA	16	11	NA	NR	NR	NR	NR	NR	NR
	6.12	NR	NA	NR	NR	NA	88.3	NA	19	8	NA	NR	NR	NR	NR	NR	NR
	6.13	NR	NA	NR	NR	NA	49.0	NA	24	13	NA	NR	NR	NR	NR	NR	NR
	6.14	NR	NA	NR	NR	NA	62.2	NA	34	13	NA	NR	NR	NR	NR	NR	NR
	6.15	NR	NA	NR	NR	NA	58.3	NA	29	11	NA	NR	NR	NR	NR	NR	NR
	6.16	NR	NA	NR	NR	NA	72.0	NA	26	11	NA	NR	NR	NR	NR	NR	NR

Table A.1b Expanded summary of test results for swab sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD defin-ition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Edmonds et al. 2009 (cont.)	6.17	NR	NA	NR	NR	NA	62.4	NA	16	13	NA	NR	NR	NR	NR	NR	NR
	6.18	NR	NA	NR	NR	NA	64.9	NA	14	10	NA	NR	NR	NR	NR	NR	NR
	6.19	NR	NA	NR	NR	NA	65.2	NA	23	17	NA	NR	NR	NR	NR	NR	NR
	6.20	NR	NA	NR	NR	NA	61.2	NA	20	13	NA	NR	NR	NR	NR	NR	NR
	6.21	NR	NA	NR	NR	NA	51.9	NA	35	11	NA	NR	NR	NR	NR	NR	NR
	6.22	NR	NA	NR	NR	NA	57.6	NA	27	8	NA	NR	NR	NR	NR	NR	NR
	6.23	NR	NA	NR	NR	NA	53.1	NA	33	9	NA	NR	NR	NR	NR	NR	NR
	6.24	NR	NA	NR	NR	NA	51.5	NA	32	10	NA	NR	NR	NR	NR	NR	NR
	6.25	NR	NA	NR	NR	NA	65.1	NA	16	14	NA	NR	NR	NR	NR	NR	NR
	6.26	NR	NA	NR	NR	NA	71.9	NA	10	10	NA	NR	NR	NR	NR	NR	NR
	6.27	NR	NA	NR	NR	NA	68.9	NA	12	10	NA	NR	NR	NR	NR	NR	NR
	6.28	NR	NA	NR	NR	NA	75.5	NA	10	11	NA	NR	NR	NR	NR	NR	NR
	6.29	NR	NA	NR	NR	NA	60.3	NA	12	10	NA	NR	NR	NR	NR	NR	NR
	6.30	NR	NA	NR	NR	NA	68.7	NA	16	10	NA	NR	NR	NR	NR	NR	NR
	6.31	NR	NA	NR	NR	NA	60.2	NA	17	20	NA	NR	NR	NR	NR	NR	NR
	6.32	NR	NA	NR	NR	NA	67.0	NA	14	13	NA	NR	NR	NR	NR	NR	NR
	6.33	2010	NA	25[(a)]	(a)	NA	42.1	NA	NR	25	NA	NR	NR	NR	NR	NR	NR
	6.34	18400	NA	29[(a)]	(a)	NA	61.1	NA	NR	29	NA	NR	NR	NR	NR	NR	NR
	6.35	221000	NA	19[(a)]	(a)	NA	75.8	NA	NR	19	NA	NR	NR	NR	NR	NR	NR
	6.36	2.36E+6	NA	26[(a)]	(a)	NA	92.7	NA	NR	27	NA	NR	NR	NR	NR	NR	NR
Valentine et al. 2008	7.1	NR	NA	NR	NR	NA	5.1	NA	NR	43	NA	NR	NR	NR	NR	NR	NR
	7.2	NR	NA	NR	NR	NA	6.6	NA	NR	33	NA	NR	NR	NR	NR	NR	NR
	7.3	NR	NA	NR	NR	NA	3.3	NA	NR	25	NA	NR	NR	NR	NR	NR	NR
	7.4	NR	NA	NR	NR	NA	1.9	NA	NR	55	NA	NR	NR	NR	NR	NR	NR
	7.5	NR	NA	NR	NR	NA	3.9	NA	NR	31	NA	NR	NR	NR	NR	NR	NR
	7.6	NR	NA	NR	NR	NA	4.2	NA	NR	28	NA	NR	NR	NR	NR	NR	NR
	7.7	NR	NA	NR	NR	NA	2.3	NA	NR	33	NA	NR	NR	NR	NR	NR	NR
	7.8	NR	NA	NR	NR	NA	1.7	NA	NR	37	NA	NR	NR	NR	NR	NR	NR
	7.9	NR	NA	NR	NR	NA	2.9	NA	NR	87	NA	NR	NR	NR	NR	NR	NR
	7.10	NR	NA	NR	NR	NA	3.9	NA	NR	40	NA	NR	NR	NR	NR	NR	NR
	7.11	NR	NA	NR	NR	NA	1.7	NA	NR	41	NA	NR	NR	NR	NR	NR	NR
	7.12	NR	NA	NR	NR	NA	1.3	NA	NR	32	NA	NR	NR	NR	NR	NR	NR
	7.13	NR	NA	NR	NR	NA	0.6	NA	NR	58	NA	NR	NR	NR	NR	NR	NR
	7.14	NR	NA	NR	NR	NA	0.9	NA	NR	39	NA	NR	NR	NR	NR	NR	NR
	7.15	NR	NA	NR	NR	NA	1.4	NA	NR	150	NA	NR	NR	NR	NR	NR	NR
	7.16	NR	NA	NR	NR	NA	0.6	NA	NR	35	NA	NR	NR	NR	NR	NR	NR
	7.17	NR	NA	NR	NR	NA	0.5	NA	NR	84	NA	NR	NR	NR	NR	NR	NR

Table A.1b Expanded summary of test results for swab sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD defin-ition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Valentine et al. 2008 (cont.)	7.18	NR	NA	NR	NR	NA	2.7	NA	NR	18	NA	NR	NR	NR	NR	NR	NR
	7.19	NR	NA	NR	NR	NA	0.8	NA	NR	35	NA	NR	NR	NR	NR	NR	NR
	7.20	NR	NA	NR	NR	NA	0.8	NA	NR	26	NA	NR	NR	NR	NR	NR	NR
Buttner et al. 2001	8.1	NR	NA	NR	NR	NA	73.5	NA	NR	7	NA	NR	NR	NR	NR	NR	NR
	8.2	NR	NA	NR	NR	NA	68.6	NA	NR	6	NA	NR	NR	NR	NR	NR	NR
	8.3	748	NA	43[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.4	149	NA	8[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.5	103	NA	63[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.6	226	NA	7[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.7	544	NA	44[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.8	93	NA	71[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.9	82	NA	107[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.10	101	NA	82[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.11	706	NA	25[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.12	164	NA	23[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.13	156	NA	44[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.14	296	NA	18[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.15	1264	NA	85[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.16	122	NA	23[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.17	84	NA	47[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	8.18	294	NA	76[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
Buttner et al. 2004a	9.1	492	NA	92[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	9.2	340	NA	44[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	9.3	492	NA	68[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	9.4	552	NA	24[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	9.5	711	NA	48[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	9.6	481	NA	56[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	9.7	523[b]	NA	NR	9[b]	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	9.8	704[b]	NA	NR	55[b]	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	9.9	594[b]	NA	NR	8[b]	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
Buttner et al. 2004b	10.1	840	NA	NR	11	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	10.2	1200	NA	NR	22	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	10.3	1030	NA	NR	NR	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	10.4	1180	NA	NR	28	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
Quizon et al. 2007	11.1	5500	NA	27[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	11.2	5110	NA	17[a]	(a)	NA	9.8	NA	(c)	(c)	NA	NR	NR	NR	NR	NR	NR
	11.3	4170	NA	36[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	11.4	5670	NA	19[a]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR

Table A.1b Expanded summary of test results for swab sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD defin-ition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Nellen et al. 2006	12.1	0.29	NA	17[(a)]	(a)	NA	13.4	NA	17[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.2	0.29	NA	17[(a)]	(a)	NA	13.4	NA	18[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.3	1.90	NA	3[(a)]	(a)	NA	88.0	NA	4[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.4	1.99	NA	1[(a)]	(a)	NA	92.2	NA	3[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.5	1.57	NA	4[(a)]	(a)	NA	72.7	NA	5[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.6	1.42	NA	6[(a)]	(a)	NA	65.8	NA	7[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.7	2.04	NA	1[(a)]	(a)	NA	94.5	NA	3[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.8	2.02	NA	4[(a)]	(a)	NA	93.6	NA	4[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.9	1.75	NA	31[(a)]	(a)	NA	66.1	NA	33[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.10	1.56	NA	30[(a)]	(a)	NA	58.9	NA	31[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.11	1.22	NA	25[(a)]	(a)	NA	46.1	NA	27[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.12	0.95	NA	33[(a)]	(a)	NA	35.9	NA	34[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.13	2.61	NA	27[(a)]	(a)	NA	64.1	NA	31[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.14	2.13	NA	25[(a)]	(a)	NA	55.9	NA	27[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.15	1.71	NA	40[(a)]	(a)	NA	44.6	NA	43[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.16	2.72	NA	24[(a)]	(a)	NA	73.7	NA	26[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.17	1.92	NA	56[(a)]	(a)	NA	53.6	NA	52[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.18	1.12	NA	47[(a)]	(a)	NA	28.1	NA	47[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.19	0.73	NA	52[(a)]	(a)	NA	19.8	NA	48[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.20	0.93	NA	52[(a)]	(a)	NA	24.9	NA	50[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.21	0.99	NA	54[(a)]	(a)	NA	27.9	NA	49[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	12.22	1.07	NA	35[(a)]	(a)	NA	28.6	NA	38[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
Hodges et al. 2010	13.1	0.48	NR	NR	NR	NR	25.7	15.6	(d)	57[(d)]	59.0	≥1 CFU/ml				0.017	NR
	13.2	3.07	NR	NR	NR	NR	15.8	24.2	(d)	34[(d)]	41.6	≥1 CFU/ml	NR	0.8	NR	0	NR
	13.3	498.22	NR	NR	NR	NR	31.0	21.1	(d)	28[(d)]	35.0	≥1 CFU/ml				0	NR
	13.4	0.99	NR	NR	NR	NR	61.0	18.2	(d)	32[(d)]	37.6	≥1 CFU/ml	NR	NR	NR	0	0.083
	13.5	9.05	NR	NR	NR	NR	63.0	12.1	(d)	10[(d)]	15.4	≥1 CFU/ml	NR	NR	NR	0	0
	13.6	1064.32	NR	NR	NR	NR	83.1	19.6	(d)	9[(d)]	21.7	≥1 CFU/ml	NR	NR	NR	0	0
	13.7	0.76	NR	NR	NR	NR	55.0	30.3	(d)	40[(d)]	50.2	≥1 CFU/ml	NR	NR	NR	0.017	NR
	13.8	4.26	NR	NR	NR	NR	27.9	46.8	(d)	33[(d)]	57.1	≥1 CFU/ml	NR	NR	NR	0	NR
	13.9	499.15	NR	NR	NR	NR	42.0	37.2	(d)	24[(d)]	44.3	≥1 CFU/ml	NR	NR	NR	0	NR
	13.10	0.71	NR	NR	NR	NR	51.6	36.8	(d)	41[(d)]	54.9	≥1 CFU/ml	NR	NR	NR	0	0.146
	13.11	5.47	NR	NR	NR	NR	35.8	45.4	(d)	15[(d)]	47.8	≥1 CFU/ml	NR	NR	NR	0	0.104
	13.12	878.27	NR	NR	NR	NR	73.9	26.7	(d)	18[(d)]	32.0	≥1 CFU/ml	NR	NR	NR	0	0

(a) Combined estimate of "run" and "sample-within-run" uncertainties.
(b) Mean and sample-within-run %RSD were calculated treating pre- and post- results in Table 1 of Buttner et al. (2004a) as replicate tests.
(c) Quizon et al. (2007) reported SE = 1.9; insufficient info to 1) know whether it includes run-to-run and/or sample-within-run uncertainties, and 2) convert the SE to a %RSD.
(d) The precision (variance within laboratories) reported by Hodges et al. (2010) is listed in this table as "sample-within-run" uncertainty.

Table A.2a Expanded summary of test conditions for wipe sampling. Acronyms and abbreviations are defined in Table 6.

Reference	Test #	Agent	Agent deposition	Agent concentration (CFU/cm^2)	Wipe type	Wetting agent	Relative humidity (%)	Surface type	Surface area sampled (cm^2)	Extraction liquid	Extraction method	Culture method, medium	# labs	# test runs	Total # test samples
Estill et al. 2009	1.1	BA Sterne	Dry aerosol	0.03	Sponge	BBT	NR	SS	929	BBT	A+C+V+S	FP, TSAB	3	3	27
	1.2	BA Sterne	Dry aerosol	0.3	Sponge	BBT	NR	SS	929	BBT	A+C+V+S	FP, TSAB	3	3	27
	1.3	BA Sterne	Dry aerosol	2	Sponge	BBT	NR	SS	929	BBT	A+C+V+S	FP, TSAB	3	3	27
	1.4	BA Sterne	Dry aerosol	0.03	Sponge	BBT	NR	Carpet	929	BBT	A+C+V+S	FP, TSAB	3	2	18
	1.5	BA Sterne	Dry aerosol	0.3	Sponge	BBT	NR	Carpet	929	BBT	A+C+V+S	FP, TSAB	3	4	36
	1.6	BA Sterne	Dry aerosol	2	Sponge	BBT	NR	Carpet	929	BBT	A+C+V+S	FP, TSAB	3	3	26
Brown et al. 2007a	2.1	BA	Dry aerosol	1E+2 – 1E+3	PR gauze	DW	NR	SS	25	BBT	S+H+V	Plate, PF	1	NR	20
	2.2	BA	Dry aerosol	1E+4 – 1E+5	PR gauze	DW	NR	SS	25	BBT	S+H+V	Plate, PF	1	NR	20
	2.3	BA	Dry aerosol	1E+2 – 1E+3	PR gauze	DW	NR	PWB	25	BBT	S+H+V	Plate, PF	1	NR	20
	2.4	BA	Dry aerosol	1E+4 – 1E+5	PR gauze	DW	NR	PWB	25	BBT	S+H+V	Plate, PF	1	NR	20
	2.5	BA	Liquid imm.	NR	PR gauze, DI	DW	NR	None	NA	BBT	S+H+V	Plate, PF	1	NR	40
	2.6	BA	Liquid drops	2.0E+5	NA	NA	NR	SS, DI	25	BBT	S+H	Plate, BHIA	1	NR	24
Buttner et al. 2001	3.1	BS	Liquid drops	1.48E+7	Sponge	PBST	NR	Glass	32.49	PBST	HS	Plate, TSAC	1	3	3
	3.2	BS	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Vinyl	32.49	PBST	HS	Plate, TSAC	1	3	3
	3.3	BS	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Cpt-R	32.49	PBST	HS	Plate, TSAC	1	3	3
	3.4	BS	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Cpt-S	32.49	PBST	HS	Plate, TSAC	1	3	3
	3.5	BS	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Cpt-C	32.49	PBST	HS	Plate, TSAC	1	3	3
	3.6	BS + PC2	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Vinyl	32.49	PBST	HS	Plate, TSAC	1	2	2
	3.7	BS + PC2	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Cpt-R	32.49	PBST	HS	Plate, TSAC	1	2	2
	3.8	BS + PC2	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Cpt-S	32.49	PBST	HS	Plate, TSAC	1	2	2
	3.9	BS + PC2	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Cpt-C	32.49	PBST	HS	Plate, TSAC	1	2	2
	3.10	BS + PC4	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Vinyl	32.49	PBST	HS	Plate, TSAC	1	2	2
	3.11	BS + PC4	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Cpt-R	32.49	PBST	HS	Plate, TSAC	1	2	2
	3.12	BS + PC4	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Cpt-S	32.49	PBST	HS	Plate, TSAC	1	2	2
	3.13	BS + PC4	Dry aerosol	1E+2 – 1E+3	Sponge	PBST	NR	Cpt-C	32.49	PBST	HS	Plate, TSAC	1	2	2
Valentine et al. 2008	4.1	BS	Liquid drops	90349.9	Cotton	PBST	NR	Plastic	104.04	PBST	V+C	Plate, TSA	1	10	10
	4.2	BS	Liquid drops	90349.9	HCW	PBST	NR	Plastic	104.04	PBST	V+C	Plate, TSA	1	10	10
	4.3	BS	Liquid drops	90349.9	PR	PBST	NR	Plastic	104.04	PBST	V+C	Plate, TSA	1	10	10
	4.4	BS	Liquid drops	90349.9	Cotton	PBST	NR	Oak	104.04	PBST	V+C	Plate, TSA	1	10	10
	4.5	BS	Liquid drops	90349.9	HCW	PBST	NR	Oak	104.04	PBST	V+C	Plate, TSA	1	10	10
	4.6	BS	Liquid drops	90349.9	PR	PBST	NR	Oak	104.04	PBST	V+C	Plate, TSA	1	10	10
	4.7	BS	Liquid drops	282,000	Cotton	PBST	NR	Monitor	25	PBST	V+C	Plate, TSA	1	10	10
	4.8	BS	Liquid drops	282,000	HCW	PBST	NR	Monitor	25	PBST	V+C	Plate, TSA	1	10	10
	4.9	BS	Liquid drops	282,000	PR	PBST	NR	Monitor	25	PBST	V+C	Plate, TSA	1	10	10
	4.10	BS	Liquid drops	90349.9	Cotton	PBST	NR	PEUF	104.04	PBST	V+C	Plate, TSA	1	10	10
	4.11	BS	Liquid drops	90349.9	HCW	PBST	NR	PEUF	104.04	PBST	V+C	Plate, TSA	1	10	10
	4.12	BS	Liquid drops	90349.9	PR	PBST	NR	PEUF	104.04	PBST	V+C	Plate, TSA	1	10	10
	4.13	BS	Liquid drops	90349.9	Cotton	PBST	NR	Carpet	104.04	PBST	V+C	Plate, TSA	1	10	10
	4.14	BS	Liquid drops	90349.9	HCW	PBST	NR	Carpet	104.04	PBST	V+C	Plate, TSA	1	10	10
	4.15	BS	Liquid drops	90349.9	PR	PBST	NR	Carpet	104.04	PBST	V+C	Plate, TSA	1	10	10

Table A.2a Expanded summary of test conditions for wipe sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

