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WORKER ENVIRONMENT BERYLLIUM CHARACTERIZATION STUDY

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WORKER ENVIRONMENT BERYLLIUM CHARACTERIZATION STUDY

Purpose

This report summarizes the conclusion of regular monitoring of occupied buildings at the Nevada Test Site (NTS) and North Las Vegas (NLV) facility to determine the extent of beryllium (Be) contamination in accordance with Judgment of Needs (JON) 6 of the August 14, 2003 “Minnema Report.”

Executive Summary

From March 2002, when the U. S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) was notified that an employee at NLV had been diagnosed with Chronic Beryllium Disease (CBD), to present (October 2009), periodic monitoring of occupied buildings at the NTS and NLV has been performed for the potential introduction or spread of Be, until the extent of contamination could be determined and controls implemented.

During this period, 228 facilities were sampled with over 11,000 surface wipe samples, along with numerous air samples obtained and analyzed. Also during this period, statistical methods of data collection, analysis, and detail were developed and sharpened to provide a high degree of confidence in all results (see Appendices 1 through 4).

All but five of the facilities examined now do not exceed the U.S. Department of Energy (DOE) release criterion (RC) of 0.2 micrograms (µg)/100 square centimeters (cm^2). Of those five, two have been demolished and the other three involve legacy equipment (not in use) or long-term storage.

Background

<u>CBD Discovery and DOE National Nuclear Security Administration Headquarters (NNSA/HQ) Investigation</u>

In March 2002, NNSA/NSO was notified that an employee at the NLV facility had been diagnosed with CBD. An NNSA/HQ investigation was chartered on August 22, 2002. The NNSA/HQ team presented its findings in “Investigation of Beryllium Exposure Cases Discovered at the North Las Vegas Facility of the National Nuclear Security Administration” (August 14, 2003), otherwise referred to as the “Minnema Report,” named after team leader Douglas Minnema.

The Minnema Report concluded that there was reason to believe that all cases of CBD and Be sensitization likely resulted from exposure to Be during DOE-sponsored activities while working on a characterization study at a facility on the NTS, exposure while working in the B-Complex at NLV, and/or exposure while working elsewhere in the DOE Complex (p. viii). The report makes specific recommendations regarding treatment of the suspect buildings (24-B01, -02, and -03 and the second floor of Building A01); see the Building Recommendation Letter (Attachment 2 of the Minnema Report). Subsequently, Buildings B01 and B02 have been demolished, while Building B03 and the second floor of Building A01 have been renovated, and have passed the Recommended Cleanup Standard stated in the Building Recommendation Letter.

Section 4 of the Minnema Report contains 18 JONs. In particular, JON 4 states that "NSO needs to ensure that the full extent of the spread of beryllium contamination (including NTS, NLV, and offsite locations) is determined, and that mitigative or corrective actions are established as appropriate." Furthermore, JON 6 states that "NSO needs to ensure that occupied buildings at NTS and NLV are regularly monitored for the potential introduction and spread of beryllium into uncontrolled areas, at least until the extent of the beryllium contamination has been determined and evaluated and controls have been identified and implemented."

NNSA/NSO Facility Survey

In response to these JONs, NNSA/NSO embarked on a broad characterization of Be surface concentrations beginning with the suspect B-Complex buildings while still occupied and extending throughout NLV, the NTS, and ancillary facilities in North Las Vegas, Los Alamos, Livermore, Special Technologies Laboratory in Santa Barbara, and the Andrews Air Force Base. Sampling of both touchable surfaces and air was conducted in occupied and incidentally occupied facilities during 2002-2004. Supplementary chemical analyses continued until early 2007, accompanied by statistical analyses of the resulting data. Some follow-up sampling took place in February 2008 and January 2009. This document reports the conclusions of the sampling and statistical analyses. EnviroStat personnel were actively involved in all stages of this survey from initial discussions with the NNSA/HQ team through sample planning, quality assurance activities, data analysis, and report preparation.

Draft DOE Technical Standard

While this survey was proceeding, NNSA/HQ and DOE were responding to JON 16, which calls on DOE to provide additional guidance on the implementation of the pertinent federal regulation (Title 10 Code of Federal Regulations [CFR] Part 850). Some of this has resulted in a draft DOE Technical Standard SAFT-0103, "Management of Items and Areas Containing Low Levels of Beryllium." The Beryllium Health and Safety Committee (BH&SC) has been active in investigating the many technical and scientific issues involved. EnviroStat personnel have been participating with the BH&SC as well.

Structure of the Survey

Two hundred twenty-eight facilities were sampled during this survey. These facilities range in size from one-room guard stations to large office buildings; they range in nature from office buildings to dormitories, shops, storage facilities, laboratories, and more; and they range in locations from the NTS forward areas to urban settings and air force bases. Over 11,000 surface wipe samples have been obtained and analyzed, along with numerous air samples. There exists a quasi-regulatory standard for surface sampling, and surface Be is ubiquitous in nearly all facilities surveyed; accordingly, the survey was designed for surface sampling. Air monitoring was also conducted while the sampling teams were in the facilities; very few of the air samples produced measurements above the laboratory reporting limit (RL) and none were above the regulatory limit. This report addresses only the surface sampling campaign and conclusions.

DOE Release Criterion

As discussed in Appendix 1, the quasi-regulatory standard used is the DOE RC of 0.2 µg/100 cm^2 given in 10 CFR 850.31(b)(1) as the limit not to be exceeded on items to be released to non-Be operations or the public. That regulation provides for an exemption for naturally occurring Be; there is evidence that naturally occurring Be, even Be ores, are nontoxic. A critical feature is the fact that analysis of wipe samples for total Be is routine and inexpensive, whereas determining the source and/or speciation (i.e., chemical binding and so on) of the Be in a given sample can be expensive. Therefore, a guiding principle of this survey has been the following:

- Survey the facility for total Be. If the facility passes, there is nothing more to be done.
- If the facility does not pass when considering the total Be, then attempt to show that the Be present is natural as opposed to anthropogenic.
- Alternately, or if the Be present may be anthropogenic, clean the facility and resample.

With the acquisition in late 2005 of its inductively coupled plasma mass spectroscopy (ICP-MS) instrument, National Security Technologies, LLC (NSTec), now has the ability to attempt to distinguish Be from native NTS soils and anthropogenic Be.

Survey Design and Evolution

Appendix 1 lays out the general strategy to be employed in this survey, and outlines discussions of some of the evolutionary enhancements added since the survey was begun in late 2002. Appendices 3 and 4 discuss in detail several issues that arose and their resolutions. A few of the major points follow.

Types of Facilities and Statistical Comparisons

Facilities fall into one of four categories:

- Facilities consisting of just one or a few Individual Work Areas (IWAs), all of which have been sampled, such as a guard station or tunnel access control station;
- Facilities consisting of multiple IWAs, too numerous to reasonably sample, such as an office building or laboratory;
- Facilities consisting of one or more open areas (Areas), such as a warehouse or shop; or
- Facilities having portions consisting of both IWAs and Areas, such as the NTS cafeteria and several shop facilities.

In the IWA cases, samplers were instructed to sample four to six locations within the IWA most likely to produce high measurements. For example, in a typical cubicle, one might select corners behind computer monitors, tops of wall dividers, or tops of computers located under desktops. If the largest value found in the IWA is no greater than the RC, the IWA itself passes. If all IWAs in a facility are sampled and pass, the facility as a whole passes.

Where there are more IWAs in a facility than can reasonably be sampled, a statistically based random selection of IWAs is made. The IWA maximum for each sampled IWA is found, and the resulting data are compared statistically with the RC. Three statistical criteria are used. The most stringent (for all but the smallest facilities) is termed the PLall approach: one uses the IWA maxima to compute a 95%-prediction limit (PL) for the maximum value that would be found in all remaining IWAs if they were also sampled. If PLall is not greater than the RC (and no individual measurement exceeds the RC), the facility passes. The PLall approach was suggested to the NNSA/HQ investigation team for use with the suspect NLV buildings, and was enthusiastically endorsed by that team.

As discussed in Appendix 1, this approach is considerably more stringent than that contained in the draft DOE Technical Standard. That document prefers a statistical comparison based on 95%-95% upper tolerance limits (UTLs), which are upper 95% confidence limits for the 95th percentile of the distributions of <u>all</u> measurements (not just the IWA maxima). Moreover, it contemplates random sampling of surfaces rather than the biased sampling described above. Accordingly, two less stringent criteria are also used in this report. One is a UTL based on the IWA maxima (see Appendix 1). Both PLall and UTL are computed for virtually all IWA facilities; so long as at least one of these is not greater than the RC (and no individual observation exceeds the RC), the facility passes. The third criterion is termed UTL_cluster. This criterion uses all data, not just the IWA maxima. The idea is that selecting IWAs and then sampling locations within IWAs is similar to “cluster sampling” in survey research methodology. The mathematics underlying this UTL method is nonstandard; see Appendix 4 for its development. Again, if the UTL_cluster is not greater than the RC (and no individual measurement exceeds the RC), the facility passes. This UTL cluster analysis approach is still more stringent than that advocated in the draft DOE Technical Standard because of the biased sampling used.

For Area facilities, a standard grid sampling plan is laid out on floors, walls, and/or shelves as appropriate to the facility, and the UTL is computed from the resulting data. This corresponds to the process anticipated in the draft DOE Technical Standard.

Finally, for facilities with both IWA and Area portions, the same techniques and comparisons are used, with confidence levels adjusted to ensure that the overall confidence for the facility is no less than the target 95%.

Chemical Analysis and Data Issues

The first 5,000+ wipe analyses were performed by DataChem (DC), an independent, American Industrial Hygiene Association-accredited subcontract laboratory. After that, Bechtel Nevada (BN) acquired its own inductively coupled plasma atomic emission spectroscopy instrument to analyze the majority of the remaining wipe samples obtained during 2003-2004. As a quality control precaution, a number of side-by-side wipes were obtained to allow comparison of the DC and BN results. For a few facilities, data from samples previously obtained and analyzed by Assay Technology's (AT's) laboratories were used.

The comparison of side-by-side results was not favorable, particularly with respect to samples obtained in shop and forward areas. An extended study of the causes of the observed discrepancies ensued. The results of this study are discussed in Appendix 3; see also Davis *et al.* (2005). The bottom line is that the particular emission line used in the BN atomic emission spectroscopy (BN-AES) analyses is subject to significant interferences from iron. Appendix 3 presents an adjustment that can be used so long as the iron interference is not too great; the resulting data are termed "BNadj" measurements.

Once that obstacle had been overcome, there remained around 1,000 samples with excessive iron interference. By that time, BN had acquired a new ICP-MS instrument. The digested wipes from the BN-AES analyses had been archived; most were reanalyzed using the BN-MS instrument. These digested samples had been held long past their usual holding time limits, however, and the analytical results were systematically notably higher than those obtained from DC analyses of side-by-side samples obtained for quality assurance. This presented a quandary.

Many of the samples reanalyzed by MS were from the Area 6 shops, which is not surprising since the iron concentrations should naturally be higher in facilities where metal work is conducted. It cannot be determined whether the higher MS values are indeed due to higher Be values, to holding time complications, or both.

The following strategy was adopted to deal with this quandary. For any individual sample location (including its side-by-side comparison location), if a DC and/or BNadj measurement was available, it (the higher, if there are both) was used. Failing that, the MS_arch value was used for that location, resulting in statistical analyses likely to be yet more conservative than UTL or PLall analyses using, say, DC data, which are already more stringent than the analyses discussed in the draft DOE Technical Standard. (These high MS_arch values were a significant motivation for the development of the UTL cluster analysis methodology.)

A number of facilities did not pass using this conservative strategy. These were resampled during January 2009 (February 2008 for Area 06-908), with wipes analyzed by ICP-MS within holding time limits. These data are denoted “MS_new.” The statistical analyses were repeated using the MS_new data in place of the MS_arch data. For a few facilities both MS_arch and MS_new data were used.

There remain a small number of facilities for which even this latest approach was unsuccessful. In anticipation of this eventuality, bulk samples had been obtained inside the facilities sampled during January 2009, and exterior soil samples were obtained as well. These bulk and soil samples were analyzed for Be concentration (in µg/kilogram). In addition, concentrations of other metals were measured in these samples and in the wipe samples with Be exceeding the DOE RC. The bulk sample Be concentrations were then compared with the range of values found in NTS soils, and the metal concentration ratios for both bulk and wipe samples were compared with the range found in NTS soils. In only six cases was there suspicion that the Be present in the samples was not from NTS soils; see the discussion in the “Survey results” section to follow.

Also, in a few cases, a facility would not pass if all data were included, but would if one or two “outlier” measurements were excluded. In these cases, an “outlier” involves both an atypically high value for that facility and a sampling location that arguably would not fit the criterion of being “touchable” during normal work activities.

Statistical Issues

Another issue has to do with the nature of the measurement data obtained. The conventional wisdom is that measurements of concentrations of environmental contaminants tend to have lognormal distributions; that is, the logs of the data have normal (Gaussian) distributions. There is some theoretical justification for this, along with considerably regulatory acceptance. Moreover, this conventional wisdom is not inconsistent with our data.

The distributions of <u>measurements</u> of those concentrations are more interesting, however. At the beginning of these investigations, the NNSA/HQ team very strongly urged following the Multi-Agency Radiation Survey and Site Investigation Manual guidance. One recommendation of that guidance is that uncensored data be obtained whenever possible; that is, one obtains and uses actual instrument measurement values for all analyses rather than allowing low measurements to be reported as “nondetects” or “<RL” for some RL, as is conventionally done. Having such a large number of uncensored observations has turned out to be highly educational, and revises our view of the conventional wisdom stated above. This is a major topic explored in

Davis *et al.* (2005), cited previously; see also Davis and Grams (2006) and Davis, Field, and Gran (2009).

It turns out that at some facilities a high proportion of data values are negative, which is impossible under the lognormal model. It has been necessary to develop a reasonable accommodation for such data; this accommodation is described in Appendix 3. Essentially, a small constant is added to the reported values to make them all positive, lognormal UTL or PLall analyses are conducted, and the constant is subtracted from the resulting limit. Appendix 3 discusses the technical issues in detail, including incorporating blank corrections to alleviate low-level discrepancies in measurements obtained using different measurement systems and in determining appropriate constants for the various measurement systems and facility types.

For a few facilities the available data are censored, either at a convention RL (for AT data) or at 0 (for some early DC data, due to a temporary flaw in database design). In these cases lognormal censored data statistical methods are used; see Davis (2006).

Survey Results

The following table summarizes the results of the survey.

Summary of Results

Facility Type	Total	Pass	Pass*	Fail
Offices, Quarters, Labs, Communications, Experimentation Facilities	71	67	4	0
Field Operations	87	77	8	2
Shops	47	35	11	1
Storage	23	16	5	2
All	228	195	28	5

* Facilities which pass when outliers are disregarded and/or Be bulk concentrations and metal ratios are considered.

Two of the five facilities that failed have been demolished. Of the others, one is a very small facility (one IWA) in Area 6; one in Area 23 has a single isolated high value on a floor swipe with a slightly low Yttrium to Be ratio (although other metal ratios are consistent with those in NTS soils); and one in Area 6 has Be on a machine tool. Detailed results by facility are given on pages 3-8 of Appendix 2.

Summary and Discussion

A large-scale survey of worker environments has been conducted at facilities under the responsibility of NNSA/NSO, triggered by the Be exposure incident reported in March 2002. That survey included measurements of both removable Be concentrations on surfaces and air Be concentrations obtained. Two hundred and twenty-eight facilities were surveyed in all, mostly located on the NTS and in NLV, but also including operations in Los Alamos, Livermore, and Andrews Air Force Base.

Of the 228 surveyed facilities, 93 are small, consisting of one to three IWAs. Sampling was based on the sampler's judgment about where the highest Be concentrations were likely to be found. If the IWA maximum value does not exceed the DOE RC of 0.2 µg/100 cm^2, the IWA is "clean." If all IWAs in a facility are clean, the facility "passes."

For larger facilities, a statistically designed sampling of IWAs or Areas was conducted. UTLs or PLs for the IWA maxima of all unsampled IWAs (PLalls) were computed and compared with the RC. A facility passes if at least one of these limits is no greater than the RC and no individual measurement exceeds the RC. For IWA facilities, this criterion is more stringent than that suggested in the draft DOE Technical Standard; accordingly, another UTL cluster analysis was developed to more nearly match that draft DOE Technical Standard.

Of the 228 surveyed facilities, 195 facilities pass the comparison with the RC. Eleven additional facilities would pass if isolated high measurements obtained at atypical locations were disregarded; an "atypical" location is one not touched during normal work activities, such as a door top or the top of an electrical box.

These conclusions are based on analysis of wipe samples for total Be, as discussed previously. This includes both naturally occurring and anthropogenic Be, whereas the relevant regulation clearly exempts Be from natural soils. The analysis for total Be is straightforward and inexpensive, whereas determining the source of the Be in a given sample is likely to be more challenging; moreover, there is clear guidance in the draft DOE Technical Standard for the comparisons regarding total Be, but the guidance is not yet so clear for the latter sorts of comparisons. Nonetheless, with the acquisition in 2005 of the ICP-MS instrument, NNSA/NSO and NSTec now have the capability of performing the sort of chemical speciation needed to support discussions of the likely origin of Be in facilities showing higher levels. In 17 of the remaining facilities, Be concentrations in bulk samples and metal ratios in bulk and wipe samples are quite consistent with those in NTS soils.

In five facilities none of the criteria allow the facility to "pass." Two of these facilities have been demolished. The others have been cleaned to below the release criteria.

Finally, JON 6 of the Minnema Report calls for regular monitoring of occupied buildings at the NTS and NLV "at least until the extent of the beryllium contamination has been determined and evaluated and controls have been identified and implemented." In this survey, 90% of facilities were found to have minimal surface total Be levels satisfying the DOE RC. Be concentrations in bulk samples and metal ratios in bulk and wipe samples show that the Be found in another 7% of facilities clearly resembles that found in NTS soils, which is not intended as "contamination" by the pertinent regulation. The very few exceptions identified or possibly identified involve legacy equipment or long-term storage.

Conclusion

Occupied buildings at NLV and the NTS have been regularly monitored for the introduction or spread of Be since 2002 with no apparent increase in contamination. All 18 JONs associated with the Minnema Report have now been completed or fulfilled. There remains only three facilities with any indication of Be over the release criteria, and those are known and controlled. It is appropriate to cease Be survey activities in areas outside identified legacy and environmental restoration operations.

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Appendix 1
DATA QUALITY OBJECTIVES AND STATISTICAL METHODS

This appendix is largely excerpted from the document “Planning a Beryllium Characterization Sampling Campaign for a DOE Facility,” prepared in August 2005. It reflects the approach adopted in structuring the beryllium (Be) sampling conducted by Bechtel Nevada (BN) and, subsequently, by National Security Technologies, LLC, at the U.S. Department of Energy (DOE), National Nuclear Security Administration (NNSA) North Las Vegas facility (NLV), Nevada Test Site (NTS), and ancillary facilities. It is not necessarily the approach that will ultimately appear in the draft DOE Technical Standard SAFT-0103, “Management of Items and Areas Containing Low Levels of Beryllium.” The reader may wish to contact David Weitzman (David.Weizman@hq.doe.gov) for updated information on the direction in which the draft DOE Technical Standard is headed.

The BN approach evolved since the earliest days of the Be investigations at selected buildings in NLV in the late summer of 2002. Some of that history is discussed in what follows. On the whole, though, this document describes a reasonable approach for NLV, NTS, and similar sites, based on the knowledge and experience gained since beginning these investigations. [Sections in reduced type size discuss modifications added during the course of this extended investigation.]

Those first steps in 2002 were influenced by three factors: (a) a perceived urgency of the situation due to possible adverse publicity along with the desire to relocate workers promptly from a possibly unhealthy environment, (b) guidance from the DOE Headquarters (HQ) investigation team that emphatically suggested following the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) to the extent possible, and (c) an initial uncertainty about whether exposure limits based on the Title 10 Code of Federal Regulations (CFR) Part 850 release criterion (RC) are in fact adequately protective of worker health.

Investigations by BN and DOE/HQ teams arrived at the following conclusions. With regard to (a), BN’s screening of individual work areas (cubicles, offices, restrooms, etc.) and personal computers in the suspect NLV workplaces gave no indication of any health hazard exposure to employees working in the areas of initial concern. The BN investigation was subsequently expanded to cover <u>all</u> occupied and “incidentally occupied” worker environments at NTS, NLV, and ancillary facilities. The results of these investigations are provided in detail in Appendix 2. As for (b), the MARSSIM document is quite useful in that it has been accepted by the DOE, U.S. Environmental Protection Agency (EPA), and other federal agencies, and it does offer generally appropriate advice on sampling for these sorts of situations. However, it is designed for radiological screening using a combination of wipe samples to ensure that average surface concentrations do not exceed acceptable levels, augmented by gamma or other scans to detect hot spots that may exist. The latter hot-spot scans are not available for Be and many other metals; nonetheless the operative regulation suggests that all workers be protected, not just workers on average. The MARSSIM guidance must, therefore, be adapted to the needs of these surveys.

With regard to (c), the NNSA investigation team concluded that there is no reason to require a lower regulatory threshold for wipe sample concentrations than the 10 CFR 850 RC. Moreover, discussions in the Beryllium Health and Safety Committee (BH&SC) reveal that it is not at all clear what role surface contamination actually plays in chronic beryllium disease (CBD) or sensitization. The latter consideration is irrelevant with respect to compliance with current regulation, although one may well recognize that the facility survey decision criteria are based on an analogy of the regulatory requirement regarding the free release of equipment for use by the public, which has commonly been adopted for the facility survey setting.

This document is organized around the seven steps of the EPA's Data/Decision Quality Objectives (DQO) process.

DQO Step 1. State the problem.

Be in metallic form is a key component in nuclear devices. It is also a valuable alloying material for other metals. Therefore, it is often found at NNSA facilities; in particular, Be has undoubtedly been scattered during device detonations at the NTS. Be is also toxic. The major problem comes from inhaling airborne particles; the major adverse consequence is CBD, an incurable debilitating lung ailment. There is a theory, not universally accepted, that CBD can be acquired in two stages, the first being sensitization and the second being an adverse reaction to subsequent exposure. Under this theory, a person can become sensitized to Be through dermal contact as well as inhalation, but acquiring CBD itself requires inhalation. This theory warrants controlling surface concentrations.

Exposure limits for Be workers are contained in Title 10 Code of Federal Regulations (CFR) Part 850, the federal regulation driving DOE and other Be investigations. In 10 CFR 850, worker exposure is defined as exposure to airborne Be of a worker not wearing respiratory protective equipment. The 10 CFR 850 action level is 0.2 micrograms per cubic meter ($\mu g/m^3$) (§850.23(a)), evaluated as an 8-hour time-weighted average exposure measured in a worker's breathing zone by personal air monitoring. Accordingly, ambient air sampling is a key component of all Be investigations. Very few air samples obtained in occupied facilities or incidentally occupied facilities (see the discussion of terms that follows) produced measurements above their detection limits of approximately 0.007 $\mu g/m^3$. Hence, no formal sampling plans have been created for air sampling; air sampling is accomplished as an adjunct to formal surface sampling conducted under the sampling plans described in this document.

Be workers must be provided with protective clothing and equipment when airborne concentrations exceed the 0.2-$\mu g/m^3$ action level or when surface concentrations exceed 3 $\mu g/100cm^2$ of removable contamination, under §850.29. Surfaces contaminated with Be-containing dust and wastes must not exceed 3 $\mu g/100cm^2$ of removable contamination during nonoperational periods, per §850.30. However, there is no similar standard in the regulation for non-Be workers.

The closest thing in the regulation to a surface concentration limit for non-Be workers is the RC for releasing equipment to non-Be facilities or the general public, stated in §850.31(b)(1). The RC is 0.2 µg/100cm^2 of removable concentration, or "the concentration level ... in the soil at the point [of] release, whichever is greater." The latter clause is difficult to interpret literally since soil concentrations would be volume concentrations (µg per unit volume) rather than surface concentrations (µg per unit area); the intent appears to be that naturally occurring Be concentrations from native soils should be excluded from this rule. This RC has generally been adopted as the threshold for surface concentrations in non-Be worker environments, although, strictly speaking, it was not promulgated as such. There are currently no Be workers at the NTS, NLV, or ancillary facilities.

[Added July 2009: Some DOE sites have elected to rely primarily on the alternate volumetric concentration comparison rather than the surface concentration comparison, particularly in dusty settings. A logical extension of the intent of that regulation is to evaluate not only volumetric concentrations of Be, but also the ratios of Be with other metals found in the environment, the chemical "fingerprint" of the sample. The draft DOE Technical Standard begins to address the volumetric comparison issue, though in a rudimentary form at this point in time; it does not address the more sophisticated fingerprint comparison. Ultimately, the NTS investigation relied on all of these in evaluating the dustiest of facilities.]

As stated previously, the RC was derived solely from housekeeping considerations and is not based on health risk. Hence, it is not clear that there is a risk of adverse affect from dermal exposure to Be-containing dust. If not, the pathway for an adverse health effect from surface contamination would involve resuspension, which was not detected in air sampling during BN's investigations of occupied and incidentally occupied facilities.

Be in the worker environment could come from a variety of sources:

- soils native to the NTS and NLV,
- surface contamination from historical site activities tracked into these facilities from field workers,
- residual contamination remaining from historical Be machining operations in various locations at NTS and NLV, and
- residual contamination from machining alloys of copper and aluminum containing minor proportions of Be.

Since Be occurs naturally in soils at the NTS and in NLV, that source should in principle be considered to be in a separate class from the others, although discriminating between natural and anthropogenic Be sources is more involved than simply measuring surface concentrations of Be. [The newly-acquired capability to perform fingerprinting provides some capabilities along these lines (July 2009).] On the other hand, even if the source is naturally occurring soil, one could argue that improved housekeeping would be in order for worker protection, regardless of the intent of the particular regulation involved, although there does appear to be evidence that naturally occurring Be presents much less risk to workers exposed, if any risk at all; see, for example, Wegner *et al.* (2000) and Deubner *et al* (2001).

Therefore, the bottom line for DQO Step 1 is to attempt to ensure that all workers at the NTS, NLV, and ancillary facilities are not exposed to removable surface contamination exceeding the 0.2 micrograms (μg)/100 square centimeters (cm^2) RC. If surface concentrations for total Be (both natural and anthropogenic) do not exceed the RC, there is no more to do. If some concentrations do exceed the RC, or the situation falls into a gray area in DQO terms (see the discussion to follow), it may be appropriate to attempt to identify the source of the Be. If it is naturally occurring, no remedy other than routine housekeeping may be needed; otherwise, one may need to take other action to avoid worker exposure.

DQO Step 2. Identify the decision.

Virtually every occupied and incidentally occupied facility at the NTS, NLV, and ancillary facilities was systematically scheduled for removing Be surface contamination. An individualized sampling plan was generated for each facility. The sample data have been analyzed statistically with a goal of demonstrating compliance with the RC.

In general, the areas sampled have been categorized one of two ways: as Individual Work Areas (IWAs) or as open areas (Areas). IWAs are cubicles and small offices, parts of large offices, other work areas, and restrooms. Areas are often warehouses or other storage areas. Either or both may be found in a given facility. If a particular facility consists almost entirely of IWAs, any Areas present may be divided into several IWAs for convenience; for example, a classroom in an office building may be divided into octants (say), and each treated as an IWA.

It is impossible in any statistical analysis to claim 100% certainty. Therefore, several approaches to demonstrating compliance have been considered and implemented. These begin with the upper tolerance limit (UTL) approach, used for Areas, and the protective limit (PL) approach, used for IWAs; details of both are provided in this appendix.

The UTL approach follows current industrial hygiene (IH) practices and the draft DOE Technical Standard. In this approach, the goal is to show with high confidence that the 95^{th} percentile of the distribution of Be surface concentrations is no greater than the RC; doing so is a surrogate for demonstrating that "all workers" are protected. The UTL approach is used for Areas, generally with conventional systematic sampling plans, and occasionally with simple random sampling. Details and formulas are provided subsequently in this appendix.

The UTL approach could be used with IWAs as well. During our initial investigations of the suspect NLV facilities, however, a more stringent PL approach was proposed. This approach received enthusiastic endorsement from the DOE/HQ Investigation Team. The PL approach differs from the UTL approach in several key ways. First, a scientific random selection of IWAs is made from a population list of all IWAs. In sampling the IWAs, however, the IH teams are instructed to swipe the locations judged most likely to provide elevated Be concentrations. This is consistent with IH training and motivation, but is contrary to the usual statistical approach in which one would attempt to specify sampling locations randomly. As an example, in a typical cubicle the locations most likely to provide elevated concentrations of Be might be corners behind computer monitors, tops of wall dividers, or tops of computers located under desktops. In an office trailer, they might be those locations as well as windowsills. The sampling teams were instructed to limit attention to locations touchable during normal work operations, however; ventilation ducts, tops of elevated wall fixtures, and surfaces above ceilings or inside walls were off limit, for example.

In this approach, any IWA in which the highest measurement obtained by such biased sampling is not greater than the RC is considered to "pass." Where a small facility consists of only one or a few IWAs and all were sampled, with the highest value being no greater than the RC, the facility as a whole is considered to "pass."

Otherwise, in the PL approach, the goal is to show with high statistical confidence that, based on data obtained from the IWAs selected for sampling, the highest measurement in all remaining unsampled IWAs would not exceed the RC. The PL approach was proposed and adopted before the BH&SC began its deliberations regarding the DOE Technical Standard, and is considerably more stringent than the UTL approach for all but the smallest facilities.

Given the draft DOE Technical Standard recommendation suggestion of using UTLs, along with the greater stringency of the PL approach, it became desirable to back away from the PL approach in favor of the UTL approach for some facilities. When applied to IWA sampling as described here, our UTL approach implementation is still be more stringent than the UTL approach described in the draft DOE Technical Standard; see the discussion to follow.

[Added December 2007: This was the original formulation of the decision problem. As discussed in Appendix 2, this UTL approach applied to IWA maxima is still more stringent than that of the draft DOE Technical Standard. Accordingly, another less stringent, UTL cluster analysis approach has been identified and implemented for certain IWA facilities as well; that is described briefly below and in detail in Appendix 4.]

Both approaches are described in this document. With either approach, the decision is made separately for each facility. If the attempt to demonstrate compliance with the RC is successful, and if no individual measurement at a facility exceeds the RC, that facility is deemed to be clean.

On the other hand, if any individual measurement exceeds the RC, an additional investigation at that facility follows along with appropriate action. In this case the appropriate action might depend on the apparent source of the excess Be concentrations (natural soil or otherwise).

The third possibility is that neither of the above conclusions can be made based on the initial sampling; this is the gray area referred to above. This would occur when all observations are below the RC, but the statistical confidence that the 95th percentile (in the UTL approach) or the highest measurement that would be obtained in the remaining unsampled IWAs (in the PL approach) is beneath the RC and is not adequately high. In this case, one of two paths can be followed. One path is to evaluate the number of additional samples that should be taken in order to demonstrate compliance with the RC, obtain the additional samples, and repeat the decision process, possibly iterating as needed. The other is to look first at the apparent source of the higher Be concentrations in the samples already obtained; if these are naturally occurring, a simple recommendation regarding housekeeping can be made and the investigation concluded for that facility. (In several cases, it turns out that the UTL or PL is high due to sampling an isolated location that does not quite fit the "touchable during normal work operations" description. An option in these cases is to simply note the unusual sample circumstance, then repeat the UTL or PL computation with the unusual data value omitted.) [Added August 2009: Alternatively, the data could be reanalyzed using the less stringent UTL cluster analysis approach, recalling that this is still more conservative than the UTL approach anticipated in the draft DOE Technical Standard.]

"Adequately high confidence" is interpreted as 95% confidence for each facility, in accordance with common IH practices and draft DOE Technical Standard recommendations.

DQO Step 3. Identify inputs needed to make decisions.
DQO Step 4. Define the boundaries of the study.

Decisions are made separately for each facility. The large majority of facilities are single buildings. In some cases a group of similar buildings, such as attached warehouses or adjacent dormitories, is treated as a single facility, so long as the environments and perceived likelihood of exposure are homogeneous. Conversely, separate areas of a single building having distinctly different uses and, hence, possibly different exposures might be considered to be separate facilities; an example might be a building housing ordinary offices and laboratories along with shops and storage areas.

The MARSSIM provides suggestions regarding the physical sizes of survey units (SUs) about which separate decisions should be made. Areas that are known to be or have been contaminated (possibly before being remediated) are in Class 1. Class 1 SUs should be no larger than 100 square meters (m^2) (~ 1076 square feet (ft^2)) in floor area. Areas that do not fit this description, but cannot be cleared *a priori* based on available information are designated as Class 2. Class 2 SUs should be no larger than 1000 m^2 (~ 10,764 ft^2) in floor area. Other areas are designated as Class 3, for which there is no floor area maximum. We consider all facilities to be Class 3, based on current experience along with a sampling strategy (discussed below) that dictates a reasonably uniform sampling of larger facilities. MARSSIM does not impose or suggest minimum sample sizes for SUs, but rather contains a lengthy discussion similar to that provided below. Note, however, that the MARSSIM discussion revolves around inferences for the population median (50^{th} percentile), whereas our inferences will be for the 95^{th} percentile in the UTL approach and something different under the PL approach; hence the MARSSIM sample size recommendations do not apply in this situation.

Sampling plans for Areas generally involve a systematic random sampling of floor, wall, and shelf or other horizontal surface areas. Areas out of reach during normal work activities, such as ceilings, tops of ceiling tiles, transoms, and tops of elevated wall-mounted fixtures are excluded from consideration, as these are not typically available for exposure through dermal contact.

Samples are taken at assigned locations located on approximately rectangular or triangular grids, designated on engineering drawings of the facilities. The number of samples to be taken is based on both a minimum sample size needed to be reasonably likely to satisfy the RC using the UTL approach on a first sampling round (see subsequent discussion) and a minimum distance between sample locations (in general no more than 20 ft between floor locations and comparably along walls). The former criterion does not vary with the facility size; the latter ensures comprehensive coverage of larger facilities.

Sampling plans for IWAs are somewhat nontraditional as is the data treatment. There is a tension between typical statistical requirements and common IH sampling practices. The IH practice is to sample the locations within a "unit" (whatever that may be) most likely to be contaminated, whereas the statistical requirement typically demands random selection of locations. The procedure adopted here combines these approaches. The IWAs to be sampled are selected essentially randomly, with some thought to balancing the representation among building wings, floors, activities, etc. (a concession to systematic sampling). If a building houses disparate types of operations, but not so disparate as to be considered to contain separate facilities, the sampling plan is biased toward those types of operations more likely to contain removable contamination.

[A historical note: Stratified sampling plans were used in the initial surveys of the suspect buildings in NLV, with heavier sampling in IWAs near air ducts in which detectable Be had been found. At that time, the validity of the RC was under suspicion, so a temporary criterion only one-tenth as high (0.02 $\mu g/100\ cm^2$) was used. This temporary criterion is uncomfortably close to "detection limits" for the standard analytical methods; moreover, values above that value were and are routinely detected in ambient dust. Therefore, this temporary criterion was taken in the MARSSIM sense; that is, as a criterion for average concentrations, and the comparison with the temporary criterion was based on upper confidence limits for the median. The statistical methodology for doing so with stratified samples is readily available. Stratified sampling does not lend itself to analyses via either the UTL or PL approaches, however, so these data are treated simply as a possibly conservatively biased sampling of IWAs in those facilities for comparisons with the current RC using those approaches.]

Within each selected IWA the sampling team was instructed to sample the locations most likely to contain removable Be contamination, typically the dustiest locations. One sample was obtained in general from each quadrant, possibly with one or two more at locations of the sampler's choosing. All samples were analyzed; the largest measured concentration in the IWA (the IWA maximum) is used as the data value for that IWA. This process results in a conservative assessment compared with random sampling of locations within the IWA. Of course, actually laying out a truly random surface sampling plan within each of the thousands of IWAs to be sampled, or even within the facilities containing those IWAs, would be extremely tedious and difficult to enforce.

As with Area sampling, samplers were instructed to restrict their attention to locations available to dermal contact in ordinary work operations. The BN experience suggests that certain locations are particularly likely to have somewhat higher removable Be surface concentrations: tops of doors, tops of door-closing mechanisms, and other wall-mounted fixtures such as electrical boxes. It is not clear that these should be included in the desired range of locations that represent typical worker exposure.

Again, as with Area sampling, the sampling plan was laid out on an engineering drawing of the facility as well as on a spreadsheet. Some facilities consist mostly of IWAs with a few open areas, such as a firehouse or a building that is primarily an office building but with a few laboratories, storage areas, or classrooms. In such cases, for convenience the open areas were divided up into subareas that were treated as additional IWAs.

Additional inputs needed include the <u>anticipated</u> distributions of data from typical facilities, the decision rule, and the desired probability of coming to the desired conclusion (no further action needed) on the basis of the initial sampling. (The probability of deciding that a facility satisfies the RC when it does not is implicitly set at 5% when the conventional 95% confidence level is adopted for the UTLs.) The costs of the exercise were considered to be of relatively minor interest, since Be analyses are relatively inexpensive and the sampling was carried out by BN personnel.

Finally, these surveys were carried out first in regularly occupied facilities. After that, "incidentally occupied" facilities were surveyed. Incidentally occupied facilities are those in which workers are present only occasionally, such as legacy facilities used occasionally for training, certain storage facilities, and certain remote facilities used only occasionally during experiments or exercises.

DQO Step 5. Develop a decision rule.

In the UTL approach, the decision for a facility is made using an upper 95% confidence limit for the 95^{th} percentile of the distribution of surface concentration measurements in the accessible worker environment. These are known as 95%-content, 95%-confidence UTLs (95%-95% UTLs, or just UTLs). The UTL is compared with the RC. If it is below the RC (and no individual measurement exceeds the RC), the facility is considered clean. This is equivalent to a statistical test rejecting the null hypothesis that the 95^{th} percentile is not below the RC, using a 5% significance level statistical test. The measurements used are the individual wipe measurements, when using the UTL approach for Areas, or the IWA maxima. If a facility is treated as containing both types of areas, higher confidence levels ($1 - \alpha_1$ and $1 - \alpha_2$ with $\alpha_1 + \alpha_2 = 0.05$) are used for the two types, so that the overall significance level remains 5% or less. Usually the significance level for the Area portion is set to 1% and that for the IWA portion is set to 4%, due to the greater stringency of the latter. [Added July 2009: When the IWA_cluster approach is employed, as discussed below and in Appendix 4, significance levels for the two portions are generally set equal to 2.5%, since that approach is not so much more stringent than the UTL approach of the draft DOE Technical Standard.] The significance levels used for the separate portions of the facility are included in the detail result listings in Appendix 2.

In the PL approach, the IWA maxima from the selected and sampled IWAs are used to compute a 95% PL (PLall) for all IWA maxima that might possibly be obtained in future sampling. The PLall is compared with the RC in the same fashion as in the UTL approach.

If the UTL or PLall along with all individual measurements are no greater than the RC, the facility is considered to be clean. If not, the next step depends on the data. If there is a measurement above the RC, an investigation and cleanup are undertaken. The investigation focuses on areas in the facility having higher measurements, and may also investigate the apparent source (natural soils or otherwise) of the contamination as discussed previously.

Otherwise, the 95% percentile of the data is below the RC but both UTL and PLall are above, and no individual measurements exceed the RC. In this case, one may compute a supplementary sample size, obtain further data, and repeat the decision process. The August 2005 document, "Planning a Beryllium Characterization Sampling Campaign for a DOE Facility," contains tables and charts that may be used in sample-size planning. Alternately, one may investigate the apparent source of the higher observations found in the initial sampling, or possibly just clean the facility and resample. As stated above at the conclusion of DQO Step 2, one option is to note an isolated high value at a non-touchable location and then repeat the UTL or PL calculation ignoring that isolated high value.

DQO Step 6. Specify limits on the probabilities of making decision errors.

Since the use of 95%-95% UTLs is well established in IH practice, the significance level of the statistical test for the UTL approach is 5% by default. This is the probability of deciding "clean" when the facility is actually "dirty"; it is adopted for the PLall approach as well. The complementary risk, of deciding in the initial sampling round that the facility is or may be "dirty" (i.e., does not meet the RC) when it is actually "clean," is in principle up to BN. One would like to keep it as low as possible consistent with reasonable sampling cost. A reasonable target for this probability would be 5-10% or so. On the other hand, failing to demonstrate compliance with the RC in the initial sampling is not necessarily the end of the process; if the data are border line, there is the possibility of augmenting the sample and repeating the decision process. This possibility was in fact exercised at a few facilities, even during the initial sampling.

DQO Step 7. Optimize the design.

<u>Prior ideas about the distributions of Be measurements</u>

What remains then is to decide on how many observations to take to be reasonably likely to come to the correct decision (clean, with no further action needed) at a typical clean facility; these are then spread around Areas or IWAs as described previously. To do this we need some prior ideas about the nature of the distributions of all measurements (for Areas) or IWA maxima (for IWAs).

Data from comparable facilities in NLV had been obtained as early as the summer of 2002 and from the NTS nearly as long ago. Following one of the MARSSIM recommendations, uncensored measurement values for nearly all observations have been obtained, and the reporting limits (RLs) that would typically be used to censor the data have been given separately. That is, for nearly all samples we are provided with actual instrument readings, even if negative, rather than data down to a certain level and below that just a “<RL” or equivalent notation. Typical RLs for our analyses would be around 0.004-0.01 μg/100cm^2.

[A technical note: The stated RLs are based on applying the usual 40 CFR 136 Appendix B algorithms to spiked reagent water samples. The relevance of these to detection and quantitation of wipe samples is not at all clear. Moreover, those algorithms are currently under a court-ordered reevaluation due to uncertainties concerning their scientific validity. Finally, determinations of RLs and quantitation limits are based in principle on statistical discussions of the interpretation of individual measurements, whereas in studies such as these the appropriate criterion should be based on the validity of the decision for a facility as a whole. For these reasons, we were happy to comply with the specific urging of the DOE/HQ investigation team that the MARSSIM admonition to obtain fully quantitated data whenever possible be followed. This and related issues have been the focus of the Data Reporting Task Force of the BH&SC; see also the discussions by Davis, Field, and Gran (2009) and Grams and Davis (2009).]

Environmental contamination data are very often modeled as having lognormal distributions. That is, the (natural) logs of the measurements are taken as having normal (“Gaussian” or “bell-shaped curve”) distributions. This model generally serves adequately for actual contaminant concentrations, but for the measurements themselves there is an added measurement error component that becomes prominent and eventually dominant at low concentrations. This added measurement error component often results in negative reported concentrations. These cannot be used as such in the standard analyses of log normally distributed data as one can take logarithms of only positive values. Accordingly, some special treatment of low values is needed in order to apply typical lognormal distribution statistical techniques. One such treatment, used here, is to artificially censor the data at some positive value. The actual cutoff value to be used ultimately is still under consideration; for purposes of the following discussions, we use a cutoff value of 0.002 μg/100cm^2, which is 1% of the RC. For plotting purposes, all negative values are plotted at zero on the original scale. Censored data normal distribution maximum likelihood estimation algorithms are used for estimating means and standard deviations of the data value logs.

[Added July 2009: The preceding paragraph describes the approach used for planning purposes. Further research, however, determined that this approach was rather excessively conservative, in that it tends to make it difficult to decide that a clean facility really is clean; see discussions by Davis, Field, and Gran (2009). A different treatment was ultimately selected for implementation; see Appendix 3. The conventional lognormal distribution assumption necessarily distorts the actual data distributions when those include high proportions of values near and below zero.]

Figure 1 on the following page shows the pooled distribution for all IWA maxima from the suspect NLV buildings. These data have some selection bias due to the stratified sampling plan used, but as it turned out the stratification was at best only mildly correlated with the results obtained. Figure 2 shows the pooled distribution for all IWA maxima from seven larger buildings containing mostly offices, located in Areas 6 and 23 at the NTS. In both cases, the

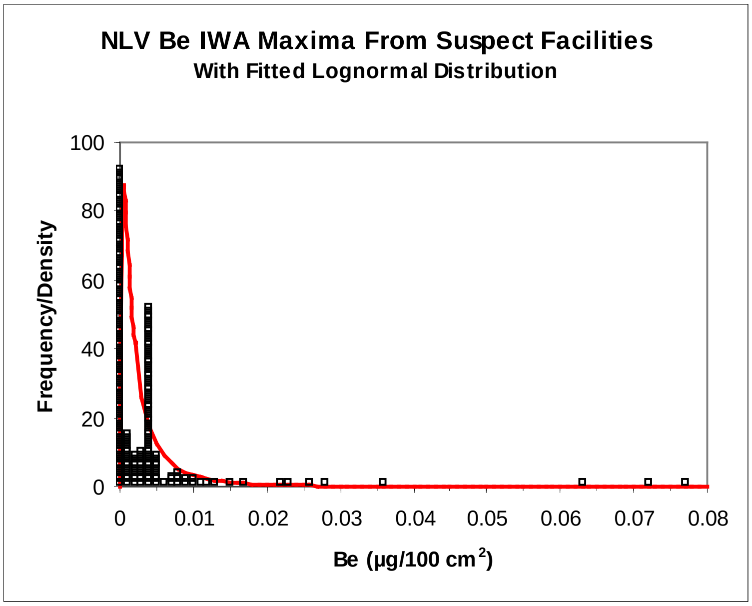


Figure 1: Distribution of IWA maxima from suspect facilities in NLV, with a fitted lognormal distribution. The lognormal distribution parameters are μ = -6.2468 and σ = 1.1873.

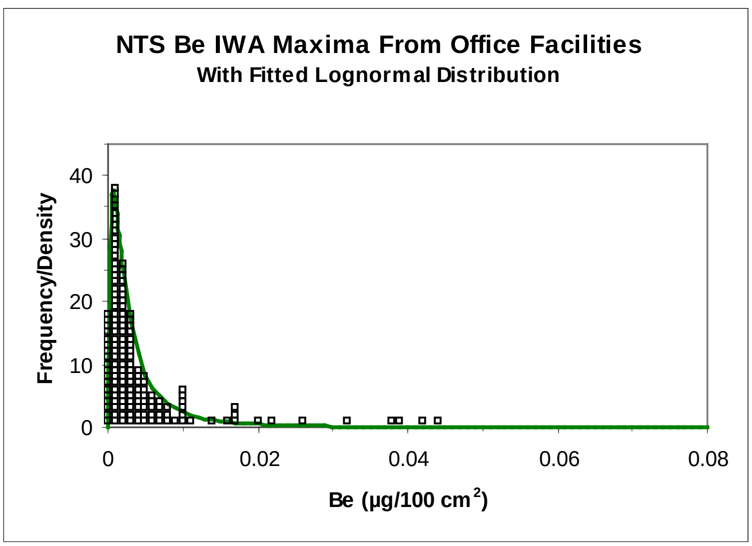


Figure 2: Distribution of IWA maxima from office facilities at the NTS, with a fitted lognormal distribution. The lognormal distribution parameters are μ = -5.9775 and σ = 1.1197.

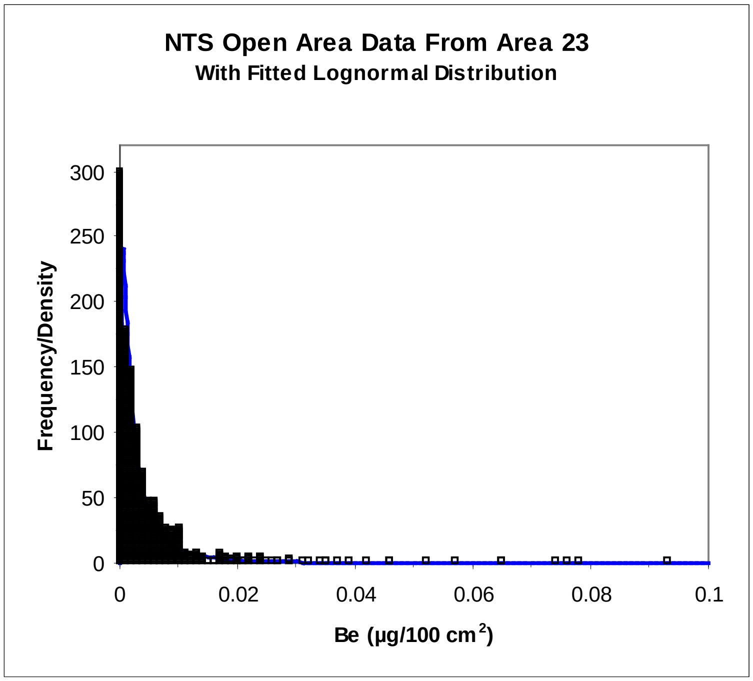


Figure 3: Distribution of data values from Area facilities in Area 23 of the NTS, with a fitted lognormal distribution. The lognormal distribution parameters are μ = -6.1497 and σ = 1.2098.

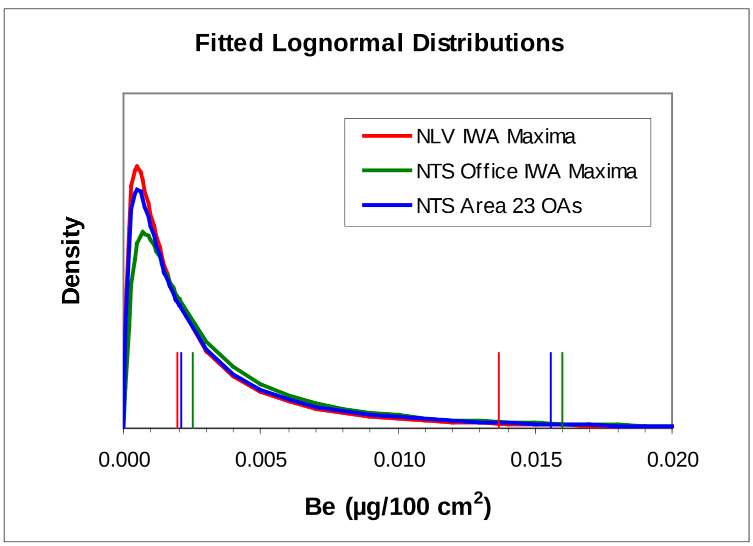


Figure 4: Comparisons of the fitted lognormal distributions in Figures 1, 2, and 3. Vertical lines mark the medians and 95th percentiles.

lognormal distributions fit quite well; "detects-only" probability plot correlations are 0.945 and 0.987, respectively, for the data at and above the cutoff. Figure 3 shows the pooled distribution of most of the Be measurements obtained in Areas in NTS Area 23 facilities; four facilities with at least one wipe measurement each above the RC are omitted. The probability plot correlation is

0.997 for values above the cutoff. Figure 4 compares the fitted distributions for Figures 1 through 3. The short vertical lines are at the median and 95th percentiles of the fitted distributions.

Only rarely is this sort of complete information available when carrying out the DQO planning process at the onset of an investigation. When planning the surveys of the suspect buildings in NLV, there was some prior information available, and the results from surveys were then available in planning the rest of the surveys. It is gratifying that the assumed planning distribution (the red probability density function in Figure 4) turned out to be quite similar to the distributions found in the subsequent studies for many facilities. The medians and 95th percentiles are slightly higher in the NTS fitted distributions than in the NLV fitted distribution. We note that the NTS Area 23 Area distribution tends slightly toward higher values in spite of being a distribution for all measurements rather than a distribution for IWA maxima; this is consistent with sampling surfaces in inherently dustier warehouse and shop areas.

For planning purposes in this document, we will assume a lognormal distribution with parameters μ = -6.25 and σ = 1.19; these are approximately the mean and standard deviation of the fitted distribution of NLV IWA log maxima. For individual facilities, the actual means and standard deviations will vary. Standard deviations for individual facilities should typically be smaller, since the fitted distributions shown in Figures 1 through 4 are each pooled across several facilities.

Appendix A of "Planning a Beryllium Characterization Sampling Campaign for a DOE Facility" (2005) discusses the UTL approach in greater detail, providing the basic formula used, a table of the multipliers K needed, and graphs giving the minimum number of wipe samples desired at a facility as a function of the Z_{RC} value, which is the distance between the RC and the data mean, in standardized units on the log scale. Details of the sample size computation are given by Davis (2004).

In sampling Area facilities, the assumption of homogeneity would in principle justify using the same number of samples in a small laboratory as in a mammoth warehouse. One must be sensitive to the possible negative stakeholder reaction to doing so and, in fact, there are always real concerns that some areas of a facility might somehow be more likely to be contaminated than others. Hence, in sampling Areas, we also require an approximate minimum grid spacing, which is on the order of 20 ft. (A facility so small that at most eight samples are obtained is treated as a single IWA.) Furthermore, in nearly every case we conducted a walkthrough of the facility before deciding on the sampling plan. In some cases, a greater overall sampling intensity or preferential attention to certain areas was suggested by observations during the walkthrough, such as with areas in which metal machining operations had taken place or which were particularly dusty.

Similar computations can be used for determining sample sizes when using the PL approach with IWA maxima. In this case, however, the desirable minimum sample size will depend on the total number of IWAs as well as Z_{RC}. Appendix B of "Planning a Beryllium Characterization Sampling Campaign for a DOE Facility" describes the procedure in greater detail, provides tables of the multipliers K needed, and gives graphs for determining the minimum numbers of observations again as functions of Z_{RC}. For example, with 100 IWAs total and $Z_{RC} = 3.90$, we should sample 16, 31, 40, 48, or 61 IWAs for 50%, 80%, 90%, 95%, or 99% power, respectively. Recall that sampling one IWA actually involves four or more samples, according to the sampling protocol described above, so these sample sizes cannot be compared directly with those obtained from the UTL approach.

[Technical notes: As with the UTL approach, if it appears that the desired sample size should be greater than 59, one could revert to a procedure that is a mixture of the UTL and PL approaches described here, which would be to use the UTL approach with the IWA maxima as data. In that case, one would not sample more than 59 IWAs in any facility. Also, in some situations it may appear that the Appendix B graphs require that all IWAs be sampled. This occurs when Z_{RC} is so small that one simply cannot obtain the desired power otherwise. In this and all other situations, we implicitly ignore the sampling variability within IWAs, and assume that any IWA whose maximum wipe value is not greater than RC should be considered clean.]

<u>On Data Distributions and Transformations</u>

The planning data and calculations presented above suggest that actual data should be expected to follow a lognormal distribution; that is, that the actual measurements should be transformed by taking logs, and the UTL or PL comparisons with the RC should then be performed on the transformed scale. In fact, if a facility is particularly homogeneous, it may be that the distribution of actual measurements is adequately normal (i.e., Gaussian or “bell-shaped-curve”) to carry out the computations reasonably reliable without data transformation. This can be checked for larger facilities directly. If this is the case, it is likely that the sample size determinations using the log data distributions described above will be conservative. Of course, that will not be known until the data become available, but should be taken into account in preparing the UTLs or PLalls. [Note: In implementation, the possibly conservative lognormal approach was used in all cases; see Appendix 3.]

Statistical Analysis of the Resulting Data

<u>The UTL Approach</u>

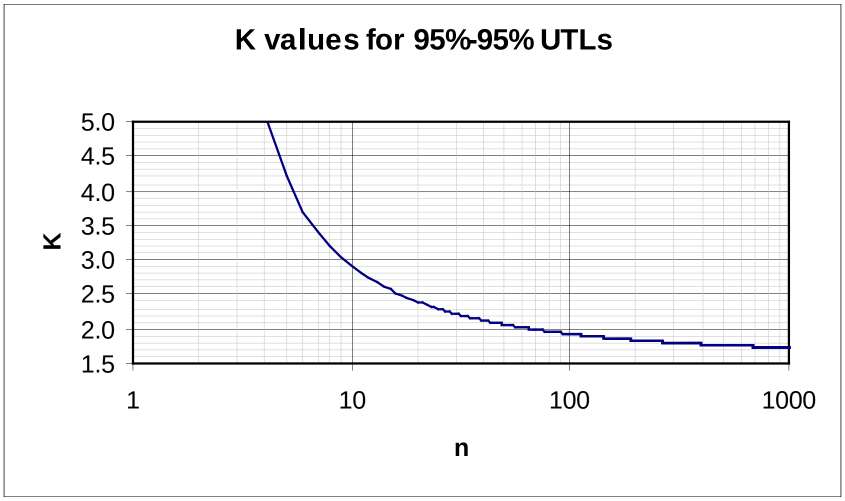
A 100γ%-100β% UTL is a 100γ% UTL for the 100β^th^ percentile of a distribution. β is called the <u>content</u> and γ the <u>confidence</u>. It is traditional in IH applications to use β = γ = 95%; we use a higher value of γ (99%) with a facility containing both Areas being handled via the UTL approach and IWAs being handled via the PLall approach, as described previously.

There are two common types of UTLs. Nonparametric UTLs are computed as an appropriate upper ordered value (always the maximum value in this setting) of the data; in order to achieve the target β = γ = 95% one must have at least 59 observations, and there is rarely incentive to obtain more. The UTL is then the largest observation, and the decision about whether the facility passes or not is based on whether the UTL is at most the RC or not. Although in principle one might obtain a larger number of observations and mathematically set the UTL to the second or third, etc., highest value, the additional requirement that all measurements should not be greater than the RC would render doing so futile.

The other type of UTL is based on normal distribution theory. Here UTL = $\overline{X} + K S$, where $\overline{X}$ and S are the usual sample mean and standard deviation on a suitably transformed scale, and the multiplier K is obtained as described elsewhere. One uses this UTL in the same manner as the nonparametric UTL in making the decision. Tables of K as a function of the number of observations are given below for 95%-95% UTLs; algorithms have been implemented to compute K for arbitrary β and γ.

K values for 95%-95% UTLs

n	K	N	K	n	K	n	K
		16	2.5237	31	2.2080	46	2.0865
2	26.2597	17	2.4863	32	2.1968	47	2.0808
3	7.6559	18	2.4529	33	2.1863	48	2.0754
4	5.1439	19	2.4230	34	2.1762	49	2.0701
5	4.2027	20	2.3960	35	2.1667	50	2.0650
6	3.7077	21	2.3714	36	2.1577	51	2.0601
7	3.3995	22	2.3490	37	2.1491	52	2.0553
8	3.1873	23	2.3283	38	2.1408	53	2.0507
9	3.0312	24	2.3093	39	2.1330	54	2.0463
10	2.9110	25	2.2917	40	2.1255	55	2.0419
11	2.8150	26	2.2753	41	2.1183	56	2.0377
12	2.7363	27	2.2600	42	2.1114	57	2.0337
13	2.6705	28	2.2458	43	2.1048	58	2.0297
14	2.6144	29	2.2324	44	2.0985	59	2.0259
15	2.5660	30	2.2198	45	2.0924	60	2.0222
62	2.0150	72	1.9843	82	1.9600	92	1.9401
64	2.0082	74	1.9790	84	1.9557	94	1.9365
66	2.0018	76	1.9739	86	1.9516	96	1.9331
68	1.9957	78	1.9691	88	1.9476	98	1.9298
70	1.9899	80	1.9644	90	1.9438	100	1.9265
105	1.9189	130	1.8883	155	1.8658	180	1.8485
110	1.9119	135	1.8833	160	1.8620	185	1.8455
115	1.9054	140	1.8785	165	1.8584	190	1.8427
120	1.8993	145	1.8741	170	1.8550	195	1.8399
125	1.8936	150	1.8698	175	1.8517	200	1.8372
300	1.7996	400	1.7778	500	1.7630	1000	1.7273



[Note: As described in Appendix 3, the methodology ultimately selected for handling the ubiquitous negative values was to add a small constant *delta* to all values, take logs of the (*x* + *delta*), use the normal-theory UTL computations with the results, exponentiate the UTL, and then subtract *delta*. This methodology, in particular the selection of *delta* for various laboratories and worker environments, is described in detail in Appendix 3; see also Davis, Field, and Gran (2009).]

<u>The PL Approach</u>

The PL approach is considerably different from the UTL approach conceptually. The idea is that we have observations from some *n* items from a population, and from these we would like to make a prediction limit that should include all of the next *r* items with suitably high confidence. In this setting, *r* = N - *n*, where N is the total number of IWAs in the facility to be surveyed and *r* is the number of unsampled IWAs.

More explicitly, our samplers were instructed to sample locations within an IWA thought most likely to produce elevated Be values. Any sampled IWA whose largest measurement is not greater than the RC is found to be clean. In our sample of *n*, IWAs all have been found clean, so we attempt to determine based on these data that, with reasonably high confidence, all the remaining IWAs would similarly be found clean if they were sampled as well. The mechanism for doing so is PLall, a PL for the largest value to be found in the remaining unsampled IWAs.

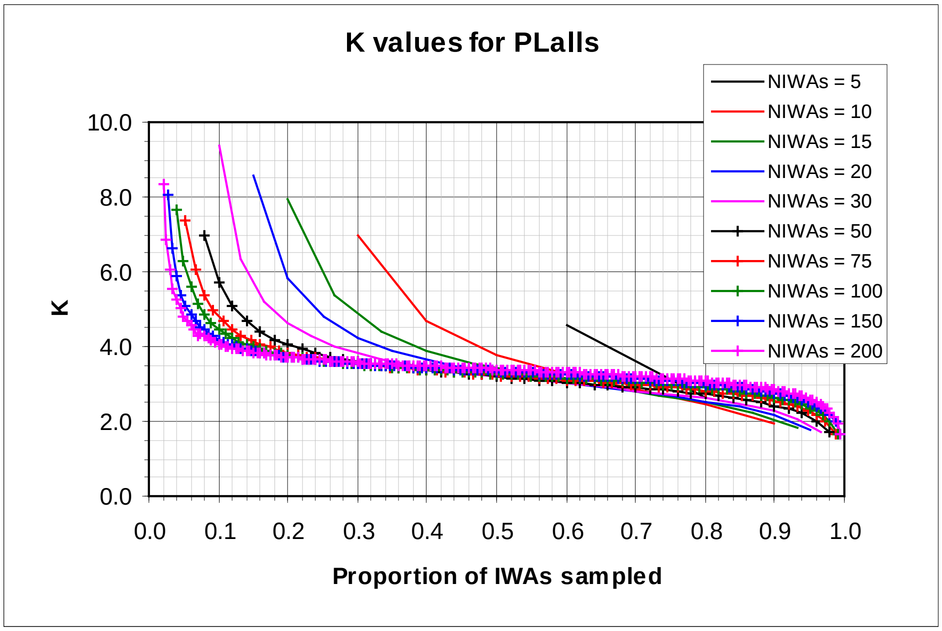
A nonparametric PLall approach would require prohibitively large numbers of observations. The normal distribution theory computation of PLall uses the algorithm described by Davis and McNichols (1987). The present computation makes prediction limits for “1 of 1” future observation at each of *r* locations, in the terminology of the title of the article.

As with the UTL approach, we compare $PL = \overline{X} + K\,S$, computed on an appropriate scale, with the RC, expressed on the same scale. Unlike the UTL approach, here the sample statistics are computed from the IWA maxima rather than from all the data. The multiplier K depends on both the sample size *n* and the number of unsampled IWAs *r*; equivalently, on *n* and the total number of IWAs, denoted N, since r = N - n. This makes tables of K as a function of n rather cumbersome; tables are given here for ten selected values of N. Software has been developed and can be made available for computing K for arbitrary n, confidence level (95% here), r, and degrees of freedom (equal to n - 1 here). The one graph presented here shows K plotted against the proportion of IWAs sampled (i.e., n / N) for each value of N; it shows some regularity across N except for the highest and lowest values of n allowable in each case.

K values for 95% PLall								
N =	5	10	15	20	30	N =	20	30
n	K	K	K	K	K	n	K	K
3	4.5722	6.9455	7.9529	8.5824	9.3875	17	2.3730	3.0757
4	2.6312	4.6866	5.3915	5.8160	6.3492	18	2.1534	3.0137
5		3.7880	4.4179	4.7783	5.2200	19	1.7791	2.9524
6		3.2587	3.8906	4.2279	4.6290	20		2.8906
7		2.8569	3.5452	3.8788	4.2611	21		2.8272
8		2.4711	3.2883	3.6310	4.0069	22		2.7606
9		1.9601	3.0769	3.4404	3.8179	23		2.6890
10			2.8868	3.2841	3.6699	24		2.6098
11			2.6998	3.1490	3.5491	25		2.5193
12			2.4961	3.0262	3.4470	26		2.4111
13			2.2416	2.9095	3.3583	27		2.2732
14			1.8331	2.7932	3.2792	28		2.0778
15				2.6713	3.2070	29		1.7303
16				2.5357	3.1397			

K values for 95% PLall													
N =	50	75	100	N =	50	75	100	N =	75	100	N =	100
n	K	K	K	n	K	K	K	n	K	K	n	K
				26	3.1698	3.4492	3.6056	51	3.0116	3.2613	76	2.9597
				27	3.1406	3.4267	3.5846	52	2.9933	3.2506	77	2.9437
				28	3.1118	3.4054	3.5649	53	2.9744	3.2399	78	2.9270
4	6.9489	7.3858	7.6798	29	3.0831	3.3849	3.5463	54	2.9550	3.2292	79	2.9097
5	5.7086	6.0615	6.2984	30	3.0546	3.3652	3.5285	55	2.9348	3.2186	80	2.8915
6	5.0638	5.3747	5.5825	31	3.0258	3.3462	3.5116	56	2.9138	3.2079	81	2.8724
7	4.6661	4.9523	5.1426	32	2.9967	3.3278	3.4955	57	2.8919	3.1971	82	2.8524
8	4.3943	4.6646	4.8435	33	2.9671	3.3100	3.4800	58	2.8690	3.1863	83	2.8313
9	4.1954	4.4550	4.6259	34	2.9366	3.2925	3.4651	59	2.8449	3.1754	84	2.8089
10	4.0424	4.2948	4.4599	35	2.9052	3.2754	3.4507	60	2.8194	3.1644	85	2.7850
11	3.9204	4.1678	4.3285	36	2.8725	3.2587	3.4368	61	2.7922	3.1533	86	2.7596
12	3.8202	4.0642	4.2217	37	2.8383	3.2422	3.4234	62	2.7632	3.1421	87	2.7321
13	3.7357	3.9778	4.1329	38	2.8021	3.2259	3.4103	63	2.7319	3.1307	88	2.7025
14	3.6632	3.9043	4.0577	39	2.7634	3.2097	3.3975	64	2.6980	3.1192	89	2.6701
15	3.5999	3.8409	3.9930	40	2.7217	3.1937	3.3852	65	2.6609	3.1075	90	2.6345
16	3.5438	3.7854	3.9366	41	2.6762	3.1777	3.3731	66	2.6198	3.0956	91	2.5950
17	3.4933	3.7363	3.8870	42	2.6259	3.1617	3.3612	67	2.5737	3.0835	92	2.5504
18	3.4474	3.6924	3.8428	43	2.5691	3.1457	3.3495	68	2.5212	3.0711	93	2.4995
19	3.4053	3.6527	3.8032	44	2.5038	3.1297	3.3380	69	2.4601	3.0584	94	2.4400
20	3.3662	3.6165	3.7673	45	2.4264	3.1135	3.3267	70	2.3870	3.0455	95	2.3687
21	3.3295	3.5834	3.7347	46	2.3310	3.0972	3.3156	71	2.2960	3.0322	96	2.2796
22	3.2949	3.5528	3.7047	47	2.2060	3.0807	3.3045	72	2.1759	3.0186	97	2.1615
23	3.2619	3.5243	3.6772	48	2.0246	3.0639	3.2936	73	2.0000	3.0046	98	1.9882
24	3.2302	3.4978	3.6516	49	1.6942	3.0468	3.2828	74	1.6772	2.9901	99	1.6689
25	3.1996	3.4728	3.6278	50		3.0294	3.2720	75		2.9752		

K values for 95% PLall											
N =	150	N =	150	N =	150	N =	150	N =	150	N =	150
n	K	n	K	n	K	n	K	n	K	n	K
		26	3.7966	51	3.4966	76	3.3325	101	3.1685	126	2.9186
		27	3.7763	52	3.4891	77	3.3264	102	3.1610	127	2.9039
		28	3.7572	53	3.4816	78	3.3202	103	3.1534	128	2.8885
4	8.0761	29	3.7393	54	3.4743	79	3.3141	104	3.1456	129	2.8724
5	6.6171	30	3.7225	55	3.4672	80	3.3080	105	3.1377	130	2.8555
6	5.8615	31	3.7066	56	3.4601	81	3.3018	106	3.1297	131	2.8377
7	5.3976	32	3.6916	57	3.4532	82	3.2956	107	3.1215	132	2.8189
8	5.0824	33	3.6773	58	3.4463	83	3.2894	108	3.1131	133	2.7990
9	4.8533	34	3.6637	59	3.4396	84	3.2831	109	3.1046	134	2.7777
10	4.6787	35	3.6507	60	3.4329	85	3.2769	110	3.0959	135	2.7551
11	4.5409	36	3.6383	61	3.4263	86	3.2706	111	3.0869	136	2.7307
12	4.4290	37	3.6265	62	3.4197	87	3.2642	112	3.0778	137	2.7045
13	4.3360	38	3.6151	63	3.4133	88	3.2578	113	3.0685	138	2.6760
14	4.2577	39	3.6041	64	3.4069	89	3.2514	114	3.0589	139	2.6448
15	4.1904	40	3.5936	65	3.4005	90	3.2449	115	3.0491	140	2.6104
16	4.1321	41	3.5834	66	3.3942	91	3.2383	116	3.0390	141	2.5721
17	4.0808	42	3.5735	67	3.3879	92	3.2317	117	3.0287	142	2.5288
18	4.0354	43	3.5640	68	3.3817	93	3.2250	118	3.0180	143	2.4792
19	3.9948	44	3.5547	69	3.3754	94	3.2182	119	3.0070	144	2.4211
20	3.9583	45	3.5458	70	3.3693	95	3.2114	120	2.9957	145	2.3512
21	3.9252	46	3.5371	71	3.3631	96	3.2045	121	2.9839	146	2.2638
22	3.8951	47	3.5286	72	3.3570	97	3.1975	122	2.9718	147	2.1477
23	3.8674	48	3.5203	73	3.3508	98	3.1904	123	2.9593	148	1.9767
24	3.8420	49	3.5123	74	3.3447	99	3.1832	124	2.9462	149	1.6607
25	3.8185	50	3.5044	75	3.3386	100	3.1759	125	2.9327	150	



K values for 95% PLall											
N =	200	N =	200	N =	200	N =	200	N =	200	N =	200
n	K	n	K	n	K	n	K	n	K	n	K
4	8.3464	37	3.7506	70	3.5222	103	3.3800	136	3.2278	169	2.9863
5	6.8343	38	3.7396	71	3.5175	104	3.3758	137	3.2224	170	2.9754
6	6.0514	39	3.7291	72	3.5128	105	3.3716	138	3.2169	171	2.9642
7	5.5708	40	3.7190	73	3.5081	106	3.3674	139	3.2114	172	2.9525
8	5.2444	41	3.7093	74	3.5035	107	3.3632	140	3.2058	173	2.9404
9	5.0072	42	3.7000	75	3.4989	108	3.3589	141	3.2001	174	2.9278
10	4.8265	43	3.6910	76	3.4944	109	3.3547	142	3.1943	175	2.9147
11	4.6840	44	3.6824	77	3.4899	110	3.3504	143	3.1884	176	2.9011
12	4.5683	45	3.6740	78	3.4855	111	3.3461	144	3.1825	177	2.8868
13	4.4723	46	3.6660	79	3.4810	112	3.3418	145	3.1764	178	2.8719
14	4.2914	47	3.6582	80	3.4766	113	3.3375	146	3.1703	179	2.8562
15	4.3220	48	3.6505	81	3.4723	114	3.3331	147	3.1640	180	2.8397
16	4.2619	49	3.6432	82	3.4680	115	3.3287	148	3.1576	181	2.8224
17	4.2092	50	3.6361	83	3.4637	116	3.3243	149	3.1512	182	2.8040
18	4.1626	51	3.6292	84	3.4594	117	3.3199	150	3.1446	183	2.7845
19	4.1210	52	3.6224	85	3.4551	118	3.3154	151	3.1378	184	2.7637
20	4.0836	53	3.6158	86	3.4509	119	3.3109	152	3.1310	185	2.7415
21	4.0498	54	3.6094	87	3.4467	120	3.3063	153	3.1240	186	2.7176
22	4.0190	55	3.6031	88	3.4424	121	3.3018	154	3.1168	187	2.6918
23	3.9909	56	3.5970	89	3.4382	122	3.2972	155	3.1096	188	2.6637
24	3.9651	57	3.5910	90	3.4341	123	3.2925	156	3.1021	189	2.6330
25	3.9413	58	3.5851	91	3.4299	124	3.2878	157	3.0945	190	2.5991
26	3.9193	59	3.5794	92	3.4257	125	3.2831	158	3.0867	191	2.5613
27	3.8988	60	3.5737	93	3.4216	126	3.2783	159	3.0788	192	2.5186
28	3.8796	61	3.5682	94	3.4174	127	3.2735	160	3.0706	193	2.4695
29	3.8618	62	3.5628	95	3.4133	128	3.2687	161	3.0622	194	2.4120
30	3.8450	63	3.5574	96	3.4091	129	3.2637	162	3.0536	195	2.3428
31	3.8292	64	3.5522	97	3.4050	130	3.2588	163	3.0448	196	2.2561
32	3.8143	65	3.5470	98	3.4008	131	3.2538	164	3.0358	197	2.1409
33	3.8002	66	3.5419	99	3.3966	132	3.2487	165	3.0265	198	1.9711
34	3.7869	67	3.5369	100	3.3925	133	3.2436	166	3.0169	199	1.6567
35	3.7742	68	3.5319	101	3.3883	134	3.2384	167	3.0070		
36	3.7621	69	3.5271	102	3.3842	135	3.2331	168	2.9968		

<u>The UTL_cluster sampling approach</u> [Added December 2007]

As noted previously, both the PLall and UTL approaches when used with IWA maxima are more stringent than the approach contemplated in the draft DOE Technical Standard, since the latter is based on UTLs for the distributions of <u>all</u> measurements (not IWA maxima) obtained from random (not biased) sampling at a facility. It turns out that these approaches are problematic with certain facilities, notably those with few IWAs and a few atypically high values in some IWAs. Some of those atypical values come from locations that might arguably not be considered part of the normal worker environment; some come from a suspect chemical analysis (see Appendix 3); some have both factors involved.

Hence there is motivation to develop a UTL approach that uses all of the data obtained from IWA facilities. That is presented in Appendix 4. The statistical model is that of traditional cluster sampling, in which (for cost and convenience) a sampling effort first identifies clusters within a population and then randomly samples within clusters. The clusters correspond to IWAs here. The mathematical setup for UTLs with cluster sampling is nonstandard, in that the usual cluster sampling efforts aim at estimating population means, whereas the 95th percentile is the target here; the details are provided in Appendix 4. The statistical issue is that there may be a systematic, though random, cluster-to-cluster (here, IWA-to-IWA) variation that would make the measurements within an IWA correlated, so that the usual UTL computation would assume that more statistically independent information is available than we have.

UTL_cluster was computed only for those facilities fitting the above description; that is, both UTL and PLall based on IWA maxima are higher than the RC although all observations are at most equal to the RC. The UTL_cluster analysis is still more conservative than the UTL approach based on simple random sampling discussed in the current draft DOE Technical Standard, in that the samplers were still looking for sampling locations particularly likely to provide high Be values rather than random locations within the facility. Hence, a facility is taken as “passing” if any of PLall, UTL, or UTL_cluster is not greater than the RC.

Appendix 2
STATISTICAL ANALYSIS DETAILS

Introduction

This appendix contains three items:

- A brief review of the statistical methodology employed,
- A concise summary table of the results by facility, and
- A detailed listing of the results for each facility.

Statistical Methodology

As discussed in Appendix 1, the statistical methodology depends on the nature of the facility in question. There are four possibilities:

- A facility consists of multiple Individual Work Areas (IWAs);
- A facility consists of one or more open Areas, such as a warehouse or shop;
- A facility has portions consisting of one or more IWAs along with open areas (Areas); and
- A facility consists of just one or a few IWAs, all of which have been sampled.

In the first case (multiple IWAs only), a random selection of IWAs was sampled. The IWA value is the largest measurement obtained in that IWA, the IWA maximum. Two sample statistics are computed initially. The first is PLall, a prediction limit designed to contain all the IWA maxima for the remaining unsampled IWAs with 95% confidence. The second is the upper tolerance limit (UTL), designed to be at least as large as the 95^{th} percentile of the distribution of the IWA maxima, which in turn will be at least as large as the 95^{th} percentile of the distribution of all possible measurements, with 95% confidence. This is compared with the U.S. Department of Energy (DOE) release criterion (RC) of 0.2 micrograms per wipe (µg/wipe), with a wipe having covered an area of 100 square centimeters (cm^2). If at least one of these is no greater than the RC (and no individual measurement exceeds the RC), the facility passes.

The PLall approach was that originally proposed in discussions with the U.S. Department of Energy, National Nuclear Security Administration Headquarters (NNSA/HQ) incident investigation team. The UTL approach is more nearly comparable with that favored in the draft DOE Technical Standard under discussion by the Beryllium Health & Safety Committee (BH&SC). The latter is a less stringent standard in most cases; the exceptions involve those facilities with only a few unsampled IWAs.

In some situations the UTL approach is still quite stringent since it uses only IWA maxima, which can be atypical observations (“outliers”). A third approach was developed for these situations, which uses all the data from each IWA. This is termed the UTL cluster analysis; see the detailed discussion in Appendix 4. This approach is still more conservative than that in the current draft DOE Technical Standard, however, since the sampling team was instructed to sample the dirtiest spots within IWAs rather than attempting to obtain random samples.

In the second case (Areas only), a systematic random sampling plan was followed. An UTL is computed from the data. If this is no greater than the RC (and no individual measurement exceeds the RC), the facility passes.

In the third case (both IWAs and Areas), a PLall and UTL are computed for the IWA portion and a UTL for the Area portion. The confidence levels used are 96% and 99%, respectively (keeping the overall significance level at the target 5%). If both portions of the facility pass (and no individual measurement exceeds the RC), the facility passes. The individual significance levels (alpha = 4% and 1%, respectively) are intentionally disproportionate, as the IWA maximum comparison is inherently a more stringent comparison than the Area UTL comparison. In one facility (35-2229), there is one IWA portion and two Area portions of different natures; in that facility three tests were conducted, using significance levels of 3%, 1%, and 1%, respectively. Where the IWA cluster analysis is used, in some cases the significance levels are set equal. In any case, the sum of the significance levels is the target 5%.

In the last case, the IWA maximum (maxima) is (are) simply compared with the DOE RC. If no IWA maximum exceeds the DOE RC, the facility passes.

Appendices 1, 3, and 4 provide the technical details of computing the PLall, IWA, and IWA_cluster values.

Exceptions

At some facilities one or two isolated high measurements prevent the facility from passing using these decision rules. In these situations one or both of the following strategies were used. One was to evaluate the location which produced the high measurement; if that location is not normally “touchable” in routine work activities (and hence less likely to be cleaned as well as other locations), the statistical analysis would be repeated with the outlying observation removed. Alternatively, and particularly if the high observation(s) exceeded the DOE RC, bulk analyses were obtained in the facility and the beryllium (Be) concentrations and metal ratios were obtained for those bulk samples as described in Appendix 4. If the January 2009 sampling produced MS_new observations above the DOE RC, metal ratios were determined for those high wipes as well. If these were generally consistent with values obtained in Nevada Test Site (NTS) soil samples, the facility is considered to pass. A summary table of the bulk sample Be results and the metal ratio results is included at the end of this appendix.

Summary of Results

Some 228 facilities were evaluated during this survey, with the following outcomes.

	Count of Results		
		Number of	
	Result	Whole facilities	Portions of facilities
	Pass	**195**	**9**
	Pass if outlier(s) omitted	**10**	**3**
	Pass taking bulk Be and/or metal ratios into account	**8**	**9**
	Fail	**4**	**1**

The following table lists the results for all facilities. There are two color–coded blocks; the left one is for the IWA portion of the facility and the right for the Area portion; a blank indicates that a facility did not have one or the other portion. Facility type is shown at the right.

Detailed results by facility follow this table for facilities for which statistical analysis was performed.

Type	Description
CO	Communications facility
EX	Experimental facility
FO	Field Operations facility
LA	Laboratory
OF	Office facility
QU	Quarters, including cafeteria
SH	Shop
ST	Storage

		FACILITY	Type	Result
		01-179491	FO	One IWA, max = 0.076 (MS_arch)
		01-181769	OF	PLall = 0.019
		01-201959	SH	Max=0.249 (MS_new) > DOE RC; other nine < 0.13; bulk Be and all ratios OK
		01-202137	FO	One IWA, max = 0.110 (MS_arch)
		01-202138	FO	One IWA, max = 0.030 (DC)
		01-202333	FO	One IWA, max = 0.036
		01-202479	ST	3 of 4 MS_new > DOE RC, max = 1.184; bulk Be and metal ratios OK
		01-202521	FO	One IWA, max = 0.124 (MS_arch); rest < 0.1
		01-202655	FO	Area UTL = 0.041
		01-202656	FO	One IWA, max = 0.214 (MS_arch) > DOE RC (windowsill) rest < 0.1; MS_new = 0.008
		01-202772	OF	UTL_cluster = 0.020
		01-408564	FO	One IWA, max = 0.175 (MS_arch) after cleaning
		01-U1H CO	FO	One IWA, max = 0.009 (DC)
		01-U1H HHOS	FO	One IWA, max = 0.092 (MS_arch)
		01-U1H LR	FO	Area UTL = 0.014
		01-U1H TLS	FO	One IWA, max = 0.176 (MS_arch); rest < 0.1
		01-U1H WM	SH	One IWA, max = 0.003 (BN_adj)
		03-3C36	OF	Two MS_new > DOE RC; max = 0.522; high values on window ledge and door top; UTL_cluster = 0.075 if high values excluded; bulk Be and ratios OK; high wipe ratios OK except for low Ni/Be
		05-026143	FO	One IWA, max = 0.073 (DC)
		05-105	ST	One IWA, max = 0.016 (DC)
		05-131045	FO	One IWA, max = 0.005 (DC)
		05-131047	FO	One IWA, max = 0.016 (DC)
		05-202177	SH	One IWA, max = 0.250 (DC) > DOE RC on outlet box, one more > 0.1; bulk concentration and metal ratios OK
		05-202533	FO	One IWA, max = 0.099 (DC)
		05-202617	FO	One IWA, max = 0.195 (MS_arch) on 10/16/03; rest < 0.1
		05-2247841	SH	One IWA, max = 0.074 (DC)
		05-24	ST	One > DOE RC; max = 0.215 (AT); UTL = 0.410; TRU pad cover; bulk concentrations and metal ratios OK
		05-31	OF	PLall = 0.096

05-32	EX	Area UTL = 0.036
05-652b	FO	Area UTL = 0.031
05-7	OF	PLall = 0.019
05-8	EX	PLall = 0.181; max = 0.014
05-83606	FO	One IWA, one swipe = 0.057 (DC)
05-8A	EX	One IWA, max = 0.005 (DC)
05-9000203	SH	One IWA, max = 0.140 (DC); rest < 0.1
05-9103	SH	One IWA, max = 0.066 (DC)
05-9105	SH	One IWA, max = 0.018 (DC)
05-9122	SH	One IWA, max = 0.130 (DC); rest < 0.1
05-9139	SH	One IWA, max = 0.110 (DC); rest < 0.1
05-9140	SH	One IWA, max = 0.100 (DC); rest < 0.1
05-925	SH	One IWA, max = 0.200 (DC) = DOE RC; rest < 0.1
05-93	SH	One IWA, max = 0.110 (DC); rest < 0.1
05-938	SH	One IWA, max = 0.016 (DC)
05-94	SH	One IWA, 2 swipes, max = 0.048 (DC)
05-AL6	FO	One IWA, max = 0.046 (DC)
05-E25175	FO	One IWA, max = 0.200 (DC) = DOE RC on window sill; rest < 0.1
05-E26303	FO	One IWA, max = 0.096 (DC)
05-E92081	FO	One IWA, 2 swipes, max = 0.074 (DC)
05-E92759	FO	One IWA, max = 0.040 (DC)
05-F800	FO	One IWA, max = 0.009 (BN_adj)
05-HAZMAT TA (machine shop)	SH	Area UTL = 0.055
05-HAZMAT TA (storage shed)	ST	One IWA, max = 0.170 (DC); rest < 0.1
05-HAZMAT TA (tool shed)	SH	One IWA, max = 0.079 (DC)
05-SGS TLR	FO	Two IWAs, both sampled, max = 0.123 (AT)
05-T00114	FO	One IWA, max = 0.088 (DC)
05-WEF-HSG	FO	One IWA; Later sampling; max = 0.151 (DC); rest < 0.1
05-WEF-OFF	FO	One IWA, max < 0.005 (AT)
05-WEF-RTR	LA	Area UTL = 0.052
06-159	SH	UTL_cluster = 0.100; Area UTL = 0.191
06-160	SH	One IWA, max = 0.015 (BN_adj)
06-270	FO	One IWA, max = 0.185 (MS_arch, on electrical conduit); rest < 0.1
06-304 DAF	EX	One IWA, max = 0.012 (BN_adj)
06-305 DAF	EX	One IWA, max = 0.065 (MS_arch)
06-310 DAF	EX	One IWA, max = 0.003 (BN-adj)
06-343 DAF	EX	One IWA, max = 0.017 (MS_arch)
06-345 DAF	SH	One IWA, max = 0.011 (MS_arch)
06-353 DAF	EX	One IWA, max = 0.015 (MS_arch)
06-400 DAF	OF	PLall = 0.010
06-500 DAF	SH	All IWAs sampled; max = 0.061 (MS_arch)
06-605 EGS DAF	FO	PLall = 0.128
06-610 DAF	OF	One IWA, max = 0.021 (MS_arch)
06-611 DAF	OF	One IWA, max = -0.002 (BN_adj)
06-618	FO	Area UTL = 0.068
06-624	SH	IWA PLall = 0.046; 3 Area swipes > DOE RC, max = 0.317 (MS_new), bulk Be and metal ratios OK
06-625	FO	PLall = 0.174
06-651 DAF	FO	One IWA, max = 0.008 (MS_arch)
06-652 DAF	FO	One IWA, max = 0.019 (MS_arch)
06-800	SH	Both IWAs sampled, max = 0.088 (MS_arch); Area UTL = 1.843 with 15 > DOE RC; bulks OK, but GW ratios not good for Sheldon lathe

06-900	OF	PLall = 0.017
06-901	FO	IWA UTL_cluster = 0.132
06-902	OF	PLall - 0.145 if MS_arch on door tops ignored
06-904	SH	PLall = 0.034, Area UTL = 0.083
06-906	SH	IWA UTL_cluster = 0.055; Area UTL = 0.282 with 4 of 68 above DOE RC; Bulks OK, GW ratios mostly OK (a couple of low Ni/Be)
06-908	SH	IWA UTL_cluster = 0.032, Area UTL = 0.046
06-914	SH	IWA UTL_cluster = 0.059; Area UTL = 0.285, 5 of 58 MS_new > DOE RC; bulks OK, GW metal ratios OK
06-922	SH	One IWA, max = 0.004 (BN_adj)
06-999387	FO	One IWA; 3 of 4 (MS_new) > DOE RC, max = 0.830; bulk Be and ratios OK, but ratios for GW show moderately relatively high Be; clean
06-CP-1	OF	PLall = 0.073
06-CP-100	ST	PLall = 0.040, Area UTL = 0.027
06-CP-160	SH	IWA UTL_cluster = 0.038; Area UTL = 0.271 with one isolated high value on mezzanine; bulk Be quite low; GW ratios OK
06-CP-161	SH	Area UTL = 0.244; bulk Be low, bulk ratios OK
06-CP-162	SH	IWA UTL_cluster = 0.065 if door top omitted; Area UTL = 0.362, 2 of 24 > DOE RC, rest quite low; bulk Be low, ratios OK; GW ratios OK
06-CP-213	LA	PLall = 0.027
06-CP-214	OF	PLall = 0.041
06-CP-215	SH	IWA UTL_cluster = 0.161; Area UTL = 0.349, 1 of 25 > DOE RC; Bulk Be and ratios OK; GW ratios OK
06-CP-45	OF	PLall = 0.054
06-CP-50	SH	PLall = 0.023, Area UTL = 0.013
06-CP-70	FO	PLall = 0.110; Area UTL = 1.201, 2 of 16 > RC, one just over but max = 0.85 (top of air vent); Area UTL = 0.147 with outliers omitted; bulk Be low, ratios OK; GW ratios OK
06-CP-72	FO	PLall = 0.117
06-CP-9	EX	IWA UTL = 0.065
06-CP-95A	LA	PLall = 0.012; Area UTL = 0.035
09-10C	FO	Three IWAs, all sampled, max = 0.150 (DC) on windowsill
12-202255	FO	One IWA, max = 0.004 (BN_adj)
12-45	QU	Max = 0.179 (MS door top); UTL = 0.162 omitting that; Bulk Be and ratios OK
12-868	SH	IWA UTL_cluster = 0.113; Area UTL = 0.251; bulk Be and ratios OK
12-U12G AC	FO	One IWA, max = 0.010 (DC)
12-U12V AC	FO	One IWA, max = 0.412 (MS_new, top of wall HVAC unit); bulk concentration and ratios OK; GW ratios OK (Ni/Be low)
16-202112	FO	One IWA, max = 0.387 MS_arch), most > 0.1; not found Jan-09
23-1000	FO	PLall = 0.015
23-1001	FO	PLall = 0.082
23-1002	FO	Area UTL = 0.021
23-1010	SH	Max MS_arch = 0.198; UTL_cluster = 0.096
23-1014	FO	One IWA, max = 0.000 (BN_adj)
23-109	ST	PLall = 0.035
23-1103	FO	IWA UTL = 0.104
23-111	OF	PLall = 0.064
23-113	OF	MS_arch max = 0.524 on electrical box in video room; UTL_cluster = 0.071 omitting high value; Bulk Be and ratios OK
23-114	OF	PLall = 0.045; Area UTL = 0.031
23-117	OF	PLall = 0.008
23-118	FO	PLall = 0.034; Area UTL = 0.055
23-128	ST	IWA UTL_cluster = 0.038; Area UTL = 0.053; bulk Be low, ratios OK
23-132	OF	PLall = 0.022
23-133	ST	PLall = 0.066; Area UTL = 0.095

		23-143	OF	PLall = 0.180
		23-151 & 154 & 156 & 158	ST	IWA UTL_cluster = 0.090, 1 of 42 > DOC RC; Area UTL = 0.082, 1 of 62 > DOE RC; bulk Be and ratios OK
		23-153	LA	PLall = 0.042; Area UTL = 0.016
		23-159	OF	All IWAs sampled; max = 0.001 (DC)
		23-160	ST	Area UTL = 0.016
		23-180	SH	PLall = 0.043
		23-190	FO	IWA PLall = 0.030, Area UTL = 0.038 excluding rooms 19 and 193; 2 of 12 MS_new in those rooms > DOE RC; bulk Be and ratios OK, GW ratios OK
		23-211	FO	PLall = 0.012; Area UTL = 0.012
		23-300	QU	PLall = 0.038, Area UTL = 0.019
		23-302	ST	One IWA, max = 0.011 (BN_adj)
		23-310	OF	PLall = 0.044
		23-425	FO	IWA UTL = 0.104
		23-475 & 476 & 478 & 479 & 526 & 527 & 529	QU	UTL_cluster = 0.026
		23-480 & 481 & 482 & 483 & 484	QU	PLall = 0.075
		23-525	OF	PLall = 0.105
		23-528 & 530	QU	PLall = 0.171
		23-531 & 532 & 535	QU	PLall = 0.011
		23-550	OF	PLall = 0.028
		23-600	EX	PLall = 0.085, Area UTL = 0.002
		23-610	FO	1 of 21 MS_new > DOE RC (windowsill, 0.314), rest < 0.06; without outlier, Area UTL = 0.106; bulk Be low, ratios OK, GW ratios OK except Ni relatively low
		23-614	OF	PLall = 0.038
		23-620	OF	PLall = 0.026
		23-630	OF	PLall = 0.021
		23-650	LA	PLall = 0.010
		23-652	OF/LA	Office PLall = 0.019; all Lab IWAs sampled; max = 0.044 (DC)
		23-675 & 676 & 678 & 679 & 680 & 681 & 683 & 684	QU	IWA UTL = 0.124
		23-700	SH	PLall = 0.064; Area UTL = 0.011
		23-701	FO	IWA UTL = 0.118
		23-703	ST	1 of 59 (MS_new = 0.411) > DOE RC; Area UTL = 0.088; bulk Be low, ratios OK; GW ratio has Be high compared with Y
		23-710	SH	IWA UTL = 0.186; Area UTL = 0.024
		23-722003	ST	One IWA, max = 0.003 (BN_adj)
		23-725	CO	PLall = 0.017
		23-726	CO	Top of RF room door > DOE RC; post; IWA UTL = 0.138 even with this value;; PLall = 0.063 without outlier
		23-750	SH	PLall = 0.028, Area UTL = 0.015
		23-775 & 776 & 777	ST	PLall = 0.073; Area UTL = 0.028
		23-B	OF	PLall = 0.011
		23-C	OF	PLall = 0.133
		23-D	OF	PLall = 0.007
		23-E106727	FO	One IWA, max = 0.698 (MS_arch) top of electrical panel, rest < 0.01; not sampled Jan-09
		23-GS100	FO	One IWA (2 swipes), max = 0.004 (BN_adj)
		23-W1	SH	PLall = 0.094, Area UTL = 0.053
		23-W2	SH	PLall = 0.066, Area UTL = 0.037
		23-W3	ST	9 of 18 (MS_arch) > DOE RC; was not resampled Jan 2009

23-W5	**ST**	**One IWA, max = 0.030 (MS-arch); Area UTL = 0.033**
23-W6	**SH**	**PLall = 0.170**
24-A01	**OF**	**PLall = 0.107**
24-A02	**OF/ST**	**PLall = 0.010; Area UTL = 0.005**
24-A02 readiness warehouse	**ST**	**NPUTL = 0.200**
24-A03	**FO**	**One IWA, max = 0.003 (DC)**
24-A04	**SH**	**IWA UTL_cluster = 0.046; Area UTL = 0.010**
24-A05	**ST**	**Max = 0.567 > DOE RC (MS_arch on electrical box); rest < 0.1; PLall = 0.095 omitting high value**
24-A07	**FO**	**Sampled 2 of 3 IWAs; max = 0.009 (DC); UTL_cluster = 0.018**
24-A10	**FO**	**One IWA, max is 0.005 (DC)**
24-A12	**SH**	**PLall = 0.007**
24-A13	**OF**	**PLall = 0.027**
24-A15	**SH**	**Area UTL = 0.026**
24-B01	**OF**	**PLall = 0.051**
24-B02	**OF**	**PLall = 0.020**
24-B03	**OF**	**PLall = 0.046**
24-B04	**FO**	**Area UTL = 0.113**
24-B05	**OF**	**Area UTL = 0.041**
24-B07	**SH**	**PLall = 0.022, Area UTL = 0.001**
24-B09	**ST**	**One IWA, max = 0.086 (MS_arch)**
24-B10	**FO**	**One IWA, max = 0.006 (DC)**
24-C01	**OF**	**PLall = 0.021**
24-C02	**OF/ST**	**PLall = 0.016, Area UTL = 0.004**
24-C03	**OF**	**PLall = 0.031**
24-C04	**FO**	**One IWA, max = 0.003 (DC)**
24-NSF	**OF**	**PLall = 0.032**
25-026107	**FO**	**One IWA, max = 0.032 (BN_adj)**
25-092728	**FO**	**One IWA, max = 0.082 (MS_arch)**
25-096380	**FO**	**One IWA, max = 0.034 (BN_adj)**
25-096593	**FO**	**One IWA, max = 0.030 (BN_adj)**
25-097499	**FO**	**One IWA, max = 0.012 (BN_adj)**
25-202616	**FO**	**1 of 18 (MS_new) > DOE RC, max = 0.274; Area UTL = 0.440; GW ratios OK**
25-202674	**FO**	**One IWA, max = 0.072 (MS_new)**
25-4117	**FO**	**PLall = 0.046**
25-4919	**FO**	**UTL_cluster = 0.173**
25-721949	**FO**	**Three IWAs, all sampled, max = 0.152 (MS_arch, windowsill), rest < 0.1**
25-E25169	**FO**	**One IWA, max = 0.359 (MS_arch) > DOE RC (windowsill), rest < 0.01**
25-SHAWTLR	**FO**	**One IWA, max = 0.003 (BN_adj)**
26-185129	**FO**	**One IWA, max = 0.002 (BN_adj)**
26-202558	**FO**	**One IWA, max = 0.031 (MS_arch)**
26-2204	**FO**	**Area UTL = 0.166; bulk Be and ratios OK**
27-250	**FO**	**One IWA, max = 0.001 (BN_adj)**
27-5100	**EX**	**PLall = 0.042, Area UTL = 0.040**
27-5110	**ST**	**One IWA, MS max = 0.312 (MS_arch, DC dup = 0.271) > DOE RC, rest < RC; bulk concentrations and ratios OK**
27-5150	**FO**	**UTL_cluster = 0.050**
27-5180	**FO**	**Area UTL = 0.044**
27-5191	**SH**	**Max = 0.367 (MS_arch) on doortop; omitting that, UTL = 0.051**
27-560	**FO**	**One IWA, max = 0.005 (BN_adj)**
27-A	**FO**	**One IWA, max = 0.005 (BN_adj)**
27-B	**FO**	**UTL_cluster = 0.053**
27-SHOWER TRLR	**FO**	**One IWA, max = 0.010 (MS_arch)**

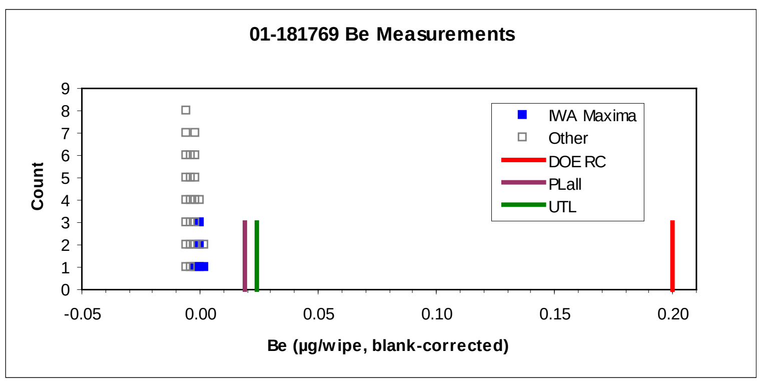
35-2211	**OF**	**PLall = 0.033, Area UTL = 0.004**
35-2215	**ST**	**Two IWAs, both sampled, max = 0.120 (DC); bulk Be and ratios OK**
35-2216	**ST**	**Area UTL = 0.040**
35-2221	**ST**	**PLall = 0.089 w/o outlier; IWA UTL_cluster = 0.039 with all data** **Bldg UTL = 0.079; Deployment items UTL = 0.030**
35-2222	**EX**	**PLall = 0.159**
35-2229	**SH**	**PLall = 0.022**
37-FG3&4	**OF**	**PLall = 0.029**
52-0378 & 0379	**FO**	**All IWAs sampled; max = 0.062 (DC, windowsill)**
BN-LAO	**LA**	**PLall = 0.032**
BN-LLO	**EX**	**IWA UTL = 0.080**
BN-RSLA	**FO**	**Area UTL = 0.040**

Detailed Results by Facility

The smallest facilities consisting of one or a few IWAs (the fourth case above) are omitted from the following list. Otherwise, for each facility a table of summary statistics and results is presented, along with a plot of the data obtained from that facility. A detailed description is given for each novel element when it first appears.

01-181769

01-181769	
IWAs	
Type	OF
N =	10
n =	5
BC(BNadj) =	-0.0062
delta =	0.005
mean of ln(x+delta) =	-5.411
ln sd =	0.445
PL K =	3.788
PLall =	**0.019**
UTL K =	4.203
UTL =	**0.024**
Alpha =	0.05
ProbPlot R =	0.923

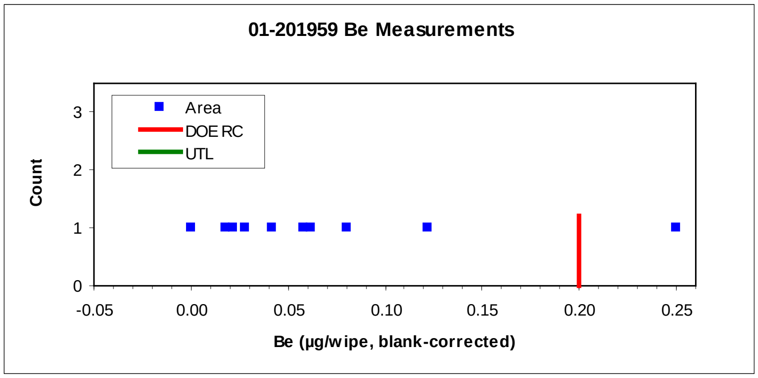


In this table N is the total number of IWAs (see Appendix 1) and n is the number of IWAs sampled. BC is the blank correction used to make the low-end distributions of data from different labs, etc., more nearly similar, and delta is the shift added to accommodate the negative values found in the data; see Appendix 4 for discussions of these elements. PLall is a prediction limit for the largest value to be found in all unsampled IWAs. Comparing PLall with the DOE RC is a more stringent test than using the UTL; the latter is recommended in the current draft DOE Technical Standard. Alpha is the significance level of the test implicitly used when comparing PLall or UTL with the DOE RC, and ProbPlot R is the normal probability plot correlation on the transformed scale.

Only the IWA maximum values are used in the computations. The plot shows these as solid squares and the other data has outline squares. Also shown are the RC, PLall, and UTL. For this facility, all data as well as PLall and UTL are far below RC; this facility is clearly “clean.”

01-201959

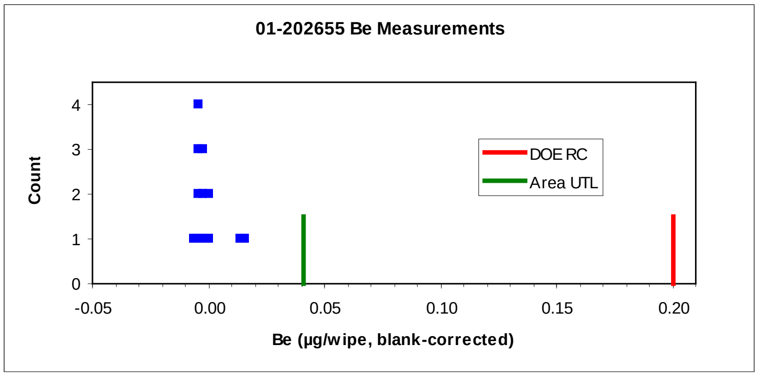
01-201959	
	Area
Type	SH
n =	10
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-2.926
ln sd =	0.921
UTL K =	2.911
UTL =	**0.774**
Alpha =	0.05
ProbPlot R =	0.988



This is a small Area facility, using the UTL approach initially. In this case the largest data value itself (0.2495 blank-corrected) exceeds the RC and UTL = 0.774 is well above it. This facility does not "pass" the UTL test. One bulk sample was obtained; its Be concentration is 1.007, about in the middle of the distribution of soil measurements (actually toward the lower end for samples in the north). The metal ratios in the bulk sample are not remarkable; Nb/Be is a bit on the high side, indicating relatively low Be. In the high wipe itself, four of six metal ratios are somewhat high. This facility is given the "blue" pass, meaning that it fails the statistical test and has a sample exceeding the DOE RC, but that there is no evidence to indicate that the high value(s) are not from naturally occurring soils.

01-202655

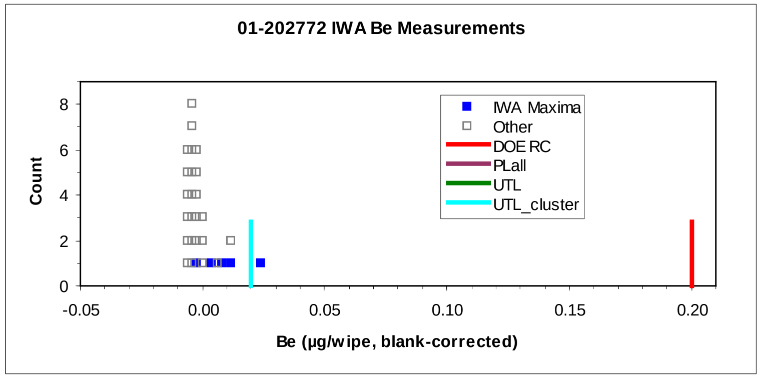
01-202655	
	Area
Type	FO
n =	12
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
delta =	0.0080
mean of ln(x+delta) =	-5.129
ln sd =	0.774
UTL K =	2.736
UTL =	**0.041**
Alpha =	0.05
ProbPlot R =	0.954



For this facility the Area UTL is not greater than the DOE RC; this facility "passes."