Reference	Test #	Agent	Agent deposition	Agent concentration (CFU/cm^2)	Wipe type	Wetting agent	Relative humidity (%)	Surface type	Surface area sampled (cm^2)	Extraction liquid	Extraction method	Culture method, medium	# labs	# test runs	Total # test samples
Buttner et al. 2004a	5.1	BAtr	Dry aerosol	107.6 - 1076.4	Swipe	PBST	NR	Vinyl	929	NR	HM	Plate, TSA	1	3	3
	5.2	BAtr	Dry aerosol	107.6 - 1076.4	Swipe	PBST	NR	Wood	929	NR	HM	Plate, TSA	1	3	3
	5.3	BAtr	Dry aerosol	107.6 - 1076.4	Swipe	PBST	NR	Metal	929	NR	HM	Plate, TSA	1	3	3
	5.4	BAtr	Dry aerosol	107.6 - 1076.4	Heavy Wipe	PBST	NR	Vinyl	929	NR	HM	Plate, TSA	1	3	3
	5.5	BAtr	Dry aerosol	107.6 - 1076.4	Heavy Wipe	PBST	NR	Wood	929	NR	HM	Plate, TSA	1	3	3
	5.6	BAtr	Dry aerosol	107.6 - 1076.4	Heavy Wipe	PBST	NR	Metal	929	NR	HM	Plate, TSA	1	3	3
	5.7	BAtr	Dry aerosol	107.6 - 1076.4	Swipe	PBST	NR	Vinyl	929	NR	HM	Plate, TSA	1	3	3
	5.8	BAtr	Dry aerosol	107.6 - 1076.4	Swipe	PBST	NR	Wood	929	NR	HM	Plate, TSA	1	3	3
	5.9	BAtr	Dry aerosol	107.6 - 1076.4	Swipe	PBST	NR	Metal	929	NR	HM	Plate, TSA	1	3	3
	5.10	BAtr	Dry aerosol	107.6 - 1076.4	Heavy Wipe	PBST	NR	Vinyl	929	NR	HM	Plate, TSA	1	3	3
	5.11	BAtr	Dry aerosol	107.6 - 1076.4	Heavy Wipe	PBST	NR	Wood	929	NR	HM	Plate, TSA	1	3	3
	5.12	BAtr	Dry aerosol	107.6 - 1076.4	Heavy Wipe	PBST	NR	Metal	929	NR	HM	Plate, TSA	1	3	3
	5.13	BAtr	Dry aerosol	107.6 - 1076.4	Swipe	PBST	NR	Vinyl	929	NR	HM	Plate, TSA	1	1	2
	5.14	BAtr	Dry aerosol	107.6 - 1076.4	Swipe	PBST	NR	Wood	929	NR	HM	Plate, TSA	1	1	2
	5.15	BAtr	Dry aerosol	107.6 - 1076.4	Swipe	PBST	NR	Metal	929	NR	HM	Plate, TSA	1	1	1
	5.16	BAtr	Dry aerosol	107.6 - 1076.4	Heavy Wipe	PBST	NR	Vinyl	929	NR	HM	Plate, TSA	1	1	2
	5.17	BAtr	Dry aerosol	107.6 - 1076.4	Heavy Wipe	PBST	NR	Wood	929	NR	HM	Plate, TSA	1	1	2
	5.18	BAtr	Dry aerosol	107.6 - 1076.4	Heavy Wipe	PBST	NR	Metal	929	NR	HM	Plate, TSA	1	1	2
Buttner et al. 2004b	6.1	BAtr	Liquid imm.	18.2	BiSKit	Dry	NR	Metal	10,000	PBST	BiSKit	Plate, TSA	1	NR	8
	6.2	BAtr	Liquid imm.	18.2	BiSKit	PBST	NR	Metal	10,000	PBST	BiSKit	Plate, TSA	1	NR	4
	6.3	BAtr	Liquid imm.	10	BiSKit	Dry	NR	Metal	10,000	PBST	BiSKit	Plate, TSA	1	NR	8
	6.4	BAtr	Liquid imm.	10	BiSKit	PBST	NR	Metal	10,000	PBST	BiSKit	Plate, TSA	1	NR	8
	6.5	BAtr	Dry aerosol	NR	BiSKit	Dry	NR	Metal	10,000	PBST	BiSKit	Plate, TSA	1	NR	4
	6.6	BAtr	Dry aerosol	NR	BiSKit	Dry	NR	Wood	10,000	PBST	BiSKit	Plate, TSA	1	NR	4
	6.7	BAtr	Dry aerosol	NR	BiSKit	PBST	NR	Metal	10,000	PBST	BiSKit	Plate, TSA	1	NR	4
	6.8	BAtr	Dry aerosol	NR	BiSKit	PBST	NR	Wood	10,000	PBST	BiSKit	Plate, TSA	1	NR	4
	6.9	BAtr	Dry aerosol	NR	BiSKit	NR	NR	Metal	10,000	PBST	BiSKit	Plate, TSA	1	NR	4
	6.10	BAtr	Dry aerosol	NR	BiSKit	NR	NR	Wood	10,000	PBST	BiSKit	Plate, TSA	1	NR	8
Frawley et al. 2008	7.1	BA Sterne	Liquid drops	1E+2 – 1E+5	Gauze wipes	Dry	NR	Plastic	1	PBST	V	Plate, SBA	1	NR	12
	7.2	BA Sterne	Liquid drops	(a)	Gauze wipes	Dry	NR	Wood	NR	PBST	V	Plate, SBA	1	NR	12
	7.3	BA Sterne	Liquid drops	(a)	Gauze wipes	Dry	NR	Cotton	NR	PBST	V	Plate, SBA	1	NR	12
	7.4	BA Sterne	Liquid drops	1E+2 – 1E+5	Gauze wipes	PBST/Tr	NR	Plastic	1	PBST	V	Plate, SBA	1	NR	24
	7.5	BA Sterne	Liquid drops	(a)	Gauze wipes	PBST/Tr	NR	Wood	NR	PBST	V	Plate, SBA	1	NR	24
	7.6	BA Sterne	Liquid drops	(a)	Gauze wipes	PBST/Tr	NR	Cotton	NR	PBST	V	Plate, SBA	1	NR	24
Einfeld et al. 2011	8.1	BAtr + grime	Dry aerosol	3.27E+4 – 3.78E+4	PR	DW	15	SS	100	BBT	S+H+V	Plate, PF	1	3	36
	8.2	BAtr	Dry aerosol	3.27E+4 – 3.78E+4	PR	DW	15	SS	100	BBT	S+H+V	Plate, PF	1	3	34
	8.3	BAtr + grime	Dry aerosol	3.66E+4 – 5.60E+4	PR	DW	82 – 90	SS	100	BBT	S+H+V	Plate, PF	1	3	28
	8.4	BAtr	Dry aerosol	3.66E+4 – 5.60E+4	PR	DW	82 – 90	SS	100	BBT	S+H+V	Plate, PF	1	3	31

Table A.2a Expanded summary of test conditions for wipe sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

Reference	Test #	Agent	Agent deposition	Agent concentration (CFU/cm^2)	Wipe type	Wetting agent	Relative humidity (%)	Surface type	Surface area sampled (cm^2)	Extraction liquid	Extraction method	Culture method, medium	# labs	# test runs	Total # test samples
Einfeld et al. 2011 (cont.)	8.5	BAtr + grime	Dry aerosol	1.83E+4 – 6.81E+4	PR	DW	90	Glass	100	BBT	S+H+V	Plate, PF	1	2	24
	8.6	BAtr	Dry aerosol	1.83E+4 – 6.81E+4	PR	DW	90	Glass	100	BBT	S+H+V	Plate, PF	1	2	24
	8.7	BAtr + grime	Dry aerosol	9.55E+0 – 6.74E+4	PR	DW	10 – 15	Marble	100	BBT	S+H+V	Plate, PF	1	5	58
	8.8	BAtr	Dry aerosol	9.55E+0 – 6.74E+4	PR	DW	10 – 15	Marble	100	BBT	S+H+V	Plate, PF	1	5	60
	8.9	BAtr + grime	Dry aerosol	5.18E+2 – 5.03E+4	PR	DW	89 – 90	Marble	100	BBT	S+H+V	Plate, PF	1	5	59
	8.10	BAtr	Dry aerosol	5.18E+2 – 5.03E+4	PR	DW	89 – 90	Marble	100	BBT	S+H+V	Plate, PF	1	5	60
Quizon et al. 2007	9.1	BAtr	Wet aerosol	NR	PR	PBST	NR	PWB	900	PBST	C+V+S	SP/FP, TSA	1	4	4
	9.2	BAtr	Wet aerosol	NR	PR	PBST	NR	SS	900	PBST	C+V+S	SP/FP, TSA	1	4	10
	9.3	BAtr	Wet aerosol	NR	PR	PBST	NR	Vinyl	900	PBST	C+V+S	SP/FP, TSA	1	4	4
	9.4	BAtr	Wet aerosol	NR	PR	PBST	NR	Wood	900	PBST	C+V+S	SP/FP, TSA	1	4	4
Krauter et al. 2011	10.1	BAtr	Liquid drops	0.00248[(b)]	Sp. stick	NB	30 − 45	SS	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.2	BAtr	Liquid drops	0.00677[(b)]	Sp. stick	NB	30 − 45	SS	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.3	BAtr	Liquid drops	0.01669[(b)]	Sp. stick	NB	30 − 45	SS	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.4	BAtr	Liquid drops	0.01519[(b)]	Sp. stick	NB	30 − 45	SS	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.5	BAtr	Liquid drops	0.02253[(b)]	Sp. stick	NB	30 − 45	SS	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.6	BAtr	Liquid drops	0.03064[(b)]	Sp. stick	NB	30 − 45	SS	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.7	BAtr	Liquid drops	0.03725[(b)]	Sp. stick	NB	30 − 45	SS	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.8	BAtr	Liquid drops	0.15629[(b)]	Sp. stick	NB	30 − 45	SS	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.9	BAtr	Liquid drops	1.85380[(b)]	Sp. stick	NB	30 − 45	SS	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.10	BAtr	Liquid drops	0.00248[(b)]	Sp. stick	NB	30 − 45	CerT	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.11	BAtr	Liquid drops	0.00677[(b)]	Sp. stick	NB	30 − 45	CerT	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.12	BAtr	Liquid drops	0.01669[(b)]	Sp. stick	NB	30 − 45	CerT	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.13	BAtr	Liquid drops	0.01519[(b)]	Sp. stick	NB	30 − 45	CerT	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.14	BAtr	Liquid drops	0.02253[(b)]	Sp. stick	NB	30 − 45	CerT	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.15	BAtr	Liquid drops	0.03064[(b)]	Sp. stick	NB	30 − 45	CerT	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.16	BAtr	Liquid drops	0.03275[(b)]	Sp. stick	NB	30 − 45	CerT	645.16	PBST	St+ C+V+S	(c)	1	1	9
	10.17	BAtr	Liquid drops	0.15629[(b)]	Sp. stick	NB	30 − 45	CerT	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.18	BAtr	Liquid drops	1.85380[(b)]	Sp. stick	NB	30 − 45	CerT	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.19	BAtr	Liquid drops	0.00248[(b)]	Sp. stick	NB	30 − 45	Vinyl tile	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.20	BAtr	Liquid drops	0.00677[(b)]	Sp. stick	NB	30 − 45	Vinyl tile	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.21	BAtr	Liquid drops	0.01669[(b)]	Sp. stick	NB	30 − 45	Vinyl tile	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.22	BAtr	Liquid drops	0.01519[(b)]	Sp. stick	NB	30 − 45	Vinyl tile	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.23	BAtr	Liquid drops	0.02253[(b)]	Sp. stick	NB	30 − 45	Vinyl tile	645.16	PBST	St+ C+V+S	(c)	1	1	10
	10.24	BAtr	Liquid drops	0.03064[(b)]	Sp. stick	NB	30 − 45	Vinyl tile	645.16	PBST	St+ C+V+S	(c)	1	1	9
	10.25	BAtr	Liquid drops	0.03275[(b)]	Sp. stick	NB	30 − 45	Vinyl tile	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.26	BAtr	Liquid drops	0.15629[(b)]	Sp. stick	NB	30 − 45	Vinyl tile	645.16	PBST	St+C+V+S	(c)	1	1	9
	10.27	BAtr	Liquid drops	1.85380[(b)]	Sp. stick	NB	30 − 45	Vinyl tile	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.28	BAtr	Liquid drops	0.00775[(b)]	Sp. stick	NB	30 − 45	FL	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.29	BAtr	Liquid drops	0.01535[(b)]	Sp. stick	NB	30 − 45	FF	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.30	BAtr	Liquid drops	0.02356[(b)]	Sp. stick	NB	30 − 45	FL	645.16	PBST	St+C+V+S	(c)	1	1	10