01-202772

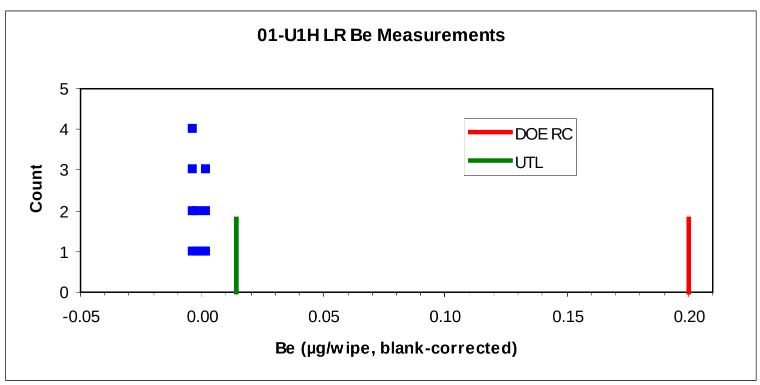
01-202772	
IWAs	
Type	OF
N =	9
n =	5
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0040
mean of ln(x+delta) =	-4.743
ln sd =	1.194
PL K =	3.583
PLall =	**0.625**
UTL K =	4.203
UTL =	**1.313**
Alpha =	0.05
ProbPlot R =	0.945
UTL cluster sampling analysis	
F =	0.37
delta =	0.0085
mean of ln(x+delta) =	-5.094
ln sd =	0.681
UTL K =	2.232
UTL =	**0.020**
ProbPlot R =	0.974



This facility contains only 9 IWAs, of which 5 were sampled. With so few IWAs sampled both PLall and UTL exceed the RC, even though all the data values are far below. The UTL cluster analysis uses all the observations, not only the IWA maxima; UTL_cluster = 0.020, far less than the RC. The F is from the analysis of variance; with F this low there is no evidence for positive correlation among measurements obtained in the same IWAs.

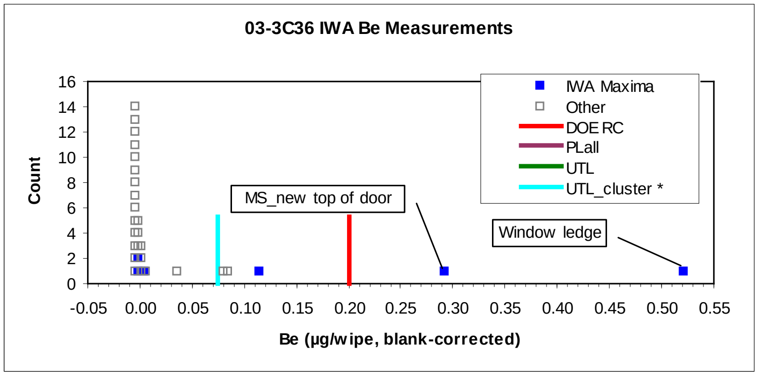
01-U1H LR

01-U1H LR	
Area	
Type	FO
n =	10
BCt(BNadj) =	-0.0062
BC(DC) =	0.0013
delta =	0.008
mean of ln(x+delta) =	-5.092
ln sd =	0.439
UTL K =	2.911
UTL =	**0.014**
Alpha =	0.05
ProbPlot R =	0.964



03-3C36

03-3C36	
IWAs	
Type	OF
N =	10
n =	6
BC(BNadj) =	-0.0062
BC(MS_new) =	0.0001
BC(DC) =	0.0013
delta =	0.0040
mean of ln(x+delta) =	-3.492
ln sd =	2.460
PL K =	3.259
PLall =	**92.137**
UTL K =	3.708
UTL =	**278.039**
Alpha =	0.05
ProbPlot R =	0.950
omitting high values	
mean of ln(x+delta) =	-4.616
ln sd =	1.498
PLall =	**1.298**
UTL =	**2.547**
ProbPlot R =	0.970
UTL cluster sampling analysis omitting high values	
F =	0.92
delta =	0.0085
mean of ln(x+delta) =	-4.759
ln sd =	1.011
UTL K =	2.246
UTL =	**0.075**
ProbPlot R =	0.851



In this facility there are two isolated high values, both MS_new, that drive PLall and UTL up. Even with those omitted values there are three right-tail outliers. This is a facility in a forward area which is likely to be dusty.

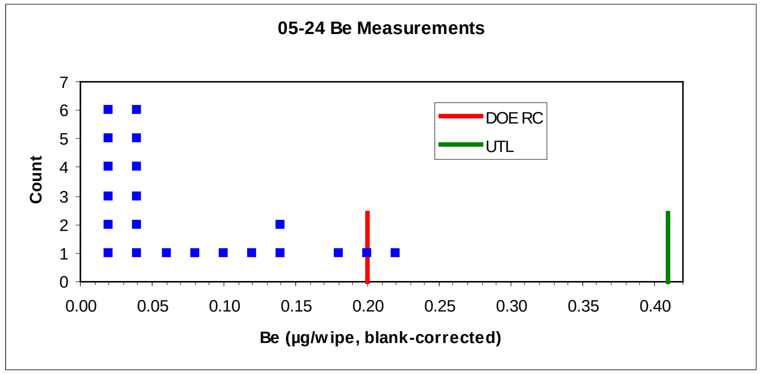
If one omits the two highest values and performs the UTL cluster sampling analysis, the result is a pass.

The Be concentration in the bulk sample obtained in this facility is consistent with background soils in the north of the NTS, as are the metal ratios in the bulk sample. The metal ratios in the highest two wipes are OK except for very low ratios of Ni/Be [nickel/beryllium].

The ProbPlot R is low due to the three remaining right-tail outliers.

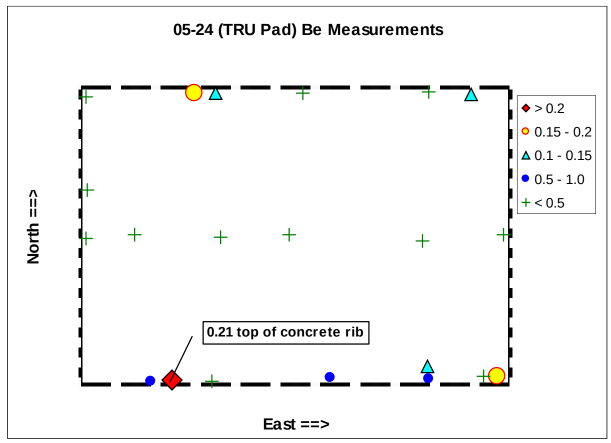
05-24

05-24	
	Area
Type	ST
n =	21
BC(AT) =	0
delta =	0
mean of ln(x+delta) =	-2.926
ln sd =	0.858
UTL K =	2.371
UTL =	**0.410**
Alpha =	0.05
ProbPlot R =	0.982



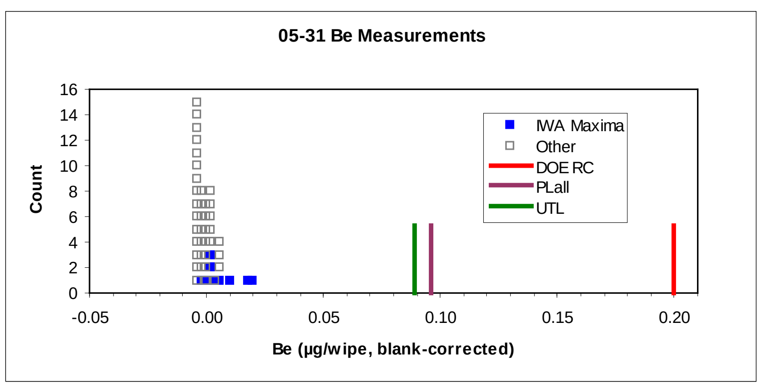
This is a storage facility for transuranic (TRU) waste in Area 5, and is inherently dusty. The high Be values were located around the periphery, as shown in the adjacent plot.

Two bulk samples were obtained inside the facility during the January 2009 sampling. Be concentrations and metal ratios for these are consistent with those of NTS soils.



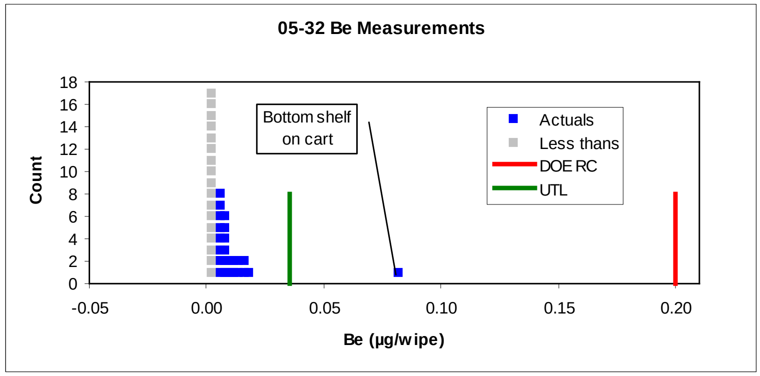
05-31

05-31	
	IWAs
Type	OF
N =	15
n =	8
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
delta =	0.005
mean of ln(x+delta) =	-4.611
ln sd =	0.704
PL K =	3.288
PLall =	**0.096**
UTL K =	3.187
UTL =	**0.089**
Alpha =	0.05
ProbPlot R =	0.978



05-32

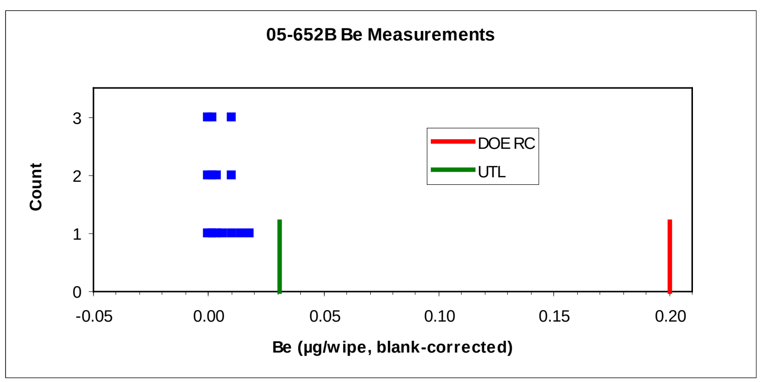
05-32	
Area	
Type	EX
n =	41
RL =	0.005
mean of ln(x) =	-5.188
ln sd =	0.832
UTL K =	2.229
UTL =	**0.036**
Alpha =	0.05
ProbPlot R =	0.939



In a few cases with Assay Technology (AT) data or early DataChem data, there are some censored values given as “< RL,” where RL is a reporting limit, or as “< 0,” where the actual negative values were not located. Censored data maximum likelihood estimation is used for these; see “Parametric 95%-95% Upper Tolerance Limits for Censored Lognormal Data” (C. B. Davis, presented at the Joint Statistical Meetings, Seattle, 2006). A calibration factor (CF) for the UTL K multipliers was presented in that paper; its function is to accommodate the loss of information resulting from the censoring. The same CF was used for the PLall K multipliers. Censored values are represented in the plot by hollow blue squares at a value half their RL, where RL > 0, or -0.002, if “<0.”

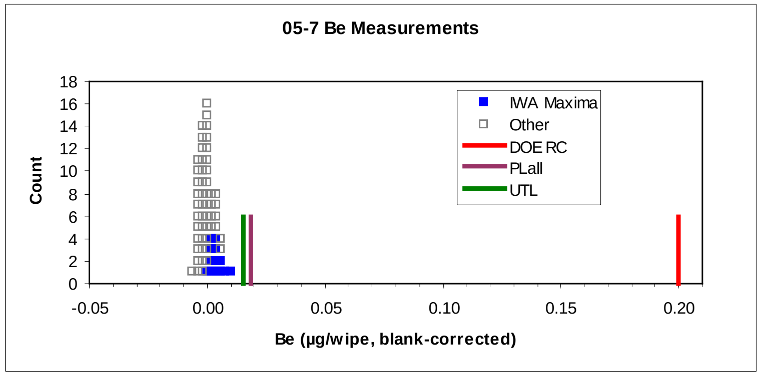
05-652B

05-652B	
Area	
Type	FO
n =	14
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.577
ln sd =	0.486
UTL K =	2.614
UTL =	**0.031**
Alpha =	0.05
ProbPlot R =	0.985



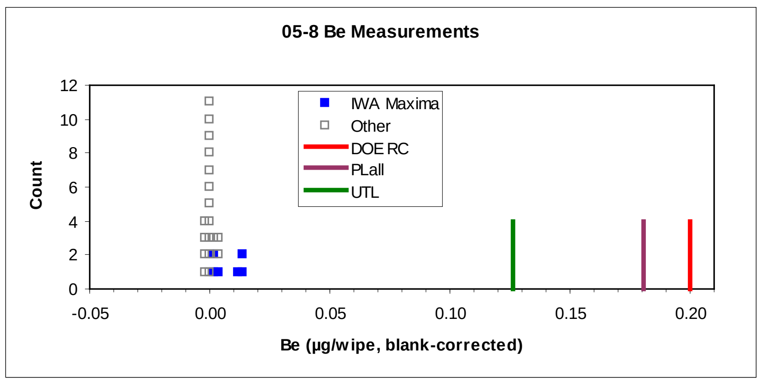
05-7

05-7	
IWAs	
Type	OF
N =	25
n =	13
BC(BNadj) =	-0.0062
BC (DC) =	0.0013
delta =	0.0050
mean of ln(x+delta) =	-4.710
ln sd =	0.306
PL K =	3.141
PLall =	**0.019**
UTL K =	2.671
UTL =	**0.015**
Alpha =	0.05
ProbPlot R =	0.993



05-8

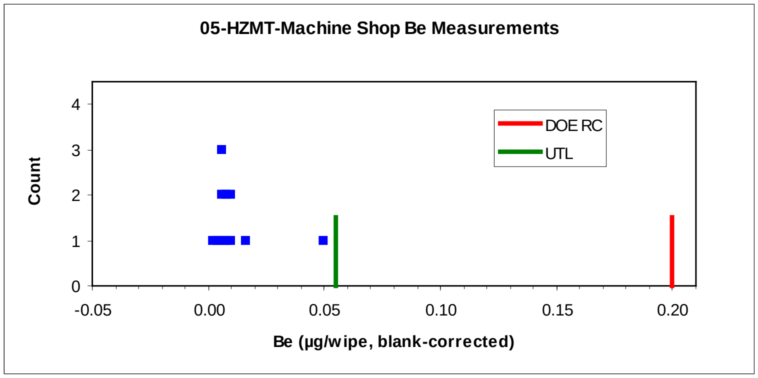
05-8	
IWAs	
Type	EX
N =	19
n =	6
BC(DC) =	0.0003
delta =	0.0020
mean of ln(x+delta) =	-4.881
ln sd =	0.762
PL K =	4.172
PLall =	**0.181**
UTL K =	3.708
UTL =	**0.126**
Alpha =	0.05
ProbPlot R =	0.944



PLall and UTL are rather far above the data values due to the fairly small number of IWAs sampled. Both are less than the DOE RC nonetheless.

05-HAZMAT Machine Shop

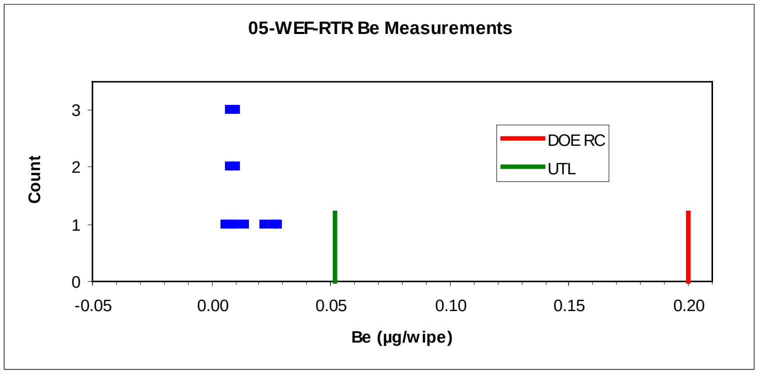
05-HZMT-Machine Shop	
	Area
Type	SH
n =	11
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.271
ln sd =	0.521
UTL K =	2.815
UTL =	**0.055**
Alpha =	0.05
ProbPlot R =	0.888



The somewhat low ProbPlot R is due to the one relatively high value in an otherwise rather clean facility.

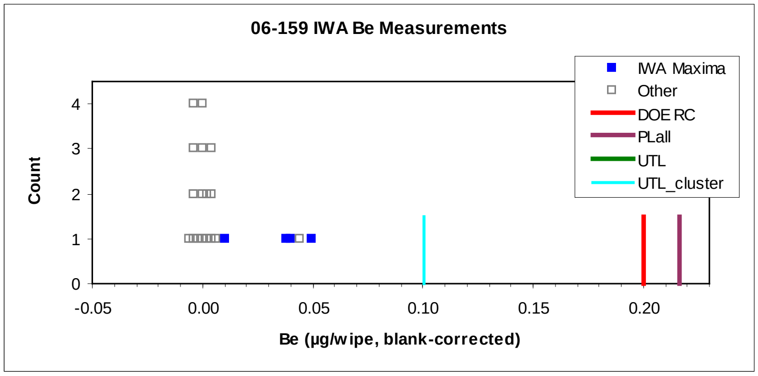
05-WEF RTR

05-WEF-RTR	
	Area
Type	LA
n =	11
BC(AT) =	0
delta =	0
mean of ln(x+delta) =	-4.427
ln sd =	0.521
UTL K =	2.815
UTL =	**0.052**
Alpha =	0.05
ProbPlot R =	0.943



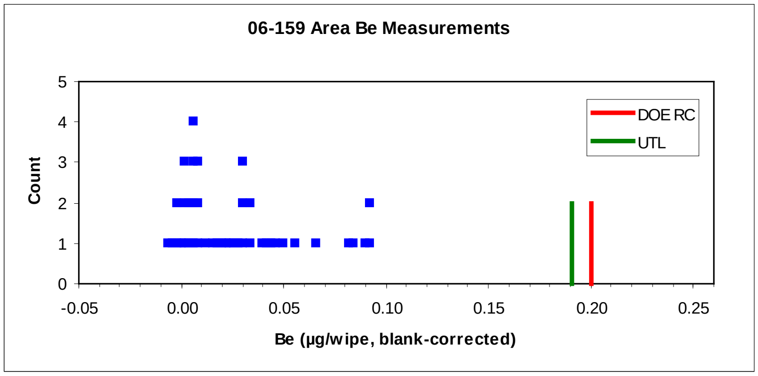
06-159

06-159	
IWAs	
Type	SH
N =	5
n =	4
BC(DC) =	0.0013
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.003
mean of ln(x+delta) =	-3.413
ln sd =	0.651
PL K =	2.913
PLall =	**0.217**
UTL K =	5.580
UTL =	**1.244**
Alpha =	0.04
ProbPlot R =	0.875
UTL cluster sampling analysis	
F =	0.40
delta =	0.0090
mean of ln(x+delta) =	-4.388
ln sd =	0.786
UTL K =	2.766
UTL =	**0.100**
Alpha =	0.040
ProbPlot R =	0.963



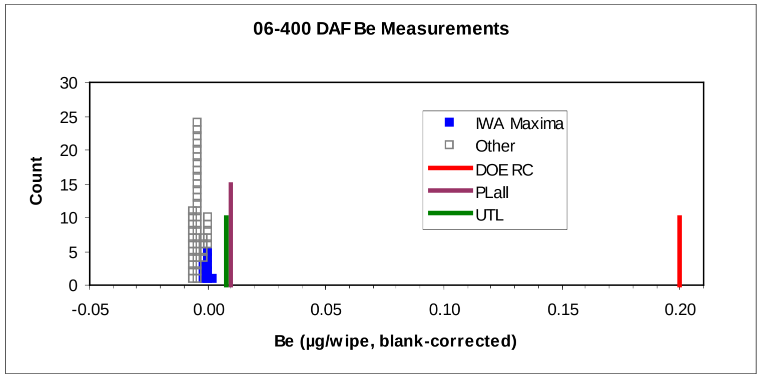
This facility consists of both IWA and Area portions. These are handled separately. The significance levels for the two statistical tests (alpha values) add up to 0.05.

06-159	
Area	
Type	SH
n =	44
BC(DC) =	0.0013
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-3.587
ln sd =	0.926
UTL K =	2.321
UTL =	**0.191**
Alpha =	0.01
ProbPlot R =	0.991



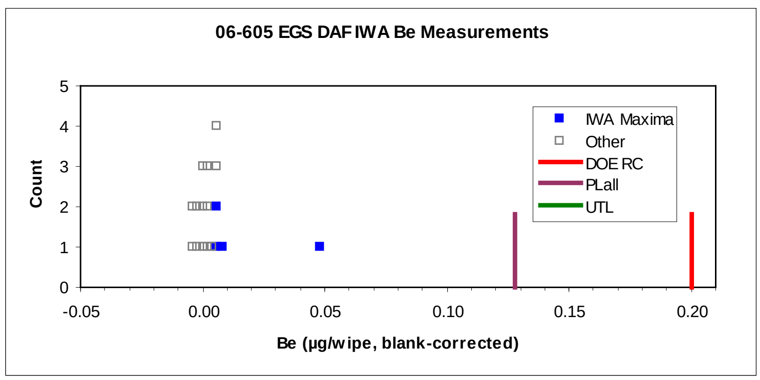
06-400 DAF

06-400 DAF	
IWAs	
Type	OF
N =	20
n =	9
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
delta =	0.0050
mean of ln(x+.delta) =	-5.436
ln sd =	0.351
PL K =	3.440
PLall =	**0.010**
UTL K =	3.031
UTL =	**0.008**
Alpha =	0.05
ProbPlot R =	0.952



06-605 EGS DAF

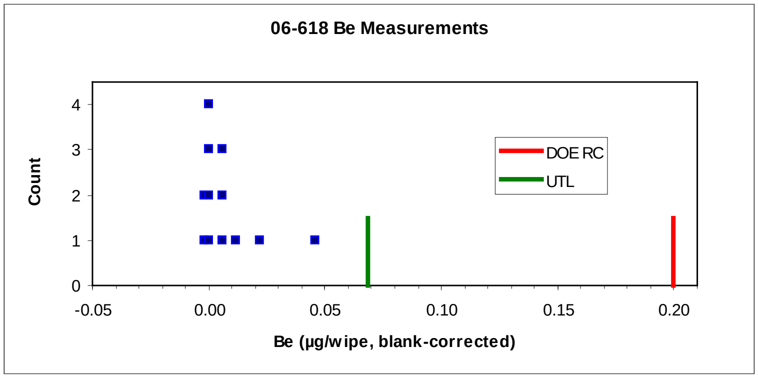
06-605 EGS DAF	
IWAs	
Type	FO
N =	5
n =	4
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.211
ln sd =	0.827
PL K =	2.631
PLall =	**0.128**
UTL K =	5.144
UTL =	**1.041**
Alpha =	0.05
ProbPlot R =	0.811



The low ProbPlot R is due to one of four IWA maxima being higher than the rest, even though all are far below the DOE RC.

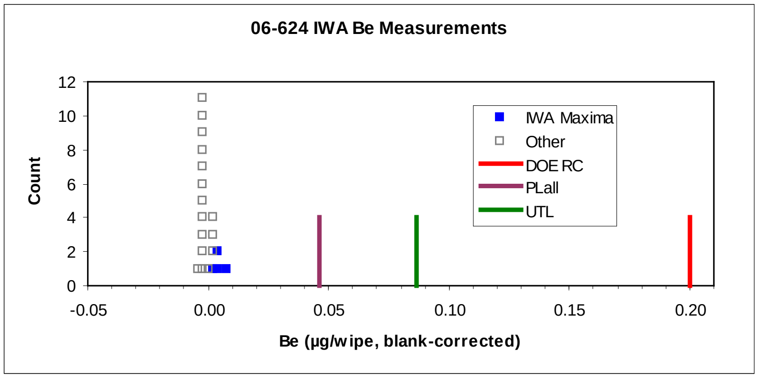
06-618

06-618	
Area	
Type	FO
n =	12
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.008
mean of ln(x+delta) =	-4.408
ln sd =	0.671
UTL K =	2.736
UTL =	**0.068**
Alpha =	0.05
ProbPlot R =	0.952

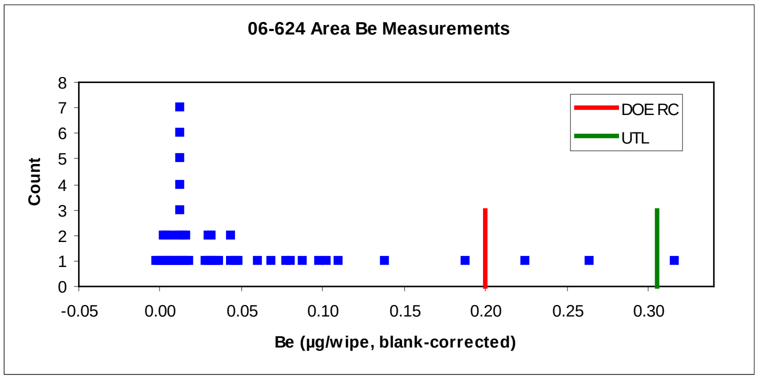


06-624

06-624	
IWAs	
Type	SH
N =	7
n =	4
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
delta =	0.003
mean of ln(x+delta) =	-4.963
ln sd =	0.386
PL K =	5.068
PLall =	**0.046**
UTL K =	6.602
UTL =	**0.086**
Alpha =	0.025
ProbPlot R =	0.933

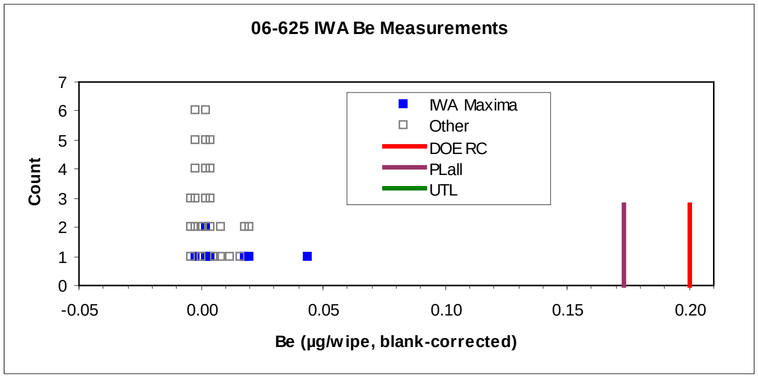


06-624	
Area	
Type	SH
n =	46
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-3.281
ln sd =	0.963
UTL K =	2.183
UTL =	**0.305**
Alpha =	0.025
ProbPlot R =	0.986



06-625

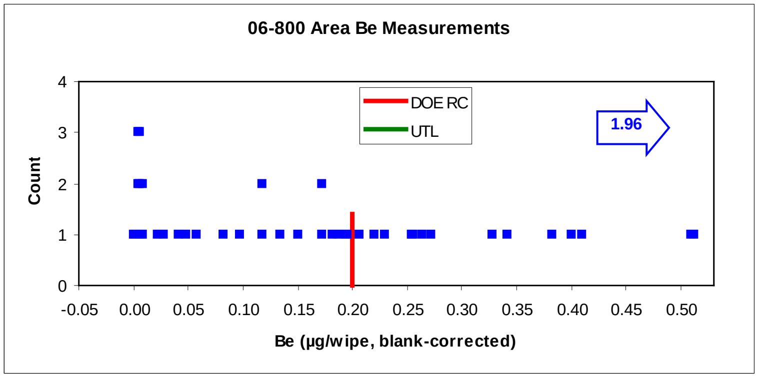
06-625	
IWAs	
Type	FO
N =	10
n =	6
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.867
ln sd =	0.961
PL K =	3.259
PLall =	**0.174**
UTL K =	3.708
UTL =	**0.269**
Alpha =	0.05
ProbPlot R =	0.969



06-800

Both IWAs were sampled; the maximum value was 0.088.

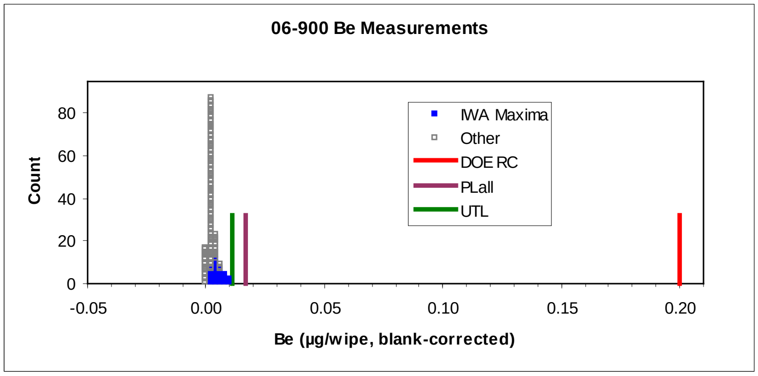
06-800	
Area	
Type	SH
n =	42
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS) =	0.0004
delta =	0.0085
mean of ln(x+delta) =	-2.299
ln sd =	1.380
UTL K =	2.111
UTL =	**1.843**
Alpha =	0.05
ProbPlot R =	0.959



Numerous MS_new measurements exceed the DOE RC; the maximum is 1.96 µg/wipe. The Be concentrations and metal ratios in the bulk samples obtained inside the facility are consistent with exterior soil. Most of the metal ratios obtained from the wipe samples with Be > DOE RC are also consistent with exterior soil ratios; the exception is a wipe sample obtained on a piece of equipment, which had Be relatively high compared with Y, Nb, and U.

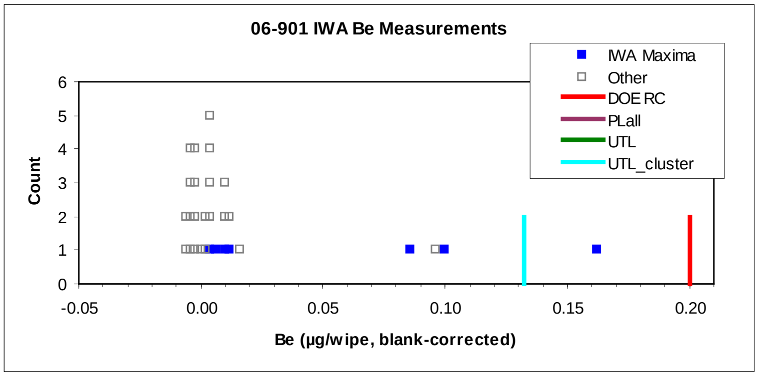
06-900

06-900	
IWAs	
Type	OF
N =	137
n =	29
BC(DC) =	0.0003
delta =	0.005
mean of ln(x+delta) =	-4.653
ln sd =	0.225
PL K =	3.699
PLall =	**0.017**
UTL K =	2.232
UTL =	**0.011**
Alpha =	0.05
ProbPlot R =	0.989



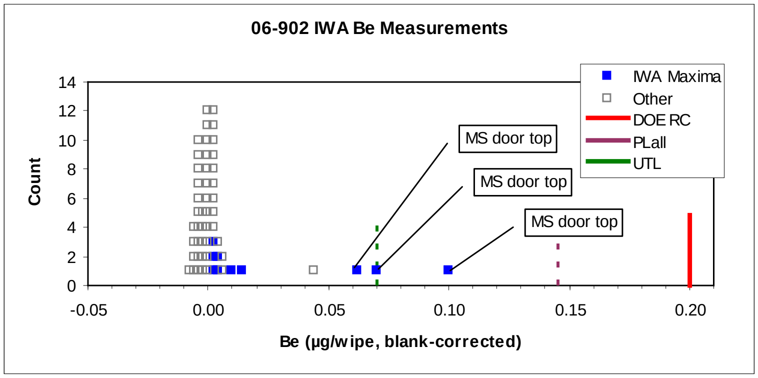
06-901

06-901	
IWAs	
Type	FO
N =	10
n =	5
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-3.513
ln sd =	1.291
PL K =	2.857
PLall =	**1.187**
UTL K =	3.400
UTL =	**2.395**
Alpha =	0.05
ProbPlot R =	0.930
UTL cluster sampling analysis	
F =	0.98
delta =	0.0090
mean of ln(x+delta) =	-4.288
ln sd =	1.044
UTL K =	2.232
UTL =	**0.132**
ProbPlot R =	0.954



06-902

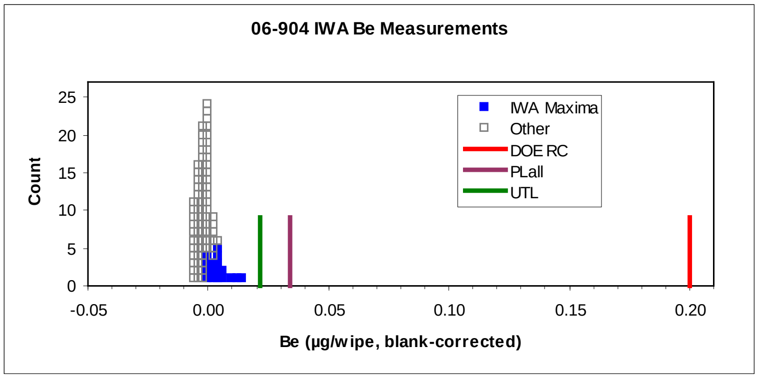
06-902	
IWAs	
Type	OF
N =	39
n =	10
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
BC(MS_new) =	0.0001
delta =	0.0030
mean of ln(x+delta) =	-4.191
ln sd =	1.218
PL K =	3.871
PLall =	**1.684**
UTL K =	2.911
UTL =	**0.521**
Alpha =	0.05
ProbPlot R =	0.931
omitting door tops	
mean of ln(x+delta) =	-4.754
ln sd =	0.735
PLall =	**0.145**
UTL =	**0.070**
ProbPlot R =	0.897



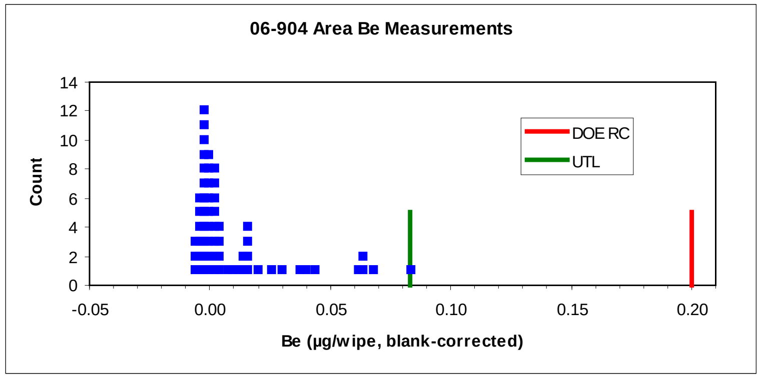
There are three outliers in the MS_arch data obtained from door tops. All are less than the DOE RC, but push both PLall and UTL over it. Both PLall and UTL are less than RC if those locations are omitted.

06-904

06-904	
IWAs	
Type	SH
N =	34
n =	17
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-5.059
ln sd =	0.532
PL K =	3.314
PLall =	**0.034**
UTL K =	2.553
UTL =	**0.022**
Alpha =	0.04
ProbPlot R =	0.988

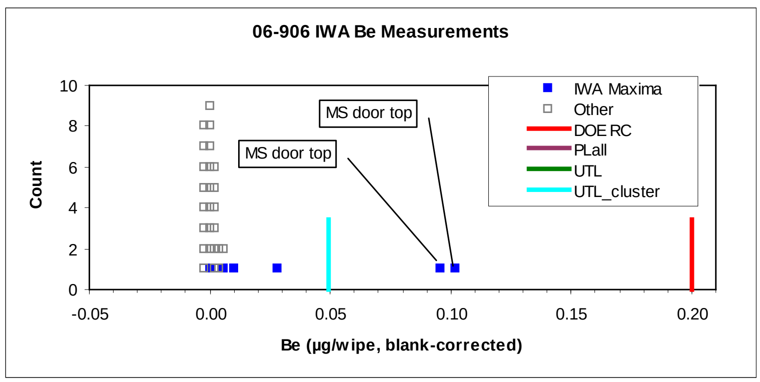


06-904	
Area	
Type	SH
n =	62
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0080
mean of ln(x+delta) =	-4.483
ln sd =	0.952
UTL K =	2.191
UTL =	**0.083**
Alpha =	0.01
ProbPlot R =	0.979



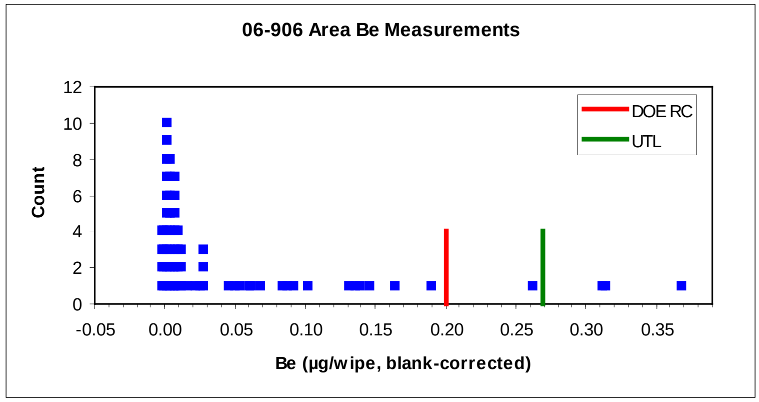
06-906

06-906	
IWAs	
Type	SH
N =	11
n =	6
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-3.827
ln sd =	1.426
PL K =	3.659
PLall =	**4.020**
UTL K =	3.918
UTL =	**5.821**
Alpha =	0.04
ProbPlot R =	0.975
omitting door tops	
mean of ln(x+delta) =	-4.853
ln sd =	0.959
PLall =	**0.257**
UTL =	**0.331**
ProbPlot R =	0.965
UTL cluster analysis, all data	
F =	0.65
delta =	0.0090
mean of ln(x+delta) =	-4.436
ln sd =	0.683
UTL K =	2.336
UTL_cluster =	**0.049**
Alpha =	0.025
ProbPlot R =	0.814



The two high values (still considerably less than the DOE RC) are MS_arch analyses from door tops. Omitting these locations does not pull PLall or UTL down quite far enough due the small number of IWAs involved. UTL_cluster is adequately low; the low ProbPlot R is due to those outliers.

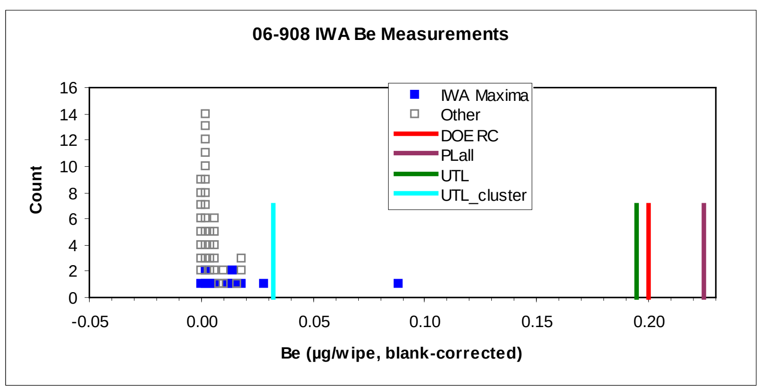
06-906	
Area	
Type	SH
n =	68
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-3.629
ln sd =	1.135
UTL K =	2.070
UTL =	**0.270**
Alpha =	0.025
ProbPlot R =	0.943



In the Area portion of the facility there are four MS_new results above the DOE RC; UTL also exceeds the DOE RC. The Be concentrations and metal ratios in the four bulk samples obtained inside the facility are consistent with exterior soil samples at the NTS. Most of the metal ratios obtained from the four high wipe samples are likewise consistent with the exterior soils; the exceptions are to Ni/Be ratios. Recall, though, that Ni/Be is the least reliable of the six metal ratios for these comparisons with exterior soils.

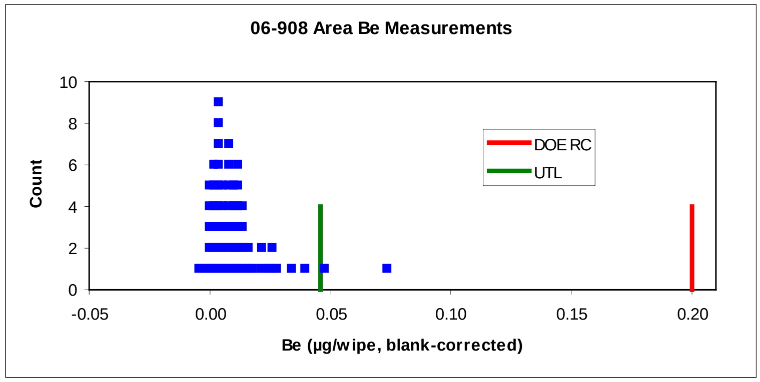
06-908

06-908	
IWAs	
Type	SH
N =	17
n =	11
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS08) =	0.0035
delta =	0.0030
mean of ln(x+delta) =	-4.366
ln sd =	0.941
PL K =	3.068
PLall =	**0.225**
UTL K =	2.916
UTL =	**0.194**
Alpha =	0.04
ProbPlot R =	0.980
UTL cluster analysis, all data	
F =	1.51
delta =	0.0090
mean of ln(x+delta) =	-4.259
ln sd =	0.467
UTL K =	2.283
UTL_cluster =	**0.032**
Alpha =	0.04
ProbPlot R =	0.911



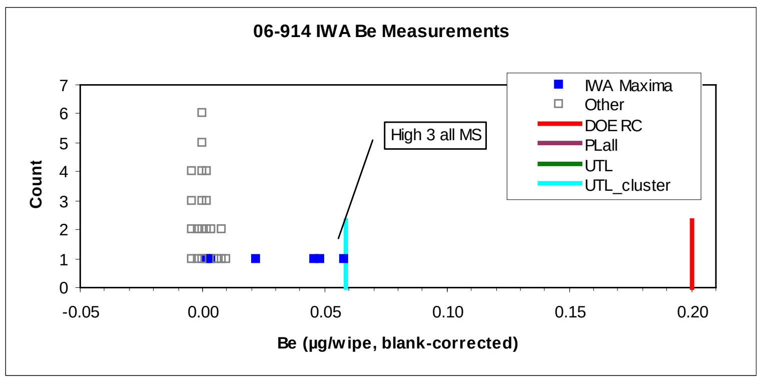
For this facility UTL is slightly less than the DOE RC; it is inflated by the one relatively high value, which came from the top of a milling machine. The UTL_cluster, which takes into account all the data rather than just the IWA maxima, is much lower.

06-908	
Area	
Type	SH
n =	62
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS) =	0.0004
delta =	0.0085
mean of ln(x+delta) =	-4.070
ln sd =	0.527
UTL K =	2.191
UTL =	**0.046**
Alpha =	0.01
ProbPlot R =	0.991



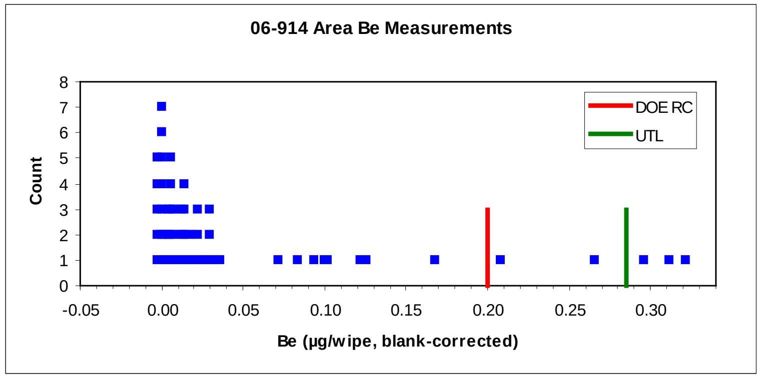
06-914

06-914	
IWAs	
Type	SH
N =	11
n =	6
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-3.819
ln sd =	1.140
PL K =	3.659
PLall =	**1.421**
UTL K =	3.918
UTL =	**1.911**
Alpha =	0.04
ProbPlot R =	0.925
UTL cluster sampling analysis	
F =	0.84
delta =	0.0090
mean of ln(x+delta) =	-4.371
ln sd =	0.694
UTL K =	2.421
UTL =	**0.059**
Alpha =	0.025
ProbPlot R =	0.926



The three relatively high values are all MS_arch.

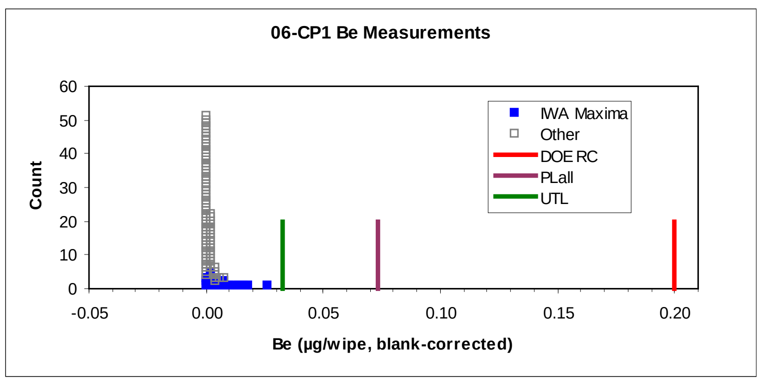
06-914	
Area	
Type	SH
n =	58
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-3.603
ln sd =	1.125
UTL K =	2.113
UTL =	**0.285**
Alpha =	0.025
ProbPlot R =	0.962



The Area UTL and five MS_new measurements exceed the DOE RC in the Area portion of this facility. The Be concentrations and metal ratios in both bulk samples are consistent with exterior soils at the NTS. The metal ratios of the high wipes are either consistent with exterior soils or reflect somewhat relatively low Be concentrations compared with the other metals.

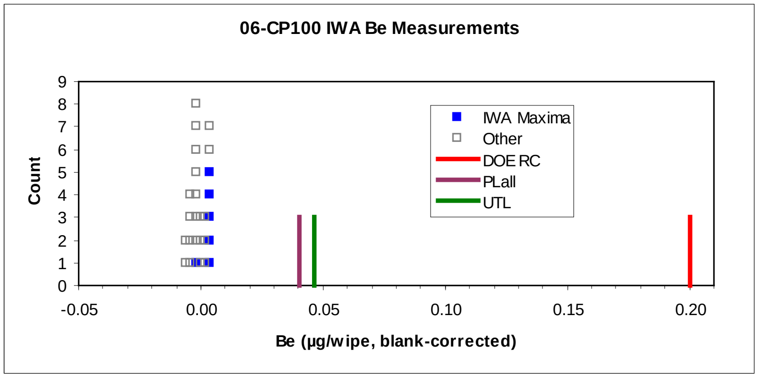
06-CP1

06-CP1	
IWAs	
Type	OF
N =	107
n =	19
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+.delta) =	-4.532
ln sd =	0.517
PL K =	3.837
PLall =	**0.073**
UTL K =	2.423
UTL =	**0.033**
Alpha =	0.05
ProbPlot R =	0.966



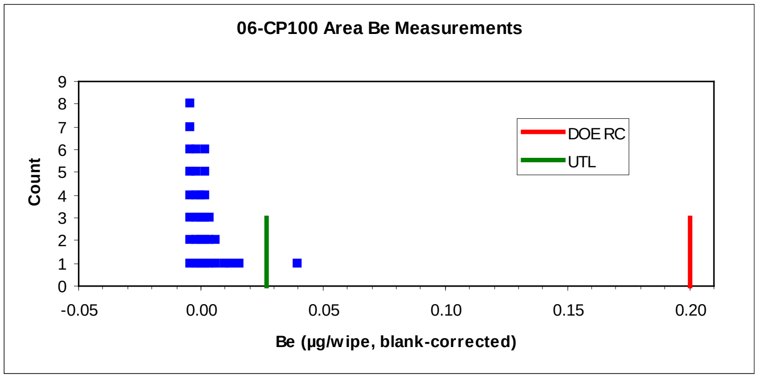
06-CP100

06-CP100	
IWAs	
Type	ST
N =	11
n =	6
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
delta =	0.0030
mean of ln(x+delta) =	-5.161
ln sd =	0.551
PL K =	3.659
PLall =	**0.040**
UTL K =	3.918
UTL =	**0.047**
Alpha =	0.04
ProbPlot R =	0.791



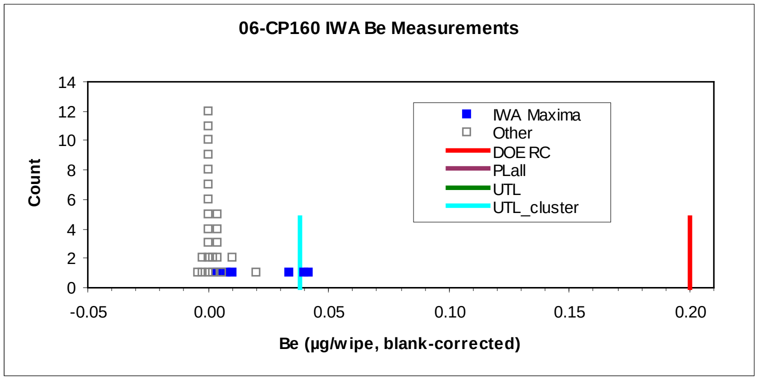
One of the IWA maxima is atypically low, hence the low ProbPlot R.

06-CP100	
Area	
Type	ST
n =	33
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS) =	0.0004
delta =	0.0080
mean of ln(x+delta) =	-4.795
ln sd =	0.587
UTL K =	2.461
UTL =	**0.027**
Alpha =	0.01
ProbPlot R =	0.967

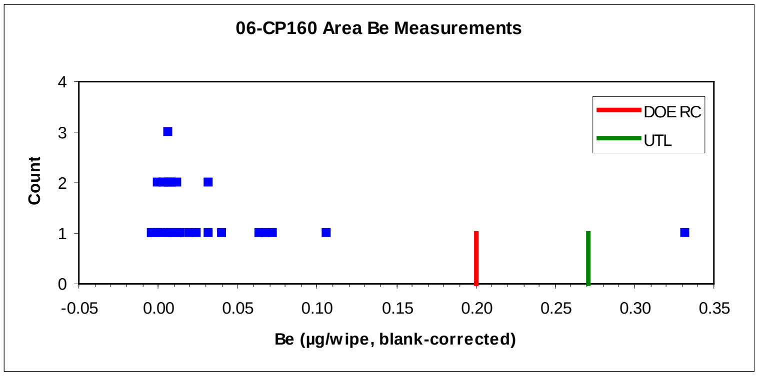


06-CP160

06-CP160	
IWAs	
Type	SH
N =	14
n =	6
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.003
mean of ln(x+delta) =	-3.899
ln sd =	0.806
PL K =	4.039
PLall =	**0.523**
UTL K =	3.918
UTL =	**0.474**
Alpha =	0.04
ProbPlot R =	0.926
UTL cluster sampling analysis	
F =	1.33
delta =	0.0090
mean of ln(x+delta) =	-4.363
tau^2 =	0.019
sig^2 =	0.293
ln sd =	0.558
UTL K =	2.351
UTL =	**0.038**
Alpha =	0.025
ProbPlot R =	0.921



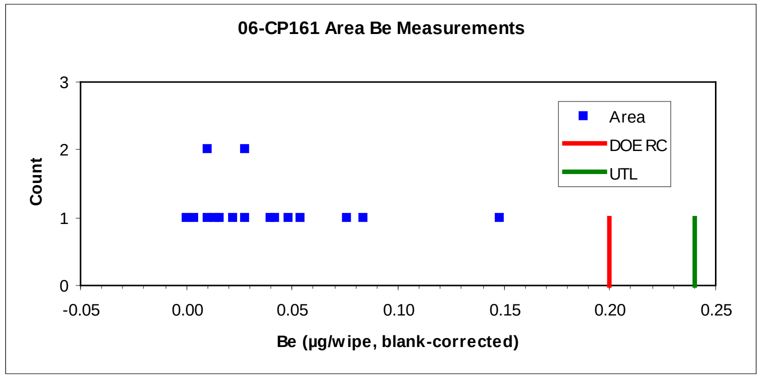
06-CP160	
Area	
Type	SH
n =	25
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_new) =	0.0001
delta =	0.0085
	-3.729
	1.005
UTL K =	2.442
UTL =	**0.271**
Alpha =	0.025
ProbPlot R =	0.977



There is an isolated MS_new value above the DOE RC in the Area portion of this facility; it was obtained on the floor of the mezzanine. The Be concentrations on the two bulk samples are rather low. The metal ratios in the high wipe sample are consistent with those in NTS exterior soils.

06-CP161

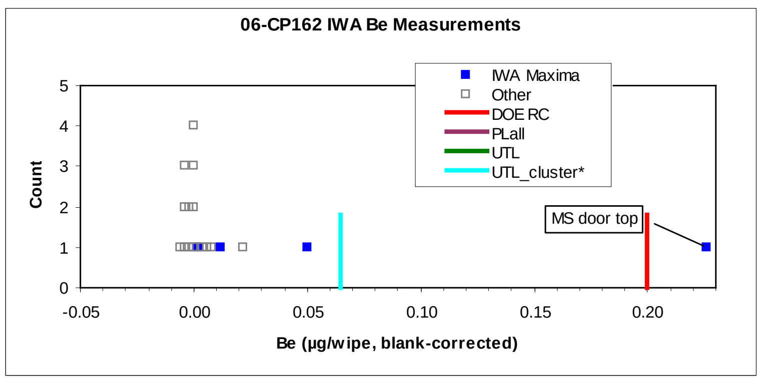
06-CP161	
	Area
Type	SH
n =	16
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS) =	0.0004
delta =	0.0085
mean of ln(x+delta) =	-3.306
ln sd =	0.758
UTL K =	2.524
UTL =	**0.240**
Alpha =	0.05
ProbPlot R =	0.997



The Be concentration in the bulk sample obtained inside this facility is on the low side; the metal ratios are consistent with NTS exterior soils.