Table A.2a Expanded summary of test conditions for wipe sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

Reference	Test #	Agent	Agent deposition	Agent concentration (CFU/cm^2)	Wipe type	Wetting agent	Relative humidity (%)	Surface type	Surface area sampled (cm^2)	Extraction liquid	Extraction method	Culture method, medium	# labs	# test runs	Total # test samples
Krauter et al. 2011 (cont.)	10.31	BAtr	Liquid drops	0.02289[(b)]	Sp. stick	NB	30 − 45	FL	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.32	BAtr	Liquid drops	0.03276[(b)]	Sp. stick	NB	30 − 45	FL	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.33	BAtr	Liquid drops	0.03834[(b)]	Sp. stick	NB	30 − 45	FL	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.34	BAtr	Liquid drops	0.05430[(b)]	Sp. stick	NB	30 − 45	FL	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.35	BAtr	Liquid drops	0.07905[(b)]	Sp. stick	NB	30 − 45	FL	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.36	BAtr	Liquid drops	0.15371[(b)]	Sp. stick	NB	30 − 45	FF	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.37	BAtr	Liquid drops	0.00775[(b)]	Sp. stick	NB	30 − 45	PW	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.38	BAtr	Liquid drops	0.01535[(b)]	Sp. stick	NB	30 − 45	PW	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.39	BAtr	Liquid drops	0.02356[(b)]	Sp. stick	NB	30 − 45	PW	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.40	BAtr	Liquid drops	0.02289[(b)]	Sp. stick	NB	30 − 45	PW	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.41	BAtr	Liquid drops	0.03276[(b)]	Sp. stick	NB	30 − 45	PW	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.42	BAtr	Liquid drops	0.03834[(b)]	Sp. stick	NB	30 − 45	PW	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.43	BAtr	Liquid drops	0.05430[(b)]	Sp. stick	NB	30 − 45	PW	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.44	BAtr	Liquid drops	0.07905[(b)]	Sp. stick	NB	30 − 45	PW	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.45	BAtr	Liquid drops	0.15371[(b)]	Sp. stick	NB	30 − 45	PW	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.46	BAtr	Liquid drops	0.00775[(b)]	Sp. stick	NB	30 − 45	PLCP	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.47	BAtr	Liquid drops	0.01535[(b)]	Sp. stick	NB	30 − 45	PLCP	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.48	BAtr	Liquid drops	0.02356[(b)]	Sp. stick	NB	30 − 45	PLCP	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.49	BAtr	Liquid drops	0.02289[(b)]	Sp. stick	NB	30 − 45	PLCP	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.50	BAtr	Liquid drops	0.03276[(b)]	Sp. stick	NB	30 − 45	PLCP	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.51	BAtr	Liquid drops	0.03834[(b)]	Sp. stick	NB	30 − 45	PLCP	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.52	BAtr	Liquid drops	0.05430[(b)]	Sp. stick	NB	30 − 45	PLCP	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.53	BAtr	Liquid drops	0.07905[(b)]	Sp. stick	NB	30 − 45	PLCP	645.16	PBST	St+C+V+S	(c)	1	1	10
	10.54	BAtr	Liquid drops	0.15371[(b)]	Sp. stick	NB	30 − 45	PLCP	645.16	PBST	St+C+V+S	(c)	1	1	10
Rose et al. 2011	11.1	BA Sterne	Liquid spread	0.01349	Sp. stick, DI	NB+ATD	NR	SS	645.16	PBST	St+C	SP/FP, TSAB	9	1	17
	11.2	BA Sterne	Liquid spread	0.27699	Sp. stick, DI	NB+ATD	NR	SS	645.16	PBST	St+C	SP/FP, TSAB	9	1	18
	11.3	BA Sterne	Liquid spread	17.123	Sp. stick, DI	NB+ATD	NR	SS	645.16	PBST	St+C	SP/FP, TSAB	9	1	16
	11.4	BA Sterne	Liquid spread	0.04046	Sp. stick	NB+ATD	NR	SS	645.16	PBST	St+C	SP/FP, TSAB	9	1	63
	11.5	BA Sterne	Liquid spread	0.83080	Sp. stick	NB+ATD	NR	SS	645.16	PBST	St+C	SP/FP, TSAB	9	1	63
	11.6	BA Sterne	Liquid spread	51.367	Sp. stick	NB+ATD	NR	SS	645.16	PBST	St+C	SP/FP, TSAB	8	1	56
	11.7	BA Sterne	Liquid spread	15.5	Rayon gauze	PBST	NR	SS	645.16	PBST	St+C	SP/FP, TSAB	1	1	10
	11.8	BA Sterne	Liquid spread	15.5	Sponge wipe	DE broth	NR	SS	645.16	PBST	St+C	SP/FP, TSAB	1	1	10
	11.9	BA Sterne	Liquid spread	15.5	Sponge wipe	BB	NR	SS	645.16	PBST	St+C	SP/FP, TSAB	1	1	10
	11.10	BA Sterne	Liquid spread	15.5	Sponge stick	PBST	NR	SS	645.16	PBST	St+C	SP/FP, TSAB	1	1	10
	11.11	BA Sterne	Liquid spread	0.0155, 0.155, 15.5	PEF sponge	PBST	NR	SS	645.16	PBST	St+C	SP/FP, TSAB	1	3	15

Table A.2a Expanded summary of test conditions for wipe sampling. Acronyms and abbreviations are defined in Table . (cont.).

Reference	Test #	Agent	Agent deposition	Agent concentration (CFU/cm^2)	Wipe type	Wetting agent	Wipe technique	Surface type	Surface area sampled (cm^2)	Extraction liquid	Extraction method	Culture method, medium	# labs	# test runs	Total # test samples
Montgomery and Camp 2008	12.1	BA Sterne	EWD	NR	PR gauze	PBSTr	Rough	HVAC filter	100	PBSTr	Shake+C	Plate, NR	1	3	5
	12.2	BA Sterne	EWD	NR	PR gauze	PBSTr	Smooth	HVAC filter	100	PBSTr	Shake+C	Plate, NR	1	2	2
	12.3	BA Sterne	EWD	NR	PR pad	PBSTr	Rough	HVAC filter	100	PBSTr	Shake+C	Plate, NR	1	2	4
	12.4	BA Sterne	EWD	NR	PR pad	PBSTr	Smooth	HVAC filter	100	PBSTr	Shake+C	Plate, NR	1	2	4

(a) 1E+2 to 1E+5/sample, sample surface area not reported.
(b) Mean of ~30 positive control samples paired with 30 test coupons in a given test run. Krauter et al. (2011) also report the %RSDs of these values.
(c) Plate with growth medium, or filter plate with TSA.

Table A.2b Expanded summary of test results for wipe sampling. Acronyms and abbreviations are defined in Table 6.