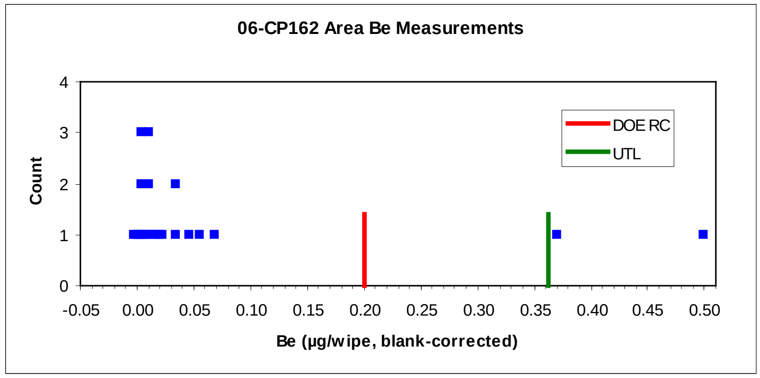
06-CP162

06-CP162	
	IWAs
Type	SH
N =	8
n =	4
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-3.432
ln sd =	1.599
PL K =	4.593
PLall =	**49.958**
UTL K =	5.580
UTL =	**242.282**
Alpha =	0.04
ProbPlot R =	0.997
omitting door top	
mean of ln(x+delta) =	-3.990
ln sd =	0.945
PLall =	**1.416**
UTL =	**3.604**
ProbPlot R =	0.993
UTL cluster analysis omitting door top	
F =	0.77
delta =	0.0090
mean of ln(x+delta) =	-4.474
ln sd =	0.693
UTL K =	2.693
UTL =	**0.065**
Alpha =	0.025
ProbPlot R =	0.980



There is one high MS_arch measurement obtained on a door top; otherwise there are few IWAs involved. Omitting the door top sample gives UTL_cluster less than the DOE RC.

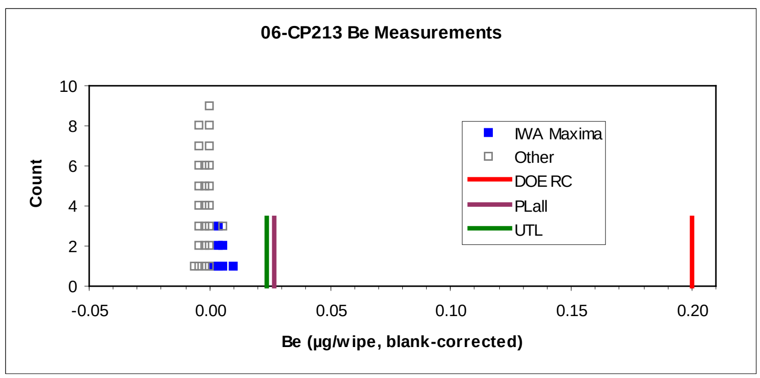
06-CP162	
Area	
Type	SH
n =	24
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-3.621
ln sd =	1.066
UTL K =	2.465
UTL =	**0.362**
Alpha =	0.025
ProbPlot R =	0.922



There are two isolated high MS_new values, both obtained near a shop door. The Be concentration and metal ratios from the bulk sample obtained inside the facility are consistent with NTS exterior soils, as are the metal ratios in the high wipes.

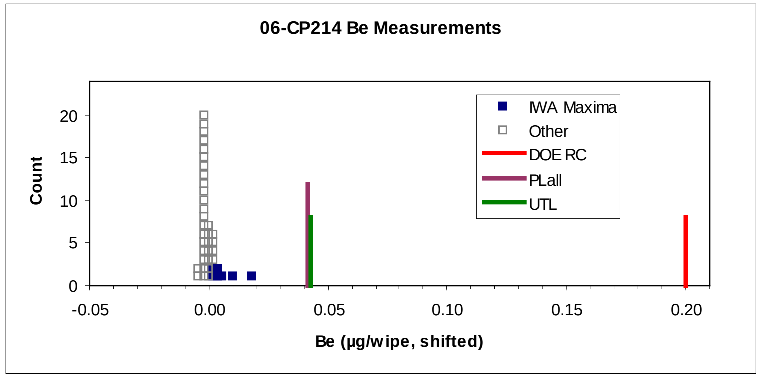
06-CP213

06-CP213	
IWAs	
Type	LA
N =	17
n =	7
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
delta =	0.002
mean of ln(x+delta) =	-5.065
ln sd =	0.413
PL K =	3.699
PLall =	**0.027**
UTL K =	3.400
UTL =	**0.024**
Alpha =	0.05
ProbPlot R =	0.969



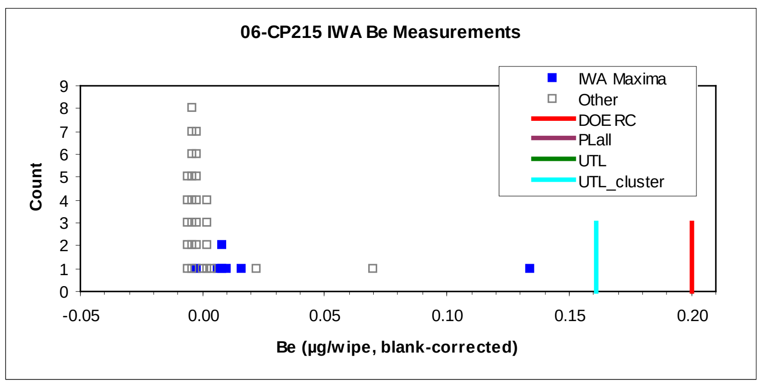
06-CP214

06-CP214	
IWAs	
Type	OF
N =	13
n =	7
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
delta =	0.0050
mean of ln(x+delta) =	-4.574
ln sd =	0.450
PL K =	3.345
PLall =	**0.041**
UTL K =	3.400
UTL =	**0.043**
Alpha =	0.05
ProbPlot R =	0.949



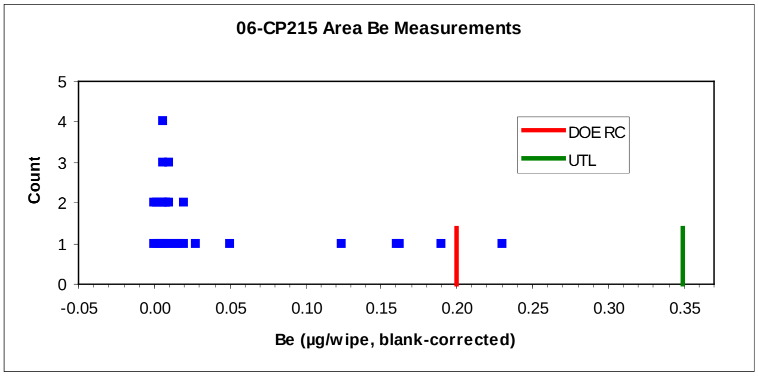
06-CP215

06-CP215	
IWAs	
Type	SH
N =	11
n =	7
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.003
mean of ln(x+delta) =	-4.432
ln sd =	1.446
PL K =	3.250
PLall =	**1.300**
UTL K =	3.569
UTL =	**2.066**
Alpha =	0.04
ProbPlot R =	0.931
UTL cluster sampling analysis	
F =	5.71
delta =	0.0090
mean of ln(x+delta) =	-4.749
tau^2 =	0.501
sig^2 =	0.425
ln sd =	0.962
UTL K =	3.096
UTL =	**0.161**
Alpha =	0.025
ProbPlot R =	0.944



The two high values are from Room 107; the highest is MS_arch. In this UTL cluster sampling analysis there is a distinct difference in levels among the IWAs sampled, as reflected in the elevated F statistic.

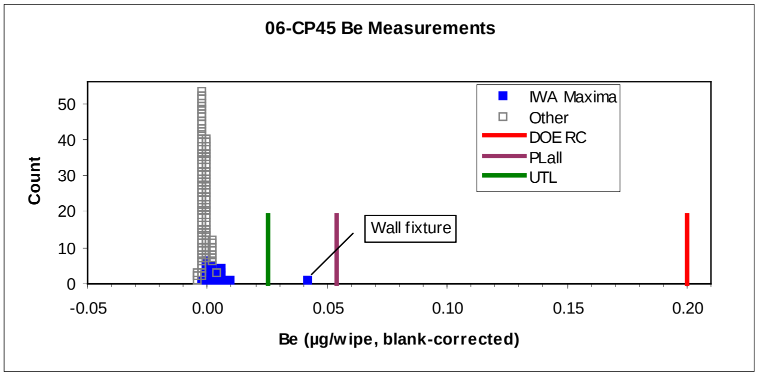
06-CP215	
Area	
Type	SH
n =	25
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-3.577
ln sd =	1.044
UTL K =	2.442
UTL =	**0.349**
Alpha =	0.025
ProbPlot R =	0.922



Several of the MS_new measurements in the Area portion of the facility are elevated, with one exceeding the DOE RC. The Be concentration and metal ratios from the bulk sample obtained within the facility are consistent with NTS exterior soils, as are the metal ratios from the wipe sample with the highest Be concentration.

06-CP45

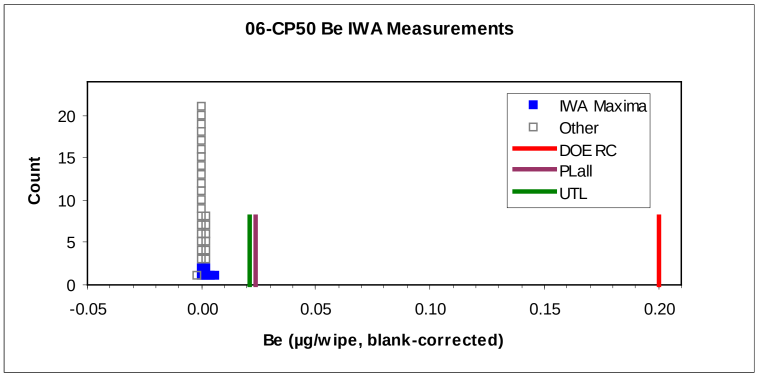
06-CP45	
IWAs	
Type	OF
N =	67
n =	21
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-4.856
ln sd =	0.575
PL K =	3.519
PLall =	**0.054**
UTL K =	2.371
UTL =	**0.025**
Alpha =	0.05
ProbPlot R =	0.945



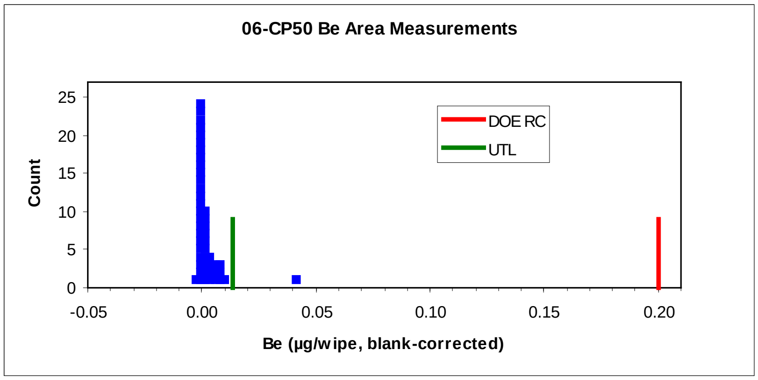
Occasionally there is an anomaly, or “outlier,” in the data that begs being pointed out. In this case the high value was obtained on a wall fixture; one might argue whether this is actually part of the normally “touchable” work environment. For this facility the outlier was small enough and there were enough other IWAs that the facility passed anyway.

06-CP50

06-CP50	
IWAs	
Type	SH
N =	15
n =	6
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-5.261
ln sd =	0.394
PL K =	4.133
PLall =	**0.023**
UTL K =	3.918
UTL =	**0.021**
Alpha =	0.04
ProbPlot R =	0.972



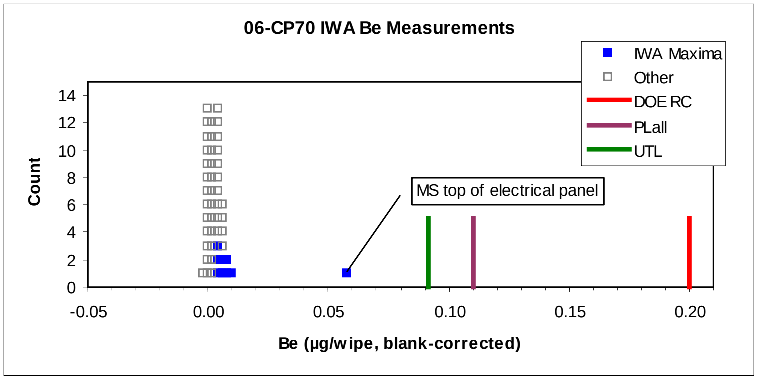
06-CP50	
Area	
Type	SH
n =	47
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.947
ln sd =	0.426
UTL K =	2.294
UTL =	**0.013**
Alpha =	0.01
ProbPlot R =	0.891



The Area ProbPlot R value is somewhat lower than one would like to see, due to a relatively high outlier that is nonetheless well below the DOE RC. This should not be considered to be a handicap in this case, since the data values are all very close to zero, and the distribution is likely affected mostly by the rounding of the data in that region.

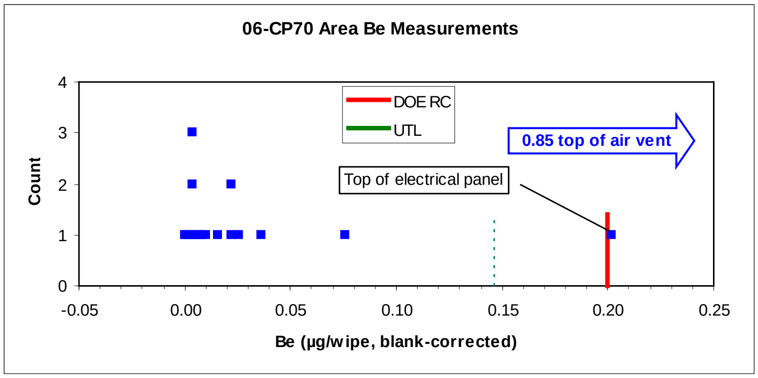
06-CP70

06-CP70	
IWAs	
Type	FO
N =	17
n =	9
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.516
ln sd =	0.685
PL K =	3.414
PLall =	**0.110**
UTL K =	3.156
UTL =	**0.092**
Alpha =	0.04
ProbPlot R =	0.815



The one relatively high value (MS_arch) was obtained on top of an electrical panel, a location that should perhaps not be considered as part of the normal "touchable" work environment. It was not omitted in this case since PLall is less that the DOE RC even with it included.

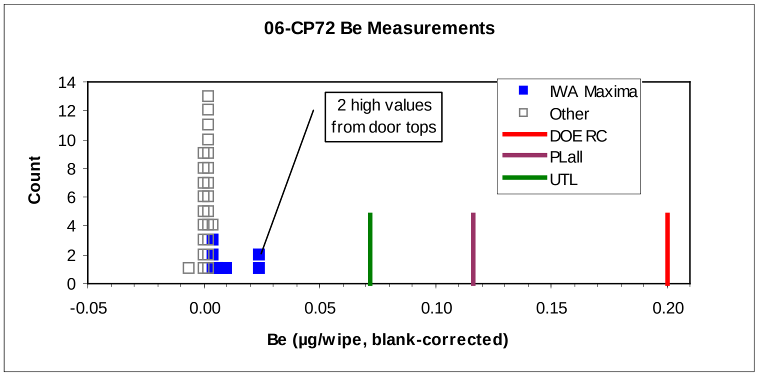
06-CP70	
Area	
Type	FO
n =	16
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-3.514
ln sd =	1.224
UTL K =	3.028
UTL =	**1.201**
Alpha =	0.01
ProbPlot R =	0.904



In the equipment bays there were two high values in locations not normally "touchable," one considerably higher than the DOE RC and one just above it, both MS_new. With these values included, the UTL is quite high; with those values omitted, UTL = 0.147. The Be concentration in the bulk sample obtained in the facility is low, and the metal ratios generally indicate relatively low Be. The metal ratios in the wipe samples with high Be concentrations are consistent with NTS exterior soils.

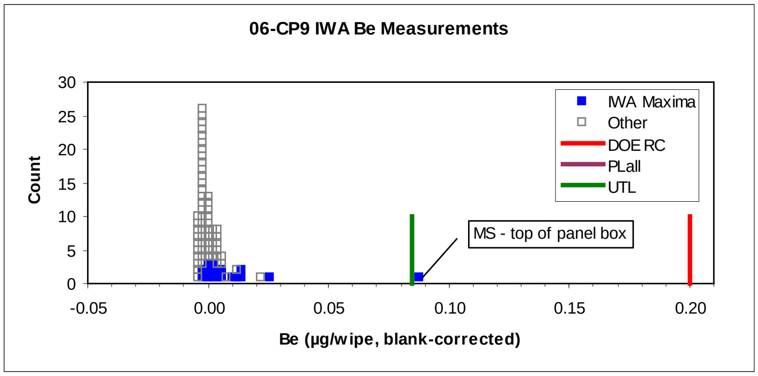
06-CP72

06-CP72	
IWAs	
Type	FO
N =	29
n =	8
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-4.498
ln sd =	0.597
PL K =	3.978
PLall =	**0.117**
UTL K =	3.187
UTL =	**0.072**
Alpha =	0.05
ProbPlot R =	0.952



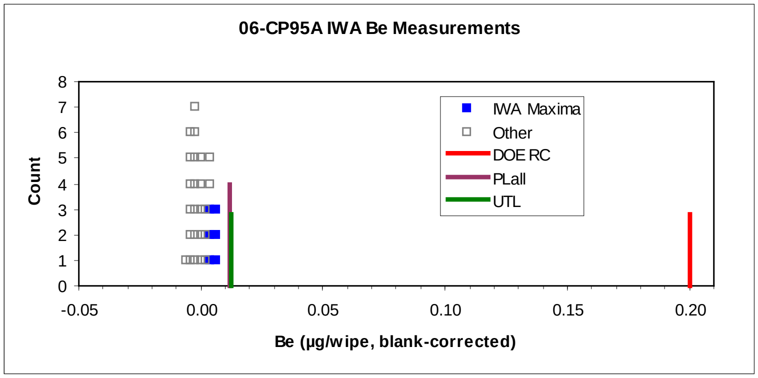
06-CP9

06-CP9	
IWAs	
Type	EX
N =	58
n =	18
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0040
mean of ln(x+delta) =	-4.716
ln sd =	0.934
PL K =	3.543
PLall =	**0.241**
UTL K =	2.453
UTL =	**0.085**
Alpha =	0.05
ProbPlot R =	0.971

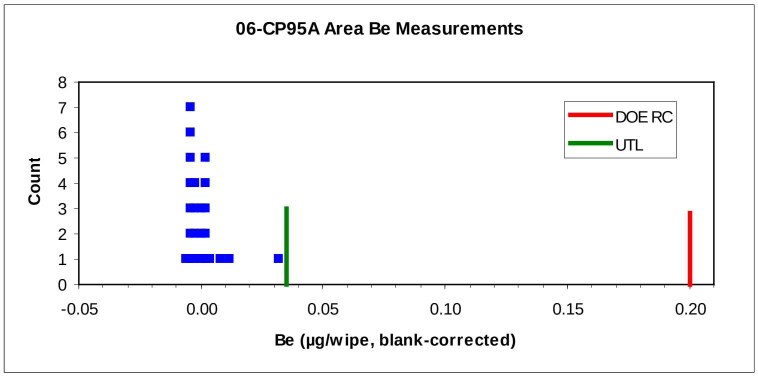


06-CP95A

06-CP95A	
IWAs	
Type	LA
N =	11
n =	6
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0040
mean of ln(x+delta) =	-4.737
ln sd =	0.162
PL K =	3.659
PLall =	**0.012**
UTL K =	3.918
UTL =	**0.013**
Alpha =	0.04
ProbPlot R =	0.985

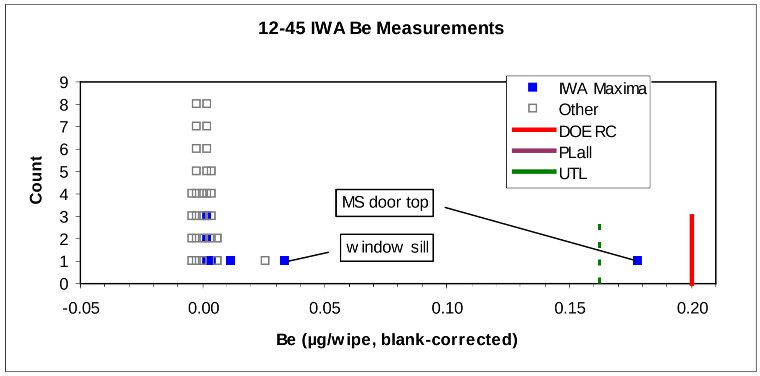


06-CP95A	
Area	
Type	LA
n =	24
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0070
mean of ln(x+delta) =	-5.108
ln sd =	0.728
UTL K =	2.662
UTL =	**0.035**
Alpha =	0.01
ProbPlot R =	0.981



12-45

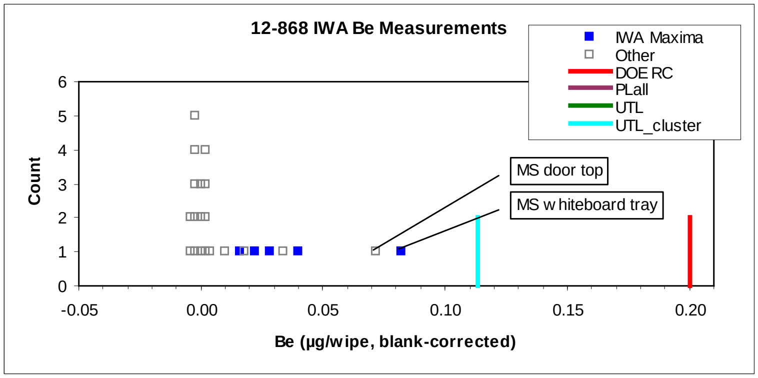
12-45	
IWAs	
Type	QU
N =	28
n =	7
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0040
mean of ln(x+delta) =	-4.030
ln sd =	1.212
PL K =	4.201
PLall =	**2.882**
UTL K =	3.400
UTL =	**1.089**
Alpha =	0.05
ProbPlot R =	0.930
omitting door top	
mean of ln(x+delta) =	-4.285
ln sd =	0.732
PL K =	4.201
PLall =	**0.295**
UTL K =	3.400
UTL =	**0.162**
ProbPlot R =	0.975



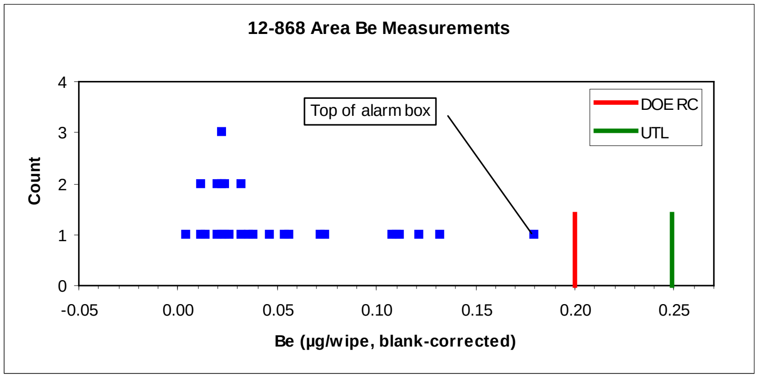
One MS_arch value obtained on a door top is slightly less than the DOE RC; omitting that value, UTL = 0.162. In addition, the Be concentration and metal ratios in the bulk sample obtained inside the facility are consistent with those in NTS soils.

12-868

12-868	
IWAs	
Type	SH
N =	9
n =	5
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-3.361
ln sd =	0.578
PL K =	3.855
PLall =	**0.319**
UTL K =	4.485
UTL =	**0.461**
Alpha =	0.04
ProbPlot R =	0.972
UTL cluster sampling analysis	
F =	0.61
delta =	0.0090
mean of ln(x+delta) =	-4.208
ln sd =	0.854
UTL K =	2.465
UTL =	**0.113**
Alpha =	0.025
ProbPlot R =	0.957



12-868	
Area	
Type	SH
n =	27
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-3.031
ln sd =	0.697
UTL K =	2.402
UTL =	**0.249**
Alpha =	0.025
ProbPlot R =	0.981

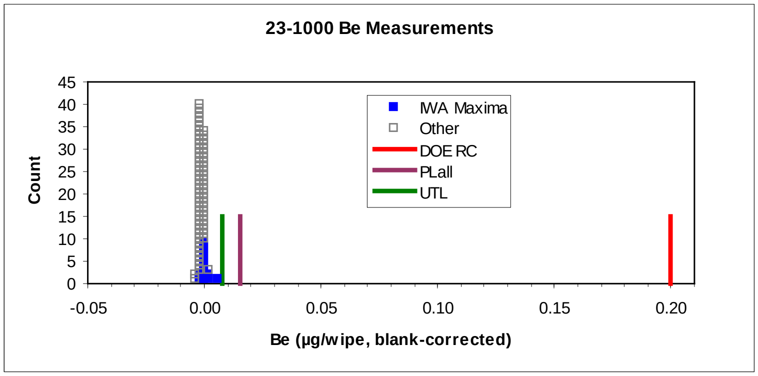


The Area data are rather spread out, so that even if the highest value (at a normally "untouchable location") is omitted, UTL remains slightly above the DOE RC. Metal ratios in the bulk sample obtained inside the building are consistent with those in NTS soils.

23-1000

23-1000	
IWAs*	
Type	FO
N =	54
n =	14
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-5.853
ln sd =	0.495
PL K =	3.712
PLall =	**0.015**
UTL K =	2.614
UTL =	**0.007**
Alpha =	0.05
ProbPlot R =	0.959

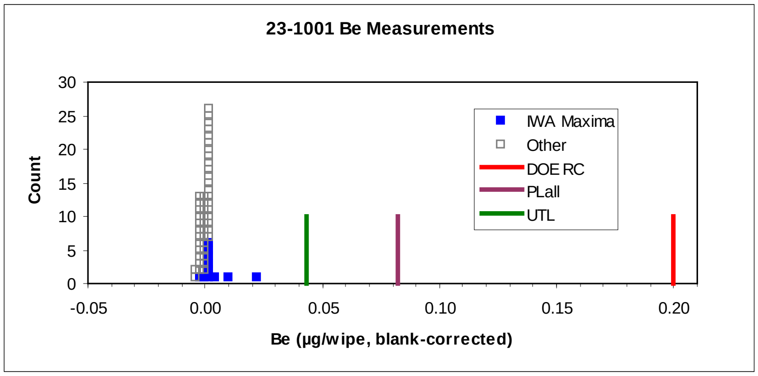
* Includes Room 124 storage areas



In some cases there is a small Area-like portion of a facility, such as a storage area, conference room, or classroom, which for convenience is simply divided into IWA-size portions and included with the IWAs.

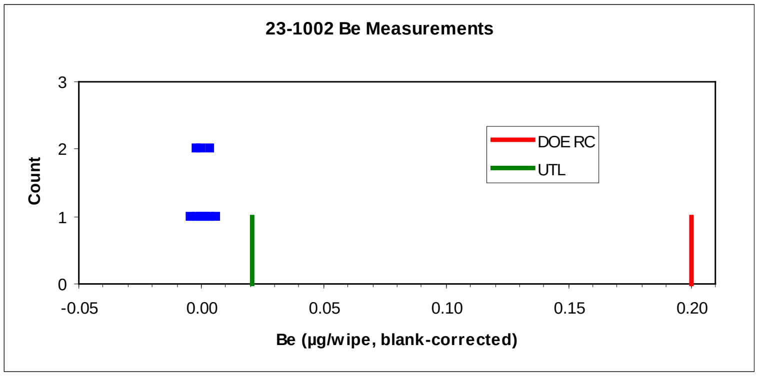
23-1001

23-1001	
IWAs	
Type	FO
N =	32
n =	11
BC(DC) =	0.0003
delta =	0.003
mean of ln(x+delta) =	-5.246
ln sd =	0.772
PL K =	3.602
PLall =	**0.082**
UTL K =	2.815
UTL =	**0.043**
Alpha =	0.05
ProbPlot R =	0.963



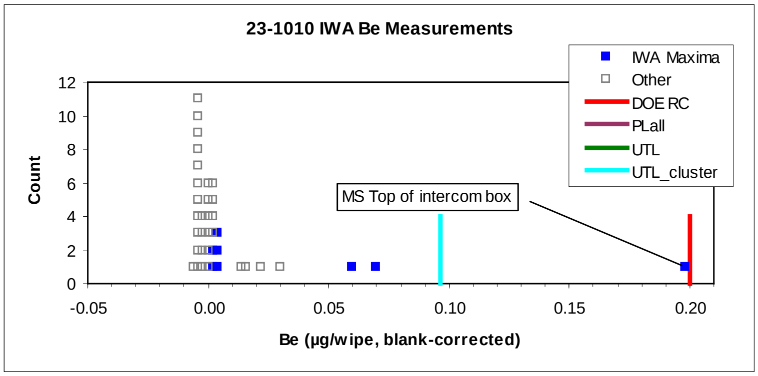
23-1002

23-1002	
Area	
Type	FO
n =	10
BC(BNadj) =	-0.0062
delta =	0.0080
mean of ln(x+delta) =	-4.806
ln sd =	0.414
UTL K =	3.031
UTL =	**0.021**
Alpha =	0.05
ProbPlot R =	0.974



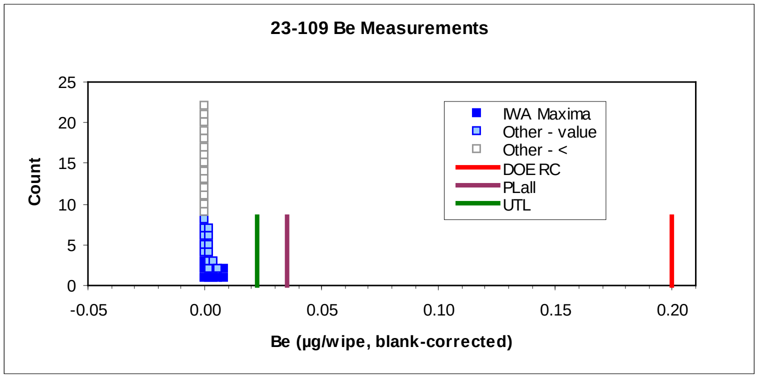
23-1010

23-1010	
IWAs	
Type	SH
N =	16
n =	8
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.070
ln sd =	1.487
PL K =	3.374
PLall =	**2.578**
UTL K =	3.187
UTL =	**1.953**
Alpha =	0.05
ProbPlot R =	0.899
UTL cluster sampling analysis	
F =	2.79
delta =	0.0090
mean of ln(x+delta) =	-4.542
tau^2 =	0.259
sig^2 =	0.578
ln sd =	0.915
UTL K =	2.506
UTL =	**0.096**
Alpha =	0.05
ProbPlot R =	0.912



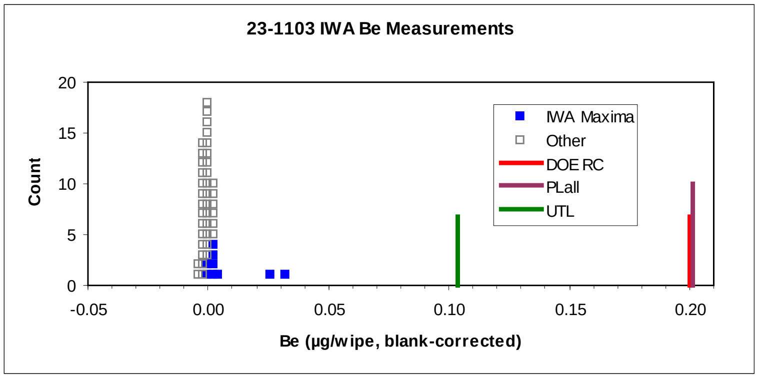
23-109

23-109	
IWAs	
Type	ST
N =	32
n =	9
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-5.144
ln sd =	0.486
PL K =	3.870
PLall =	**0.035**
UTL K =	3.031
UTL =	**0.022**
Alpha	0.05
ProbPlot R =	0.975



23-1103

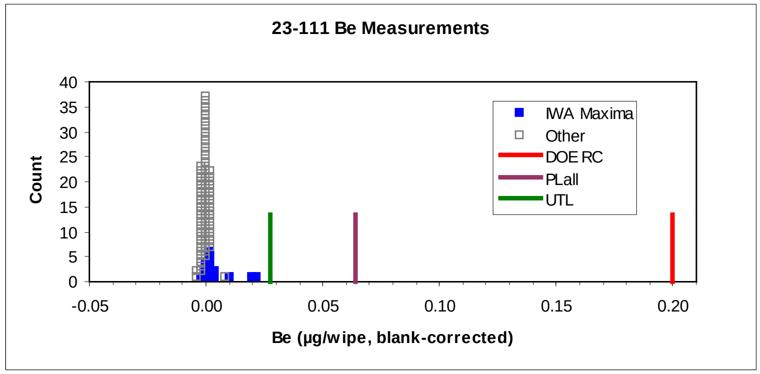
23-1103	
IWAs	
Type	FO
N =	28
n =	5
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.930
ln sd =	0.889
PL K =	3.760
PLall =	**0.201**
UTL K =	3.031
UTL =	**0.104**
Alpha =	0.05
ProbPlot R =	0.883



The low ProbPlot R is due to the two relatively isolated values.

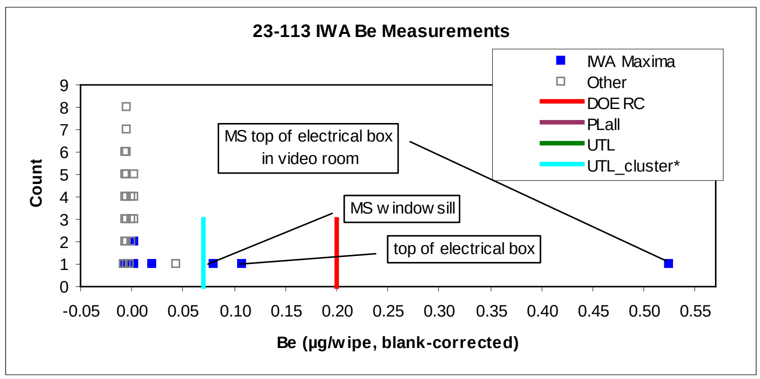
23-111

23-111	
	IWAs
N =	85
n =	16
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-4.859
ln sd =	0.567
PL K =	3.853
PLall =	**0.064**
UTL K =	2.524
UTL =	**0.027**
Alpha =	0.05
ProbPlot R =	0.921



23-113

23-113	
	IWAs
Type	OF
N =	23
n =	7
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.005
mean of ln(x+delta) =	-3.453
ln sd =	1.755
PL K =	3.811
PLall =	**36.665**
UTL K =	3.400
UTL =	**12.352**
Alpha =	0.05
ProbPlot R =	0.957
UTL cluster sampling omitting video room high value	
F =	0.97
delta =	0.0085
mean of ln(x+delta) =	-4.946
ln sd =	1.079
UTL K =	2.232
UTL =	**0.071**
ProbPlot R =	0.945

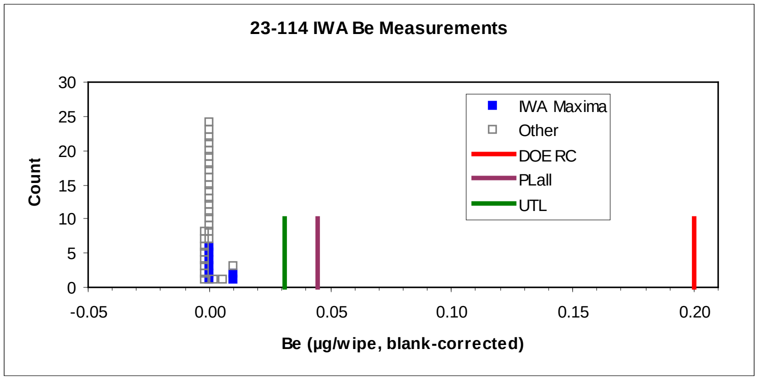


There is a very high value (MS_arch) on the top of an electrical power box in a video room that is rarely entered. Omitting that value, UTL_cluster = 0.071.

Be concentrations and metal ratios in two bulk samples obtained in that video room show relatively low Be concentrations compared with NTS soils.

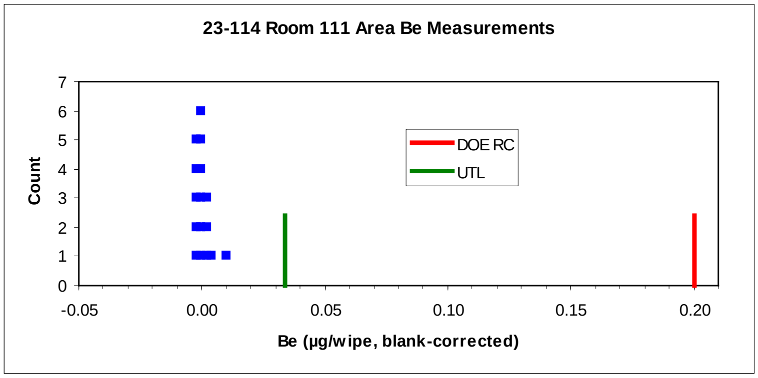
23-114

23-114	
IWAs	
Type	OF
N =	24
n =	8
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-4.967
ln sd =	0.492
PL K =	4.001
PLall =	**0.045**
UTL K =	3.331
UTL =	**0.031**
Alpha =	0.04
ProbPlot R =	0.857



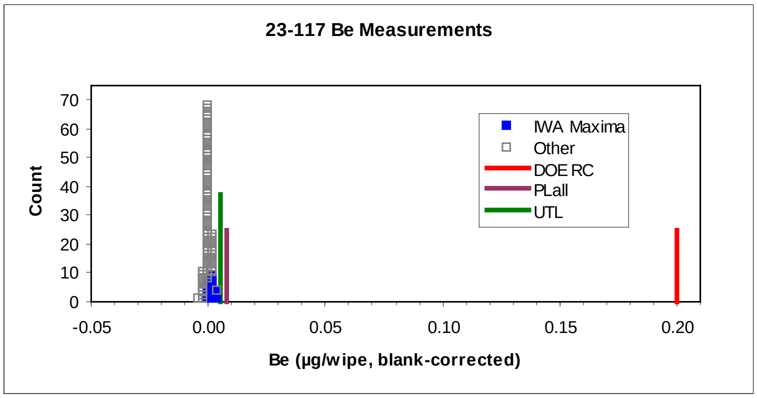
The relatively low ProbPlot R for IWAs reflects the curious data configuration of the IWA maxima. The values are all quite low, though, so there is no concern.

23-114	
Area	
Type	OF
n =	16
shift =	0.0003
delta =	0.0020
mean of ln(x+delta) =	-6.235
ln sd =	0.958
UTL K =	3.028
UTL =	**0.034**
Alpha =	0.01
ProbPlot R =	0.970



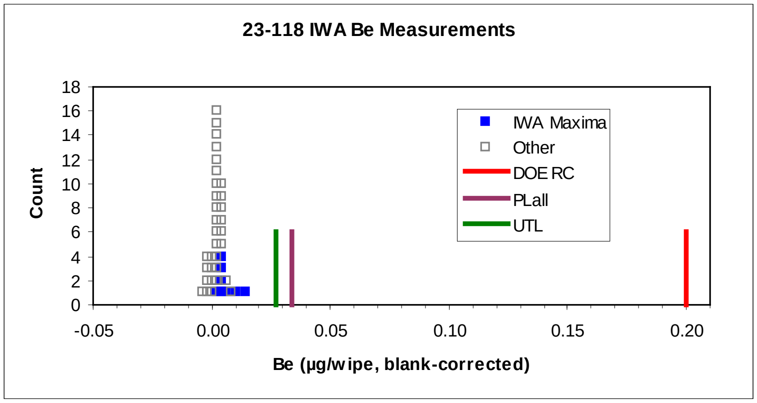
23-117

23-117	
IWAs	
Type	OF
N =	100
n =	19
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-5.073
ln sd =	0.191
PL K =	3.803
PLall =	**0.008**
UTL K =	2.423
UTL =	**0.005**
Alpha =	0.05
ProbPlot R =	0.983

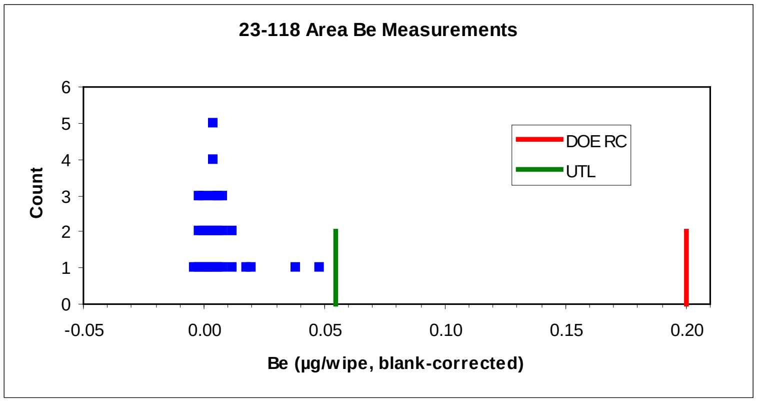


23-118

23-118	
IWAs	
Type	FO
N =	26
n =	9
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.739
ln sd =	0.370
PL K =	3.884
PLall =	**0.034**
UTL K =	3.331
UTL =	**0.027**
Alpha =	0.04
ProbPlot R =	0.949

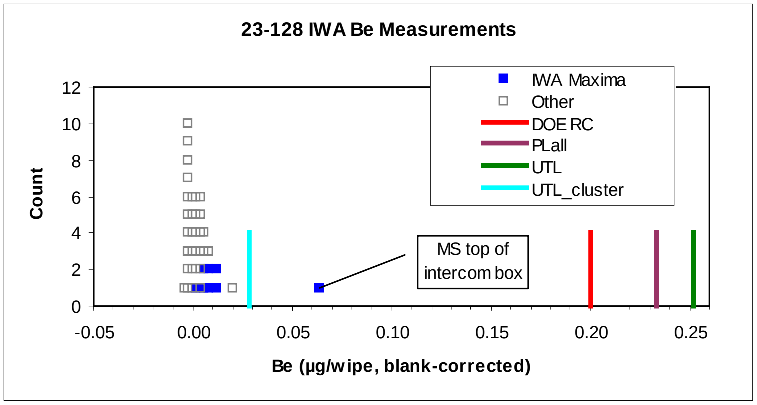


23-118	
Area	
Type	FO
n =	26
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0080
mean of ln(x+delta) =	-4.336
UTL K =	2.606
UTL =	**0.055**
Alpha =	0.01
ProbPlot R =	0.981



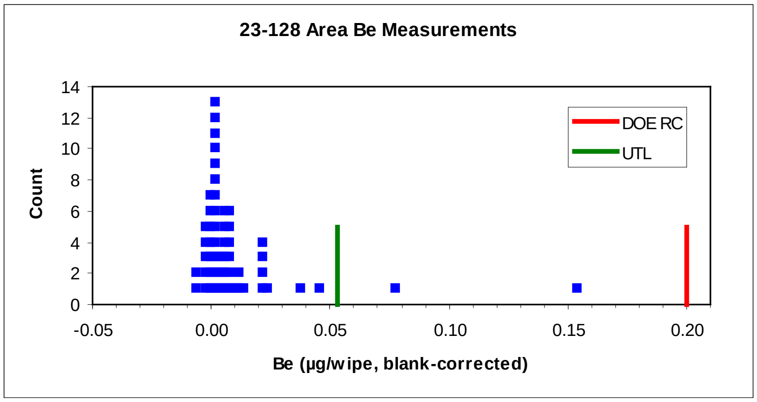
23-128

23-128	
IWAs	
Type	ST
N =	13
n =	8
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.268
ln sd =	0.871
PL K =	3.244
PLall =	**0.233**
UTL K =	3.331
UTL =	**0.252**
Alpha =	0.04
ProbPlot R =	0.958
UTL cluster sampling analysis	
F =	2.39
delta =	0.0090
mean of ln(x+delta) =	-4.421
tau^2 =	0.055
sig^2 =	0.199
ln sd =	0.504
UTL K =	2.687
UTL =	**0.038**
Alpha =	0.025
ProbPlot R =	0.929



The relatively high value (MS_arch) is in a difficult-to-reach location. This data value would be a candidate for omission; however, UTL_cluster which takes into account all data values, not just the IWA maxima, is less than the DOE RC.

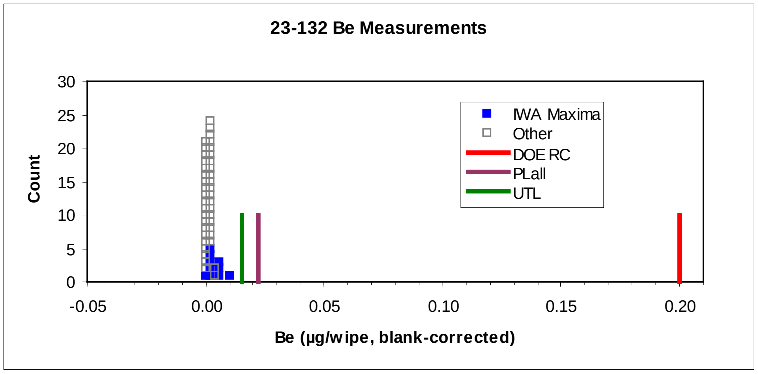
23-128	
Area	
Type	ST
n =	40
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-4.283
ln sd =	0.700
UTL K =	2.128
UTL =	**0.053**
Alpha =	0.025
ProbPlot R =	0.988



Also, four bulk samples were obtained inside this facility; the Be concentrations and metal ratios were consistent with NTS soils for all of these samples.

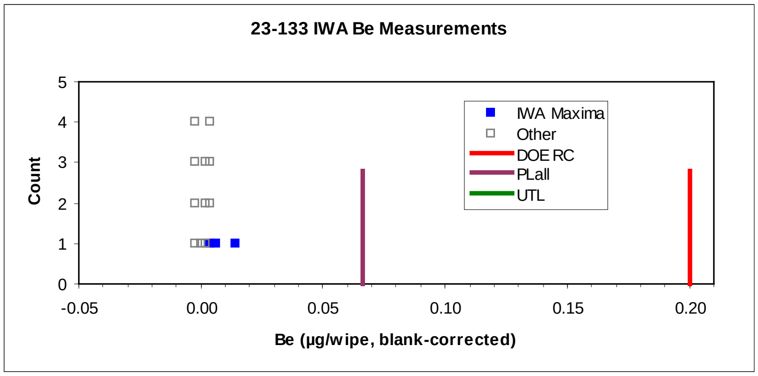
23-132

23-132	
IWAs	
Type	OF
N =	38
n =	10
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-4.782
ln sd =	0.307
PL K =	3.853
PLall =	**0.022**
UTL K =	2.911
UTL =	**0.016**
Alpha =	0.05
ProbPlot R =	0.962

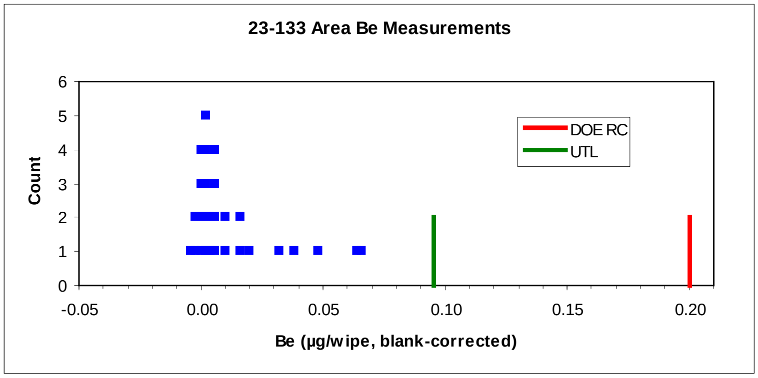


23-133

23-133	
IWAs	
Type	ST
N =	4
n =	3
BC(BNadj) =	-0.0062
BC(MS) =	0.0004
delta =	0.003
mean of ln(x+delta) =	-4.639
ln sd =	0.514
PL K =	3.833
PLall =	**0.066**
UTL K =	8.591
UTL =	**0.795**
Alpha =	0.04
ProbPlot R =	0.987

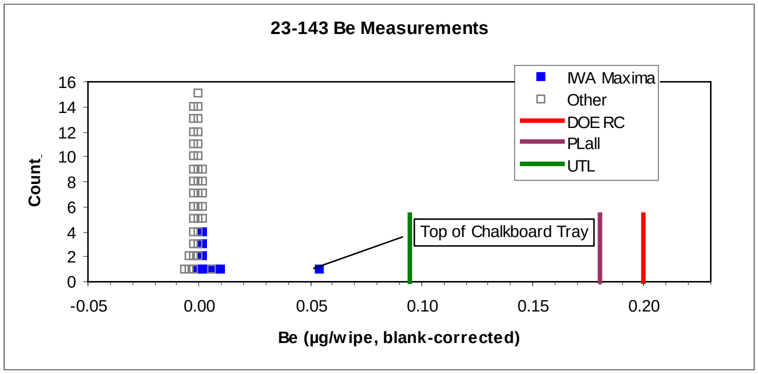


23-133	
Area	
Type	ST
n =	28
BC(BNadj) =	-0.0062
BC(MS) =	0.0004
delta =	0.008
mean of ln(x+delta) =	-4.186
ln sd =	0.750
UTL K =	2.558
UTL =	**0.095**
Alpha =	0.01
ProbPlot R =	0.962



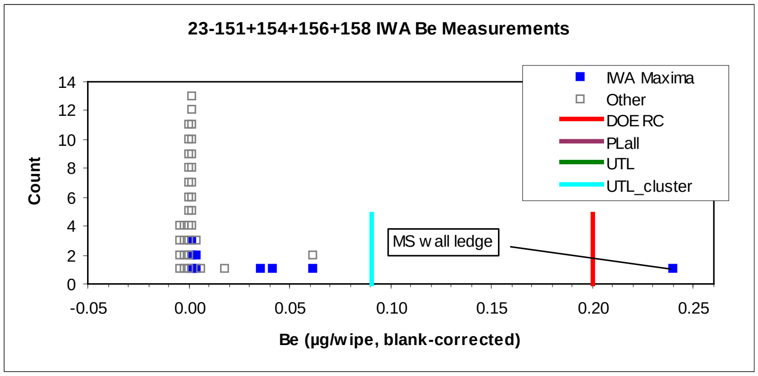
23-143

23-143	
	IWAs
Type	OF
N =	31
n =	9
BC(BNadj) =	-0.0062
delta =	0.0050
mean of ln(x+delta) =	-4.603
ln sd =	0.759
PL K =	3.845
PLall =	**0.180**
UTL K =	3.031
UTL =	**0.095**
Alpha =	0.05
ProbPlot R =	0.886



23-151 & 154 & 156 & 158

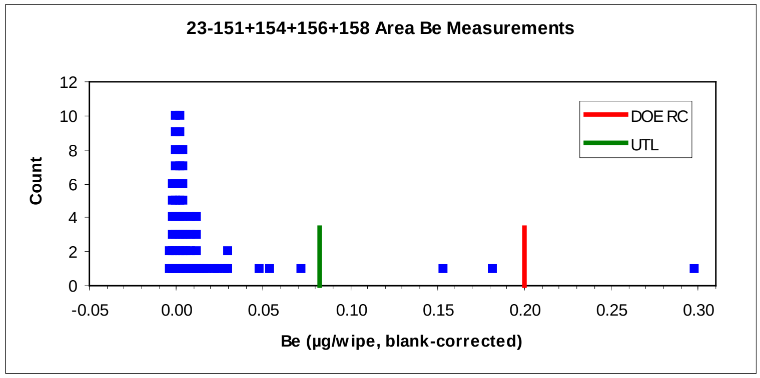
23-151+154+156+158	
	IWAs
Type	ST
N =	22
n =	9
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.017
ln sd =	1.421
PL K =	3.708
PLall =	**3.495**
UTL K =	3.156
UTL =	**1.594**
Alpha =	0.04
ProbPlot R =	0.918
UTL cluster sampling analysis	
F =	2.38
delta =	0.0090
mean of ln(x+delta) =	-4.406
tau^2 =	0.168
sig^2 =	0.489
ln sd =	0.811
UTL K =	2.585
UTL =	**0.090**
Alpha =	0.025
ProbPlot R =	0.862



This facility is a group of connected buildings which serve as core storage at the NTS, treated as one facility for this survey.

There is one isolated MS_arch value on a wall ledge. Even including this value, UTL_cluster is well below the DOE RC.

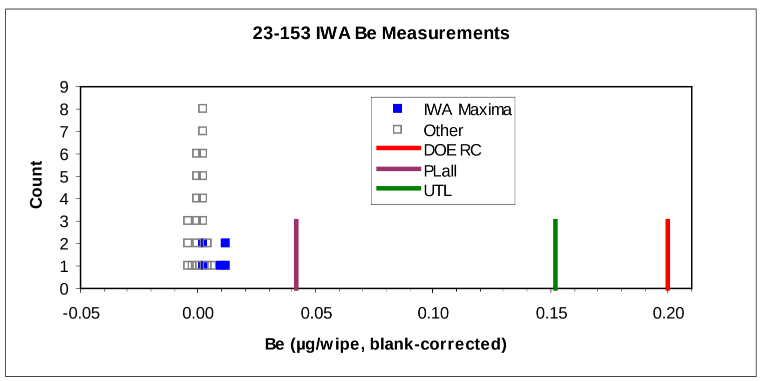
23-151+154+156+158	
Area	
Type	ST
n =	62
BC(BNadj) =	-0.0062
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-4.158
ln sd =	0.840
UTL K =	2.094
UTL =	**0.082**
Alpha =	0.025
ProbPlot R =	0.922



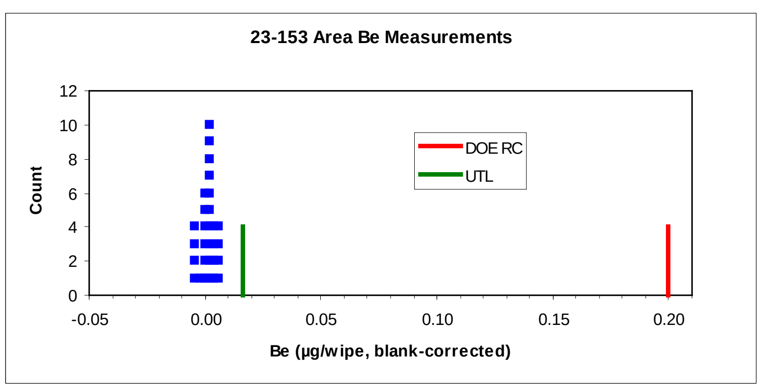
There is one MS_new value above the DOE RC. However, Be concentrations and metal ratios in six bulk samples obtained inside the facility are consistent with NTS soils, as are the metal ratios in the MS_new analysis of the wipe with high Be.

23-153

23-153	
IWAs	
Type	LA
N =	6
n =	5
BC(BNadj) =	0.0003
BC(DC) =	-0.0062
delta =	0.0020
mean of ln(x+delta) =	-4.809
ln sd =	0.655
PL K =	2.556
PLall =	**0.042**
UTL K =	4.485
UTL =	**0.152**
Alpha =	0.04
ProbPlot R =	0.967



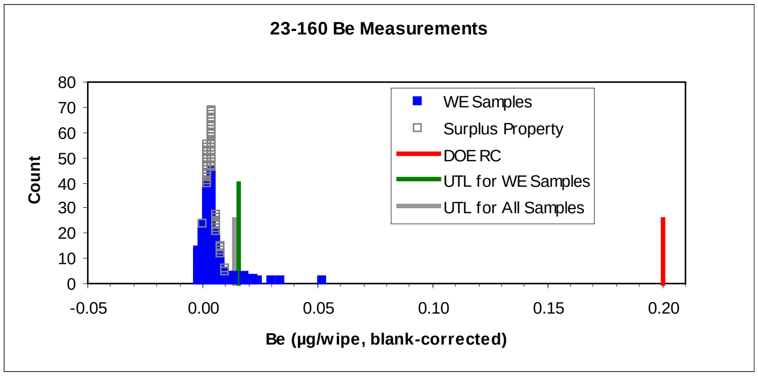
23-153	
Areas	
Type	LA
n =	29
BC(BNadj) =	0.0003
BC(DC) =	-0.0062
delta =	0.0070
mean of ln(x+delta) =	-4.866
ln sd =	0.434
UTL K =	2.536
UTL =	**0.016**
Alpha =	0.01
ProbPlot R =	0.954



23-160

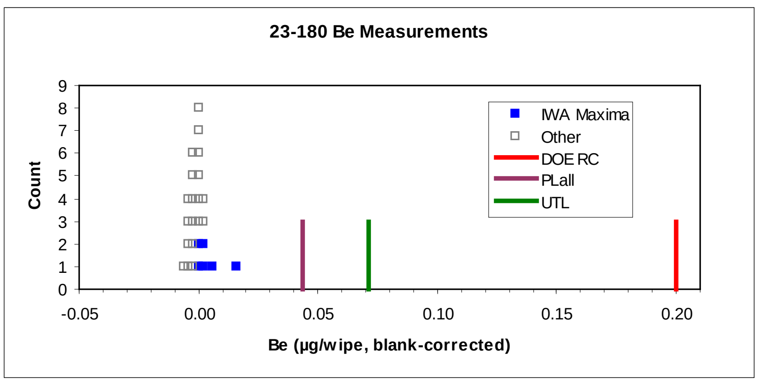
23-160			
Worker Environment		All Samples	
Type	ST		
n =	171	n =	225
BC(DC) =	0.0003	BC(DC) =	0.0003
delta =	0.0055	delta =	0.0055
mean of ln(x+delta) =	-4.697	mean of ln(x+delta) =	-4.692
ln sd =	0.452	ln sd =	0.406
UTL K =	1.848	UTL K =	1.821
UTL =	**0.016**	**UTL =**	**0.014**
Alpha =	0.05	Alpha =	0.05
ProbPlot R =	0.986	ProbPlot R =	0.980

This is the surplus property warehouse in Mercury. Systematic sampling was conducted of the worker environment; in addition, samples were taken from specific designated surplus property streams for another purpose. Analyses of the worker environment data or of the combined data come to the same conclusion.



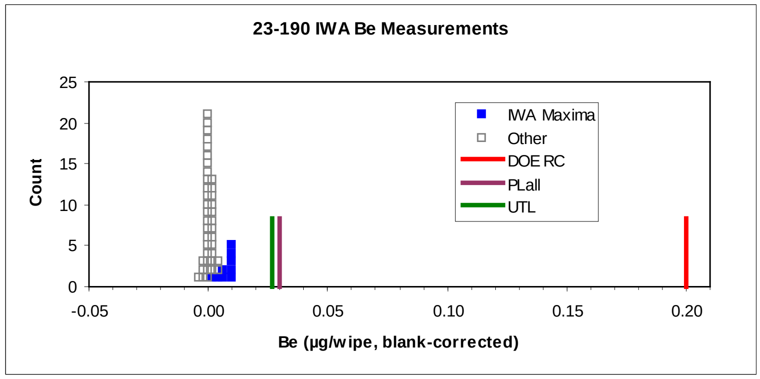
23-180

23-180	
IWAs	
Type	SH
N =	9
n =	6
BC(BNadj) =	-0.0062
delta =	0.0030
mean of ln(x+delta) =	-5.171
ln sd =	0.692
PL K =	3.033
PLall =	**0.043**
UTL K =	3.708
UTL =	**0.071**
Alpha =	0.05
ProbPlot R =	0.925

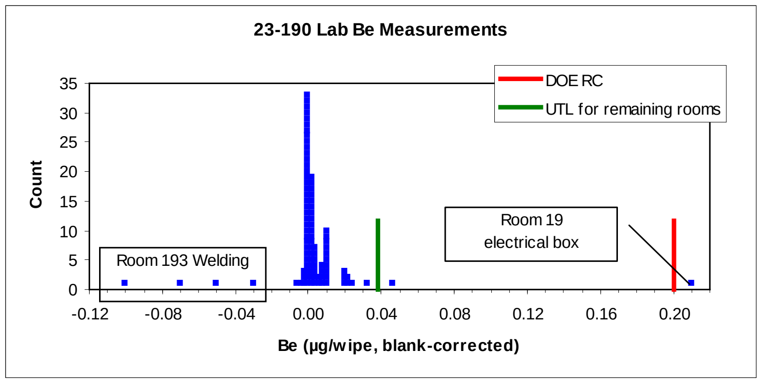


23-190

23-190	
IWAs	
Type	FO
N =	19
n =	9
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-4.364
ln sd =	0.267
PL K =	3.549
PLall =	**0.030**
UTL K =	3.156
UTL =	**0.027**
Alpha =	0.04
ProbPlot R =	0.961



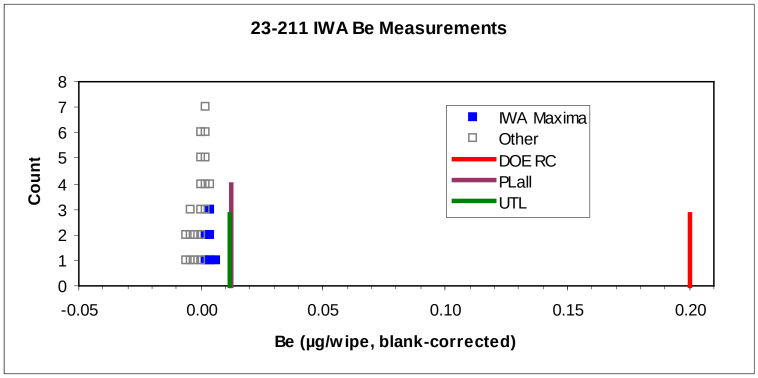
23-190	
Labs	
Type	FO
n =	93
NPUTL =	**0.210**
Excluding Rooms 19, 193	
n =	82
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.775
ln sd =	0.776
UTL K =	2.107
UTL =	**0.038**
Alpha =	0.01
ProbPlot R =	0.942



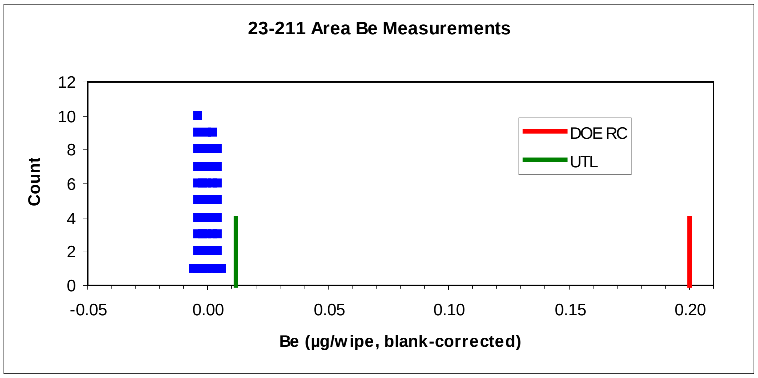
This facility contains offices and various geotechnical laboratories. Lab Room 19, used for cutting soil cores, has a value (DC) above the DOE RC. Room 193 is a welding shop. Four of five measurements obtained there were extremely negative. These two rooms are omitted from the statistical analysis presented above. They were resampled during January 2009, with 2 of 12 wipe values exceeding the DOE RC (one in each room). However, the Be concentrations and metal ratios in all four bulk samples were consistent with those of NTS soils, as were the metal ratios in the two high wipe samples.

23-211

23-211	
IWAs	
Type	FO
N =	14
n =	6
BC(BNadj) =	-0.0062
BC(MS) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-5.051
ln sd =	0.217
PL K =	4.039
PLall =	**0.012**
UTL K =	3.918
UTL =	**0.012**
Alpha =	0.04
ProbPlot R =	0.977

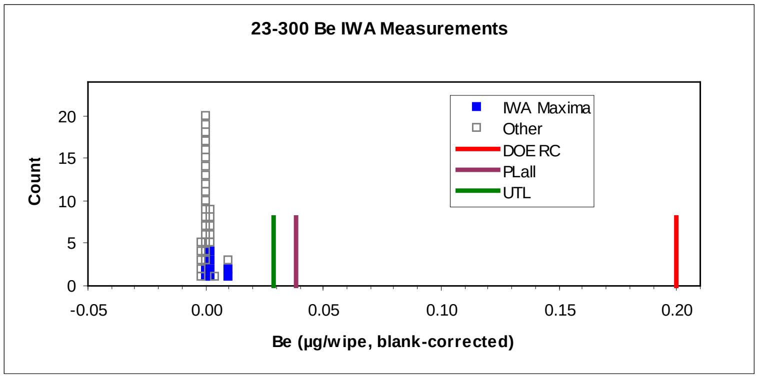


23-211	
Area	
Type	FO
n =	46
BC(BNadj) =	-0.0062
BC(MS) =	0.0004
delta =	0.0080
mean of ln(x+delta) =	-4.937
ln sd =	0.440
UTL K =	2.303
UTL =	**0.012**
Alpha =	0.01
ProbPlot R =	0.970

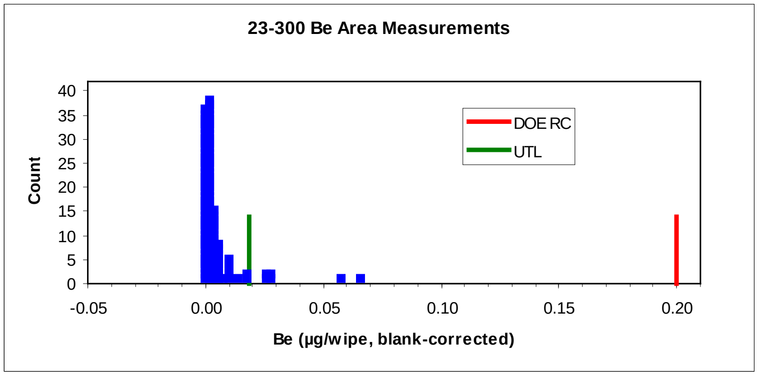


23-300

23-300	
IWAs	
Type	QU
N =	22
n =	8
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-4.846
ln sd =	0.436
PL K =	3.916
PLall =	**0.038**
UTL K =	3.331
UTL =	**0.029**
Alpha =	0.04
ProbPlot R =	0.934

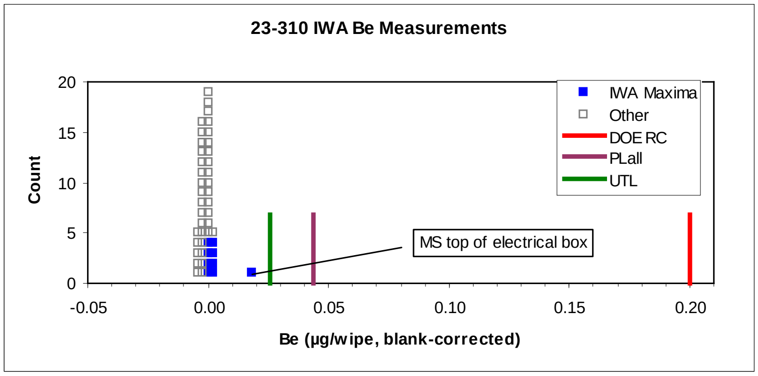


23-300	
Areas	
Type	QU
n =	112
shift =	0.0003
delta =	0.0020
mean of ln(x+delta) =	-5.433
ln sd =	0.765
UTL K =	2.030
UTL =	**0.019**
Alpha =	0.01
ProbPlot R =	0.944



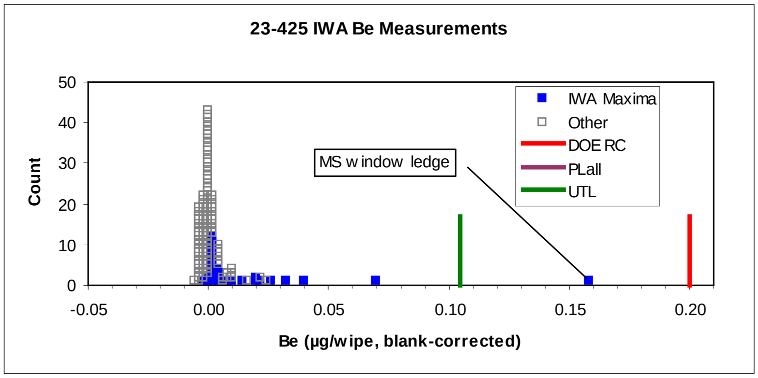
23-310

23-310	
IWAs	
Type	OF
N =	33
n =	9
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0040
mean of ln(x+delta) =	-5.169
ln sd =	0.546
PL K =	3.894
PLall =	**0.044**
UTL K =	3.031
UTL =	**0.026**
Alpha =	0.05
ProbPlot R =	0.833



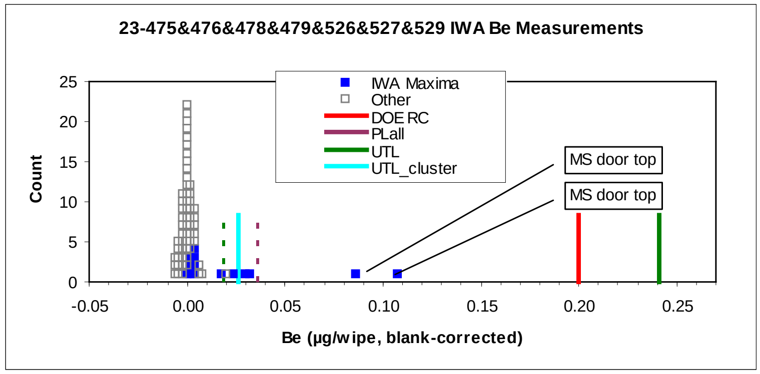
23-425

23-425	
IWAs	
Type	FO
N =	50
n =	30
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.600
ln sd =	1.067
PL K =	3.055
PLall =	**0.259**
UTL K =	2.220
UTL =	**0.104**
Alpha =	0.05
ProbPlot R =	0.978



23-475 & 476 & 478 & 479 & 526 & 527 & 529

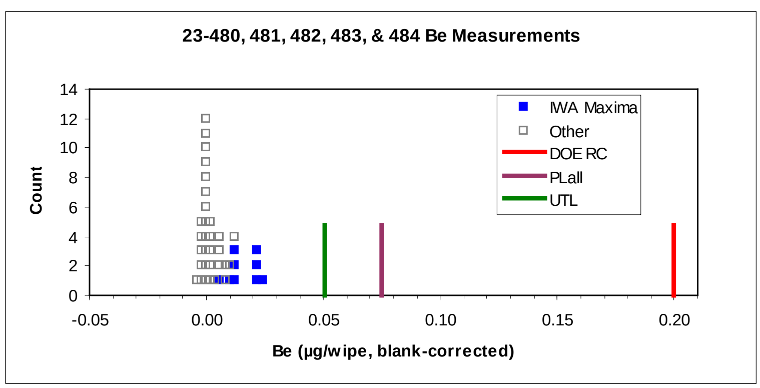
23-475 etc.	
IWAs	
Type	QU
N =	87
n =	14
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.004
mean of ln(x+delta) =	-4.200
ln sd =	1.069
PL K =	3.985
PLall =	**1.057**
UTL K =	2.614
UTL =	**0.241**
Alpha =	0.05
ProbPlot R =	0.931
omitting door tops	
mean of ln(x+delta) =	-4.845
ln sd =	0.409
PLall =	**0.036**
UTL =	**0.019**
ProbPlot R =	0.930
UTL cluster sampling analysis	
F =	0.87
delta =	0.0085
mean of ln(x+delta) =	-4.612
ln sd =	0.631
UTL K =	1.984
UTL =	**0.026**
ProbPlot R =	0.916



This facility is a group of adjacent dormitories with very similar attributes, treated as one unit for this survey. The two somewhat elevated MS_arch door top values push PLall and UTL over the DOE RC. When these are omitted, or when the UTL cluster analysis is performed, which uses all data rather than just the IWA maxima, the facility “passes.”

23-480 & 481 & 482 & 483 & 484

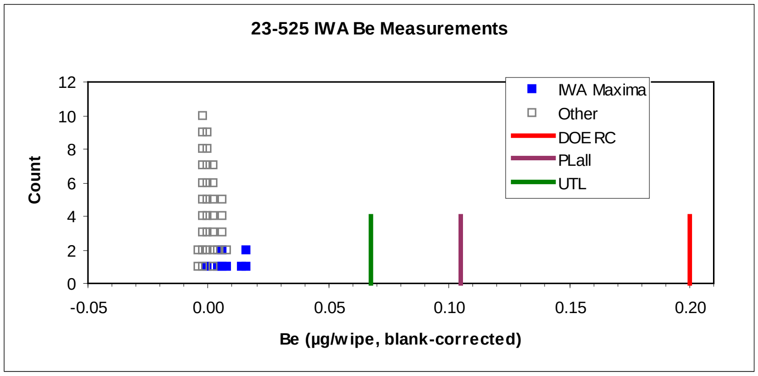
23-480 through 484	
IWAs	
Type	QU
N =	41
n =	9
BC(DC) =	0.0013
delta =	0.005
mean of ln(x+delta) =	-3.961
ln sd =	0.354
PL K =	4.057
PLall =	**0.075**
UTL K =	3.031
UTL =	**0.051**
Alpha =	0.05
ProbPlot R =	0.961



This facility consists of four contiguous dormitories and their associated dayroom.

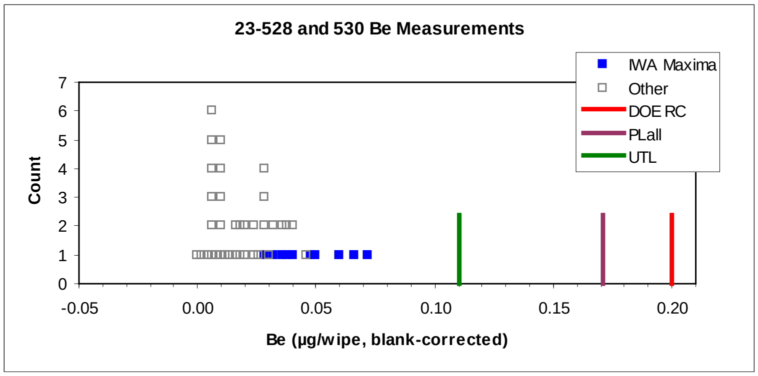
23-525

23-525	
IWAs	
Type	OF
N =	27
n =	8
BC(BNadj) =	-0.0062
BC(MS) =	0.0004
delta =	0.0040
mean of ln(x+delta) =	-4.476
ln sd =	0.577
PL K =	3.917
PLall =	**0.105**
UTL K =	3.187
UTL =	**0.067**
Alpha =	0.05
ProbPlot R =	0.931



23-528 & 530

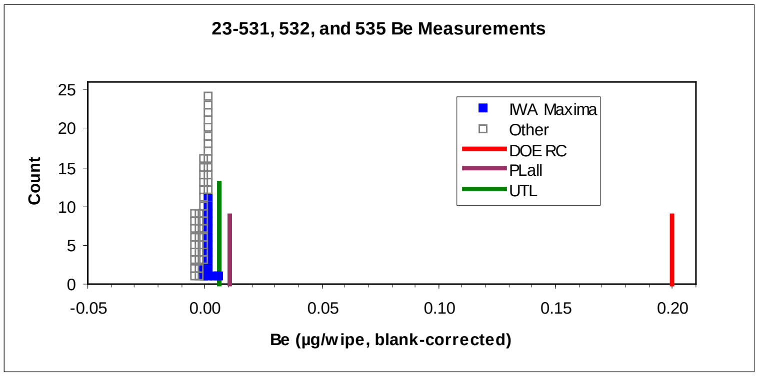
23-528 & 530	
IWAs	
Type	QU
N =	86
n =	10
BC(DC) =	0.0013
delta =	0.0050
mean of ln(x+delta) =	-3.002
ln sd =	0.289
PL K =	4.375
PLall =	**0.171**
UTL K =	2.911
UTL =	**0.110**
Alpha =	0.05
ProbPlot R =	0.988



This facility consists of two adjacent similar dormitories.

23-531 & 532 & 535

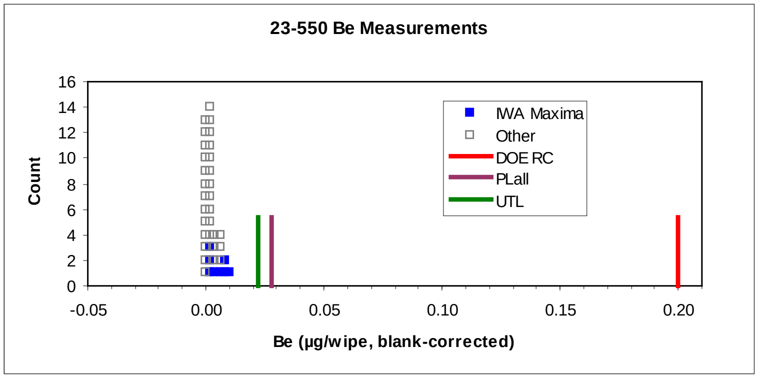
23-531 & 532 & 535	
IWAs	
Type	QU
N =	159
n =	15
BC(BNadj) =	-0.0062
delta =	0.0050
mean of ln(x+delta) =	-4.965
ln sd =	0.192
PL K =	4.218
PLall =	**0.011**
UTL K =	2.566
UTL =	**0.006**
Alpha =	0.05
ProbPlot R =	0.949



This facility consists of three adjacent similar dormitories.

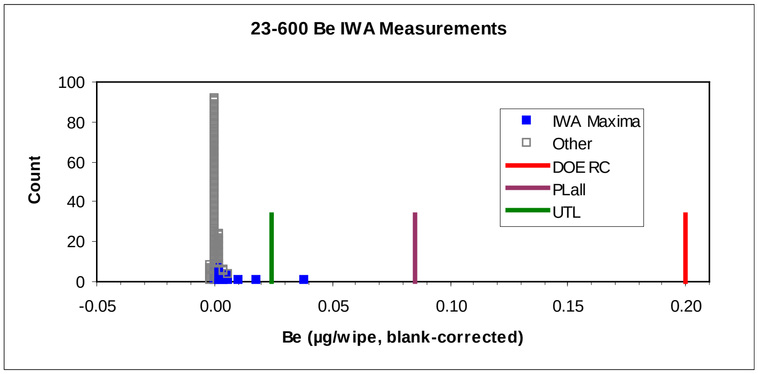
23-550

23-550	
IWAs	
Type	OF
N =	23
n =	8
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-4.675
ln sd =	0.336
PL K =	3.771
PLall =	**0.028**
UTL K =	3.187
UTL =	**0.022**
Alpha =	0.05
ProbPlot R =	0.967

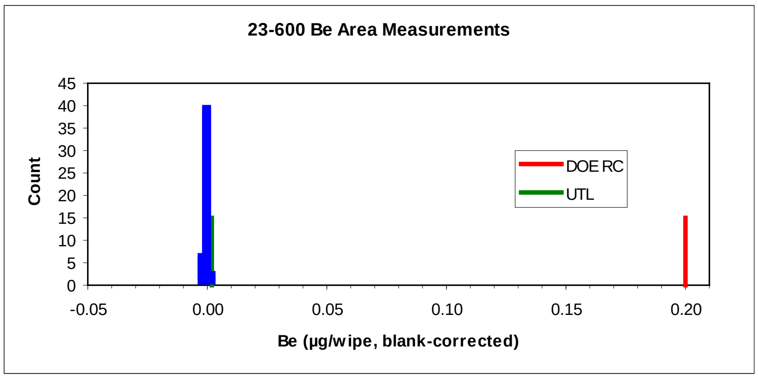


23-600

23-600	
IWAs	
Type	EX
N =	142
n =	27
BC(DC) =	0.0003
delta =	0.0020
mean of ln(x+delta) =	-5.449
ln sd =	0.782
PL K =	3.847
PLall =	**0.085**
UTL K =	2.307
UTL =	**0.024**
Alpha =	0.04
ProbPlot R =	0.968

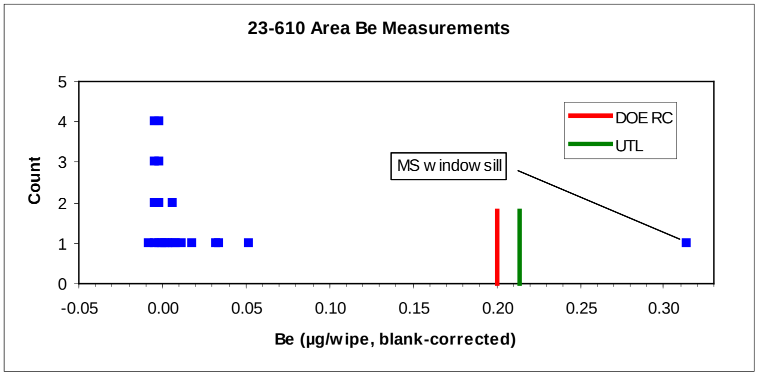


23-600	
Areas	
Type	EX
n =	47
shift =	0.0003
delta =	0.0070
mean of ln(x+delta) =	-5.035
ln sd =	0.122
UTL K =	2.294
UTL =	**0.002**
Alpha =	0.01
ProbPlot R =	0.945



23-610

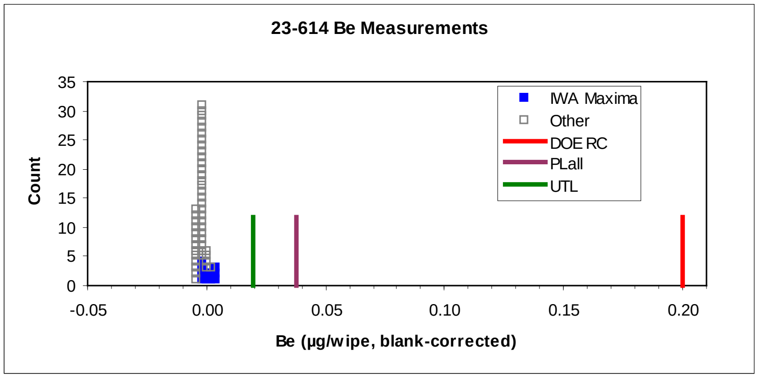
23-610	
	Area
Type	FO
n =	21
BC(BNadj) =	-0.0062
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-4.409
ln sd =	1.212
UTL K =	2.371
UTL =	**0.214**
Alpha =	0.05
ProbPlot R =	0.962
omitting windowsill	
n =	20
delta =	0.0085
mean of ln(x+delta) =	-4.573
ln sd =	0.976
UTL K =	2.396
UTL =	**0.106**
Alpha =	0.05
ProbPlot R =	0.976



There is one isolated MS_new value on a windowsill that is above the DOE RC; omitting that, UTL is less than the RC. The bulk sample Be is low and the metal ratios are consistent with NTS soils. The metal ratios for the high wipe are consistent with NTS soils except that Ni is reported as zero.

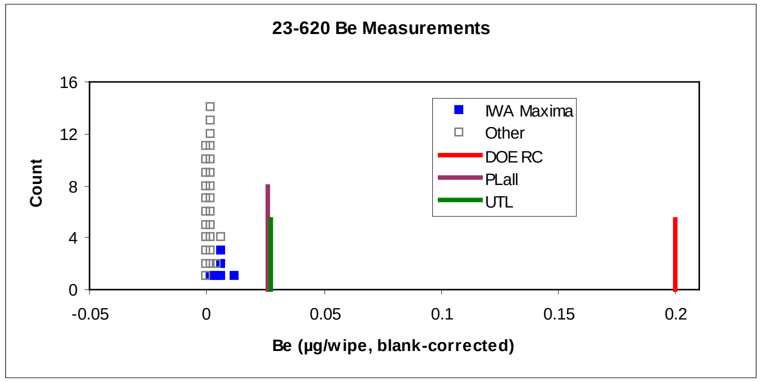
23-614

23-614	
	IWAs
Type	OF
N =	40
n =	11
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-5.312
ln sd =	0.574
PL K =	3.769
PLall =	**0.038**
UTL K =	2.815
UTL =	**0.020**
Alpha =	0.05
ProbPlot R =	0.968



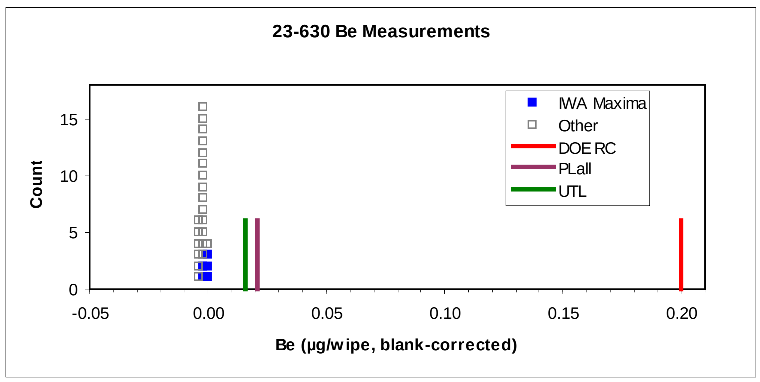
23-620

23-620	
IWAs	
Type	OF
N =	12
n =	6
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-4.552
ln sd =	0.299
PL K =	3.576
PLall =	**0.026**
UTL K =	3.708
UTL =	**0.027**
Alpha =	0.05
ProbPlot R =	0.978



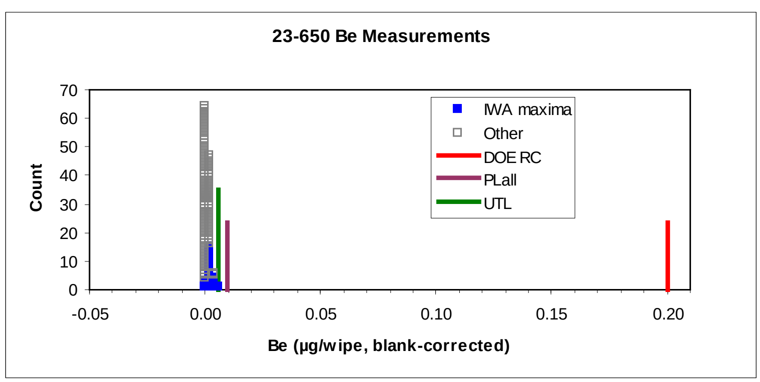
23-630

23-630	
IWAs	
Type	OF
N =	20
n =	5
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-5.505
ln sd =	0.388
PL K =	4.778
PLall =	**0.021**
UTL K =	4.203
UTL =	**0.016**
Alpha =	0.05
ProbPlot R =	0.959



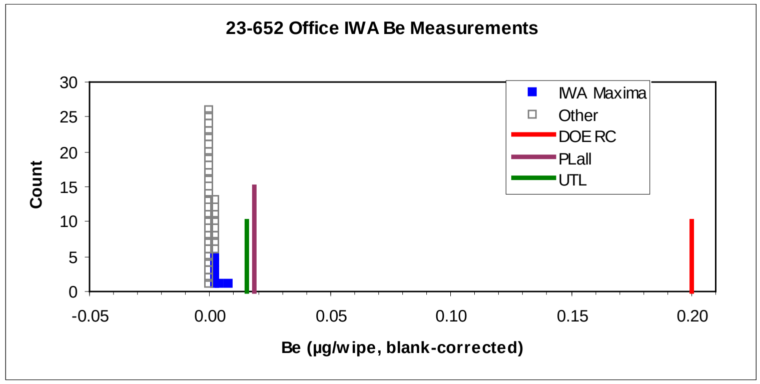
23-650

23-650	
IWAs	
Type	LA
N =	139
n =	23
BC(DC) =	0.0003
delta =	0.002
mean of ln(x+delta) =	-5.546
ln sd =	0.286
PL K =	3.833
PLall =	**0.010**
UTL K =	2.328
UTL =	**0.006**
Alpha =	0.05
ProbPlot R =	0.959



23-652

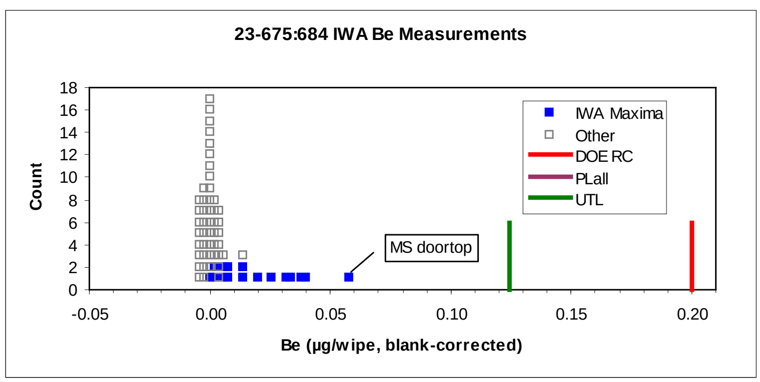
23-652	
Office IWAs	
Type	OF
N =	19
n =	7
BC(DC) =	-0.0062
delta =	0.0050
mean of ln(x+delta) =	-4.927
ln sd =	0.263
PL K =	4.495
PLall =	**0.019**
UTL K =	3.940
UTL =	**0.015**
Alpha =	0.025
ProbPlot R =	0.904



This facility consists of two distinct areas: offices and laboratories. With the initial sampling, the offices were fine, but the laboratory areas had a different and somewhat higher distribution of Be measurements. The lab IWAs were resampled so that wipes were taken from the dustiest corners in each designated lab IWA. The highest wipe obtained in the laboratories was 0.044 µg/wipe (DC).

23-675 & 676 & 678 & 679 & 680 & 681 & 683 & 684

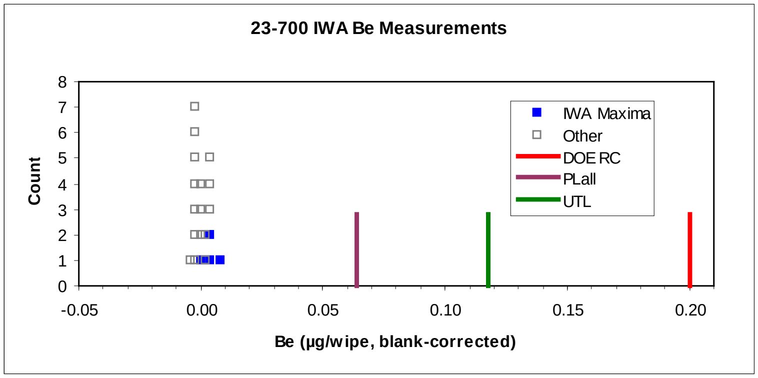
23-675+	
IWAs	
Type	QU
N =	96
n =	16
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0040
mean of ln(x+delta) =	-4.022
ln sd =	0.780
PL K =	3.916
PLall =	**0.375**
UTL K =	2.524
UTL =	**0.124**
Alpha =	0.05
ProbPlot R =	0.986



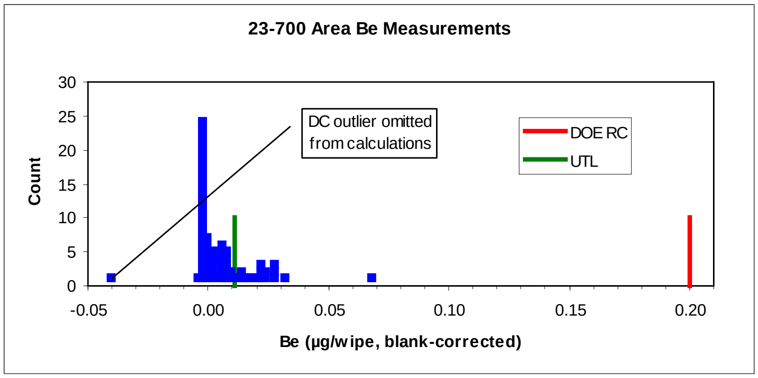
This facility consists of adjacent dormitories.

23-700

23-700	
IWAs	
Type	SH
N =	9
n =	4
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-5.101
ln sd =	0.536
PL K =	4.472
PLall =	**0.064**
UTL K =	5.580
UTL =	**0.118**
Alpha =	0.04
ProbPlot R =	0.960



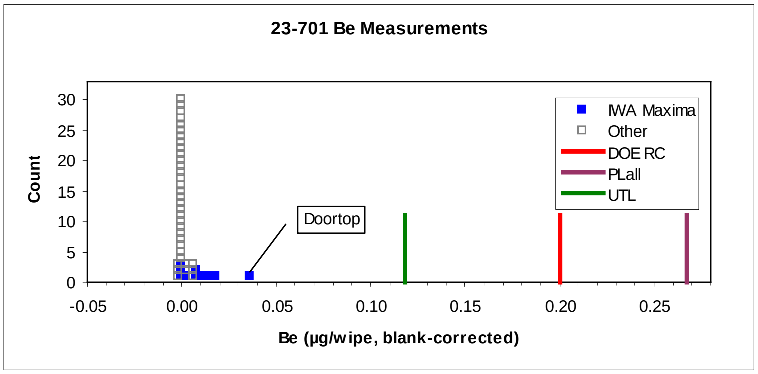
23-700	
Area	
Type	SH
n =	66
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0080
mean of ln(x+delta) =	-4.488
ln sd =	0.685
UTL K =	2.171
UTL =	**0.011**
Alpha =	0.01
ProbPlot R =	0.964



The extreme negative outlier in the shop Area was omitted from the UTL calculation.

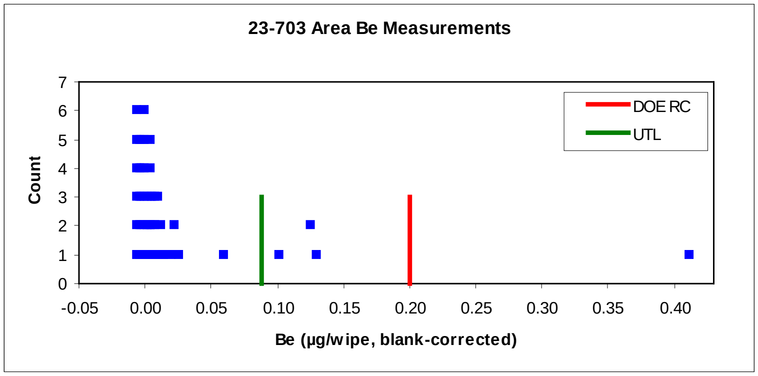
23-701

23-701	
IWAs	
Type	FO
N =	36
n =	10
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-4.712
ln sd =	0.893
PL K =	3.813
PLall =	**0.267**
UTL K =	2.911
UTL =	**0.118**
Alpha =	0.05
ProbPlot R =	0.959



23-703

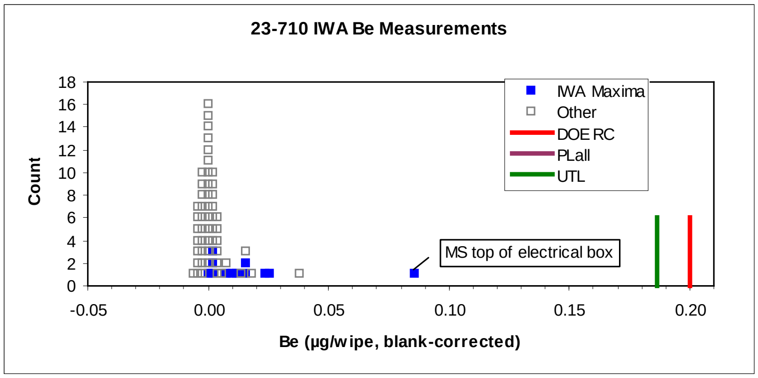
23-703	
Area	
Type	ST
n =	59
BC(BNadj) =	-0.0062
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-4.380
ln sd =	1.008
UTL K =	2.026
UTL =	**0.088**
Alpha =	0.05
ProbPlot R =	0.959



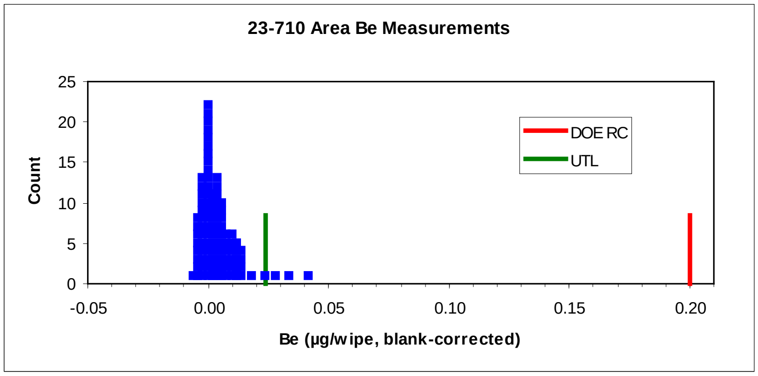
There is one wipe (MS_new) with Be greater than the DOE RC. The Be concentrations in three bulk samples obtained within the facility are low and their metal ratios are consistent with NTS soils. Be is somewhat elevated with respect to Y in the high wipe sample obtained on the floor, however.

23-710

23-710	
IWAs	
Type	SH
N =	41
n =	9
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.341
ln sd =	0.946
PL K =	3.829
PLall =	**0.485**
UTL K =	2.829
UTL =	**0.186**
Alpha =	0.04
ProbPlot R =	0.976

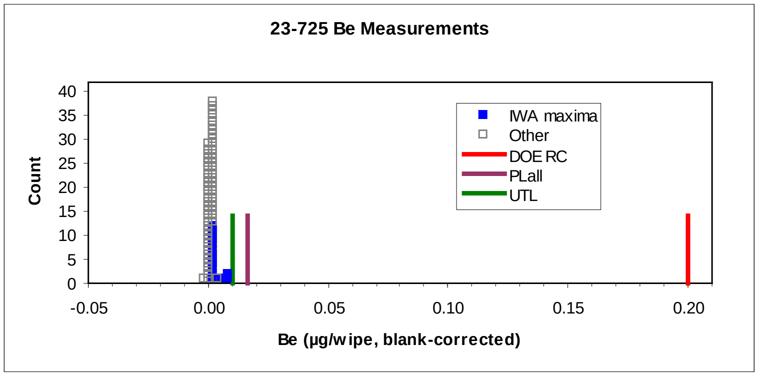


23-710	
Area	
Type	SH
n =	104
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0080
mean of ln(x+delta) =	-4.562
ln sd =	0.549
UTL K =	2.047
UTL =	**0.024**
Alpha =	0.01
ProbPlot R =	0.995



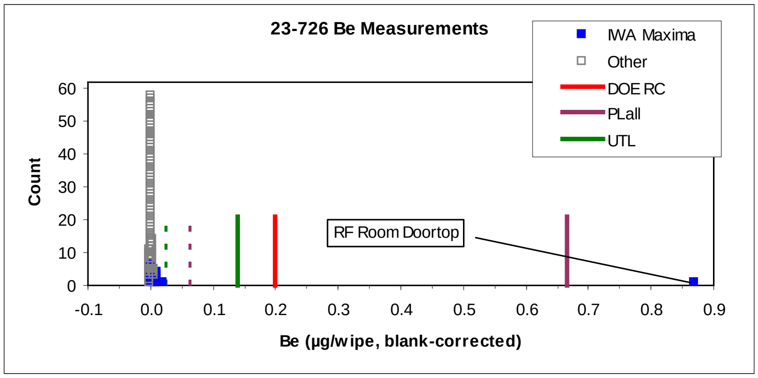
23-725

23-725	
IWAs	
Type	CO
N =	53
n =	15
BC(DC) =	0.0003
delta =	0.0020
mean of ln(x+delta) =	-5.476
ln sd =	0.412
PL K =	3.637
PLall =	**0.017**
UTL K =	2.566
UTL =	**0.010**
Alpha =	0.05
ProbPlot R =	0.862



23-726

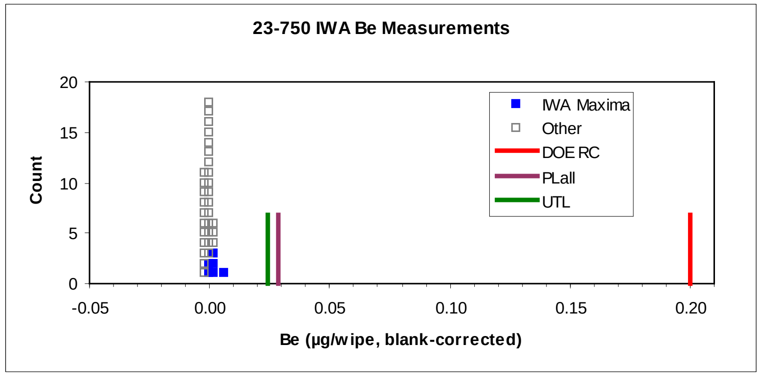
23-726	
IWA	
Type	CO
N =	72
n =	22
BC(DC) =	0.0003
delta =	0.0020
mean of ln(x+delta) =	-5.064
ln sd =	1.320
PL K =	3.530
PLall =	**0.665**
UTL K =	2.349
UTL =	**0.138**
Alpha =	0.05
ProbPlot R =	0.861
omitting RF-screened room door top	
mean of ln(x+delta) =	-5.305
ln sd =	0.729
PLall =	**0.063**
UTL =	**0.026**
Alpha =	0.05
ProbPlot R =	0.988



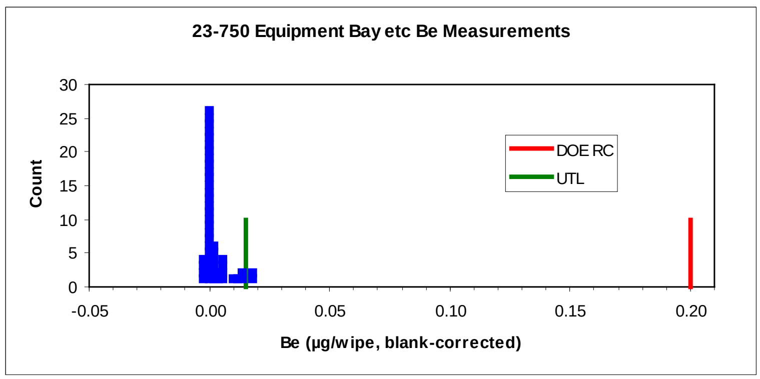
There is one anomalous value, obtained from a door top in the RF-screened room. This Be likely comes from a Be-Cu alloy used in the screening and, hence probably cannot be cleaned to the DOE RC reliably. It is suggested that the specific location be posted and potentially affected parties notified. Even with that value included, the UTL is below the DOE RC. With that value omitted, both the UTL and PLall are less than the RC.

23-750

23-750	
IWAs	
Type	SH
N =	16
n =	6
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-5.451
ln sd =	0.472
PL K =	4.217
PLall =	**0.028**
UTL K =	3.918
UTL =	**0.024**
Alpha =	0.04
ProbPlot R =	0.979

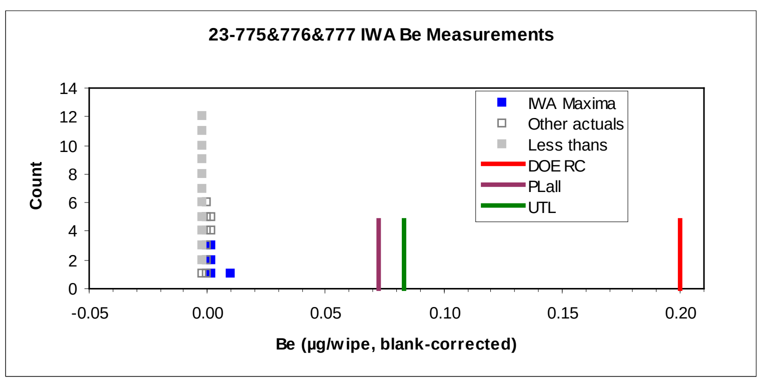


23-750	
Equipment bays etc	
Type	SH
n =	48
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.988
ln sd =	0.485
UTL K =	2.285
UTL =	**0.015**
Alpha =	0.01
ProbPlot R =	0.926



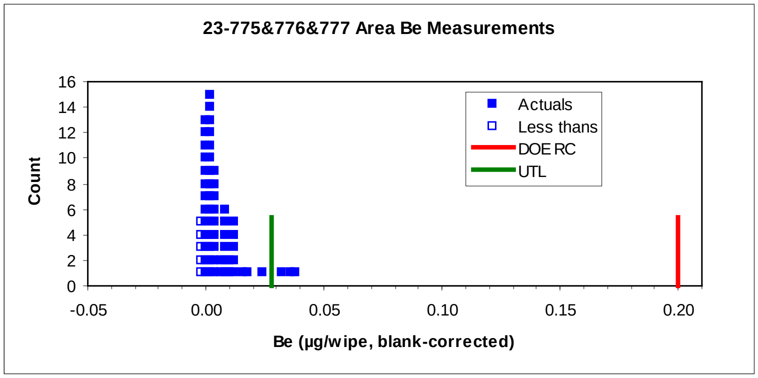
23-775 & 776 & 777

23-775 & 776 & 777	
IWAs	
Type	ST
N =	11
n =	4
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-5.088
ln sd =	0.473
PL K =	5.301
PLall =	**0.073**
UTL K =	5.580
UTL =	**0.083**
Alpha =	0.04
ProbPlot R =	0.928



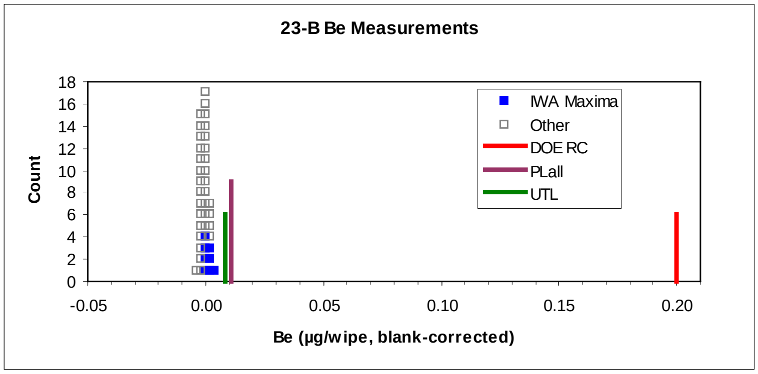
Some of the negative values in these early DC data were recorded only as “< 0”; hence censored-data UTL procedures were used.