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD definition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Estill et al. 2009	1.1	0.023	9	0	200	200	31	14	0	160	160	≥3	LOD_{95}	0.15	95% CI: 0.076 – 0.84	NR	4/30 = 0.133
	1.2	0.084	27	28	76	85	22	29	13	78	84						
	1.3	0.500	25	45	61	80	18	19	8	53	57						
	1.4	0.017	26	0	180	182	120	0	0	220	220	≥1	LOD_{95}	0.099	95% CI: 0.046 – 7.6	NR	0/30 = 0
	1.5	0.034	9	52	100	113	21	11	58	99	120						
	1.6	0.350	9	47	37	60	23	8	63	40	75						
Brown et al. 2007a	2.1	NR	NA	NR	NR	NA	31.2	NA	NR	32	NA	≥1 CFU/ml	NR	3.6	NR	NR	NR
	2.2	NR	NA	NR	NR	NA	39.2	NA	NR	35	NA	≥1 CFU/ml	NR	3.6	NR	NR	NR
	2.3	NR	NA	NR	NR	NA	32.5	NA	NR	48	NA	≥1 CFU/ml	NR	4.2	NR	NR	NR
	2.4	NR	NA	NR	NR	NA	25.2	NA	NR	59	NA	≥1 CFU/ml	NR	4.2	NR	NR	NR
	2.5	NR	NA	NR	NR	NA	93.2	NA	NR	9	NA	≥1 CFU/ml	NR	NR	NR	NR	NR
	2.6	NR	NA	NR	NR	NA	99.9	NA	NR	0.1	NA	≥1 CFU/ml	NR	NR	NR	NR	NR
Buttner et al. 2001	3.1	NR	NA	NR	NR	NA	74.3	NA	NR	7	NA	NR	NR	NR	NR	NR	NR
	3.2	1283	NA	14[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	3.3	268	NA	17[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	3.4	135	NA	10[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	3.5	273	NA	51[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	3.6	983	NA	33[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	3.7	512	NA	34[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	3.8	127	NA	42[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	3.9	326	NA	27[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	3.10	817	NA	101[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	3.11	234	NA	0.6[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	3.12	155	NA	40[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	3.13	339	NA	36[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
Valentine et al. 2008	4.1	NR	NA	NR	NR	NA	5.4	NA	NR	32	NA	NR	NR	NR	NR	NR	NR
	4.2	NR	NA	NR	NR	NA	7.1	NA	NR	18	NA	NR	NR	NR	NR	NR	NR
	4.3	NR	NA	NR	NR	NA	7.9	NA	NR	30	NA	NR	NR	NR	NR	NR	NR
	4.4	NR	NA	NR	NR	NA	5.0	NA	NR	34	NA	NR	NR	NR	NR	NR	NR
	4.5	NR	NA	NR	NR	NA	6.0	NA	NR	33	NA	NR	NR	NR	NR	NR	NR
	4.6	NR	NA	NR	NR	NA	5.3	NA	NR	22	NA	NR	NR	NR	NR	NR	NR
	4.7	NR	NA	NR	NR	NA	4.1	NA	NR	84	NA	NR	NR	NR	NR	NR	NR
	4.8	NR	NA	NR	NR	NA	5.8	NA	NR	40	NA	NR	NR	NR	NR	NR	NR
	4.9	NR	NA	NR	NR	NA	5.9	NA	NR	62	NA	NR	NR	NR	NR	NR	NR
	4.10	NR	NA	NR	NR	NA	1.4	NA	NR	20	NA	NR	NR	NR	NR	NR	NR
	4.11	NR	NA	NR	NR	NA	2.1	NA	NR	20	NA	NR	NR	NR	NR	NR	NR
	4.12	NR	NA	NR	NR	NA	2.0	NA	NR	28	NA	NR	NR	NR	NR	NR	NR

Table A.2b Expanded summary of test results for wipe sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD defin-ition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Valentine et al. 2008 (cont.)	4.13	NR	NA	NR	NR	NA	2.6	NA	NR	38	NA	NR	NR	NR	NR	NR	NR
	4.14	NR	NA	NR	NR	NA	3.6	NA	NR	37	NA	NR	NR	NR	NR	NR	NR
	4.15	NR	NA	NR	NR	NA	4.2	NA	NR	22	NA	NR	NR	NR	NR	NR	NR
Buttner et al. 2004a	5.1	1786	NA	36[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.2	938	NA	8[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.3	1452	NA	36[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.4	1592	NA	0[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.5	1387	NA	16[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.6	1592	NA	16[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.7	1076	NA	36[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.8	1236	NA	36[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.9	817	NA	36[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.10	711	NA	24[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.11	1180	NA	24[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.12	6950	NA	44[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.13	820	NA	NA	3	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.14	506	NA	NA	95	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.15	841	NA	NA	NA	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.16	637	NA	NA	12	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.17	883	NA	NA	4	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.18	667	NA	NA	13	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
Buttner et al. 2004b	6.1	3.35	NA	NR	NR	NA	18.4	NA	NR	NR	NA	≥1 CFU/ml	NR	0.0042	SE = 5.8E-04	NR	NR
	6.2	2.05	NA	NR	NR	NA	11.3	NA	NR	NR	NA	≥1 CFU/ml	NR	0.01005	SE = 1.02E-03	NR	NR
	6.3	NR	NA	NR	NR	NA	NR	NA	NR	NR	NA	≥1 CFU/ml	NR	0.0042	SE = 5.8E-04	NR	NR
	6.4	NR	NA	NR	NR	NA	NR	NA	NR	NR	NA	≥1 CFU/ml	NR	0.01005	SE = 1.02E-03	NR	NR
	6.5	395	NA	27	NR	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	6.6	590	NA	14	NR	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	6.7	360	NA	38	NR	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	6.8	360	NA	39	NR	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	6.9	215	NA	23	NR	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	6.10	115	NA	84	NR	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
Frawley et al. 2008	7.1	NR	NA	NR	NR	NA	0.9	NA	NR	63	NA	NR	NR	NR	NR	NR	NR
	7.2	NR	NA	NR	NR	NA	0.2	NA	NR	70	NA	NR	NR	NR	NR	NR	NR
	7.3	NR	NA	NR	NR	NA	0.9	NA	NR	55	NA	NR	NR	NR	NR	NR	NR
	7.4	NR	NA	NR	NR	NA	6.6	NA	NR	60	NA	NR	NR	NR	NR	NR	NR
	7.5	NR	NA	NR	NR	NA	6.0	NA	NR	58	NA	NR	NR	NR	NR	NR	NR
	7.6	NR	NA	NR	NR	NA	4.0	NA	NR	46	NA	NR	NR	NR	NR	NR	NR

Table A.2b Expanded summary of test results for wipe sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD definition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Einfeld et al. 2011	8.1	NR	NA	NR	NR	NA	96.8	NA	29[(b)]	(b)	NA	NR	NR	NR	NR	NR	NR
	8.2	NR	NA	NR	NR	NA	79.7	NA	43[(b)]	(b)	NA	NR	NR	NR	NR	NR	NR
	8.3	NR	NA	NR	NR	NA	19.8	NA	67[(b)]	(b)	NA	NR	NR	NR	NR	NR	NR
	8.4	NR	NA	NR	NR	NA	18.0	NA	81[(b)]	(b)	NA	NR	NR	NR	NR	NR	NR
	8.5	NR	NA	NR	NR	NA	54.7	NA	78[(b)]	(b)	NA	NR	NR	NR	NR	NR	NR
	8.6	NR	NA	NR	NR	NA	33.3	NA	81[(b)]	(b)	NA	NR	NR	NR	NR	NR	NR
	8.7	NR	NA	NR	NR	NA	59.5	NA	73[(b)]	(b)	NA	NR	NR	NR	NR	NR	NR
	8.8	NR	NA	NR	NR	NA	48.2	NA	71[(b)]	(b)	NA	NR	NR	NR	NR	NR	NR
	8.9	NR	NA	NR	NR	NA	68.5	NA	96[(b)]	(b)	NA	NR	NR	NR	NR	NR	NR
	8.10	NR	NA	NR	NR	NA	43.6	NA	73[(b)]	(b)	NA	NR	NR	NR	NR	NR	NR
Quizon et al. 2007	9.1	6670	NA	8[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	9.2	16335	NA	20[(a)]	(a)	NA	39.5	NA	(c)	(c)	NA	NR	NR	NR	NR	NR	NR
	9.3	12000	NA	11[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	9.4	14615	NA	9[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
Krauter et al. 2011	10.1	0.00155	NA	NR	105	NA	62.5	NA	NR	106	NA	≥1				0.600	0.0
	10.2	0.00372	NA	NR	77	NA	55.0	NA	NR	77	NA	≥1				0.367	0.0
	10.3	0.00961	NA	NR	32	NA	57.6	NA	NR	32	NA	≥1				0.033	0.0
	10.4	0.00961	NA	NR	28	NA	63.3	NA	NR	28	NA	≥1			95% CI:	0.0	0.0
	10.5	0.01116	NA	NR	14	NA	49.5	NA	NR	14	NA	≥1	LOD_{95}	0.013	(0.010, 0.015)	0.0	0.0
	10.6	0.01581	NA	NR	20	NA	51.6	NA	NR	29	NA	≥1	LOD_{90}	0.015	NR	0.0	0.0
	10.7	0.01333	NA	NR	22	NA	35.8	NA	NR	22	NA	≥1				0.0	0.0
	10.8	0.07194	NA	NR	14	NA	46.0	NA	NR	14	NA	≥1				0.0	0.0
	10.9	0.97402	NA	NR	8.8	NA	52.5	NA	NR	8.9	NA	≥1				0.0	0.0
	10.10	0.00093	NA	NR	161	NA	37.5	NA	NR	161	NA	≥1				0.800	0.0
	10.11	0.00217	NA	NR	96	NA	32.1	NA	NR	96	NA	≥1				0.567	0.0
	10.12	0.00899	NA	NR	60	NA	53.9	NA	NR	60	NA	≥1				0.100	0.0
	10.13	0.01147	NA	NR	42	NA	75.5	NA	NR	42	NA	≥1			95% CI:	0.0	0.0
	10.14	0.01085	NA	NR	28	NA	48.2	NA	NR	28	NA	≥1	LOD_{95}	0.013	(0.007, 0.015)	0.0	0.0
	10.15	0.01581	NA	NR	28	NA	51.6	NA	NR	28	NA	≥1	LOD_{90}	0.015	NR	0.033	0.0
	10.16	0.01584	NA	NR	18	NA	42.5	NA	NR	18	NA	≥1				0.0	0.0
	10.17	0.07037	NA	NR	12	NA	45.0	NA	NR	12	NA	≥1				0.0	0.0
	10.18	0.99355	NA	NR	6.6	NA	53.6	NA	NR	6.6	NA	≥1				0.0	0.0
	10.19	0.00031	NA	NR	316	NA	12.5	NA	NR	316	NA	≥1				0.933	0.0
	10.10	0.00217	NA	NR	96	NA	32.1	NA	NR	96	NA	≥1				0.600	0.0
	10.21	0.01085	NA	NR	43	NA	65.0	NA	NR	43	NA	≥1				0.0	0.0
	10.22	0.00713	NA	NR	21	NA	46.9	NA	NR	21	NA	≥1			95% CI:	0.0	0.0
	10.23	0.00341	NA	NR	67	NA	15.1	NA	NR	67	NA	≥1	LOD_{95}	0.038	(0.029, 0.047)	0.367	0.0
	10.24	0.00586	NA	NR	32	NA	19.1	NA	NR	32	NA	≥1	LOD_{90}	0.031	NR	0.074	0.0

Table A.2b Expanded summary of test results for wipe sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD defin-ition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Krauter et al. 2011 (cont.)	10.25	0.00682	NA	NR	29	NA	18.3	NA	NR	29	NA	≥1				0.067	0.0
	10.26	0.03548	NA	NR	18	NA	22.7	NA	NR	18	NA	≥1				0.0	0.0
	10.27	0.46934	NA	NR	11	NA	25.3	NA	NR	11	NA	≥1				0.0	0.0
	10.28	0.00031	NA	NR	316	NA	4.0	NA	NR	317	NA	≥1				0.933	0.0
	10.29	0.00651	NA	NR	42	NA	42.4	NA	NR	42	NA	≥1				0.100	0.0
	10.30	0.00837	NA	NR	30	NA	35.5	NA	NR	31	NA	≥1				0.033	0.0
	10.31	0.00682	NA	NR	29	NA	29.8	NA	NR	29	NA	≥1			95% CI:	0.033	0.0
	10.32	0.00899	NA	NR	25	NA	27.4	NA	NR	26	NA	≥1	LOD_{95}	0.018	(0.010, 0.022)	0.033	0.0
	10.33	0.00930	NA	NR	35	NA	24.3	NA	NR	35	NA	≥1	LOD_{90}	0.015	NR	0.033	0.0
	10.34	0.01550	NA	NR	21	NA	28.5	NA	NR	21	NA	≥1				0.0	0.0
	10.35	0.06076	NA	NR	28	NA	76.9	NA	NR	28	NA	≥1				0.0	0.0
	10.36	0.08339	NA	NR	19	NA	54.3	NA	NR	19	NA	≥1				0.0	0.0
	10.37	0.00124	NA	NR	129	NA	16.0	NA	NR	129	NA	≥1				0.733	0.0
	10.38	0.00279	NA	NR	82	NA	18.2	NA	NR	82	NA	≥1				0.500	0.0
	10.39	0.00713	NA	NR	21	NA	30.3	NA	NR	21	NA	≥1				0.0	0.0
	10.40	0.00589	NA	NR	30	NA	25.7	NA	NR	30	NA	≥1			95% CI:	0.077	0.0
	10.41	0.00341	NA	NR	52	NA	10.4	NA	NR	52	NA	≥1	LOD_{95}	0.021	(0.018, 0.024)	0.333	0.0
	10.42	0.00930	NA	NR	31	NA	24.3	NA	NR	31	NA	≥1	LOD_{90}	0.023	NR	0.0	0.0
	10.43	0.01798	NA	NR	16	NA	33.1	NA	NR	16	NA	≥1				0.0	0.0
	10.44	0.03906	NA	NR	16	NA	49.4	NA	NR	16	NA	≥1				0.0	0.0
	10.45	0.05642	NA	NR	19	NA	36.7	NA	NR	19	NA	≥1				0.0	0.0
	10.46	0.0	NA	NR	0.0	NA	0.0	NA	NR	0.0	NA	≥1				1.0	0.0
	10.47	0.00031	NA	NR	316	NA	2.0	NA	NR	316	NA	≥1				0.933	0.0
	10.48	0.00155	NA	NR	105	NA	6.6	NA	NR	105	NA	≥1				0.67	0.0
	10.49	0.00031	NA	NR	316	NA	1.4	NA	NR	316	NA	≥1			95% CI:	0.933	0.0
	10.50	0.00093	NA	NR	161	NA	2.8	NA	NR	161	NA	≥1	LOD_{95}	0.051	(0.049, 0.054)	0.800	0.0
	10.51	0.00527	NA	NR	40	NA	13.7	NA	NR	40	NA	≥1	LOD_{90}	0.039	NR	0.200	0.0
	10.52	0.00651	NA	NR	35	NA	12.0	NA	NR	35	NA	≥1				0.100	0.0
	10.53	0.01395	NA	NR	24	NA	17.6	NA	NR	24	NA	≥1				0.0	0.0
	10.54	0.03968	NA	NR	22	NA	25.8	NA	NR	22	NA	≥1				0.0	0.0
Rose et al. 2011	11.1	0.00636	NR	NR	NR	NR	46.1	48	NA	54	72	≥1				0.159	0.0
	11.2	0.17469	NR	NR	NR	NR	66.5	30	NA	20	36	≥1	NR	NR	NR	0.0	0.0
	11.3	13.341	NR	NR	NR	NR	77.9	14	NA	11	18	≥1				0.0	0.056
	11.4	0.01302	NR	NR	NR	NR	32.4	31	NA	69	76	≥1				NR	NR
	11.5	0.20553	NR	NR	NR	NR	24.4	31	NA	35	47	≥1	NR	0.031	NR	NR	NR
	11.6	15.475	NR	NR	NR	NR	30.1	20	NA	20	28	≥1				NR	NR

Table A.2b Expanded summary of test results for wipe sampling. Acronyms and abbreviations are defined in Table 6. (cont.)

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD defin-ition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Rose et al. 2011 (cont.)	11.7	NR	NR	NR	NR	NR	30.8	NA	NA	50	NA	NR	NR	NR	NR	NR	NR
	11.8	NR	NR	NR	NR	NR	32.3	NA	NA	30	NA	NR	NR	NR	NR	NR	NR
	11.9	NR	NR	NR	NR	NR	26.8	NA	NA	21	NA	NR	NR	NR	NR	NR	NR
	11.10	NR	NR	NR	NR	NR	36.3	NA	NA	25	NA	NR	NR	NR	NR	NR	NR
	11.11	NR	NR	NR	NR	NR	26.0	NA	NA	38	NA	NR	NR	NR	NR	NR	NR
Montgomery and Camp 2008	12.1	NR	NA	NR	NR	NA	19.9	NA	10	27	NA	NR	NR	NR	NR	NR	NR
	12.2	NR	NA	NR	NR	NA	14.5	NA	21	0	NA	NR	NR	NR	NR	NR	NR
	12.3	NR	NA	NR	NR	NA	15.7	NA	37	14	NA	NR	NR	NR	NR	NR	NR
	12.4	NR	NA	NR	NR	NA	16.3	NA	26	12	NA	NR	NR	NR	NR	NR	NR

(a) Combined estimate of "run" and "sample-within-run" uncertainties.
(b) Data were available to calculate "run" and "sample-within-run" uncertainties, but they were not reported by Einfeld et al. (2011). The uncertainty values reported are listed in the "RE run %RSD" column, even though the values have contributions from "runs" as well as "samples within runs".
(c) Quizon et al. (2007) reported a SE = 7.6, but not enough information was provided to 1) know whether it includes run-to-run and/or sample-within-run uncertainties, and 2) convert the SE value to a %RSD value.

Table A.3a Expanded summary of test conditions for vacuum sampling. Acronyms and abbreviations are defined in Table 6.