23-775 & 776 & 777	
Warehouse areas	
n =	63
shift =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.726
ln sd =	0.587
UTL K =	2.261
UTL =	**0.028**
Alpha =	0.01
ProbPlot R =	0.946



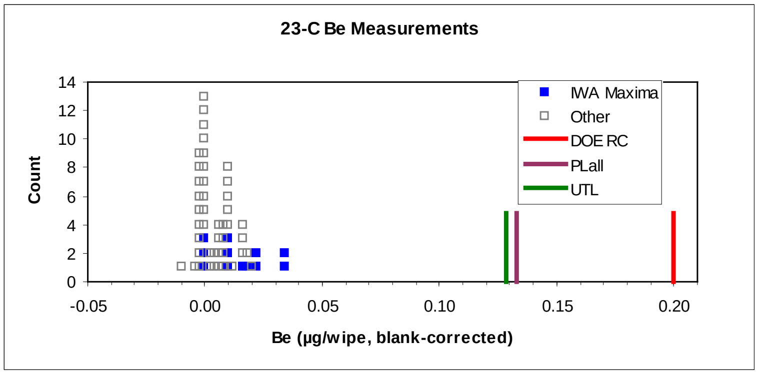
23-B

23-B	
IWAs	
Type	OF
N =	23
n =	8
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-5.110
ln sd =	0.254
PL K =	3.771
PLall =	**0.011**
UTL K =	3.187
UTL =	**0.009**
Alpha =	0.05
ProbPlot R =	0.968



23-C

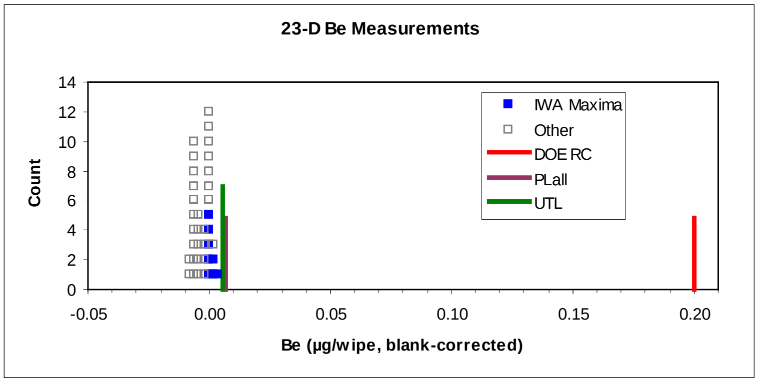
23-C	
IWAs	
Type	OF
N =	17
n =	12
BC(BNadj) =	-0.0062
BC(DC G) =	0.0013
BC(DC W) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-4.170
ln sd =	0.788
PL K =	2.775
PLall =	**0.133**
UTL K =	2.736
UTL =	**0.128**
Alpha =	0.05
ProbPlot R =	0.948



This facility did not pass using the PLall test with only n = 8 IWAs sampled, although none of the individual measurements exceeded the DOE RC. Four additional IWAs were subsequently sampled.

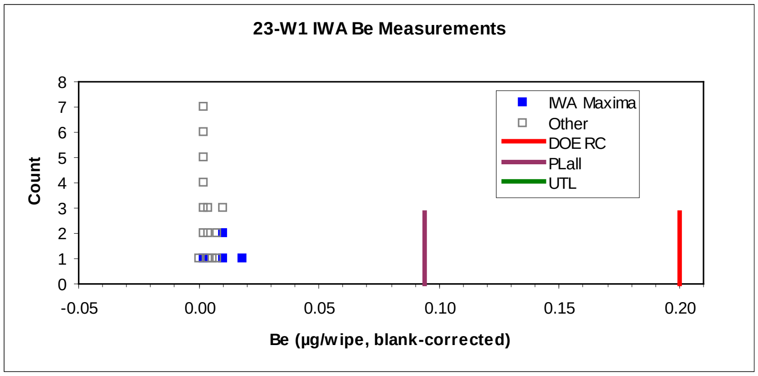
23-D

23-D	
IWAs	
N =	23
n =	8
BC (BNadj) =	-0.0062
delta =	0.0050
mean of ln(x+delta) =	-5.068
ln sd =	0.166
PL K =	3.771
PLall =	**0.007**
UTL K =	3.187
UTL =	**0.006**
Alpha =	0.05
ProbPlot R =	0.955

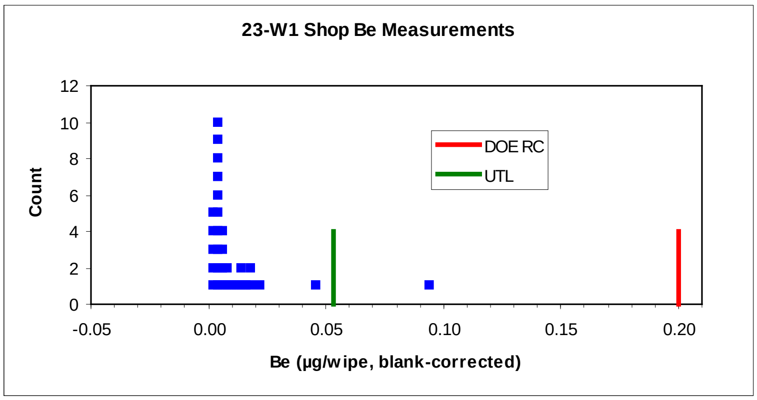


23-W1

23-W1	
IWAs	
Type	SH
N =	6
n =	4
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-4.444
ln sd =	0.567
PL K =	3.730
PLall =	**0.094**
UTL K =	5.580
UTL =	**0.274**
Alpha =	0.04
ProbPlot R =	0.967

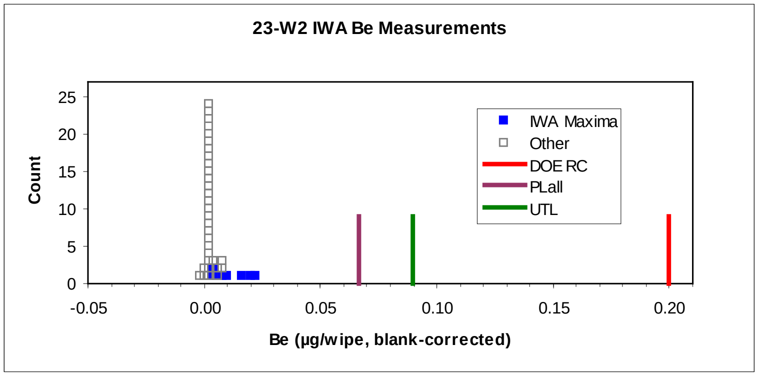


23-W1	
Shop areas	
Type	SH
n =	31
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.588
ln sd =	0.704
UTL K =	2.496
UTL =	**0.053**
Alpha =	0.01
ProbPlot R =	0.934

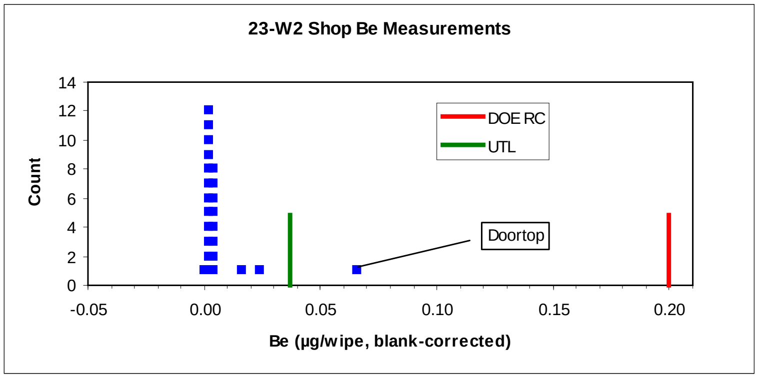


23-W2

23-W2	
IWAs	
Type	SH
N =	10
n =	7
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-4.317
ln sd =	0.542
PL K =	3.042
PLall =	**0.066**
UTL K =	3.569
UTL =	**0.089**
Alpha =	0.04
ProbPlot R =	0.976

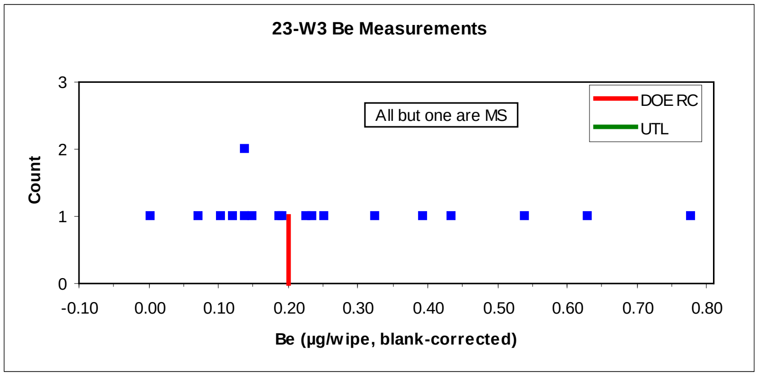


23-W2	
Shop areas	
Type	SH
n =	24
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.664
ln sd =	0.565
UTL K =	2.662
UTL =	**0.037**
Alpha =	0.01
ProbPlot R =	0.808



23-W3

23-W3	
Area	
Type	ST
n =	18
mean of ln(x+delta) =	-1.582
ln sd =	0.947
UTL K =	2.453
UTL =	**2.092**
Alpha =	0.05
ProbPlot R =	0.935

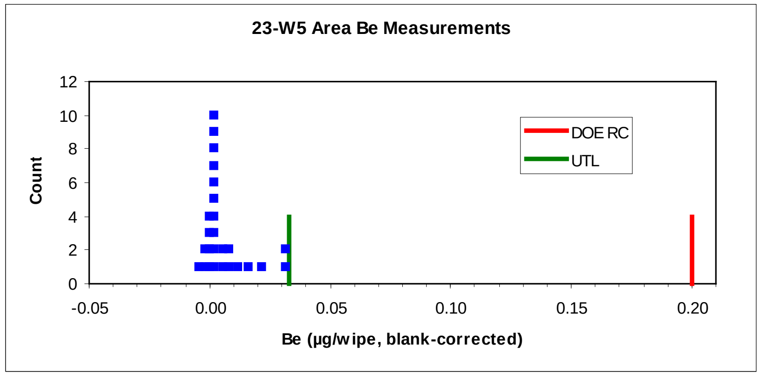


Nine of eighteen MS_arch data are above the DOE RC. This facility has been demolished.

23-W5

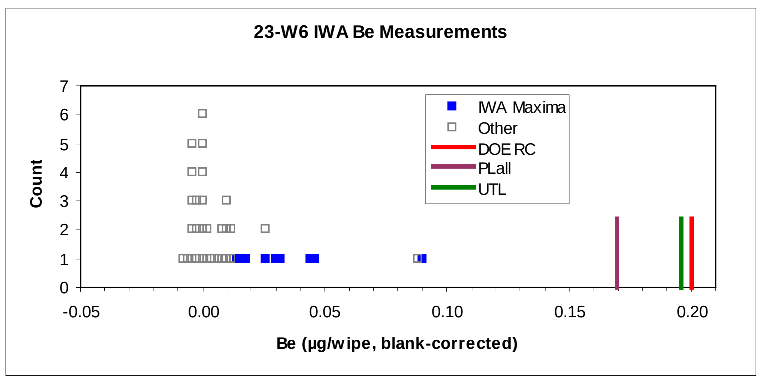
The one IWA was sampled; the maximum value was 0.030 µg/wipe.

23-W5	
Area	
Type	ST
n =	26
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0080
mean of ln(x+delta) =	-4.459
ln sd =	0.558
UTL K =	2.275
UTL =	**0.033**
Alpha =	0.05
ProbPlot R =	0.964



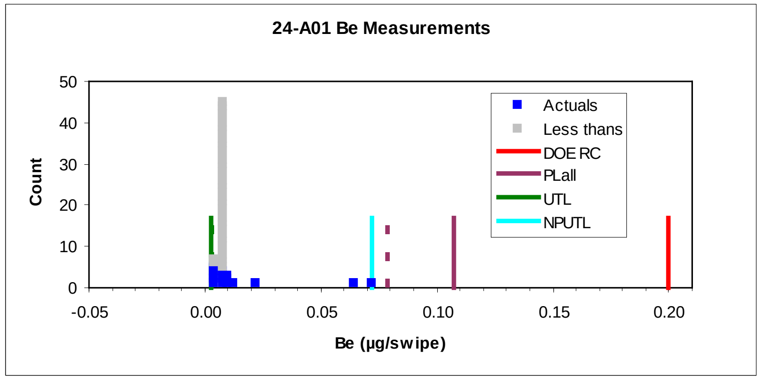
23-W6

23-W6	
IWAs	
Type	SH
N =	12
n =	8
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-3.343
ln sd =	0.542
PL K =	2.926
PLall =	**0.170**
UTL K =	3.187
UTL =	**0.196**
Alpha =	0.05
ProbPlot R =	0.980



24-A01

24-A01	
IWAs	
Type	OF
Conservative	
N =	140
n =	59
mean of ln(x+delta) =	-5.305
ln sd =	0.872
PL K =	3.526
PLall =	**0.107**
UTL K =	2.100
UTL =	**0.003**
NPUTL =	**0.072**
Alpha =	0.05
Alternate	
mean of ln(x+delta) =	-5.296
ln sd =	0.783
PLall =	**0.079**
UTL =	**0.003**
NPUTL =	**0.072**



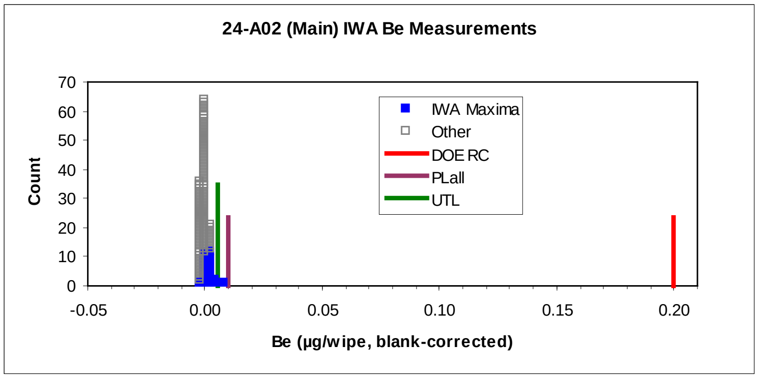
This facility had been abandoned before the Worker Environment Survey commenced. A sampling plan was developed following the principles set out in Appendix 1, and then old data were found to fit that plan as nearly as possible. These data came from variety of samplings and laboratories. Determining the maximum value for a given IWA was somewhat problematic because of differing reporting limits and the general unavailability of uncensored data. Two approaches were used. The conservative approach uses the highest value for any IWA, whether an actual value or a reporting limit. The alternate approach uses the highest actual value found, if any, and otherwise the highest reporting limit. Censored data maximum likelihood estimates are used as appropriate; this approach allows a variety of different reporting limits (see “Parametric 95%-95% Upper Tolerance Limits for Censored Lognormal Data,” C. B. Davis, presented at the Joint Statistical Meetings, Seattle, WA, 2006).

The NPUTL (nonparametric upper tolerance limit) is the largest of 59 observations. It is considerably above the UTL value, reflecting the fact that the two highest values are outliers. Only the IWA maxima are shown; the solid squares are actual values and the empty square are “less than” values, plotted at half their respective reporting limits. The UTL values are buried in the data in either case.

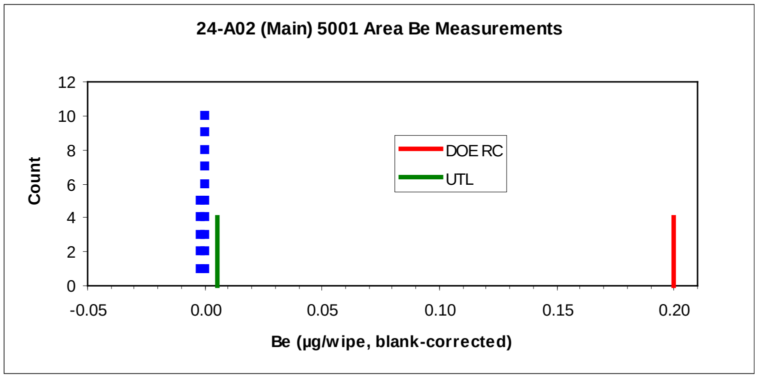
24-A02

Room 5082, the Readiness Warehouse located at the east end, is not accessible from the rest of the building and is only incidentally occupied. It is treated as a separate facility.

24-A02	
IWAs	
Type	OF
N =	95
n =	27
BC(DC) =	0.0003
delta =	0.005
mean of ln(x+delta) =	-5.136
ln sd =	0.259
PL K =	3.654
PLall =	**0.010**
UTL K =	2.307
UTL =	**0.006**
Alpha =	0.04
ProbPlot R =	0.974



24-A02	
5001 Area	
Type	ST
n =	15
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-5.416
ln sd =	0.279
UTL K =	3.102
UTL =	**0.005**
Alpha =	0.01
ProbPlot R =	0.956



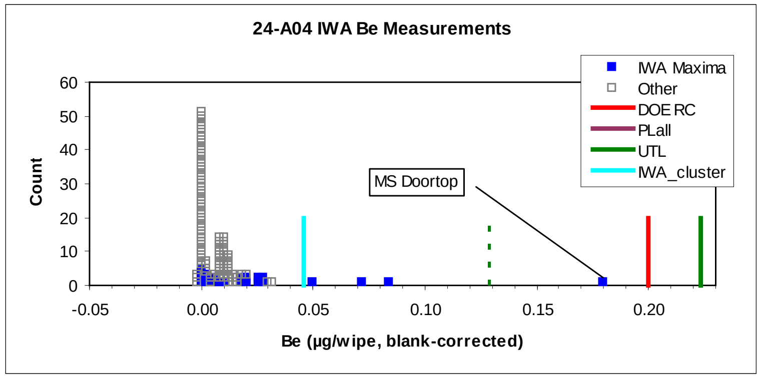
24-A02 Readiness Warehouse (Room 5082)

24-A02	
5082	
Type	ST
n =	62
BC(DC) =	0.0003
NPUTL =	**0.200**
Alpha =	0.042

The nonparametric UTL (NPUTL) is the largest observation with a total of 59 to 92 observations.

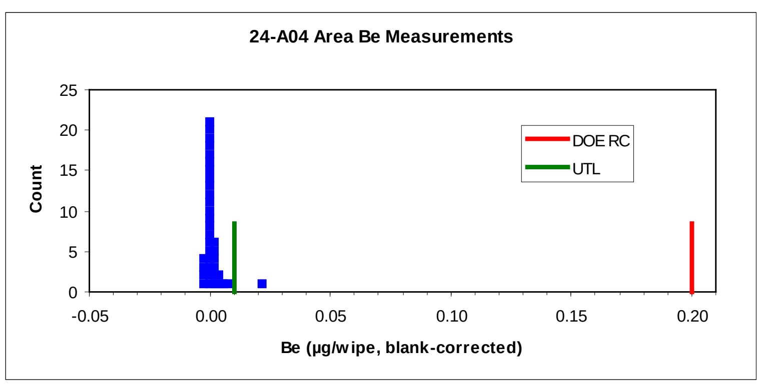
24-A04

24-A04	
IWAs	
Type	SH
N =	57
n =	24
BC(BNadj) =	-0.0062
BC(DC,Ghost) =	0.0013
BC(DC,Whatmann) =	0.0003
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.238
ln sd =	1.166
PL K =	3.426
PLall =	**0.782**
UTL K =	2.360
UTL =	**0.223**
Alpha =	0.04
ProbPlot R =	0.977
omitting 2 door tops	
mean of ln(x+delta) =	-4.365
ln sd =	0.991
PLall =	**0.377**
UTL =	**0.129**
ProbPlot R =	0.974
UTL cluster analysis	
F =	5.12
delta =	0.0090
mean of ln(x+delta) =	-4.248
tau^2 =	0.209
sig^2 =	0.203
ln sd =	0.641
UTL K =	2.086
UTL =	**0.046**
ProbPlot R =	0.928



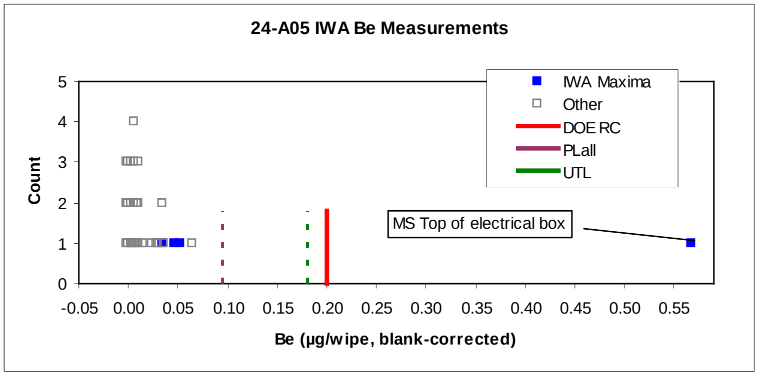
None of the data values exceed the DOE RC; there are a couple of high MS_arch values which push PLall and UTL up.

24-A04	
Area	
Type	SH
n =	36
BC(DC,Whatmann) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-5.117
ln sd =	0.396
UTL K =	2.415
UTL =	**0.010**
Alpha =	0.01
ProbPlot R =	0.914



24-A05

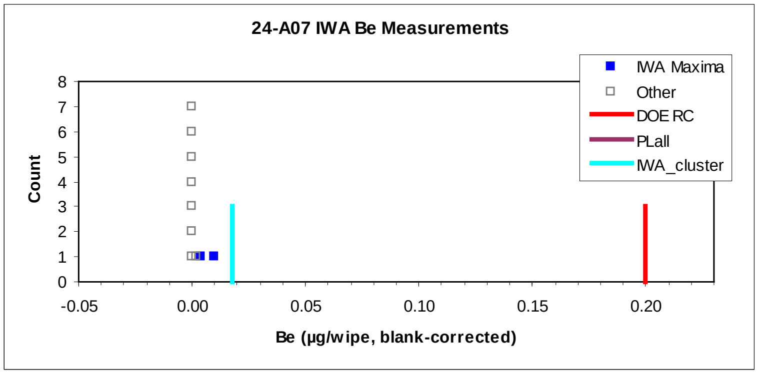
24-A05	
IWAs	
Type	ST
N =	5
n =	4
BC(BNadj) =	-0.0062
BC(DC) =	0.0003
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-2.445
ln sd =	1.266
PL K =	2.631
PLall =	**2.420**
UTL K =	5.144
UTL =	**58.284**
Alpha =	0.05
ProbPlot R =	0.865
omitting MS_arch on electrical box	
mean of ln(x+delta) =	-2.977
ln sd =	0.250
PLall =	**0.095**
UTL =	**0.181**
ProbPlot R =	0.994



The high value (MS_arch) is in a location not typically touched in normal work practice. The Be concentrations in the other wipes are far below the DOE RC.

24-A07

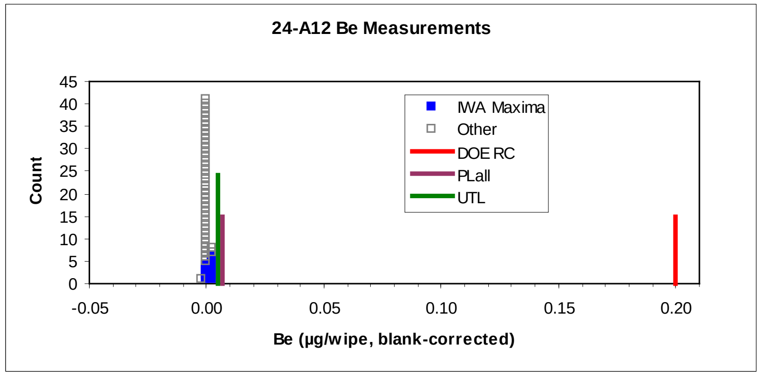
24-A07	
IWAs	
Type	FO
N =	3
n =	2
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-4.733
ln sd =	0.473
PL K =	7.733
PLall =	**0.342**
Alpha =	0.05
UTL cluster sampling analysis	
F =	0.45
delta =	0.0055
mean of ln(x+delta) =	-5.016
ln sd =	0.335
UTL K =	2.911
UTL =	**0.018**
ProbPlot R =	0.886



The PLall and UTL multipliers are quite high with very few IWAs sampled.

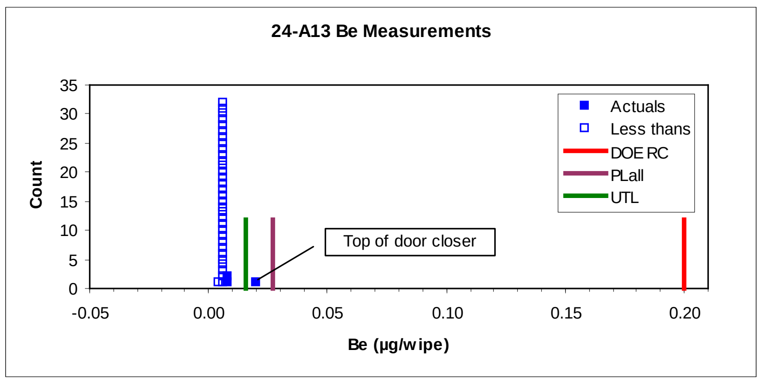
24-A12

24-A12	
IWAs	
Type	SH
N =	38
n =	10
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-5.425
ln sd =	0.209
PL K =	3.853
PLall =	**0.007**
UTL K =	2.911
UTL =	**0.005**
Alpha =	0.05
ProbPlot R =	0.995



24-A13

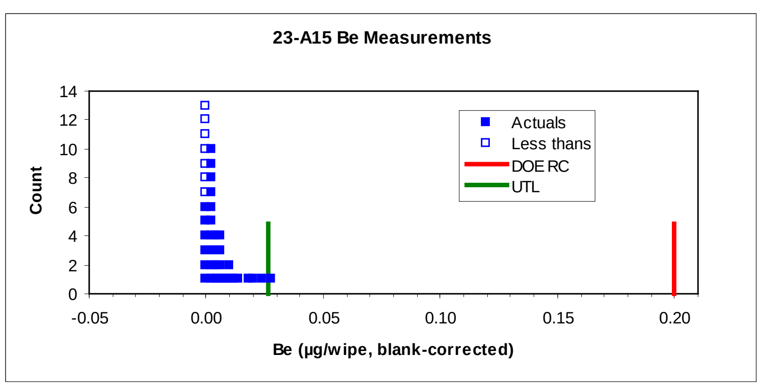
24-A13	
IWAs	
Type	OF
N =	~138
n =	36
BC =	0
delta =	0
mean of ln(x+delta) =	-5.010
ln sd =	0.391
PL K =	3.815
PLall =	**0.027**
UTL K =	2.158
UTL =	**0.016**
Alpha =	0.05



This facility was sampled prior to the organized Be sampling campaign. Available data are used to simulate a sampling plan that might have been used if the Appendix 1 principles had been followed. All data values are quite low; this substitution is quite reasonable.

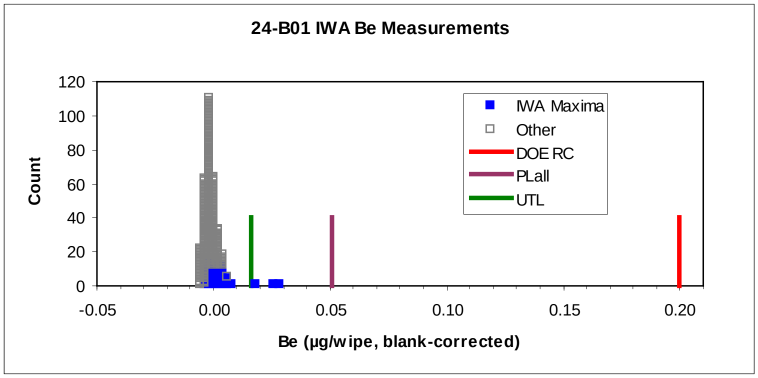
24-A15

24-A15	
Area	
Type	SH
n =	40
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.820
ln sd =	0.612
UTL K =	2.240
UTL =	**0.026**
Alpha =	0.05
ProbPlot R =	0.939



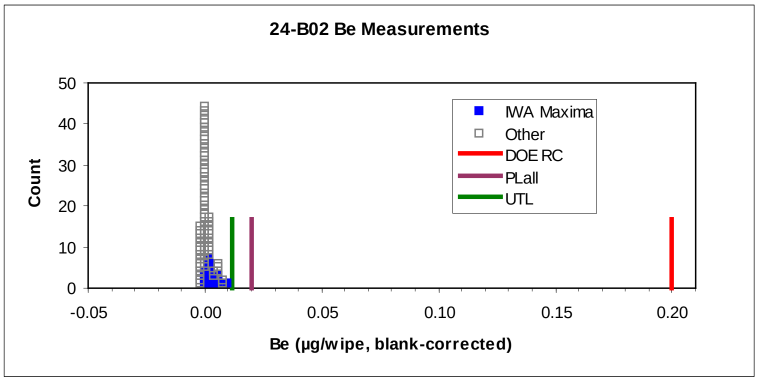
24-B01

24-B01	
IWAs	
Type	OF
N =	217
n =	56
BC(DC,G) =	0.0041
BC(DC,H) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-5.110
ln sd =	0.611
PL K =	3.632
PLall =	**0.051**
UTL K =	2.038
UTL =	**0.016**
Alpha =	0.05
ProbPlot R =	0.979



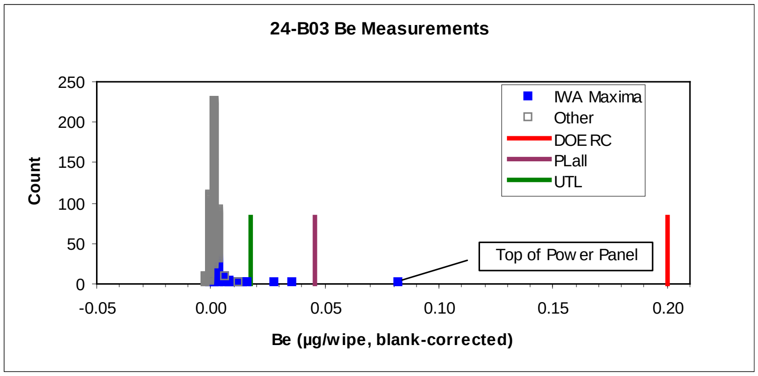
24-B02

24-B02	
IWAs	
Type	OF
N =	65
n =	17
BC(DC,G) =	0.0041
delta =	0.005
mean of ln(x+delta) =	-4.948
ln sd =	0.342
PL K =	3.656
PLall =	**0.020**
UTL K =	2.486
UTL =	**0.012**
Alpha =	0.05
ProbPlot R =	0.977



24-B03

24-B03	
IWAs	
Type	OF
N =	385
n =	66
BC(G) =	0.0041
BC(H) =	0.0003
delta =	0.005
mean of ln(x+delta) =	-4.665
ln sd =	0.447
PLall K =	3.756
PLall =	**0.046**
UTL K =	1.964
UTL =	**0.018**
Alpha =	0.05
ProbPlot R =	0.886



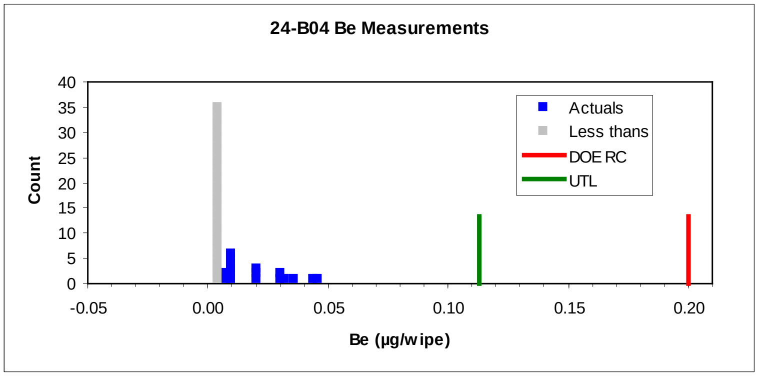
These samples from B01, B02, and B03 were obtained during September 2002 just before the facility personnel were relocated to the Cheyenne Facility. The different blank corrections (BC) reflect different biases in low-level measurements found in blank data generated by two analytical instruments.

The low ProbPlot R value reflects the three anomalous observations visible in the plot. In spite of this value, the low PLall and very low UTL, along with the fact that the highest of the anomalous observations comes from a location that would arguably not be considered a normal part of the “touchable” work environment, suggests that there is no cause for concern with this facility.

Alternately, with over 59 IWAs sampled, one could simply rely on the NPUTL which is the largest IWA maximum value.

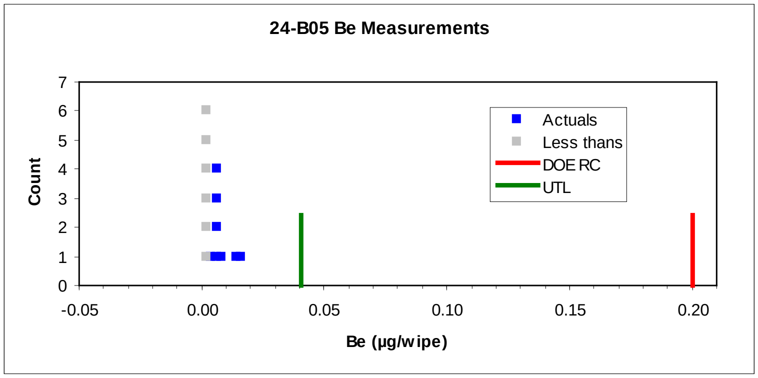
24-B04

24-B04	
Area	
Type	FO
n =	52
BC =	0
mean of ln(x+delta) =	-6.267
ln sd =	1.909
UTL K =	2.140
UTL =	**0.113**
Alpha =	0.05
ProbPlot R =	0.948



24-B05

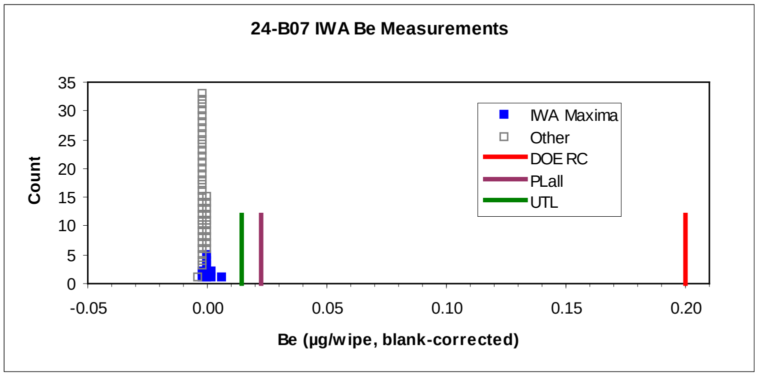
24-B05	
	Area
Type	OF
n =	14
BC =	0
mean of ln(x+delta) =	-5.404
ln sd =	0.729
UTL K =	3.015
UTL =	**0.041**
Alpha =	0.05
ProbPlot R =	0.951



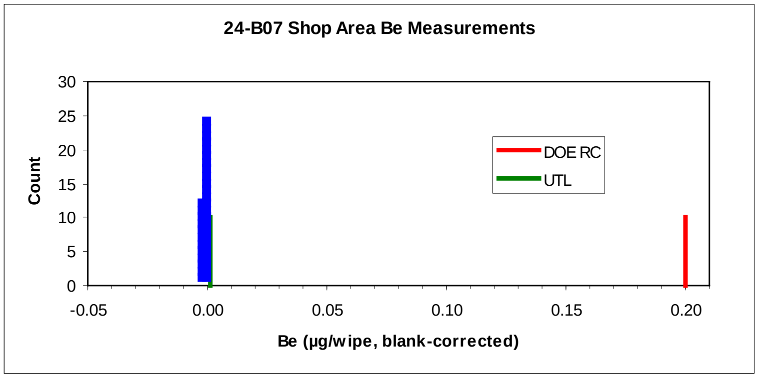
Prior data were used with these two facilities. We assume that the sampling plans at least reasonably approximated a systematic sampling plan, and note the low values obtained. The ProbPlot R values are based on "detects" only.

24-B07

24-B07	
	IWAs
Type	SH
N =	24
n =	10
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-5.869
ln sd =	0.605
PL K =	3.629
PLall =	**0.022**
UTL K =	3.022
UTL =	**0.015**
Alpha =	0.04
ProbPlot R =	0.967

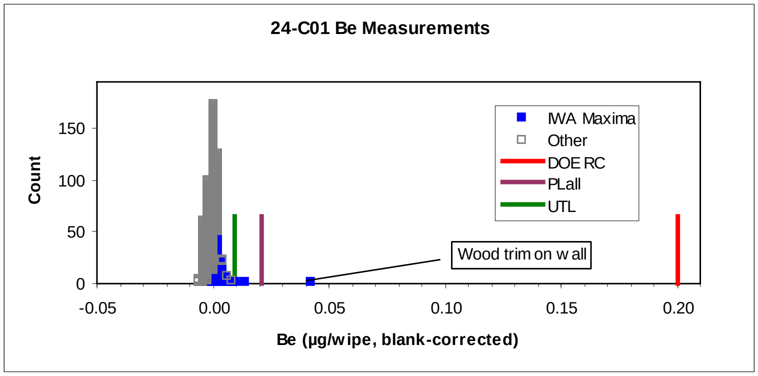


24-B07	
	Areas
Type	SH
n =	36
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-5.392
ln sd =	0.166
UTL K =	2.415
UTL =	**0.001**
Alpha =	0.01
ProbPlot R =	0.966



24-C01

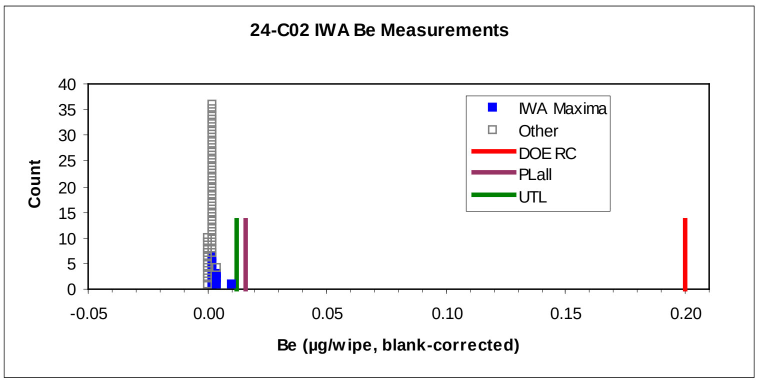
24-C01	
IWAs	
Type	OF
N =	521
n =	94
BC(BNadj) =	-0.0062
delta =	0.0050
mean of ln(x+delta) =	-4.887
ln sd =	0.323
PL K =	3.827
PLall =	**0.021**
UTL K =	1.937
UTL =	**0.009**
Alpha =	0.05
ProbPlot R =	0.891



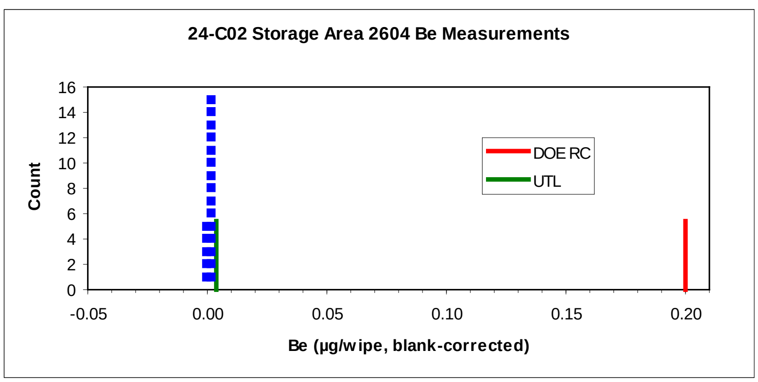
The low ProbPlot R is due to the outlier.

24-C02

24-C02	
IWAs	
Type	OF
N =	29
n =	10
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-4.836
ln sd =	0.254
PL K =	3.801
PLall =	**0.016**
UTL K =	3.022
UTL =	**0.012**
Alpha =	0.04
ProbPlot R =	0.954

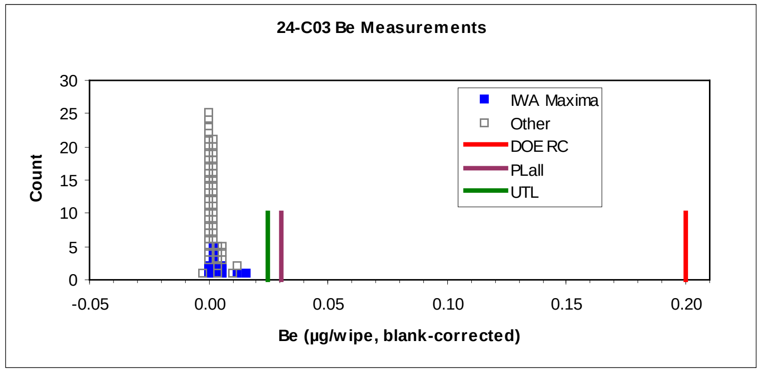


24-C02	
Storage area 6204	
Type	ST
n =	20
BC(DC) =	0.0000
delta =	0.0055
mean of ln(x+delta) =	-4.970
ln sd =	0.097
UTL K =	2.808
UTL =	**0.004**
Alpha =	0.01
ProbPlot R =	0.980



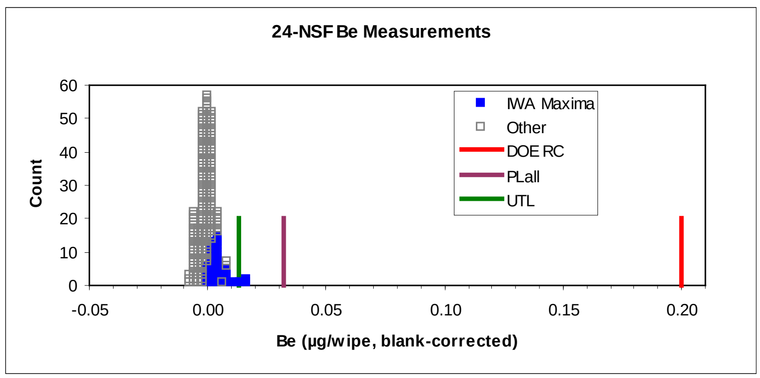
24-C03

24-C03	
IWAs	
Type	OF
N =	22
n =	11
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-4.746
ln sd =	0.433
PL K =	3.258
PLall =	**0.031**
UTL K =	2.815
UTL =	**0.024**
Alpha =	0.05
ProbPlot R =	0.937



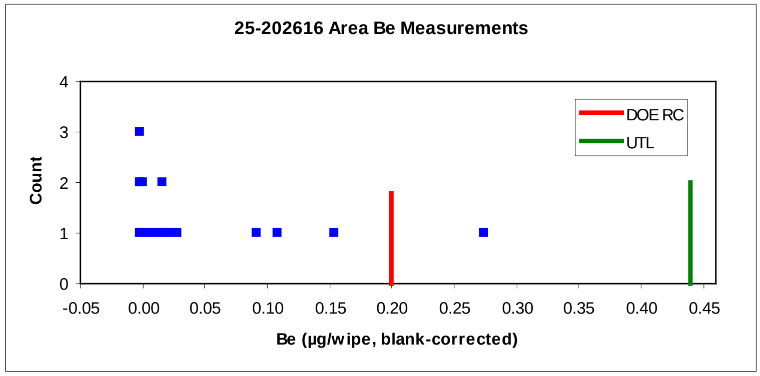
24-NSF

24-NSF	
IWAs	
N =	687
n =	43
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
delta =	0.0050
mean of ln(x+delta) =	-4.750
ln sd =	0.353
PL K =	4.138
PLall =	**0.032**
UTL K =	2.105
UTL =	**0.013**
Alpha =	0.05
ProbPlot R =	0.959



25-202616

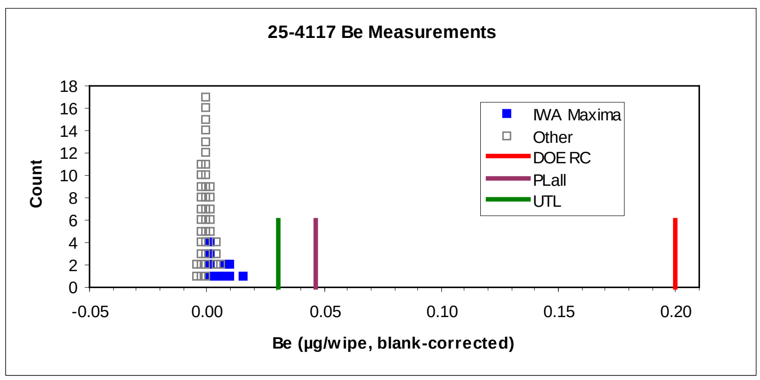
25-202616	
Area	
Type	FO
n =	18
BC(DC) =	0.0003
BC(BNadj) =	-0.0062
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-3.670
ln sd =	1.165
UTL K =	2.453
UTL =	**0.440**
Alpha =	0.05
ProbPlot R =	0.971



The metal ratios in the highest wipe are consistent with those in NTS soils.

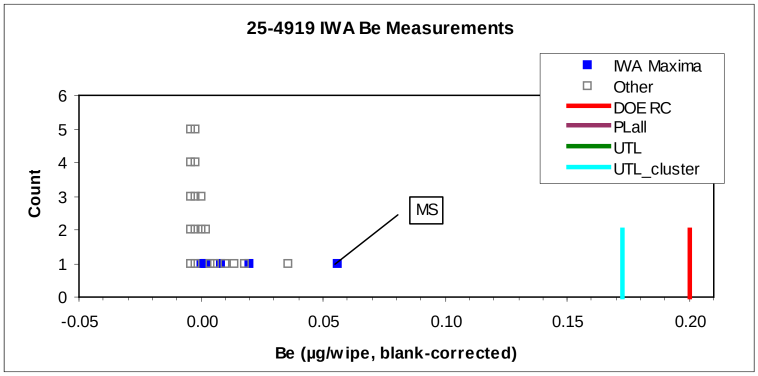
25-4117

25-4117	
IWAs	
Type	FO
N =	32
n =	11
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
delta =	0.0030
mean of ln(x + delta) =	-4.776
ln sd =	0.490
PL K =	3.602
PLall =	**0.046**
UTL K =	2.815
UTL =	**0.030**
Alpha =	0.05
ProbPlot R =	0.964



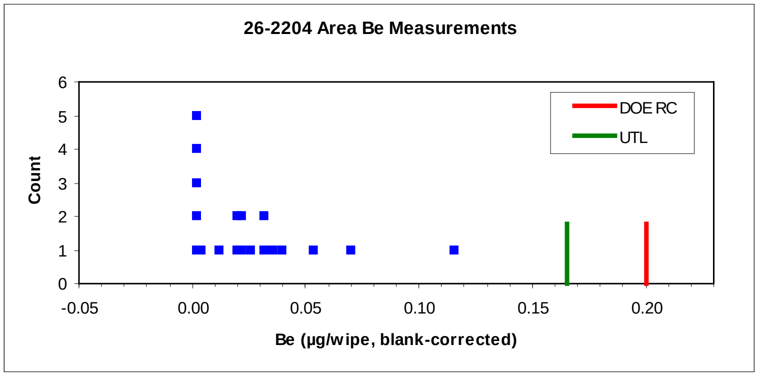
25-4919

25-4919	
IWAs	
Type	FO
N =	10
n =	5
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.472
ln sd =	1.231
PL K =	3.788
PLall =	**1.208**
UTL K =	4.203
UTL =	**2.014**
Alpha =	0.05
ProbPlot R =	0.998
UTL cluster sampling analysis	
F =	9.76
delta =	0.0090
mean of ln(x+delta) =	-4.413
tau^2 =	0.392
sig^2 =	0.179
ln sd =	0.756
UTL K =	3.538
UTL =	**0.173**
ProbPlot R =	0.967



26-2204

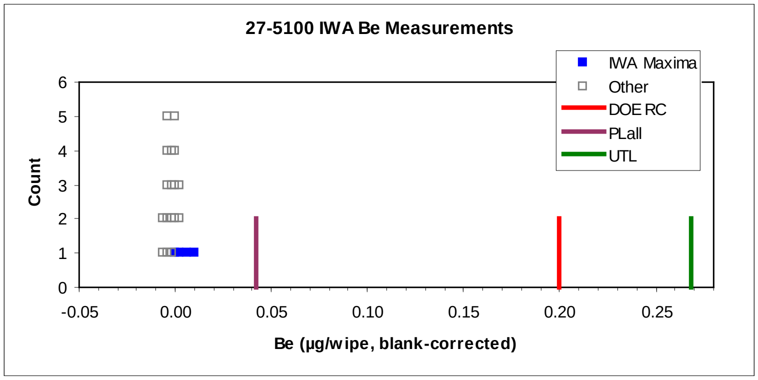
26-2204	
Area	
Type	FO
n =	20
BC(MS_new) =	0.0001
delta =	0.0085
mean of ln(x+delta) =	-3.582
ln sd =	0.748
UTL K =	2.396
UTL =	**0.166**
Alpha =	0.05
ProbPlot R =	0.967



The Be concentration and metal ratios in the bulk sample obtained within the facility are consistent with NTS soils.

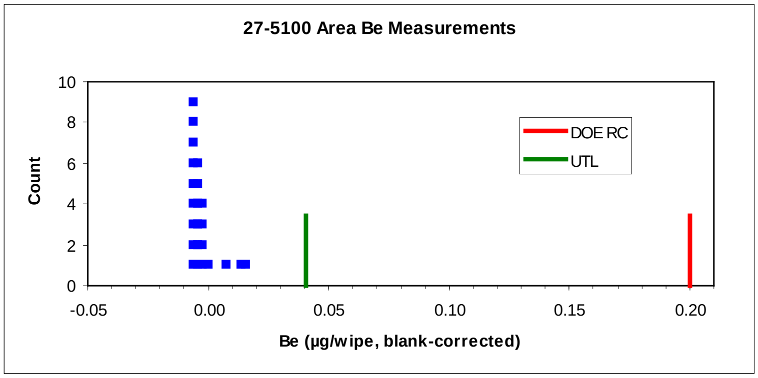
27-5100

27-5100	
IWAs	
Type	EX
N =	5
n =	4
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
delta =	0.0030
mean of ln(x+delta) =	-5.052
ln sd =	0.672
PL K =	2.913
PLall =	**0.042**
UTL K =	5.580
UTL =	**0.268**
Alpha =	0.04
ProbPlot R =	0.989



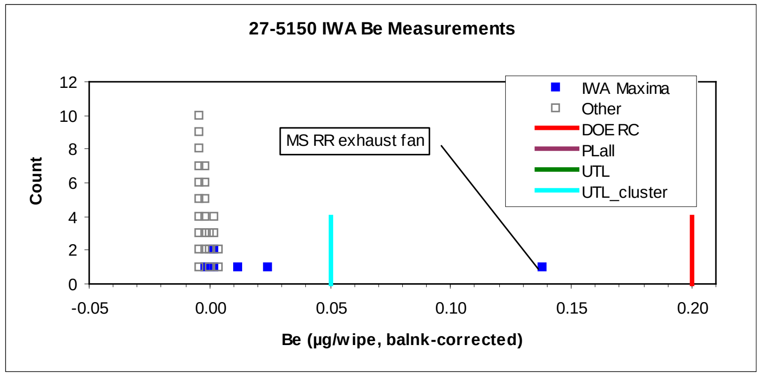
Four of five IWAs were sampled, and PLall is well below the DOE RC. UTL is above; nonetheless the facility passes.