Reference	Test #	Agent[a]	Agent[b] deposition	Agent[c] concentration (CFU/cm^2)	Vacuum filter type	Vacuum tech-nique[a]	Relative humidity (%)	Surface type	Surface area sampled (cm^2)	Extraction liquid	Extraction method	Culture method, medium	# labs	# test runs	Total # test samples
Estill et al. 2009	1.1	BA Sterne	Dry aerosol	0.03	HEPA sock	P2D	NR	SS	929	BBT	A+C+V+S	FP, TSAB	1	3	27
	1.2	BA Sterne	Dry aerosol	0.3	HEPA sock	P2D	NR	SS	929	BBT	A+C+V+S	FP, TSAB	1	3	27
	1.3	BA Sterne	Dry aerosol	2	HEPA sock	P2D	NR	SS	929	BBT	A+C+V+S	FP, TSAB	1	3	27
	1.4	BA Sterne	Dry aerosol	0.03	HEPA sock	P2D	NR	Carpet	929	BBT	A+C+V+S	FP, TSAB	1	2	18
	1.5	BA Sterne	Dry aerosol	0.3	HEPA sock	P2D	NR	Carpet	929	BBT	A+C+V+S	FP, TSAB	1	4	36
	1.6	BA Sterne	Dry aerosol	2	HEPA sock	P2D	NR	Carpet	929	BBT	A+C+V+S	FP, TSAB	1	3	27
Brown et al. 2007c	2.1	BA	Dry aerosol	1E+2 – 1E+3	HEPA filter	PP2D	30 – 40	SS	100	BBT	S+H+V	Plate, PF	1	NR	23
	2.2	BA	Dry aerosol	1E+4 – 1E+5	HEPA filter	PP2D	30 – 40	SS	100	BBT	S+H+V	Plate, PF	1	NR	13
	2.3	BA	Dry aerosol	1E+2 – 1E+3	HEPA filter	PP2D	30 – 40	PWB	100	BBT	S+H+V	Plate, PF	1	NR	14
	2.4	BA	Dry aerosol	1E+4 – 1E+5	HEPA filter	PP2D	30 – 40	PWB	100	BBT	S+H+V	Plate, PF	1	NR	22
	2.5	BA	Dry aerosol	1E+2 – 1E+3	HEPA filter	PP2D	30 – 40	Carpet	100	BBT	S+H+V	Plate, PF	1	NR	16
	2.6	BA	Dry aerosol	1E+4 – 1E+5	HEPA filter	PP2D	30 – 40	Carpet	100	BBT	S+H+V	Plate, PF	1	NR	24
	2.7	BA	Dry aerosol	1E+2 – 1E+3	HEPA filter	PP2D	30 – 40	Concrete	100	BBT	S+H+V	Plate, PF	1	NR	21
	2.8	BA	Dry aerosol	1E+4 – 1E+5	HEPA filter	PP2D	30 – 40	Concrete	100	BBT	S+H+V	Plate, PF	1	NR	23
Einfeld et al. 2011	3.1	BAtr + grime	Dry aerosol	1.42E+3 – 2.00E+4	PE filter	NR	36 – 48	Marble	100	BBT	S+H+V	Plate, PF	1	3	33
	3.2	BAtr	Dry aerosol	1.42E+3 – 2.00E+4	PE filter	NR	36 – 48	Marble	100	BBT	S+H+V	Plate, PF	1	3	36
	3.3	BAtr + grime	Dry aerosol	3.80E+3 – 8.78E+4	PE filter	NR	77 – 82	Marble	100	BBT	S+H+V	Plate, PF	1	3	36
	3.4	BAtr	Dry aerosol	3.80E+3 – 8.78E+4	PE filter	NR	77 – 82	Marble	100	BBT	S+H+V	Plate, PF	1	3	35
	3.5	BAtr + grime	Dry aerosol	1.31E+3 – 7.75E+3	PE filter	NR	89 – 90	Concrete	100	BBT	S+H+V	Plate, PF	1	5	59
	3.6	BAtr	Dry aerosol	1.31E+3 – 7.75E+3	PE filter	NR	89 – 90	Concrete	100	BBT	S+H+V	Plate, PF	1	5	58
Quizon et al. 2007	4.1	BAtr	Wet aerosol	NR	HEPA sock	SVH	NR	Ceiling tile	900	PBST	C+V+S	SP/FP, TSA	1	4	6
	4.2	BAtr	Wet aerosol	NR	HEPA sock	SVH	NR	Carpet	900	PBST	C+V+S	SP/FP, TSA	1	4	4
	4.3	BAtr	Wet aerosol	NR	HEPA sock	SVH	NR	PWB	900	PBST	C+V+S	SP/FP, TSA	1	4	4
	4.4	BAtr	Wet aerosol	NR	HEPA sock	SVH	NR	SS	900	PBST	C+V+S	SP/FP, TSA	1	4	10
	4.5	BAtr	Wet aerosol	NR	HEPA sock	SVH	NR	Vinyl	900	PBST	C+V+S	SP/FP, TSA	1	4	4
	4.6	BAtr	Wet aerosol	NR	HEPA sock	SVH	NR	Wood	900	PBST	C+V+S	SP/FP, TSA	1	4	4
Montgomery and Camp 2008	5.1	BA Sterne	EtOH drops	798.25	HEPA sock	Rough	NR	HVAC filter	309.68	PBSTr	Shake+C	NR, NR	1	3	NR
	5.2	BA Sterne	EtOH drops	798.25	TECF	Gentle	NR	HVAC filter	309.68	PBSTr	Shake+C	NR, NR	1	3	9
	5.3	BA Sterne	EtOH drops	798.25	TECF	Rough	NR	HVAC filter	309.68	PBSTr	Shake+C	NR, NR	1	3	9
	5.4	BA Sterne	EtOH drops	9.0E+4	TECF	Rough	NR	HVAC filter	309.68	PBSTr	Shake+C	NR, NR	1	NR	NR
	5.5	BA Sterne	EtOH drops	9.1E+6	TECF	Rough	NR	HVAC filter	309.68	PBSTr	Shake+C	NR, NR	1	NR	NR
	5.6	BA Sterne	EWD	167	TECF	V. slide	NR	Carpet	400	PBSTr	Shake+C	NR, NR	1	1	3
	5.7	BA Sterne	EWD	167	TECF	Tilt drag	NR	Carpet	400	PBSTr	Shake+C	NR, NR	1	1	3
	5.8	BA Sterne	EWD	201	TECF	V. slide	NR	Carpet	400	PBSTr	Shake+C	NR, NR	1	1	6
	5.9	BA Sterne	H2O drops	111	TECF	V. slide	NR	Carpet	400	PBSTr	Shake+C	NR, NR	1	1	3
	5.10	BA Sterne	H2O drops	111	TECF	Tilt push	NR	Carpet	400	PBSTr	Shake+C	NR, NR	1	1	3

(a) V. slide = vertical slide

Table A.3b Expanded summary of test results for vacuum sampling. Acronyms and abbreviations are defined in Table 6.

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/cm^2)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD defin-ition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Estill et al. 2009	1.1	0.0043	38	50	98	116	5.5	16	5	90	92	≥3	LOD_{95}	0.44	95% CI: 0.24 – 1.4	NR	8/30 = 0.267
	1.2	0.018	18	0	82	84	4.7	13	0	81	82						
	1.3	0.1	35	6	82	89	3.7	31	0	73	79						
	1.4	0.0011	0	0	170	170	6.3	0	0	130	130	≥1	LOD_{95}	0.28	95% CI: 0.14 – 1.3	NR	2/30 = 0.067
	1.5	0.0061	0	57	110	124	3.7	0	61	110	130						
	1.6	0.062	30	37	44	65	4.7	18	89	50	100						
Brown et al. 2007c	2.1	NR	NA	NR	NR	NA	32.1	NA	NR	45	NA	≥1 CFU/ml	NR	NR	NR	NR	NR
	2.2	NR	NA	NR	NR	NA	23.1	NA	NR	46	NA	≥1 CFU/ml	NR	NR	NR	NR	NR
	2.3	NR	NA	NR	NR	NA	24.5	NA	NR	78	NA	≥1 CFU/ml	NR	NR	NR	NR	NR
	2.4	NR	NA	NR	NR	NA	25.0	NA	NR	44	NA	≥1 CFU/ml	NR	NR	NR	NR	NR
	2.5	NR	NA	NR	NR	NA	36.1	NA	NR	47	NA	≥1 CFU/ml	NR	NR	NR	NR	NR
	2.6	NR	NA	NR	NR	NA	22.9	NA	NR	28	NA	≥1 CFU/ml	NR	NR	NR	NR	NR
	2.7	NR	NA	NR	NR	NA	21.6	NA	NR	90	NA	≥1 CFU/ml	NR	NR	NR	NR	NR
	2.8	NR	NA	NR	NR	NA	16.4	NA	NR	43	NA	≥1 CFU/ml	NR	NR	NR	NR	NR
Einfeld et al. 2011	3.1	NR	NA	NR	NR	NA	10.0	NA	NR	123	NA	NR	NR	NR	NR	NR	NR
	3.2	NR	NA	NR	NR	NA	11.9	NA	NR	129	NA	NR	NR	NR	NR	NR	NR
	3.3	NR	NA	NR	NR	NA	17.0	NA	NR	50	NA	NR	NR	NR	NR	NR	NR
	3.4	NR	NA	NR	NR	NA	12.1	NA	NR	57	NA	NR	NR	NR	NR	NR	NR
	3.5	NR	NA	NR	NR	NA	19.7	NA	NR	53	NA	NR	NR	NR	NR	NR	NR
	3.6	NR	NA	NR	NR	NA	16.5	NA	NR	50	NA	NR	NR	NR	NR	NR	NR
Quizon et al. 2007	4.1	5200	NA	9[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	4.2	4600	NA	19[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	4.3	4800	NA	18[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	4.4	2670	NA	9[(a)]	(a)	NA	4.4	NA	(b)	(b)	NA	NR	NR	NR	NR	NR	NR
	4.5	1225	NA	13[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	4.6	890	NA	20[(a)]	(a)	NA	NR	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
Montgomery and Camp 2008	5.1	NR	NA	NR	NR	NA	2.42	NA	1.3	24	NA	NR	NR	NR	NR	NR	NR
	5.2	NR	NA	NR	NR	NA	1.16	NA	28	25	NA	NR	NR	NR	NR	NR	NR
	5.3	NR	NA	NR	NR	NA	2.85	NA	16	13	NA	NR	NR	NR	NR	NR	NR
	5.4	NR	NA	NR	NR	NA	3.52	NA	26[(a)]	(a)	NA	NR	NR	NR	NR	NR	NR
	5.5	NR	NA	NR	NR	NA	2.84	NA	NR	NR	NA	NR	NR	NR	NR	NR	NR
	5.6	NR	NA	NR	NR	NA	0.48	NA	NA	60	NA	NR	NR	NR	NR	NR	NR
	5.7	NR	NA	NR	NR	NA	0.20	NA	NA	10	NA	NR	NR	NR	NR	NR	NR
	5.8	NR	NA	NR	NR	NA	0.41	NA	NA	37	NA	NR	NR	NR	NR	NR	NR
	5.9	NR	NA	NR	NR	NA	2.26	NA	NA	18	NA	NR	NR	NR	NR	NR	NR
	5.10	NR	NA	NR	NR	NA	1.69	NA	NA	32	NA	NR	NR	NR	NR	NR	NR

(a) Combined estimate of "run" and "sample-within-run" uncertainties.
(b) Quizon et al. (2007) reported a SE = 1.1, but not enough information was provided to 1) know whether it includes run-to-run and/or sample-within-run sources of uncertainty, and 2) convert the SE value to a %RSD value.

Table A.4a Expanded summary of test conditions for storage and stability tests. Acronyms and abbreviations are defined in Table 6.

Reference	Test #	Agent (a)	Agent deposition (b)	Agent concen-tration (CFU/ml)	Sampling medium type (b)	Wetting agent (b)	Relative humidity	Surface type & area sampled (b)	Storage conditions			Extract-ion liquid (a)	Extract-ion method (a)	Culture method, medium	# labs	# test runs	Total # test samples
									Additive (c)	Temp. (°C)	# Days						
Almeida et al. 2008	1.1	BA Sterne	Liquid	NR	NA	NA	NR	NA	None	4	0	NA	NA	Plate, LBA	NR	3 lots	19
	1.2	BA Sterne	Liquid	NR	NA	NA	NR	NA	None	4	0	NA	NA	Plate, LBA	NR	1	3
	1.3	BA Sterne	Liquid	NR	NA	NA	NR	NA	None	4	182	NA	NA	Plate, LBA	NR	1	3
	1.4	BA Sterne	Liquid	NR	NA	NA	NR	NA	None	4	279	NA	NA	Plate, LBA	NR	1	3
	1.5	BA Sterne	Liquid	NR	NA	NA	NR	NA	Phenol	4	0	NA	NA	Plate, LBA	NR	1	3
	1.6	BA Sterne	Liquid	NR	NA	NA	NR	NA	Phenol	4	182	NA	NA	Plate, LBA	NR	1	3
	1.7	BA Sterne	Liquid	NR	NA	NA	NR	NA	Phenol	4	279	NA	NA	Plate, LBA	NR	1	3
	1.8	BA Sterne	Liquid	NR	NA	NA	NR	NA	EDTA	4	0	NA	NA	Plate, LBA	NR	1	3
	1.9	BA Sterne	Liquid	NR	NA	NA	NR	NA	EDTA	4	182	NA	NA	Plate, LBA	NR	1	3
	1.10	BA Sterne	Liquid	NR	NA	NA	NR	NA	EDTA	4	279	NA	NA	Plate, LBA	NR	1	3
	1.11	BA Sterne	Liquid	NR	NA	NA	NR	NA	Ethanol	4	0	NA	NA	Plate, LBA	NR	1	3
	1.12	BA Sterne	Liquid	NR	NA	NA	NR	NA	Ethanol	4	182	NA	NA	Plate, LBA	NR	1	3
	1.13	BA Sterne	Liquid	NR	NA	NA	NR	NA	Ethanol	4	279	NA	NA	Plate, LBA	NR	1	3
	1.14	BA Sterne	Liquid	NR	NA	NA	NR	NA	PBSTr	4	0	NA	NA	Plate, LBA	NR	1	3
	1.15	BA Sterne	Liquid	NR	NA	NA	NR	NA	PBSTr	4	182	NA	NA	Plate, LBA	NR	1	3
	1.16	BA Sterne	Liquid	NR	NA	NA	NR	NA	PBSTr	4	279	NA	NA	Plate, LBA	NR	1	3
	1.17	BA Sterne	Liquid	NR	NA	NA	NR	NA	None	-20	182	NA	NA	Plate, LBA	NR	1	3
	1.18	BA Sterne	Liquid	NR	NA	NA	NR	NA	None	-20	279	NA	NA	Plate, LBA	NR	1	3
	1.19	BA Sterne	Liquid	NR	NA	NA	NR	NA	None	-80	182	NA	NA	Plate, LBA	NR	1	3
	1.20	BA Sterne	Liquid	NR	NA	NA	NR	NA	None	-80	279	NA	NA	Plate, LBA	NR	1	3

(a) The BA Sterne spores were diluted with PBS (10 mmol/L phosphate, 138 mmol/L NaCl, and 2.7 mmol/L KCl, pH 7.4) containing 0.01% Triton X-100, and vigorously mixed by vortexing.
(b) This study used only liquid samples containing the agent, so neither deposition onto surfaces nor sampling of surfaces was involved.
(c) Additives to sterile water: Ethanol = ethanol 20% (v/v), EDTA = ethylendediamainetetraacetic acid, 10 mmol/L, pH 8.0, Phenol = phenol 1% (v/v), PBSTr = PBS containing 0.01% (v/v) Triton × 100.

Table A.4b Expanded summary of test results for storage and stability tests. Acronyms and abbreviations are defined in Table 6.

		Recovery concentration results – Mean & %RSDs					Recovery efficiency (RE) – Mean & %RSDs					LOD, FNR, and FPR					
Reference	Test #	Mean (CFU/ml)	Lab %RSD	Run %RSD	Sample-within-run %RSD	Total %RSD	RE [(a)] mean (%)	RE lab %RSD	RE run %RSD	RE sample-within-run %RSD	RE total %RSD	Positive result (CFU)	LOD defin-ition	LOD (CFU/cm^2)	LOD SD or 95% CI (CFU/cm^2)	FNR	FPR
Almeida et al. 2008	1.1	6.19E+9	NA	174	25	NA	111	NA	22	24	NA	NR	NR	NR	NR	NR	NR
	1.2	1.25E+8	NA	NA	31	NA	NA	NA	NA	NA	NA	NR	NR	NR	NR	NR	NR
	1.3	1.00E+8	NA	NA	12	NA	81	NA	NA	33	NA	NR	NR	NR	NR	NR	NR
	1.4	1.17E+8	NA	NA	7	NA	96	NA	NA	30	NA	NR	NR	NR	NR	NR	NR
	1.5	1.42E+8	NA	NA	7	NA	NA	NA	NA	NA	NA	NR	NR	NR	NR	NR	NR
	1.6	1.12E+8	NA	NA	17	NA	79	NA	NA	18	NA	NR	NR	NR	NR	NR	NR
	1.7	1.29E+8	NA	NA	7	NA	92	NA	NA	10	NA	NR	NR	NR	NR	NR	NR
	1.8	1.47E+8	NA	NA	86	NA	NA	NA	NA	NA	NA	NR	NR	NR	NR	NR	NR
	1.9	1.08E+8	NA	NA	6	NA	71	NA	NA	55	NA	NR	NR	NR	NR	NR	NR
	1.10	1.20E+8	NA	NA	20	NA	75	NA	NA	54	NA	NR	NR	NR	NR	NR	NR
	1.11	1.47E+8	NA	NA	4	NA	NA	NA	NA	NA	NA	NR	NR	NR	NR	NR	NR
	1.12	1.24E+8	NA	NA	15	NA	85	NA	NA	16	NA	NR	NR	NR	NR	NR	NR
	1.13	1.32E+8	NA	NA	4	NA	90	NA	NA	6	NA	NR	NR	NR	NR	NR	NR
	1.14	1.95E+8	NA	NA	43	NA	NA	NA	NA	NA	NA	NR	NR	NR	NR	NR	NR
	1.15	1.25E+8	NA	NA	8	NA	71	NA	NA	45	NA	NR	NR	NR	NR	NR	NR
	1.16	1.37E+8	NA	NA	6	NA	77	NA	NA	43	NA	NR	NR	NR	NR	NR	NR
	1.17	1.61E+8	NA	NA	84	NA	NA	NA	NA	NA	NA	NR	NR	NR	NR	NR	NR
	1.18	1.28E+8	NA	NA	21	NA	NA	NA	NA	NA	NA	NR	NR	NR	NR	NR	NR
	1.19	1.37E+8	NA	NA	39	NA	NA	NA	NA	NA	NA	NR	NR	NR	NR	NR	NR
	1.20	1.20E+8	NA	NA	7	NA	NA	NA	NA	NA	NA	NR	NR	NR	NR	NR	NR

(a) For Test 1.1, the REs at different storage times were calculated relative to the values for 0 days storage for each of three lots. Results did not appear to depend on storage time or lot, so the RE Mean was calculated over all lots and storage times. For Tests 1.2 to 1.20, RE could not be calculated using the data from 0-, 189-, and 279-day tests relative to the "true" concentration for each test, because that value was not reported by Almeida et al. (2008). For Tests 1.2 to 1.16, having several additives combined with spore solutions and stored for 0, 182, and 279 days, the RE mean values for 182 and 279 days were calculated relative to the results at 0 days. Hence, RE shows the effect of storage time on recovery of spores for those tests, although the effects of the plating and counting steps on RE are not included.

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