27-5100	
Areas	
Type	EX
n =	29
shift(BNadj) =	-0.0062
shift(DC) =	0.0013
delta =	0.0070
mean of ln(x+delta) =	-5.818
ln sd =	1.028
UTL K =	2.694
UTL =	**0.040**
Alpha =	0.01
ProbPlot R =	0.985



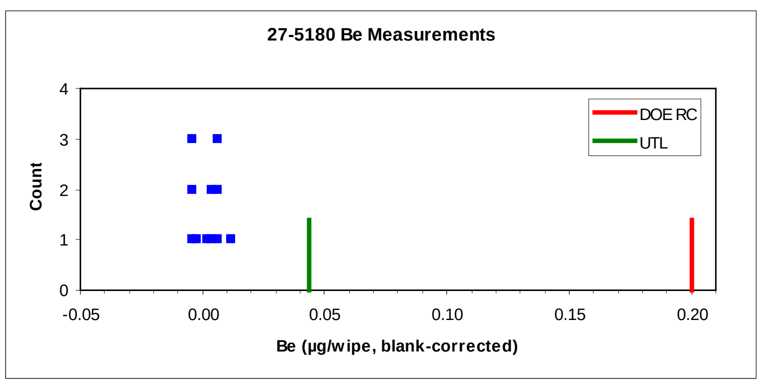
27-5150

27-5150	
IWAs	
Type	FO
N =	15
n =	6
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.546
ln sd =	1.676
PL K =	3.891
PLall =	**7.197**
UTL K =	3.708
UTL =	**5.297**
Alpha =	0.05
ProbPlot R =	0.988
UTL cluster analysis	
F =	2.12
delta =	0.0090
mean of ln(x+delta) =	-4.728
tau^2 =	0.115
sig^2 =	0.408
ln sd =	0.722
UTL K =	2.633
UTL =	**0.050**
ProbPlot R =	0.829



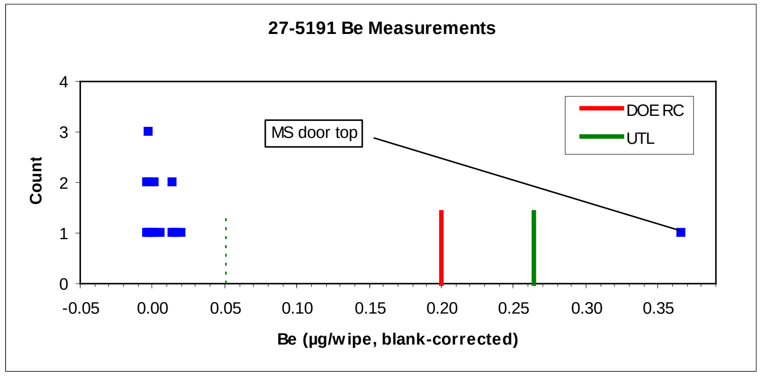
27-5180

27-5180	
Area	
Type	FO
n =	11
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0080
mean of ln(x+delta) =	-4.711
ln sd =	0.564
UTL K =	2.815
UTL =	**0.044**
Alpha =	0.05
ProbPlot R =	0.946



27-5191

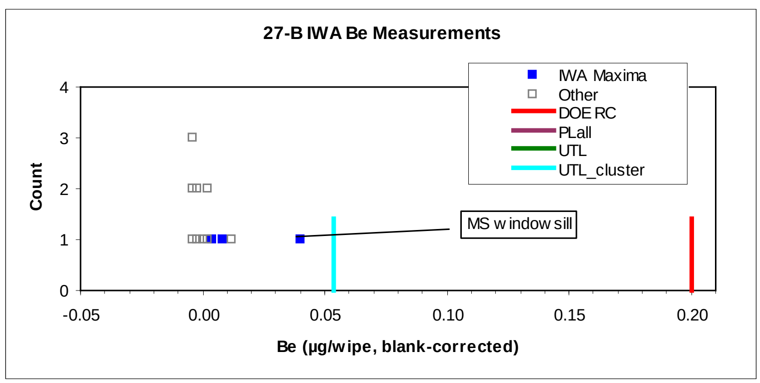
27-5191	
Area	
Type	SH
n =	14
BC(DC) =	0.0013
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.008
mean of ln(x+delta) =	-4.384
ln sd =	1.179
UTL K =	2.614
UTL =	**0.264**
Alpha =	0.05
ProbPlot R =	0.877
omitting door top	
mean of ln(x+delta) =	-4.646
ln sd =	0.683
UTL K =	2.671
UTL =	**0.051**
ProbPlot R =	0.948



One isolated MS_arch measurement is above the DOE RC. Omitting the high measurement, obtained in a location not normally touchable during routine work, UTL is beneath the DOE RC.

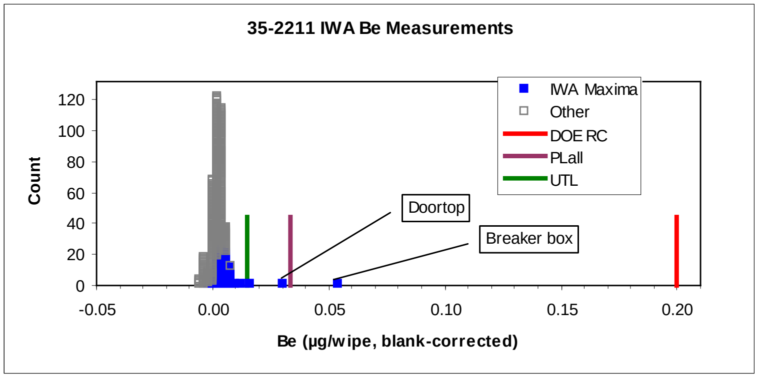
27-B

27-B	
IWAs	
Type	FO
N =	5
n =	3
BC(BNadj) =	-0.0062
BC(DC) =	0.0013
BC(MS_arch) =	0.0004
delta =	0.0030
mean of ln(x+delta) =	-4.239
ln sd =	0.978
PL K =	4.572
PLall =	**1.259**
UTL K =	7.656
UTL =	**25.770**
Alpha =	0.05
ProbPlot R =	0.961
UTL cluster analysis	
F =	0.26
delta =	0.0090
mean of ln(x+delta) =	-4.519
ln sd =	0.637
UTL K =	2.736
UTL =	**0.053**
ProbPlot R =	0.954

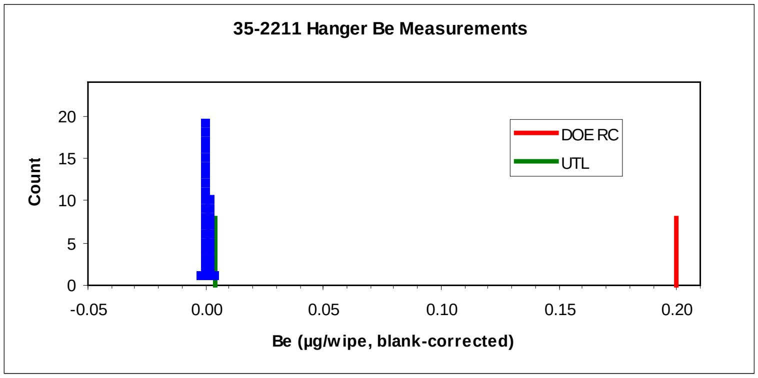


35-2211

35-2211	
IWAs	
Type	OF
N =	358
n =	87
BC(DC) =	0.0003
delta =	0.0050
mean of ln(x+delta) =	-4.646
ln sd =	0.366
PL K =	3.777
PLall =	**0.033**
UTL K =	1.971
UTL =	**0.015**
Alpha =	0.04
ProbPlot R =	0.923

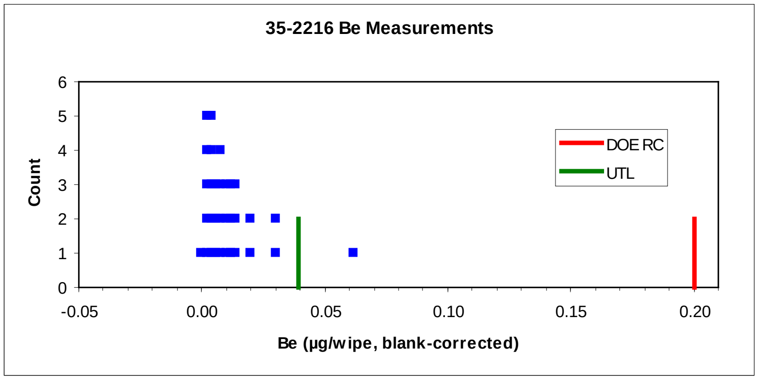


35-2211	
Hanger area	
Type	FO
n =	31
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-5.111
ln sd =	0.191
UTL K =	2.496
UTL =	**0.004**
Alpha =	0.01
ProbPlot R =	0.995



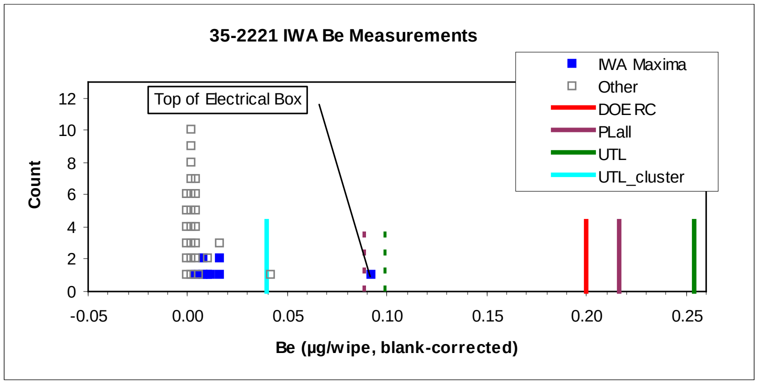
35-2216

35-2216	
Area	
Type	ST
n =	32
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.273
ln sd =	0.534
UTL K =	2.197
UTL =	**0.040**
Alpha =	0.05
ProbPlot R =	0.973



35-2221

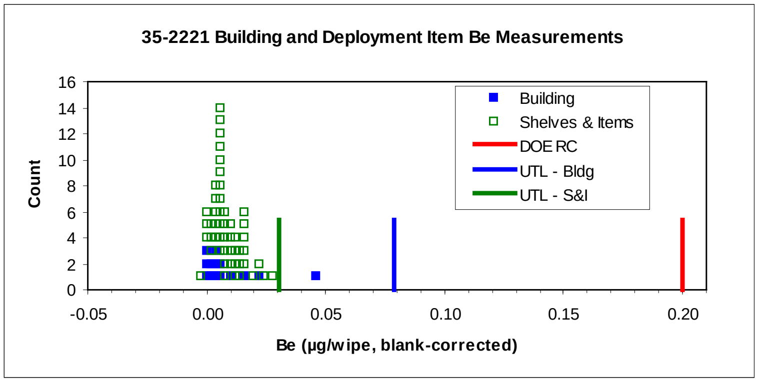
35-2221	
IWAs	
Type	ST
N =	12
n =	8
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-4.109
ln sd =	0.781
PL K =	3.318
PLall =	**0.216**
UTL K =	3.519
UTL =	**0.254**
Alpha =	0.03
ProbPlot R =	0.892
Omitting outlier	
mean of ln(x+delta) =	-4.205
ln sd =	0.547
PLall =	**0.089**
UTL =	**0.099**
ProbPlot R =	0.965
UTL cluster analysis	
F =	0.88
delta =	0.0085
mean of ln(x+delta) =	-4.283
ln sd =	0.522
UTL K =	2.265
UTL =	**0.039**
ProbPlot R =	0.866



This facility is the Remote Sensing Laboratory (RSL) Deployment Warehouse. There are 12 IWAs in the facility as well as numerous shelves containing equipment, much of it containerized. For analysis purposes three portions were used: the IWAs, the building proper, and the shelves and items on the shelves.

There is one outlier observation in the IWA portion, obtained atop an electrical box. The facility passes using the UTL cluster analysis with all data, not just the IWA maxima, or if the analysis is done omitting the high observation.

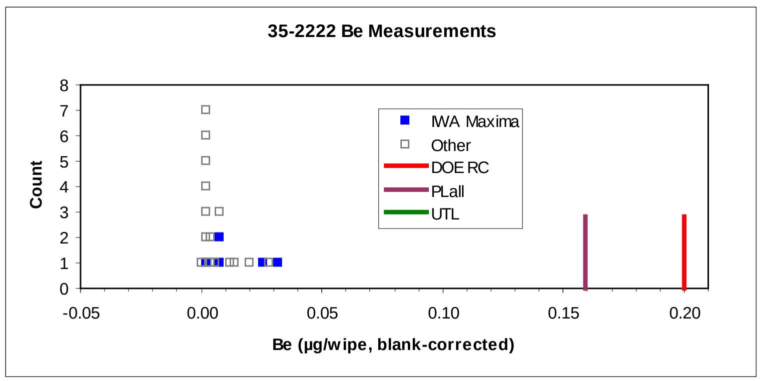
35-2221	
Building components	
Type	ST
n =	14
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.474
ln sd =	0.627
UTL K =	3.189
UTL =	**0.079**
Alpha =	0.01
ProbPlot R =	0.944



35-2221	
Shelves and items	
Type	ST
n =	50
BC(DC) =	0.0003
delta =	0.0055
mean of ln(x+delta) =	-4.347
ln sd =	0.450
UTL K =	2.269
UTL =	**0.030**
Alpha =	0.01
ProbPlot R =	0.995

35-2222

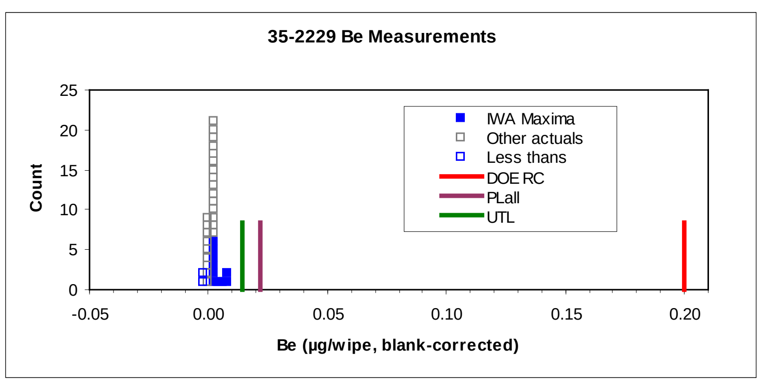
35-2222	
IWAs	
Type	EX
N =	7
n =	5
BC(DC) =	0.0003
delta =	0.0020
mean of ln(x+delta) =	-4.354
ln sd =	0.857
PL K =	2.952
PLall =	**0.159**
UTL K =	4.203
UTL =	**0.469**
Alpha =	0.05
ProbPlot R =	0.975



The UTL is much higher than the PLall for this small facility. The latter is well below the DOE RC, though, so the facility passes.

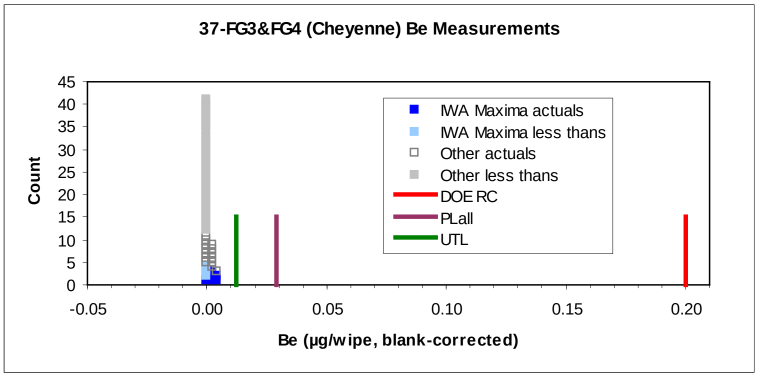
35-2229

35-2229	
IWAs	
Type	SH
N =	48
n =	10
BC(DC) =	0.0003
delta =	0.0030
mean of ln(x+delta) =	-5.045
ln sd =	0.337
PL K =	4.015
PLall =	**0.022**
UTL K =	2.911
UTL =	**0.014**
Alpha =	0.05
ProbPlot R =	0.953



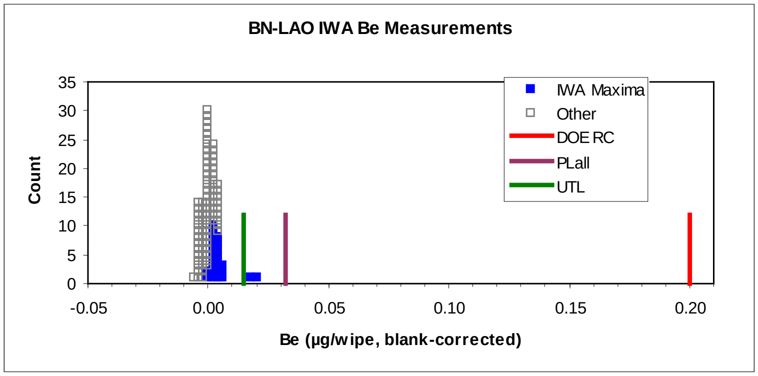
37-FG3 and FG4 (Cheyenne Facility)

37-FG3&4	
IWAs	
Type	OF
N =	198
n =	9
BC(DC) =	0.0003
sd =	0.0050
mean of ln(x+delta) =	-5.122
ln sd =	0.280
PL K =	6.190
PLall =	**0.029**
UTL K =	3.754
UTL =	**0.012**
Alpha =	0.05
ProbPlot R =	0.958



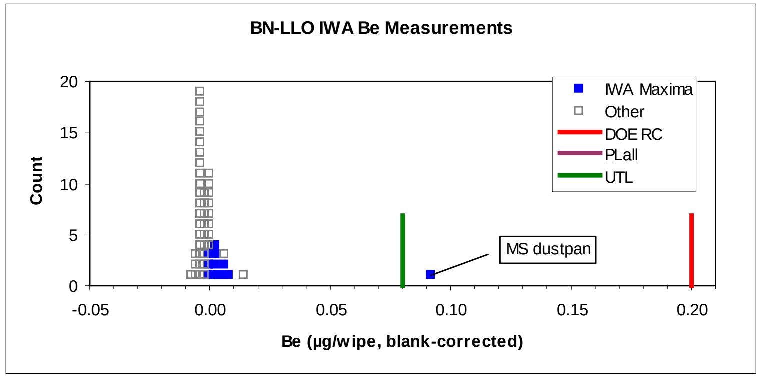
BN-LAO

BN-LAO	
IWAs	
Type	LA
N =	195
n =	25
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0040
mean of ln(x+delta) =	-4.891
ln sd =	0.399
PL K =	3.931
PLall =	**0.032**
UTL K =	2.292
UTL =	**0.015**
Alpha =	0.05
ProbPlot R =	0.907



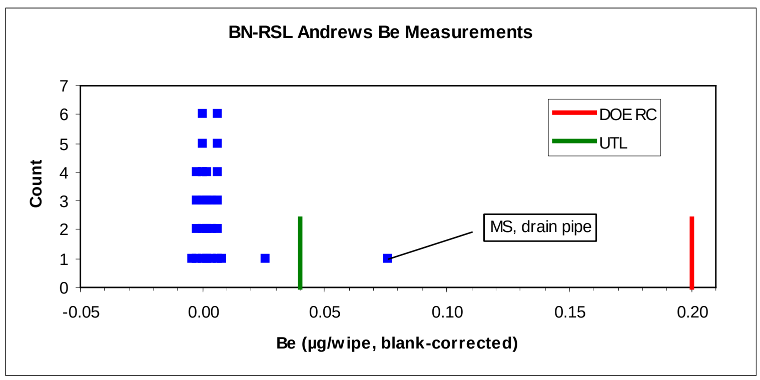
BN-LLO

BN-LLO	
IWAs	
Type	EX
N =	114
n =	12
BC(BNadj) =	-0.0062
BC(MS(arch) =	0.0004
delta =	0.0040
mean of ln(x+delta) =	-4.829
ln sd =	0.859
PL K =	4.290
PLall =	**0.314**
UTL K =	2.736
UTL =	**0.080**
Alpha =	0.05
ProbPlot R =	0.839



BN-RSL Andrews

BN-RSL Andrews	
Area	
Type	FO
n =	27
BC(BNadj) =	-0.0062
BC(MS_arch) =	0.0004
delta =	0.0080
mean of ln(x+delta) =	-4.526
ln sd =	0.584
UTL K =	2.260
UTL =	**0.040**
Alpha =	0.05
ProbPlot R =	0.913



Be and Metal Ratio Results from Bulk and High Wipe Samples

During the January 2009 resampling, bulk samples were obtained from numerous facilities, along with exterior soil samples in the vicinities of those facilities. As discussed in Appendix 4, these were analyzed for Be and also for Co [cobalt], Ni [nickel], Cu [copper], Y [ytritium], Nb [niobium] and ^{238}U ([uranium-238]). From these data, 95% central intervals were constructed for soil Be and for the logs of the ratios Cu/Be and so on; plots of the soil data and log ratios are given in Appendix 4.

The first table below lists Be values and coded log metal ratio data for the bulk samples. The Be values are in their original units. The log metal ratio data are in coded units: the median log ratio of the soil data is coded to 12, with each unit from that representing a decrease or an increase of 25%. This coding allows us to view the ratios for the different metals on a more-or-less common scale. Recall, however, that the ratios for Y/Be (especially), Nb/Be, and U/Be are much more consistent in NTS soils than those for the other three metals and, hence, should be taken as more reliable indicators that a particular sample resembles NTS soils in its chemical fingerprint.

Cells highlighted in green have Be values or metal ratios with relatively less Be than NTS soils. Cells highlighted in rose have metal ratios with relatively more Be than NTS soils. The value "∞" for a ratio indicates that the Be measurement was negative; the value "-∞" for a ratio involving Ni indicates that the Ni measurement is reported as zero.

There are no bulk samples with relatively higher Be than NTS soils. There are several with relatively less Be; presumably these samples contain major portions of materials other than soils. There is one sample with a relatively lower Y/Be ratio than NTS soils. In a sample obtained in 06-CP160, the ratio is only slightly lower than the "normal" range for NTS soils. The Nb/Be ratio is also somewhat low in another bulk sample from that facility.

Bulk Sample (January 2009) Metal Ratio Results

Facility	Be mg/Kg	Co/Be	Ni/Be	Cu/Be	Y/Be	Nb/Be	U/Be
		Coded values for log(ratio) Soil median = 12; one unit = 25% change					
Soil 2.5 percentile	0.379	5.7	5.1	3.0	10.0	9.7	8.4
Soil Median	1.122	12.0	12.0	12.0	12.0	12.0	12.0
Soil 97.5 percentile	1.865	18.3	18.9	21.0	14.0	14.3	15.6
01-201959	1.01	12.8	14.7	15.8	11.7	16.4	11.7
01-202479	1.40	11.1	13.3	12.0	12.5	11.6	11.1
03-3C36	1.73	9.9	9.3	8.5	11.2	13.1	10.3
05-24	1.09	10.2	6.2	8.2	11.9	13.7	11.2
05-24	1.17	9.9	8.3	9.2	11.3	12.7	11.3
05-202177	1.18	14.9	15.1	14.2	12.2	12.3	11.4
06-159	0.77	19.5	27.5	34.3	13.2	13.7	13.8
06-159	0.77	17.3	21.5	28.6	12.3	13.2	13.6
06-624	1.11	10.0	12.6	12.5	12.5	11.7	12.2
06-624	1.05	10.3	12.7	13.8	12.3	11.8	12.6
06-625	1.01	10.1	8.6	8.4	12.8	12.5	12.1
06-800	0.89	13.9	17.5	23.6	12.5	13.4	13.1
06-800	0.93	13.6	14.9	25.6	12.6	12.7	12.5
06-906	1.20	13.1	14.5	20.5	11.7	12.3	11.7
06-906	0.92	15.5	14.3	19.0	11.2	12.4	11.8
06-906	0.65	18.4	18.0	33.9	10.5	12.2	12.8
06-906	1.08	13.4	15.6	19.4	11.7	11.7	12.0
06-914	1.11	11.0	11.6	21.4	11.7	12.2	12.0
06-914	0.79	14.4	16.0	25.3	12.4	13.0	12.1
06-999387	1.04	11.3	13.6	11.4	12.1	12.3	11.9
06-CP070	0.07	19.0	18.3	27.4	11.9	24.2	18.9
06-CP160	0.11	29.6	29.8	36.9	13.7	5.2	26.8
06-CP160	0.22	23.1	28.2	34.1	9.7	13.3	25.5
06-CP160	-0.06	∞	∞	∞	∞	∞	∞
06-CP161	0.47	17.7	28.9	39.4	10.7	16.9	15.4
06-CP162	0.33	18.5	23.1	39.3	10.5	16.4	12.2
06-CP215	1.24	13.7	15.5	19.5	10.6	11.8	11.2
12-45	1.51	11.3	8.4	24.4	10.1	13.2	10.1
12-868	1.31	12.6	13.5	15.0	11.0	11.8	11.5
12-U12V AC	1.50	10.7	13.5	21.9	11.5	11.5	12.3
23-113	0.15	31.7	16.2	56.0	12.6	14.3	14.2
23-113	0.77	17.8	20.2	46.0	11.8	11.5	12.6
23-128	0.09	17.9	19.4	26.1	11.0	19.8	13.7
23-128	0.39	15.6	16.6	22.6	12.4	12.8	18.2
23-128	0.02	27.6	29.8	34.5	14.0	16.6	16.5
23-128	0.73	16.9	17.9	20.9	12.6	14.0	13.4

23-151	0.91	15.7	14.6	22.6	12.7	13.4	13.5
23-151	0.48	21.4	24.6	28.8	12.9	14.5	13.3
23-151	0.64	14.8	14.2	19.6	11.7	12.6	12.8
23-151	0.65	14.2	12.6	12.1	12.8	12.2	13.5
23-154	0.98	13.2	13.6	21.3	12.0	13.5	12.8
23-158	0.75	16.0	21.3	21.2	12.6	15.4	25.8
23-190	1.03	20.8	23.0	27.5	12.0	13.0	15.8
23-190	1.28	16.9	22.6	23.6	12.0	13.4	13.6
23-190	0.11	31.5	33.0	31.1	21.0	34.0	25.7
23-190	0.09	31.6	37.0	36.6	20.9	34.1	25.5
23-610	0.17	19.2	19.4	25.5	14.1	15.3	14.9
23-703	0.23	17.6	17.8	28.4	10.4	15.3	13.6
23-703	0.41	17.4	17.7	23.1	12.1	14.5	13.4
23-703	0.32	19.7	18.4	37.8	10.6	13.8	15.8
23-703	-0.25	∞	∞	∞	∞	∞	∞
24-A03	0.49	17.2	16.9	21.9	12.9	12.4	14.7
25-202674	1.30	11.8	13.7	15.0	11.8	12.4	10.6
26-2204	1.06	17.1	14.4	17.1	12.6	11.5	11.8
27-5110	0.61	17.3	16.4	26.7	12.7	13.6	12.0
27-5110	0.57	16.3	16.2	21.1	11.8	13.2	12.0
35-2215	0.47	17.6	22.2	24.7	12.3	12.4	16.0

The final table in this appendix shows the log metal ratios from wipe samples obtained in January 2009 in which the Be concentration exceeds the DOE RC. The coding is the same as in the previous table.

There are a few wipe samples in which the Y/Be ratio is lower than the normal range for NTS soils. Those with the ratio mildly lower than the normal range were obtained in 06-800 and 24-703; in one of these (in 06-800) the Nb/Be ratio was also rather low. That wipe was taken on a lathe. Otherwise, the Cu/Be ratio seems somewhat high for a number of these samples and the Ni/Be ratio seems somewhat low; given the wide range of variation of these ratios seen in the NTS soils, less importance is placed on these ratios.

Ghost Wipe (January 2009) Metal Ratio Results

	Co/Be	Ni/Be	Cu/Be	Y/Be	Nb/Be	U/Be
		Coded values for log(ratio)				
Facility		Soil median = 12; one unit = 25% change				
Soil 2.5 percentile	5.7	5.1	3.0	10.0	9.7	8.4
Soil Median	12.0	12.0	12.0	12.0	12.0	12.0
Soil 97.5 percentile	18.3	18.9	21.0	14.0	14.3	15.6
01-201959	20.0	23.0	28.6	13.4	16.9	13.9
01-202479	11.9	12.9	8.0	13.5	12.9	12.6
01-202479	11.6	14.8	15.7	12.4	12.2	11.0
01-202479	10.7	-4.8	-1.0	12.9	13.7	12.1
03-3C36	10.7	-8.3	4.5	11.4	13.7	11.1
03-3C36	11.6	-∞	14.3	11.5	13.4	11.9
06-624	14.0	13.1	25.9	12.6	12.6	11.5
06-624	12.9	7.7	18.6	12.7	14.0	12.4
06-624	12.8	9.5	23.7	12.6	13.7	12.4
06-800	22.0	5.2	21.4	12.4	13.7	12.5
06-800	14.4	10.9	23.3	12.4	14.5	13.0
06-800	13.4	11.8	21.8	11.5	12.5	12.3
06-800	16.2	24.3	26.0	12.1	13.6	12.8
06-800	17.0	15.2	31.8	12.1	13.1	12.8

06-800	17.6	15.8	34.8	11.6	12.7	12.5
06-800	13.0	-∞	21.3	12.1	12.7	12.1
06-800	13.7	13.7	28.5	9.8	11.0	10.9
06-800	14.8	14.9	23.6	11.3	12.5	13.1
06-800	14.9	11.4	24.0	12.2	12.7	12.6
06-800	19.7	20.6	21.2	12.5	13.6	12.4
06-800	16.5	19.6	27.9	12.8	13.8	12.8
06-800	15.6	19.5	25.9	12.3	13.4	16.9
06-800	20.8	23.1	37.6	12.0	13.3	12.3
06-800	17.4	40.8	58.3	8.1	1.2	8.7
06-906	17.3	18.9	22.1	11.9	13.6	12.8
06-906	15.8	-1.8	22.2	12.2	12.8	13.4
06-906	16.0	13.7	17.9	12.3	13.8	12.6
06-906	21.2	-∞	33.5	12.0	13.0	13.8
06-914	18.2	19.5	31.9	12.4	13.0	12.7
06-914	23.5	20.3	32.1	12.6	13.3	13.2
06-914	20.8	13.4	29.6	12.1	13.0	15.4
06-914	16.4	15.3	30.3	12.3	12.9	13.7
06-914	19.8	23.0	30.1	12.2	13.4	13.7
06-999387	10.4	5.0	11.6	12.3	13.3	12.3
06-999387	10.7	7.0	10.7	12.3	13.2	12.3
06-999387	11.1	-∞	15.2	12.3	13.2	12.2
06-CP-070	15.2	14.5	26.2	13.9	14.5	15.4
06-CP-070	12.9	15.1	24.9	10.7	11.6	15.2
06-CP-160	15.0	15.0	26.8	12.1	12.8	12.2
06-CP-162	18.6	11.2	17.4	12.2	13.5	13.4
06-CP-162	24.7	20.5	31.9	12.5	12.8	12.5
06-CP-215	20.1	12.3	28.6	11.4	12.0	13.9
12-U12	9.5	2.1	21.9	11.3	13.5	11.6
23-151	17.0	13.1	18.2	14.4	14.3	14.9
23-190	15.6	25.1	25.9	12.7	13.3	16.2
23-190	20.6	23.7	28.0	12.2	14.1	15.8
23-610	11.9	-∞	8.4	12.0	13.1	11.9
23-703	14.3	18.2	33.2	8.1	11.4	12.4
25-202616	13.4	15.2	10.2	12.0	13.3	12.0

Appendix 3
CHEMICAL ANALYSIS AND DATA ISSUES

Overview

Most of the first 5,000 or so samples obtained for this study were analyzed by DataChem, an independent, subcontract laboratory accredited by the American Industrial Hygiene Association (AIHA). With the exception of minor issues that are addressed by subtracting the means of appropriate sets of blank observations, these data are used as provided by the laboratory. The minor issues are discussed in Appendix 4. These data are designated "DC" in the discussions and plots that follow. The wipes were taken and analyses performed from late 2002 through the middle of 2003.

The large majority of the next 6,000 or so samples (obtained from the middle of 2003 into 2004) were analyzed by Bechtel Nevada (BN) personnel on an inductively coupled plasma mass spectroscopy (ICP-AES) instrument acquired for that purpose, using the 234.861-nanometer (nm) emission line. As a precaution, side-by-side wipes were obtained for every tenth sample obtained at most facilities, in addition to the usual quality control (QC) samples. One of each pair was analyzed using this system (BN-AES), and the other by DC. For logistical reasons unrelated to the study itself, review of the QC sample results was delayed. Nonetheless, analyses proceeded using BN-AES (except for the DC side-by-side samples) with the 234.861-nm line.

When the QC side-by-side data were eventually evaluated, significant discrepancies between the BN-AES and DC data were found. The discrepancies appeared greater in sample pairs obtained in shop and similar facilities than those obtained in office buildings and similar facilities. Considerable effort was expended in determining the cause of these discrepancies, as is discussed in "What is a Beryllium Measurement? A Critical Look at Beryllium Quantitation" (C. B. Davis, D. E. Field, J. W. Hess, and D. A. Jensen, presented at the *Second Symposium on Beryllium Particulates and Their Detection*, November 8-9, 2005, Salt Lake City, UT). It was determined that the source of the discrepancies was interference due to a minor iron (Fe) peak located at approximately 234.841 nm, just outside the window used by the ICP-AES instrument in its beryllium (Be) analyses. This Fe interference was unanticipated – this peak is not listed in the *NIST Handbook of Basic Atomic Spectroscopic Data*, for example – but is nonetheless sufficiently large to significantly decrease the instrument's response to low concentrations of Be using the 234.861-nm spectral line. One of the clues to the nature of the interference is the types of facilities in which the discrepancies were greatest.

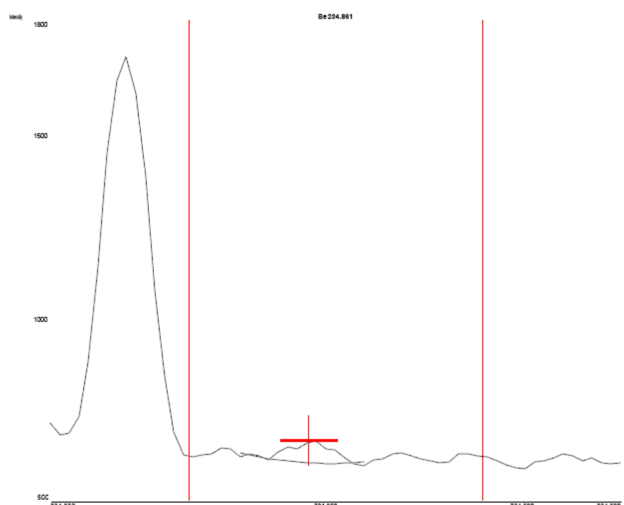
Upon determination of the nature of the problem, a study was conducted to identify a solution. It turns out that for many of the samples analyzed by BN-AES a simple correction based on the iron peak height (FePH) can be made, so long as the FePH is not too great, although the resulting adjusted data will be somewhat more variable than would otherwise be anticipated. Upon comparing the resulting BN-adj data with the DC results from the side-by-side wipes, a modest correlation (0.547 after deleting a small number of outliers) is found. This is not unreasonable given the generally low Be values found in the relatively "clean" samples which also have low Fe. Also, one must recognize that side-by-side samples are not true duplicates, particularly when sampling particulate materials. The second major section of this appendix details the FePH correction study.

The remaining BN-AES samples (approximately 900 in number) were reanalyzed using a newly acquired ICP-MS instrument (denoted “BN-MS” or “MS_arch”). These reanalyses are somewhat problematic, in that they use archived digestates from the original analyses that had been stored for several years beyond the usual holding time limit. Again, the best comparison for evaluating these samples is the side-by-side DC analyses. In this case, the side-by-side evaluations are not limited to relatively “clean” samples, and (again, after deleting a few outliers) a decent correlation of 0.876 is seen. The BN-MS data do tend to be higher than the DC data, though; a weighted-least-squares line is DC = 0.5646 * MS_arch. On the other hand, BN-MS analyses of archived Fe/Be spiked samples discussed in the second section suggest that the BN-MS analyses do not tend to be either systematically high or low compared with the true values. Those Fe/Be spiked samples (prepared in October 2005) have not been held for nearly as long as the archived digestates of environmental samples, which had been held since late 2003 through 2004.

These results present a quandary. Clearly the BN-MS results are informative, given the high correlation with DC side-by-side data. Should these (a) be adjusted by the DC = 0.5646 * MS fitted line to produce data more nearly resembling those obtained from the third-party AIHI-accredited lab, (b) be used as is, or (c) treated in some intermediate fashion? After discussion and deliberation, it was decided to follow the conservative approach of relying on the MS_arch data as is. The third major section of this appendix presents detailed analyses of these data.

Adjusting ICP-AES (234.861 nm) Measurements for Iron Peak Interference

The nominal Be wavelength used for the BN-AES analyses was 234.861 nm, with a typical spectral window extending ±0.016 nm. A broad interference peak is found centered at approximately 234.841 nm. This peak is found in virtually all analyses, suggesting that the interferent is present in all samples, even blanks. For example, the figure to the right shows a spectrum obtained from analysis of a ghost wipe spiked only with 0.01 micrograms (µg) Be. The peak in the center is the Be peak; that on the left is the interferent peak. For comparison with subsequent discussions, the interferent peak height is 1,739 in this spectrum.

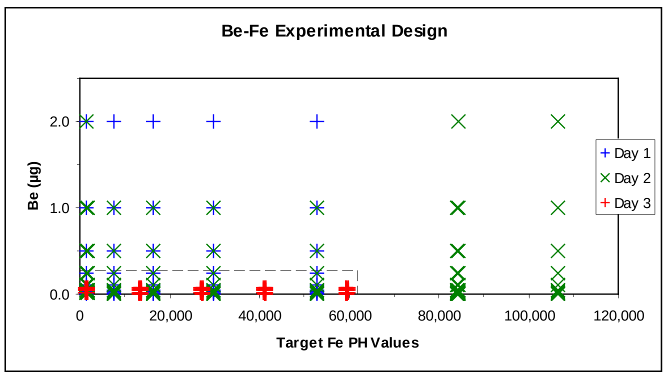


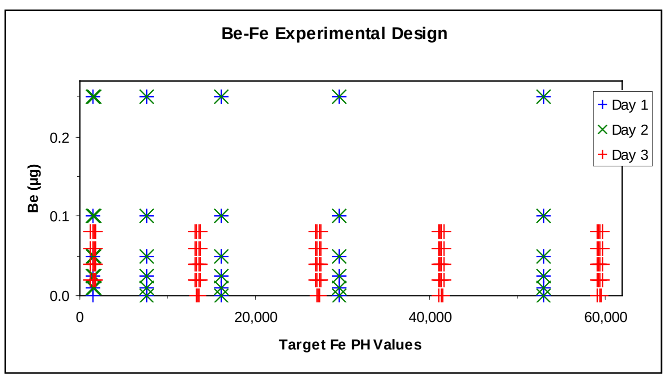
Analyses of ghost wipe samples spiked with a variety of substances suggested that the interferent is virtually certainly Fe. Therefore, a quantitative model of the effect of the Fe peak on Be quantitation was developed, toward a goal of providing a defensible adjustment procedure for samples in which the FePH is not excessive. Since the release criterion (RC) for Be wipe samples is 0.2 µg per wipe, Be concentrations of interest range from 0.0 to 0.2 µg/sample.

Analyses of spiked ghost wipes were conducted by BN personnel on October 12, 13, and 27, 2005. Conclusions obtained from analyzing the resulting data are the following:

- The upper limit of FePH values for making adjustments is approximately 65,000. (FePH values as high as 12,000,000 have been found.)
- For measured Be values less than approximately 0.2 µg, a reasonable adjustment is $\text{BN-adj} = \frac{M + 0.20626\,F}{1 - 4.1405\,F}$, where BN-adj is the adjusted value, M the reported value, and $F = \text{FePH} \times 10^{-6}$. An M above 0.2 µg already exceeds the RC; since the adjustment can only increase that value, there is no reason to adjust measured values above 0.2 µg.
- This adjustment should provide BN-adj measurements that are approximately unbiased for $0 \leq \text{FePH} \leq 65{,}000$ and $0 \leq T \leq 0.2$, where T is the true concentration (i.e., the amount of Be spiked into the ghost wipe). BN-adj measurements will be somewhat "noisier" than unadjusted measurements, by a proportion ranging from about 19% at T = 0 to about 27% at T = 0.2 µg.
- The increased analytical variability due to the adjustment will be only a small proportion of the total variability where there is a substantial spatial component of variation. The bottom-line statistical procedure automatically accounts for the inherent variability of measurement data. Hence, there is no reason to modify the bottom-line statistical procedure (upper tolerance limit or prediction limit) because of the adjustment.

<u>Details</u>

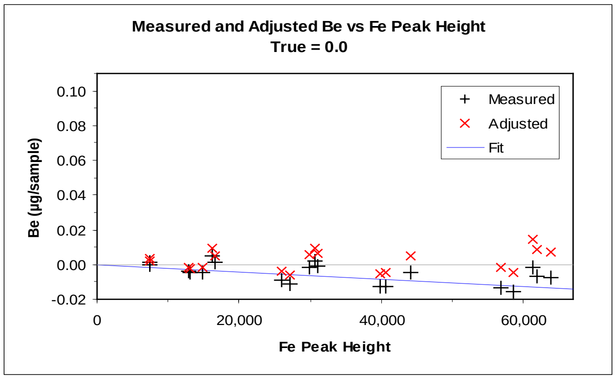


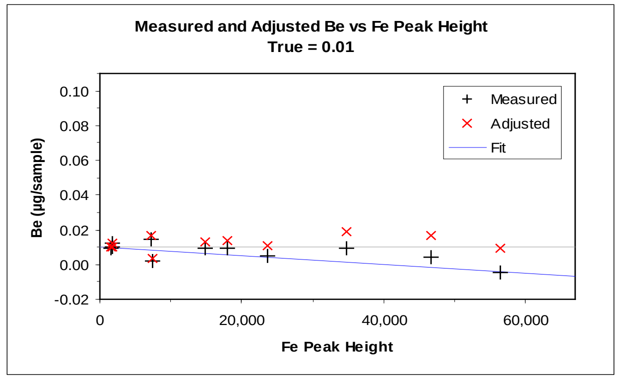


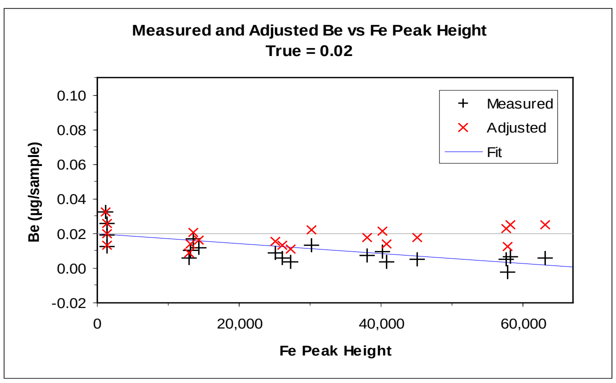
Ghost wipes were spiked with solutions of Be and Fe and analyzed using the BN-AES instrument on three days (October 12, 13, and 27, 2005, referred to as Days 1, 2, and 3). Analysis of the Day 1 and Day 2 data established the soundness of the concept of making this sort of adjustment, and established that the upper limit of FePH should be in the neighborhood of 70,000. Adding the Day 3 data further confirmed the concept and provided additional insight into the nature of the measurement variation involved. A preliminary study with Fe alone had allowed the specification of spiking concentrations that achieved approximately the target FePH values. The design is represented in the accompanying figures; the second is a blown-up version of the lower left portion of the first. Replicates are represented by slightly "jittered" points, particularly for Day 3.

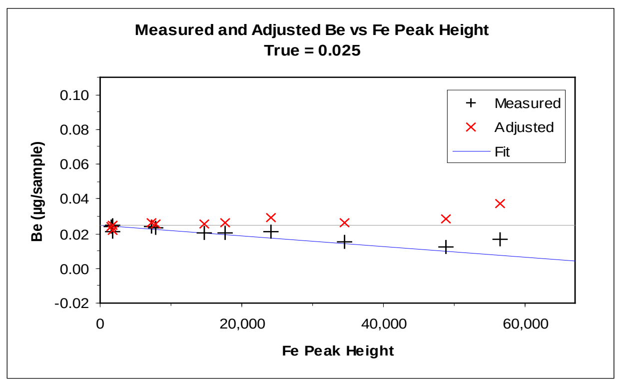
A series of straight-line fits of measured value M as a function of FePH were made, one for each separate value of the true concentration (T). In each case the intercept of the line was not significantly different from T, so the fitted line was forced through the point (0,T). Since there is a negative slope in every case, and since ghost wipes apparently do contain some Fe, this implies that the fitted M value will be slightly less than T even if no Fe is added to the wipe. The slopes themselves form a nice linear trend as a function of T, so a second level of fitting (of slope to T) was employed. This doubly fitted model is M = T + (a + bT)*F + error, where F = FePHx10^{-6} for convenience. The fitted values are a = -0.20626 and b = -4.1405. If we insert an actual measurement value for M, set "error" to 0, and solve for T, the result is the adjusted measurement $\text{BN-adj} = \dfrac{M + 0.20626\,F}{1 - 4.1405\,F}$.

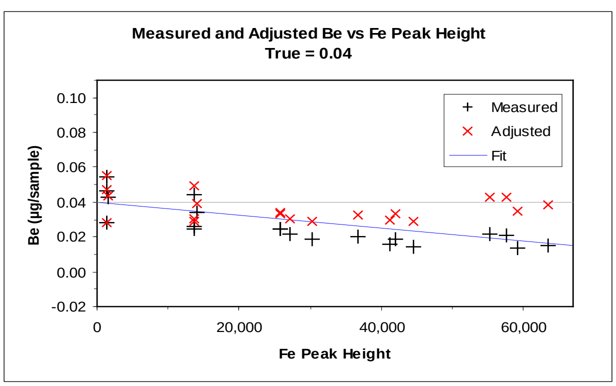
The following plots show all measured and adjusted values in the region of interest.

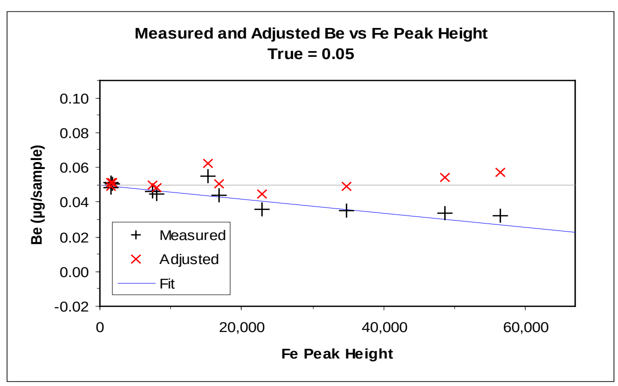


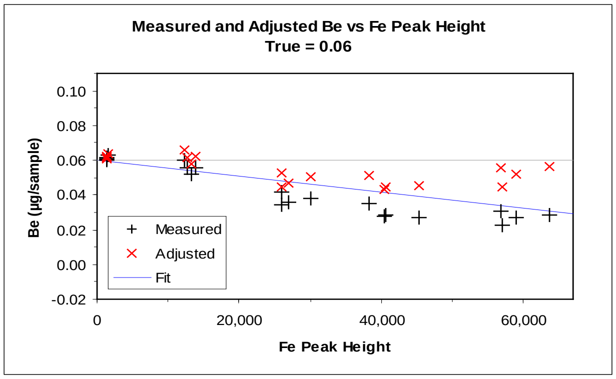


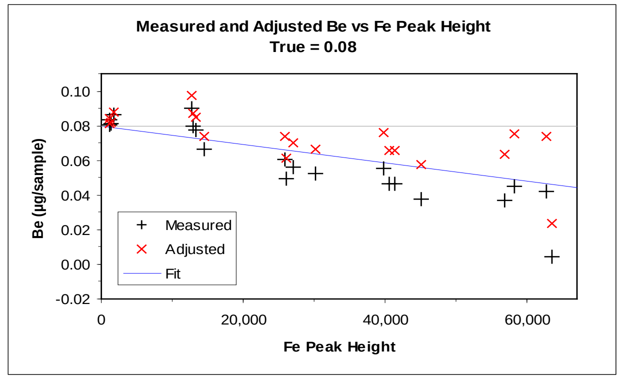


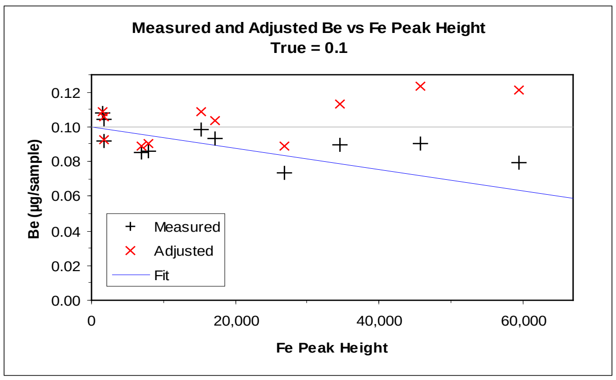


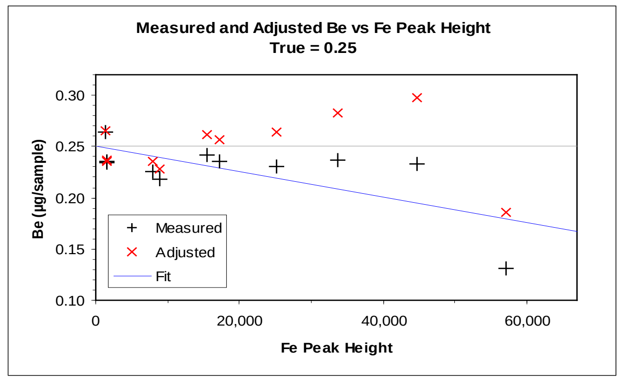




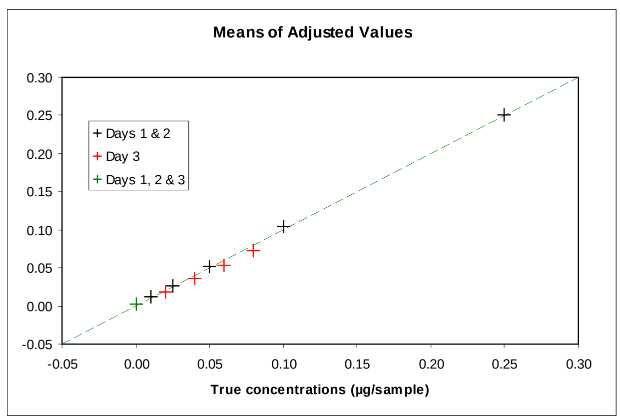




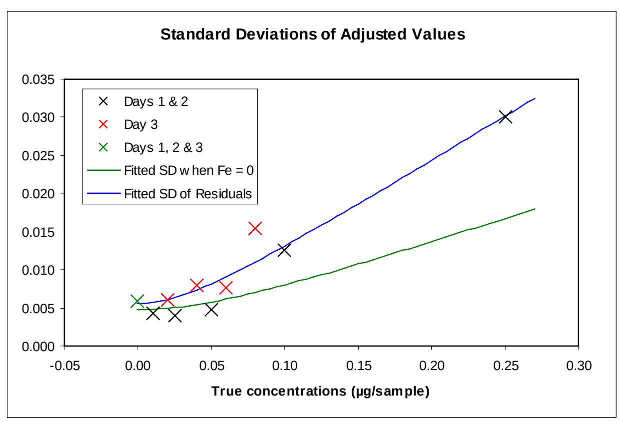




Overall the fitted values estimate their targets nicely, as expected. There are minor deviations from day to day, as seen in the plot at right; these will be of little practical significance.

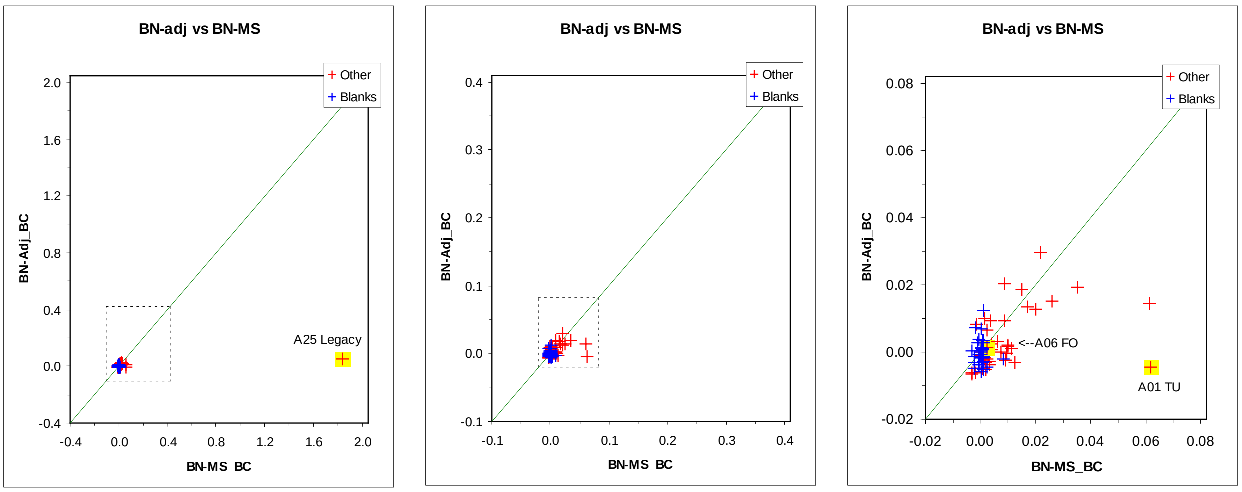


The standard deviations of the adjusted values are shown in the next plot, along with a fitted curve (blue) of form $SD^2 = A^2 + B^2T^2$. This model provides for two statistically independent components of analytical variability: one (with standard deviation $A \approx 0.0056$) independent of T, and the other with relative standard deviation B (≈ 0.064). The green curve is fitted to standard deviations of ghost wipes spiked with Be only; the distance between the curves reflects the noise added by the FePH adjustment process.



Validation with Side-by-Side DC Samples

BN-adj values were computed for all BN-AES analyses with FePH < 65,000. As discussed in Appendix 4, the mean of field blanks for the entire study period was slightly positive (0.0062), so data were blank-corrected by subtracting this quantity. (A similar blank correction was made for the DC and BN-MS data as well.) The following series of plots show the side-by-side BN-MS and DC blank-corrected (_BC) values. The area included in dotted lines in the first is the whole of the second, and similarly with the second and third.



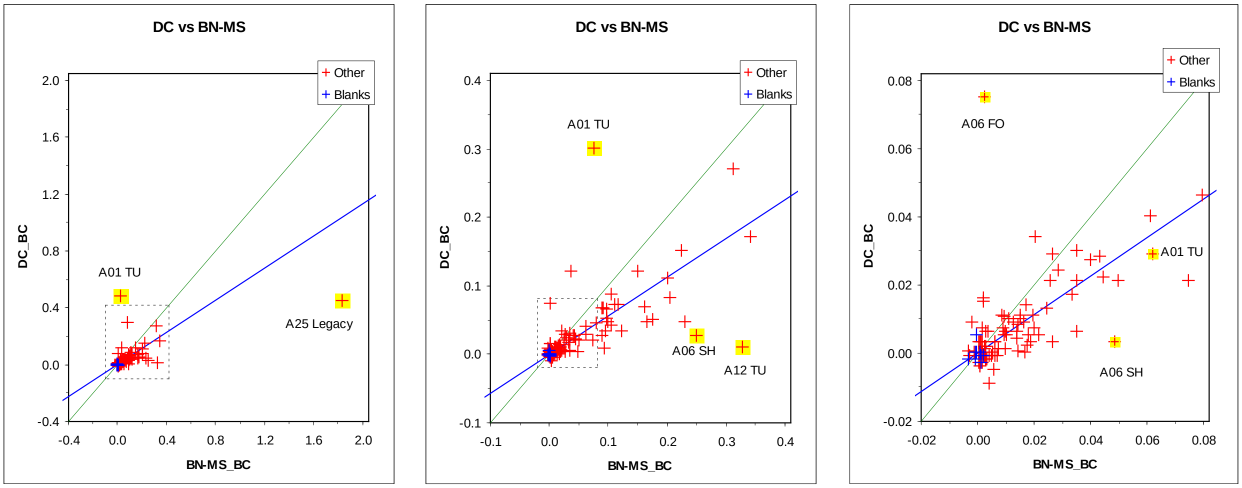
Three outliers are highlighted in yellow, identified in at least two of the three two-way comparisons of paired values; these are omitted from the weighted-least-squares analysis of the BN-MS and DC pair data in the following section. The causes of these outliers are not known. Otherwise, as stated, the correlation between BN-adj and DC is modest, but that is due mostly to the fact that nearly all Be values are low. This is, of course, a consequence of the exclusion of samples with FePH > 65,000.

Reanalysis of Archived Samples by ICP-MS

Around 900 of the digested wipes from the BN-AES analyses were reanalyzed (December 2006-June 2007) using an ICP-MS instrument. These include the majority of those samples with FePH > 65,000, where those samples are critical to the data analysis for their particular facilities, along with a number of QC samples for which BN-adj and/or DC data values are available. In this section the side-by-side BN-MS (MS_arch) and DC pair and the BN-MS and BN-adj pair of data are reviewed.

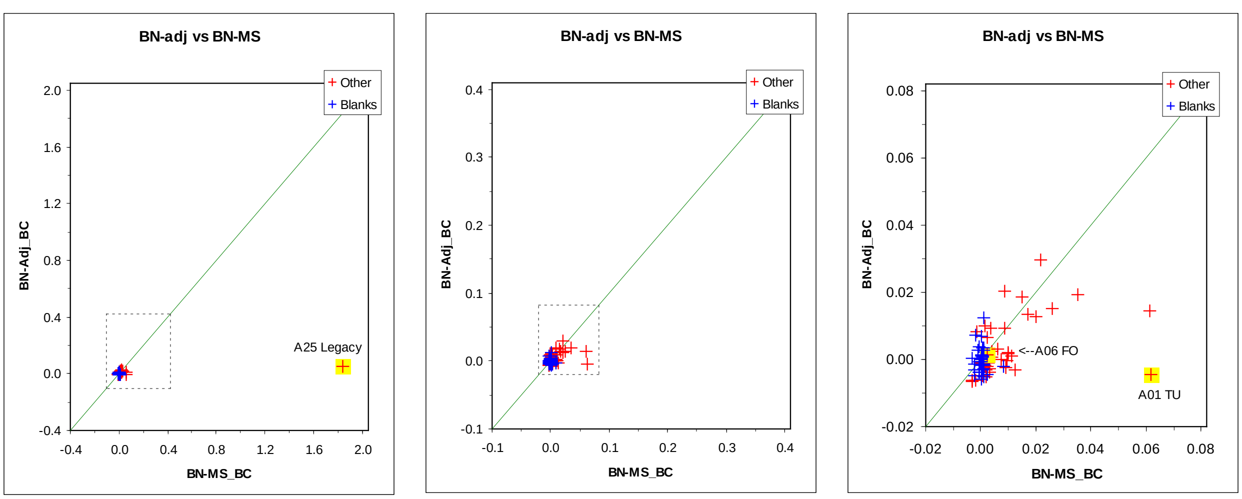
The side-by-side comparisons with DC data are not constrained by the limited range since Fe is not involved. There are 113 pairs of samples, of which 8 are identified as outliers. With the remaining 105 pairs the correlation between the BN-MS and DC values is a respectable 0.876, as stated previously.

There is concern, however, in that the slope of the linear relationship between the DC and BN-MS data is not 1, as desired, but rather a little less than 0.6; a weighted-least-squares fit gives a slope of 0.56458. (The intercept was not significantly different from zero, after blank correction, and accordingly was omitted from the predictive model.) The "*y*=*x*" line is green in the following plots, whereas the weighted least square (WLS) fitted line for predicting the DC values from the MS values is in blue.



Outliers identified in these plots, and omitted in the WLS fit, include those identified in the plots presented in the previous section. Since these are side-by-side wipes, rather than true duplicates, occasional outliers can be due to one sample of a pair including a particle not included in the other, so these are not unexpected.

For comparison, plots of BN-adj vs. BN-MS results are included as well. With the outliers omitted, the correlation is a moderate 0.617, again related to the compressed range of available data once the samples with higher FePH values are removed. (With the right-most non-highlighted point in the right plot omitted, the correlation rises to only 0.669.) These data are not inconsistent with the WLS fit obtained from the DC vs. BN-MS plot, although the small range of values allows more variability in the slope of a fitted line.



As mentioned, reanalysis of a few archived digestates from the Fe/Be spiked ghost wipe study suggests that there might be no similar disparity between the BN-MS analyses of archived samples and the actual concentrations. A number of explanations are possible. One is that digestates from the Fe/Be study have not been in storage nearly as long as the digestates of environmental samples, and have not experienced concentration due to aging. Another explanation, though, is that the DC analyses (performed using ICP-AES, but with a different spectral line) may also be subject to interferences other than Fe. There may be other explanations; it is not possible to decide among the various possibilities at this point.

Path Forward

The BN-adj data are used without concern, as stated previously.

The BN-MS (MS_arch) reanalysis data are also used as is. This analysis is conservative, because the slope of the WLS line discussed above is considerably less than 1. If a facility satisfies the established criteria using this approach, no further analysis is performed.

If a facility does not satisfy the RC using this conservative approach, further investigation is needed. This further investigation involves resampling facilities as needed, at least in the vicinity of high values, possibly preceded by a preemptive cleaning. The fresh samples, obtained during January 2009 (February 2008 for 06-908) were again analyzed by ICP-MS; these data are designated MS_new. In addition, bulk samples were obtained inside the facility as well is in the soils in the vicinities of the facilities, as described in the following section.

Alternate Facility Evaluation Methods

The discussion and methods discussed so far in this report deal with satisfying regulatory criteria framed in terms of the Title 10 Code of Federal Regulations 850 U.S. Department of Energy (0.2 µg/100 cm^2) [0.2 micrograms/100 square centimeters]. There is an alternative also contained in that regulation that can be considered, which is to show that Be concentrations in bulk samples obtained within a facility are not higher than those in surrounding soils. The apparent objective of that regulatory alternative is to demonstrate that the Be contained in dust inside the facility is not anthropogenic, but rather could reasonably have originated in native soils.

Another way of approaching this issue would be to compare ratios of certain metals contained in either bulk or wipe samples obtained within the facility with those found in native soils. Both of these approaches were used with certain facilities. A more detailed discussion of these approaches is found in Appendix 4.

Appendix 4
ADDITIONAL STATISTICAL ISSUES

Overview

This appendix discusses several technical statistical issues.

The conventional assumption is that environmental contaminant concentrations follow lognormal models; that is, that logs of the concentrations have normal distributions. The distributions of measurements, however, are more complicated; most obviously, measurements can be negative, which is inconsistent with the lognormal assumption. Nearly all measurements used in this study are uncensored, meaning that actual ("raw") values are reported and used, in order to avoid the loss of information (statistical power) inherent in censoring data. The main issue discussed in this appendix is the treatment of these uncensored data.

Also, recall that the regulation that provides the U.S. Department of Energy (DOE) regulatory criteria (RC) allows an alternate comparison, which is that surface beryllium (Be) concentrations on items to be released to the public should not be higher than concentrations in neighboring soils. The intent is apparently to allow one to distinguish between naturally occurring and anthropogenic Be. An extension of that concept is to evaluate not only Be concentrations in bulk material samples but also ratios of other common metals with Be, a so-called "fingerprint" analysis. The other metals involved are cobalt (Co), nickel (Ni), copper (Cu), yttrium (Y), niobium (Nb), and uranium-238 (^{238}U); these analyses are available in wipe and bulk samples analyzed using the inductively coupled plasma mass spectroscopy (ICP-MS) instrument. This appendix also includes evaluations of the soil Be concentrations and metal ratios and a discussion of the comparison of bulk and wipe samples with the soil data.

The structure of this appendix is as follows:

- The main issue and its implications are first discussed in greater detail.

- The distributions of blank measurements are evaluated. It turns out that there are highly statistically significant and non-negligible differences among groups of blank measurements. To compensate for these differences, data are "blank-corrected"; that is, adjusted for the apparent low-end bias as reflected in the blank measurements.

- A simple heuristic for handling the negative values is described. That heuristic involves adding a small constant (delta) to all data values, doing the lognormal analysis, and then subtracting delta from the resulting prediction level (PLall) or upper tolerance limit (UTL). The algorithm for selecting delta is presented; delta varies by analytical method and type of facility.

- A method for performing UTL analyses using all Individual Work Area (IWA) data, rather than just the IWA maxima, is presented. This is termed "UTL cluster analysis";

the observations from a given IWA are treated as coming from a cluster in statistical survey terms, where one allows for the possibility that values in the same cluster might be positively correlated.

- Finally, an analysis of Be data and metal ratio data in soil samples is presented.

The Main Statistical Issue

As discussed in Appendix 1, the lognormal statistical model is used as the basis for the statistical analyses presented in this document. There is a considerable weight of tradition behind the selection of this model for distributions of environmental contaminants. A mechanism that might generate this model is the following: if one considers the concentration at a given point to be a random fraction of a random fraction of … of some source, that concentration would be a product of random quantities, and so one might posit a central-limit-theorem argument on the log scale to support the lognormal assumption. On the other hand, the common use of the lognormal model is likely based much more on perceived ease of use, in that the model is non-negative and right-skewed, and one can “just take logs and use normal-theory methods.”

This model is somewhat simplistic, but nonetheless useful if handled with care. In the words of the eminent statistician G. E. P. Box, “All models are wrong, but some are useful.” (“Robustness in the Strategy of Scientific Model-Building”, in R. Launer and G. Wilkenson, eds, *Robustness in Statistics*, 1979). Recently other not-so-heavy-tailed models have been proposed for environmental contaminants, notably gamma distribution models. Empirical evidence supporting one model over the other is difficult to come by, since the main differences are in the extreme upper tails where data are rare. The not-so-heavy-tailed models are likely to give more palatable upper limits, though, and perhaps that is a reason for their appeal; one may therefore consider the lognormal models to be possibly conservative.

Although the lognormal model may arguably be appropriate for the distribution of Be concentrations, sample preparation and analytical variation (“error”) impact, in particular, the lower tail of the distribution of measurements. For some facilities over half the measurements are negative, which makes the idea that one should “just take logs and use standard normal distribution methods” problematic. Even if all data were positive, this added variation causes difficulties since on the log scale the difference between 0.0001 and 0.001 is the same as the difference between 0.1 and 1.0, whereas in real-life exposure terms these are not at all the same. The distributions of the sample preparation and analytical variation components are nicely modeled using normal (not lognormal) distributions; see “What is a Beryllium Measurement? A Critical Look at Beryllium Quantitation” (C. B. Davis, D. Field, J. Hess, and D. Jensen, presented at *Beryllium Particulates and Their Detection*, Salt Lake City, UT, 2005).

Distributions of Be measurements are thus neither lognormal nor normal in general, but rather follow distributions with two variance components, one of each type. There are two limiting cases. When little Be is present, the minor lognormal component itself looks nearly normal, as does the overall measurement distribution. At the opposite extreme, the sampling and analytical error component becomes negligible and the lognormal component predominates. Most often, though, the bulk of the data is nearly normally distributed around or close to zero, with an upper tail of somewhat higher measurements.

A more accurate model for the actual distribution of measurements is described in “A Model for Measurements of Lognormally Distributed Environmental Contaminants” (C. B. Davis, D. Field, and T. E. Gran, presented at the Joint Statistical Meetings in Washington, D.C., 2009). This model may be viewed as an extension of the D. M. Rocke and S. Lorenzato model (“A Two-Component Model for Measurement Error in Analytical Chemistry,” *Technometrics* 37, 1995). It is as yet intractable for making UTL- or PLall-type decisions directly, but is useful for testing the performance of UTL and PLall procedures such as those used in this study and others that have been proposed.

Most often data of this sort are <u>censored</u>, which means reporting all values less than some reporting limit (RL) as simply “<RL.” When data are censored, one is generally unaware of the actual distributions of the low-level measurements that typically form the majority of measurements from most facilities.

There are three possible statistical approaches: (1) one can use nonparametric statistical methods that rely only on the sample size and the upper-most data value(s); (2) one can use censored-data statistical methods such as those evaluated in “Parametric 95%-95% Upper Tolerance Limits for Censored Lognormal Data” (C. B. Davis, presented at the Joint Statistical Meetings in Seattle, WA, 2006); or (3) one can use uncensored-data methods when available.

We note that when data are censored, the distribution question does not arise so long as nonparametric statistical methods are used. However, as discussed by Davis and Grams (“When Laboratories Should Not Censor Analytical Data, and Why”, C. Davis and N. Grams, U.S. Environmental Protection Agency 25th Annual Conference on Managing Environmental Quality Systems, Austin, TX2006), in many cases this practice leads to high sample-size requirements and inefficiencies. The reason for this is that for clean facilities, in particular, the non-detect proportions tend to be high, and therefore nonparametric statistical methods with their higher sample-size requirements are needed. Using nonparametric statistical methods, the PLall approach is simply not available for any reasonable sample size; see “Simultaneous Nonparametric Prediction Limits” (with discussion and response, C. B. Davis and R. J. McNichols, *Technometrics* Vol. 41, pp. 89-112, 1999). The minimum sample size for 95%-95% UTLs is n = 59. The irony is that the cleaner the facility, the more likely the need for larger sample sizes under this approach.

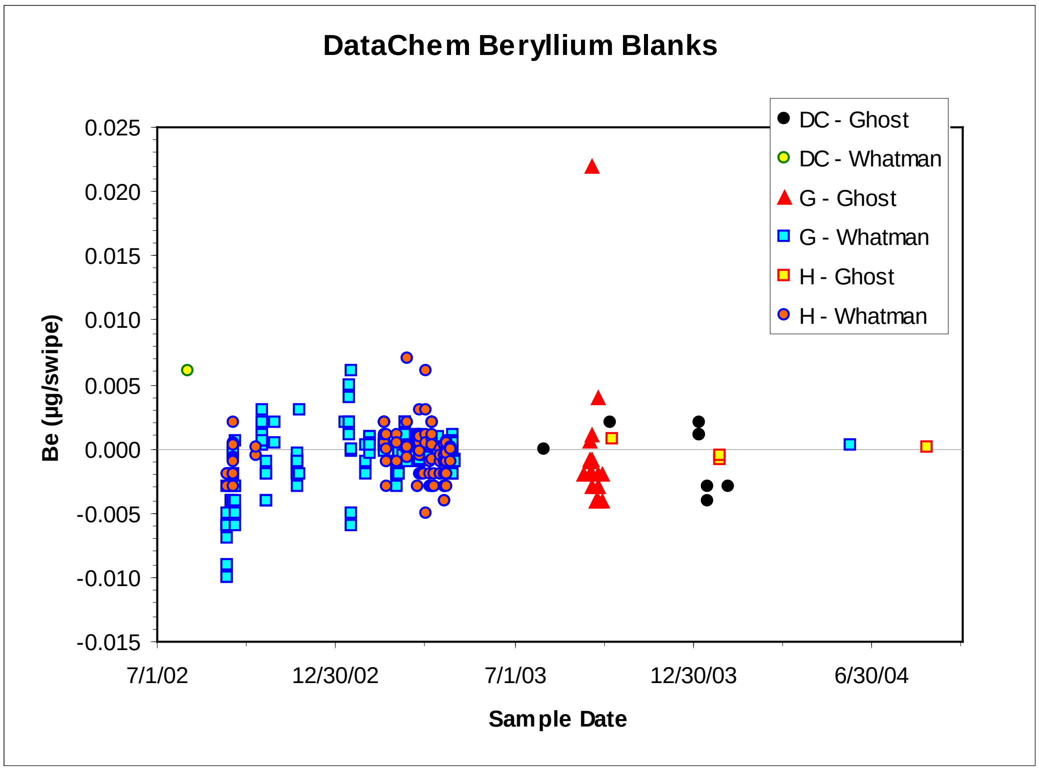
It turns out that even when there are enough “detects” to use the censored-data lognormal methods presented by Davis (2006, see above), the distortion implicit in using the lognormal model can reduce the statistical power considerably. Paradoxically, this loss of efficiency is greater when the RL is lower; the mechanism seems to be that implicitly assigning all the negative values to the interval between zero and the RL, creates a much more peaked (and hence, long-tailed) fitted model than is appropriate for the actual data, as discussed by Davis, Field, and Gran (2009, see above). We prefer to deal with the uncensored data.

The results reported in this appendix address these issues in two steps. The first is to examine the distributions of measurements of blank wipe samples. The second is to develop and validate a heuristic approach for dealing with the impact of the lower tail of the distribution on the decision-making process.

Distributions of Blank Measurements

<u>DataChem</u>

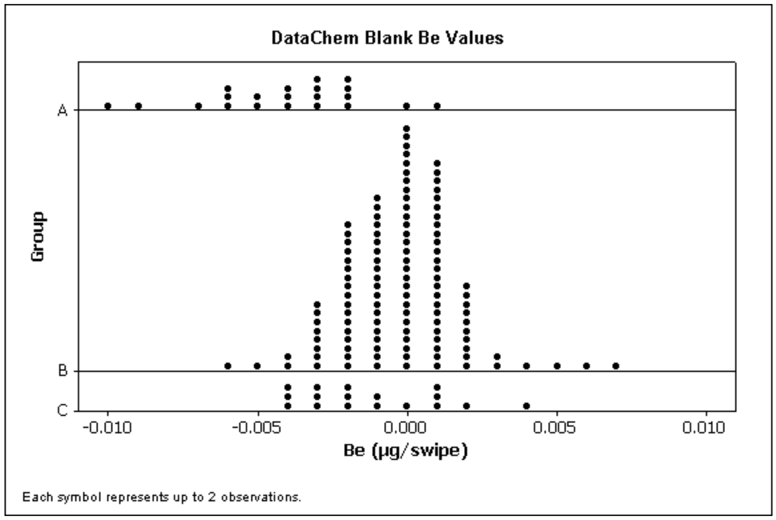
The DataChem blanks are the most interesting. These are shown in the following plot, color-coded by instrument and material. DataChem used two instruments, "G" and "H," and two types of wipe material (ghost wipes and Whatman filters) during different periods. There was generally no discernable difference between the distributions of Whatman filter blank measurements, with the critical exception of those from instrument G during September 2002, which show a pronounced negative bias. There is a milder negative bias for ghost wipe blanks, but no statistically significant difference between instruments. (Where the instrument is given as "DC," the instrument used is not known.)



We have three periods: September 2002, October 2002 through May 2003, and July 2003 through January 2004. These are the

DataChem Blanks				
Group	Description	n	Mean	StDev
A	Instrument G, Whatman Filter, September 2002	36	-0.0041	0.0026
B	Other Whatman Filter (through May 2003)	227	-0.0003	0.0018
C	Ghost Wipe (starting July 2003)	32	-0.0013	0.0022

sampling dates; analysis dates are assumed to follow promptly. Three samples obtained outside these time periods are excluded from the analysis, as is the outlier. Excluding the "DC" samples, there were originally six groups (period A ghost, etc.). Groups whose mean values were not statistically significantly different were combined. Means and standard deviations for each of the resulting three groups are given in the table; dot plots follow.



These distributions are very nearly normal; probability plot correlation coefficients (ProbPlot Rs) are 0.979, 0.983, and 0.991 for the three groups, respectively. The ProbPlot R for the pooled, centered data is 0.977.

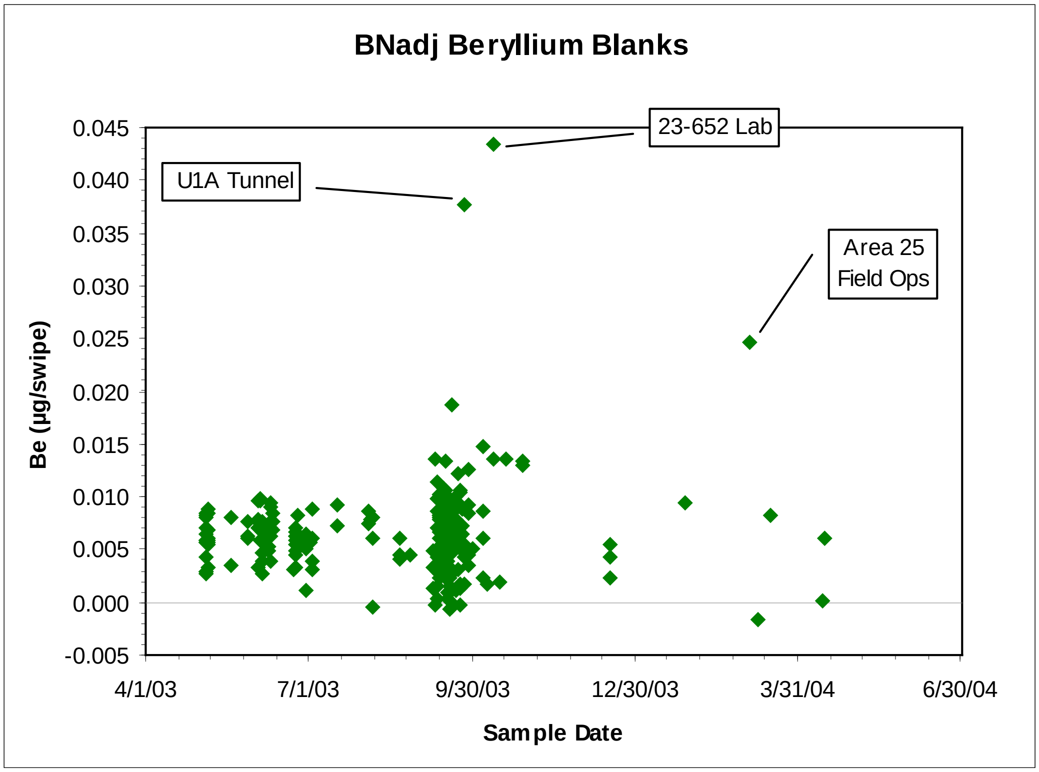
The negative bias in Group A was enough to make the large majority of measurements obtained in some critical buildings in the B Complex in North Las Vegas (NLV) negative. More importantly, both instruments were used in the analyses for two of those which were sampled during September 2002. For these reasons, it was decided to subtract the appropriate blank mean from each observation before proceeding with the statistical analysis; this is termed "blank correction." ("BC" in the tables in Appendix 2 is the negative of the blank mean.) Doing otherwise would artificially increase the variability seen in very low measurements; recall that when using lognormal models small relative variation in low measurements can have the same effect as large relative variation in higher measurements. In particular, such spurious variation in low-level measurements can have the adverse effect of inflating UTLs, PLalls, and so on.

For some facilities, work environment data obtained prior to September 2002 were used. These facilities had been occupied, and it was considered appropriate to include them in the study. They had been vacated by the time the systematic survey started, however. The data for these facilities were reported using the standard conventions regarding RLs and "non-detects"; accordingly, no low-level bias correction is available for these facilities, and our analyses use the censored-data lognormal approach recommended by Davis (2006, see above).

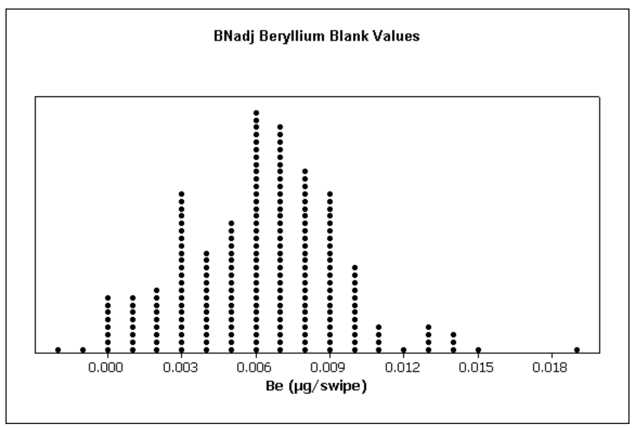
<u>Bechtel Nevada (BN) Adjusted</u>

The story is considerably different with the BNadj (see Appendix 3) blank data. Whether adjusted or not, these data show a considerable positive bias. The data were examined to determine whether there are any systematic relationships between the type of facility or the Nevada Test Site (NTS) area in which the blank was "obtained," but no such relationships were found (*p*-values were 0.549 and 0.223, respectively). There were three high outliers, as seen in the following plot; these were deleted from the statistical summary.

It should also be noted that the iron (Fe) peak heights were atypically elevated in some field blank wipes associated with areas where Fe would be expected, particularly Area 1, 6, and 23 shops involving metal work. The Fe peak height exceeded the cutoff value of 65K in two of these (see the Appendix 3 discussion). Again, though, no systematic relationship could be determined.



Excluding these three outliers, the distribution of BNadj blank values is as shown in the plot to the right and the table below. The normal distribution ProbPlot R is 0.992.



BNadj Blanks		
n	Mean	StDev
218	0.0062	0.0032

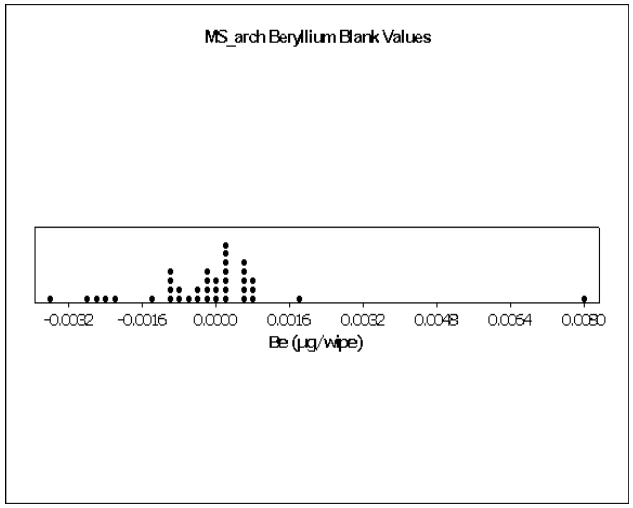
For comparability with DataChem data at the low end of the distribution, a BC of (-0.0062) is added to BNadj data; doing so is particularly important for those facilities with both DataChem and BNadj data.

<u>MS Analyses of Archived Samples</u>

As discussed in Appendix 3, in many samples analyzed by BN using its ICP-AES instrument, the Fe peak was too high to allow one to comfortably use the adjustment procedure. These samples were archived (retained as digestates) and reanalyzed quite some time later by ICP-MS. These analyses, denoted MS_arch, appear to be quite conservative as discussed in Appendix 3. Accordingly, if using the MS_arch data would allow a facility to “pass” the statistical test, this result was accepted.

The MS_arch blank data are shown in the next table and dot plot.

MS_arch Blanks		
n	**Mean**	**StDev**
38	-.0004	0.0011

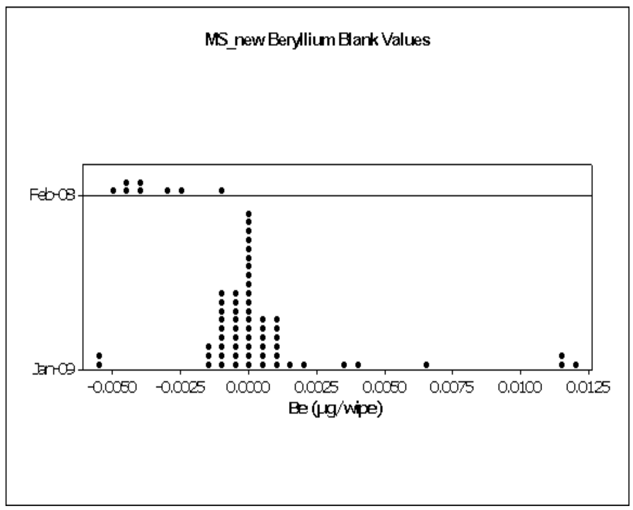


The normal probability plot correlation is only 0.850 with the outlier included. With that omitted, it is 0.960. The mean used for the blank correction omits the outlier.

<u>MS Analyses of New Samples</u>

The ad hoc approach of using the conservative MS_arch results was unsuccessful with a number of facilities. These were resampled during February 2008 (06-908) and January 2009 (numerous facilities; see Appendix 2). These data are denoted MS_new. The adjacent table and dot plot show the blank data associated with these samples and analyses.

MS_new Blanks			
	n	**Mean**	**StDev**
Feb-08	8	-0.0035	0.0013
Jan-09	53	-0.0001	0.0007



There are eight outliers in the January 2009 blank data which are omitted from the mean calculation. Including the outliers the normal probability plot correlation is only 0.798; without them it is 0.978.

Dealing with Negative Values

The heuristic adopted for dealing with negative values is to add a small constant (delta) to each measurement, compute PLall and/or UTL with the resulting positive numbers using standard lognormal methods, and then subtract delta from the result. There are two issues: determining an appropriate value of delta; and demonstrating that the resulting shifted distribution is adequately lognormal. It is well known that probability distribution tests require moderate to large

Type	Description
CO	Communications facility
EX	Experimental facility
FO	Field Operations facility
LA	Laboratory
OF	Office facility
QU	Quarters, including cafeteria
SH	Shop
ST	Storage

samples for reliability, whereas the data from many of our facilities contain fairly small numbers of IWA maxima, particularly, or Work Area (Area) values. The solution is to pool data across similar facilities, similar being defined in terms of facility use. Recall the codes used in Appendix 2, shown in the table on the previous page. Facility location (NTS area) was also considered as a factor in determining delta, but eventually discarded.

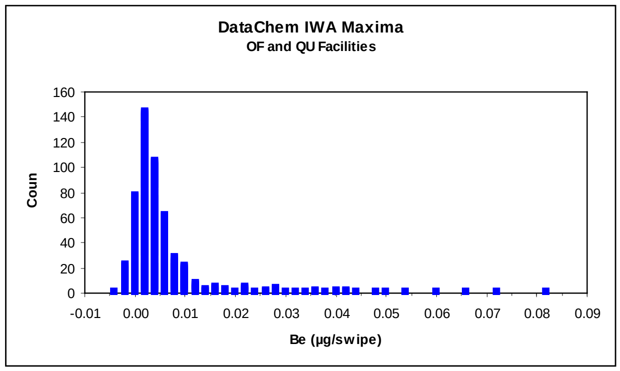
DataChem

Based on comparisons of DataChem distributions and sample sizes, the following groupings were decided upon. This table contains also the delta and probability plot correlations (R and R90) for each group; these will be discussed presently. A very small number of high and low outliers are omitted in these analyses.

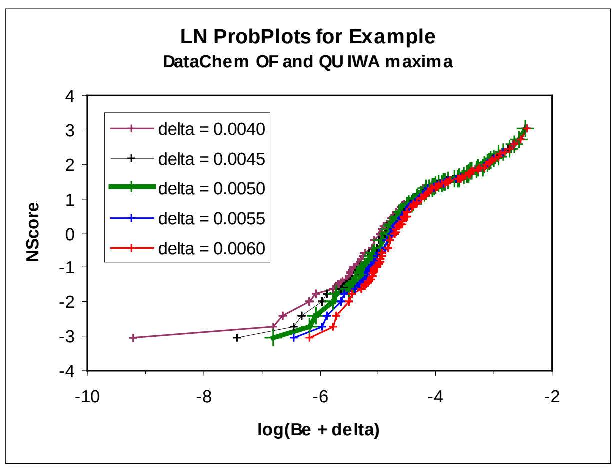
DataChem delta Selection

Type of Analysis	Facility Types	N	delta	R	R90
IWA	OF QU	513	0.0050	0.961	0.988
	CO EX LA	99	0.0020	0.893	0.971
	FO SH ST	165	0.0030	0.974	0.976
Area	OF QU	132	0.0020	0.932	0.969
	EX	47	0.0070	0.945	0.925
	FO SH ST	779	0.0055	0.955	0.986

As an example of the working of this heuristic method, consider the data from OF [office facility] and QU [quarters] facility types. After adding the low-level shifts for blank correction, the distribution of the pooled IWA maximum data is shown in the plot at the right. The minimum value is -0.0039.



We wish to avoid having low values too near zero after adding delta; a rule of thumb seems to be that after adding delta the minimum value should not be less than approximately 0.001, and certainly never negative, after removing obvious outliers.

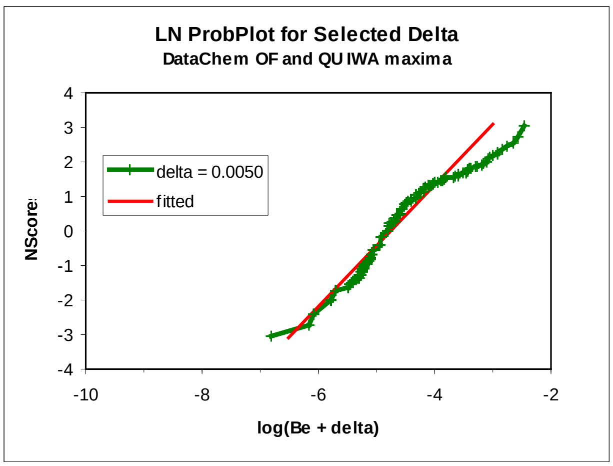


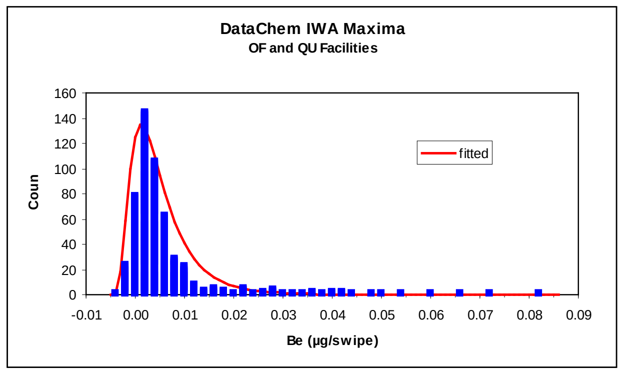
In this example, the minimum delta should therefore be around 0.0050 or so. For illustration, we try values starting at 0.0040, increasing in increments of 0.0005. A lognormal probability plot is constructed for each candidate delta value. The ideal for such a plot is a straight line; the probability plot correlation (ProbPlot R) measures the straightness of the line. With a perfect straight line R = 1. Because there are sporadic high measurements in some facilities, the probability plot correlation of the lowest 90% of measurements (R90) is also taken into consideration.

delta	R	R90
0.0040	0.959	0.954
0.0045	0.965	0.982
0.0050	**0.961**	**0.988**
0.0055	0.956	0.980
0.0060	0.952	0.991
0.0065	0.947	0.991

Clearly the value of delta has little effect on the high values, which in this example range up to 0.0811. With the smallest delta candidates (0.0040 and 0.0045), the lowest values become excessively spread away from the body of the distribution, whereas with the larger candidate values the distribution tends toward a general concave appearance, indicating that the transformed data are still right-skewed. In this example, the highest R of 0.965 is obtained with delta = 0.0045, but R90 is still increasing at that point. The next trial value (delta = 0.0050) is selected as a compromise.

The lognormal probability plot (LN ProbPlot) for the selected delta (left below) shows some deviation from the ideal straight line, but no consistent downward curvature at the upper tail and, more importantly, no lower-tail outliers, both of which are of concern for PLall and UTL inferences. The fitted shifted lognormal distribution using delta = 0.0050 is shown in the plot on the right below.





Incidentally, for this example, the normal (not lognormal) ProbPlot R is 0.746, decidedly lower than acceptable. As delta increases, the transformed data ProbPlot R decreases toward this value, and the UTL and PLall values decrease toward those that would be obtained using normal distribution methods without data transformation. In the delta selection reported here, the preference is for the smallest delta values that provide adequately high R and R90 correlations.

BN Adjusted

These data are actually a mixture of BNadj data with some DataChem data, all data being blank-corrected as discussed previously. The latter are included for one of three reasons: (a) DataChem side-by-side values were used where the BN sample Fe peak height was excessive (see Appendix 3), (b) DataChem side-by-side values were used when they are higher than the BNadj values, and (c) in a couple of instances initial small data sets of samples analyzed by DataChem were augmented by additional samples with BNadj analyses.

BN-adj delta Selection					
Type of Analysis					
	Facility Types	**N**	**delta**	**R**	**R90**
IWA	OF QU	238	0.0050	0.943	0.971
	EX LA	48	0.0020	0.987	0.984
	FO SH ST	54	0.0030	0.976	0.991
Area	EX LA	75	0.0070	0.989	0.992
	FO	105	0.0080	0.988	0.989

For the most part, the delta values selected in the previous section for DataChem will work nicely with the BNadj data. The exception is with FO [Field Operations] Area measurements, as seen in the adjacent table.

BN Adjusted Along with BN-MS Archived Sample Analyses

As discussed elsewhere, there are a number of measurements with high Fe peak heights that preclude the adjustment described in Appendix 3. The digestates from these analyses were archived. These archived digestates were reanalyzed during January-April 2007 using a newly acquired ICP-MS instrument, giving the MS_arch data. As discussed in Appendix 3, there is concern about the quality of these data, given the excessive holding time involved. Many of the MS_arch values seem rather high; this could be consistent with either concentration of the digestate via evaporation while it was archived or higher Be concentrations accompanying the higher Fe concentrations in some areas of some facilities. For the purposes of this report, it was decided to use the MS_arch values where possible, recognizing that they may be biased high and, therefore, result in conservative analyses or decisions. For facilities for which this stratagem did not provide satisfactory results, a supplemental round of sampling was conducted during January 2009 (February 2008 for 06-908), with fresh samples analyzed by ICP-MS (MS_new data); see the discussion to follow.

The data sets that result include a mixture of MS_arch, BNadj, and DataChem data. Accordingly, deltas for these data sets are determined separately from those for only BNadj and/or DataChem. These are given in the table at the right.

Mixed BNadj and MS_arch delta Selection					
Type of Analysis					
	Facility Types	**N**	**delta**	**R**	**R90**
IWA	OF QU	84	0.0040	0.969	0.966
	EX LA	80	0.0040	0.958	0.949
	FO SH ST	34	0.0030	0.969	0.975
Area	LA	52	0.0070	0.974	0.969
	FO SH ST	975	0.0080	0.980	0.979

Shift analyses for cluster sampling

An alternate analysis of the IWA data uses all the values, not just the IWA maxima, as discussed in the following section. The delta values should be expected to be larger than those for the IWA maxima, since the distribution of all IWA data values includes lower values. Two versions are done: one for those facilities with data from only DataChem and the other for facilities with BNadj data and possibly also some DataChem and/or MS_arch data.

DataChem delta selection for all IWA data					
Type of Analysis					
	Facility Types	**N**	**delta**	**R**	**R90**
IWA	OF QU	2618	0.0085	0.955	0.967
all	CO EX LA	476	0.0040	0.949	0.972
	FO SH ST	785	0.0055	0.929	0.963

BNadj etc. delta selection for all IWA data					
Type of Analysis					
	Facility Types	**N**	**delta**	**R**	**R90**
IWA	OF QU	1675	0.0085	0.958	0.972
all	EX LA	453	0.0080	0.982	0.987
	FO SH ST	1718	0.0090	0.938	0.981

New ICP-MS analyses

The table to the right shows the delta values for MS_new mixed with other analyses. There are relatively few data values, particularly for the IWA analyses, and most come from very similar environments.

Mixed MS_new and other delta Selection					
Type of Analysis					
	Facility Types	N	delta	R	R90
IWA	OF FO ST	28	0.0030	0.980	0.971
Area	FO SH ST	651	0.0085	0.979	0.975

UTL analyses with cluster sampling data

The sampling plans used for IWA facilities and portions of facilities are similar to cluster samples in surveys. A basic model for such measurements is

$$X_{ij} = \mu + W_i + Z_{ij},$$

where μ is the overall mean value for the facility, X_{ij} is the j^{th} measurement in the i^{th} cluster (here, i^{th} IWA), W_i represents any random effect common to all measurements in cluster *i*, and Z_{ij} represents the random variation in the measurements that are independent of those for other measurements. There are I clusters (IWAs) in all, and J_i measurements in the i^{th} cluster. In this study, J_i is nearly always between 4 and 6; for various facilities, I can range from 2 to nearly 100.

We assume that data are normally distributed after appropriate transformation. In particular, the W_i are independent, normally distributed random variables with mean 0 and standard deviation τ; the Z_{ij} are independent, normally distributed random variables with mean 0 and standard deviation σ; and the Z_{ij} are independent of the W_i. The distribution of the X_{ij} is then normal with mean μ and variance (squared standard deviation) $(\tau^2 + \sigma^2)$, denoted as VAR in the following.

The following derivations are for J_i all the same (= J), which is approximately true in this survey. The average of measurements for the i^{th} cluster is $\overline{X}_{i.}$, which has variance $(\tau^2 + \sigma^2/J)$, and the overall average of measurements is $\overline{X}_{..}$, which has variance $(\tau^2/I + \sigma^2/IJ)$. We have the usual sums of squares between and within clusters from the Analysis of Variance (ANOVA):

$$SSB = J\sum_i (\overline{X}_{i.} - \overline{X}_{..})^2 \text{ and } SSW = \sum_i \sum_j (X_{ij} - \overline{X}_{i.})^2,$$

and the usual mean squares

$$MSB = SSB/(I-1) \text{ and } MSW = SSW/(I(J-1)).$$

The sums of squares are proportion to independent chi-square random variates:

$$SSB \sim (J\tau^2 + \sigma^2)\,\chi^2(I-1) \text{ and } SSW \sim \sigma^2\,\chi^2(I(J-1)).$$

To estimate VAR, we find an unbiased estimator which is a linear combination of *MSB* and *MSW*; this is

$$\hat{\mathrm{V}}\mathrm{AR} = \frac{1}{\mathrm{J}} MSB + \frac{\mathrm{J}-1}{\mathrm{J}} MSW .$$

Being a linear combination of independent χ^2 random variables, its distribution is approximately that of a multiple of a χ^2 random variable having the right mean. The estimated approximate degrees of freedom are given by the Satterthwaite formula, which becomes

$$\hat{\mathrm{D}}\mathrm{F} = \frac{\left(\frac{1}{\mathrm{J}} MSB + \frac{\mathrm{J}-1}{\mathrm{J}} MSW \right)^2}{\frac{(\frac{1}{\mathrm{J}} MSB)^2}{\mathrm{I}-1} + \frac{(\frac{\mathrm{J}-1}{\mathrm{J}} MSW)^2}{\mathrm{I}(\mathrm{J}-1)}} .$$

This simplifies to the satisfying formula

$$\hat{\mathrm{D}}\mathrm{F} = \frac{(F + \mathrm{J}-1)^2}{\frac{F^2}{\mathrm{I}-1} + \frac{\mathrm{J}-1}{\mathrm{I}}},$$

where *F* = *MSB*/*MSW* is the usual *F* statistic from the ANOVA. Note that as *F* becomes large $\hat{\mathrm{D}}\mathrm{F}$ approaches (I-1), which is the appropriate degrees of freedom for the case with predominant cluster-to-cluster variation, whereas for *F* small (around 1) $\hat{\mathrm{D}}\mathrm{F}$ is close to its correct value (IJ-1) for the case with negligible cluster-to-cluster variation.

In the standard independent sampling situation, the UTL multiplier K is given by

$$\mathrm{K} = \frac{1}{\sqrt{\mathrm{n}}} \mathrm{T}^{-1}(\gamma, \mathrm{DF}, \mathrm{DEL}),$$

where T is the non-central *t* distribution cumulative distribution function, γ is the desired confidence level, n is the number of observations, and DF is the degrees of freedom (generally n-1). $\mathrm{DEL} = z_\beta \sqrt{\mathrm{n}}$ is the noncentrality parameter, where $z_ß$ is the 100ßth percentile of the standard normal distribution and 100ß is the desired percentile for the UTL. In this application ß = 0.95; γ is generally also 0.95, except in cases where a facility is treated as consisting of two or more parts and we want the overall confidence level to be no less than 95%, so the individual confidence levels are set higher (see Appendix 1).

The function of n in the derivation of the UTL K multiplier is to account for the variability of the mean. In the standard situation, without cluster sampling, Var($\overline{X}$) = σ^2/n. With cluster sampling, though, Var($\overline{X}_{..}$) = $\frac{1}{\mathrm{I}}\tau^2 + \frac{1}{\mathrm{IJ}}\sigma^2$. As a first approach to accounting for this variation, we derive a pseudo-sample size N^* by setting $\frac{1}{N^*}(\tau^2 + \sigma^2) = \frac{1}{I}\tau^2 + \frac{1}{IJ}\sigma^2$. Solving for N^* and substituting their estimators for the unknown parameters τ^2 and σ^2, leads to the satisfying formula

$$N^* = I(1 + (J-1)/F).$$

Note that for F large this approaches I, as it should if the analytical variation is negligible relative to between-cluster variation, and if $F \sim 1$ this is just IJ, the total number of measurements, as is appropriate if cluster-to-cluster variation is negligible.

If F is 1 or less, a standard UTL analysis is used with no allowance for a cluster effect.

Unfortunately, between this approximation and the Satterthwaite approximation the actual confidence level is a bit too variable, as was discovered during Monte Carlo simulations. In particular, for small I (fewer than 10 IWAs) and large τ/σ, the confidence was lower than desired. (In preliminary analyses, τ/σ was found to range from 0 to somewhat less than 1 for our data.) Accordingly, three UTL multipliers are formed:

> K1 uses N^* and $\hat{D}F$;
> K2 uses I and $\hat{D}F$; and
> K3 uses I and (I-1) for the sample size and degrees of freedom, respectively.

K2 and K3 are conservative. Weighted averages of these, with weights depending on the number of IWAs I, are found to maintain the desired confidence level reasonably well (between 93% and 97% for $0 \leq \tau/\sigma \leq 1$):

> K12 = a K1 + (1-a) K2 for $I \geq 10$, and
> K123 = 0.5 K1 + 0.5 (K2+K3)/2 for $I < 10$, where
> a = 0.6 – 1/I.

The Monte Carlo simulations used J = 5, being approximately the average number of measurements taken per IWA.

The formulas for the unbalanced case (J_i not all the same) are considerably more complicated. An adequate approximation is obtained, though, using the variance component estimates and F ratio obtained from the data using standard commercial statistical software.

Analysis of Soil and Bulk Samples and Metal Ratios

As discussed in Appendix 1, applying the DOE RC with UTLs (or PLalls) for facility surveys is borrowed from the Title 10 Code of Federal Regulations Part §850.31(b)(1) provisions for acceptable surface contamination levels associated with items to be released to the public. That regulation allows an alternate comparison with soils near the equipment or items involved. To apply this alternate comparison to facility surveys, one obtains soil samples outside the facility and bulk material samples inside and compares the Be concentrations in those samples.

The regulatory provision is clearly intended to avoid deciding that equipment is “dirty” and in need of cleanup simply due to naturally occurring Be in the soils. Accordingly, in pursuing this mode of decision-making, National Security Technologies, LLC, has extended this approach to include evaluation of metal ratios. The ICP-MS analyses used most recently in the January 2009 resampling of certain facilities allow for determination of several other metals that are found naturally in the soils at the NTS and ancillary facilities. Those metals are Co, Ni, Cu, Y, Nb, and ^{238}U.

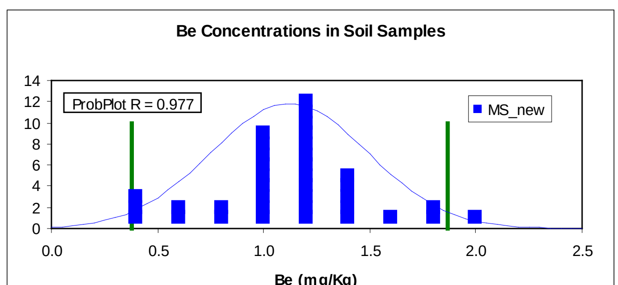
The approach adopted is the following. Small numbers of bulk samples were obtained inside most of the facilities involved in the January 2009 resampling, along with exterior soil samples; theses were analyzed for the additional metals. In addition, any wipe sample whose Be concentration exceeded the DOE RC of 0.2 µg/100cm^2 [micrograms per square centimeters] was also analyzed for those additional metals. Typical intervals for the Be soil concentrations were obtained; those are shown graphically below. Also, typical intervals for logs of the ratios were obtained.

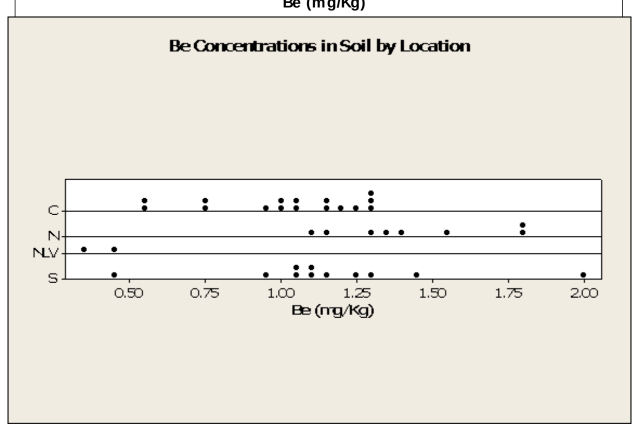
The draft DOE Technical Standard does not at this time contain a protocol for comparisons between bulk and soil concentrations or for comparing metal ratios. For the purposes of this study, these comparisons are used to supplement comparisons of surface concentrations with the DOE RC in cases where a facility does not “pass” using the RC comparisons. The Be concentrations in bulk samples with high Be concentrations were compared with metal ratios found in exterior soils. Where the Be concentrations in interior bulk samples and/or the metal ratios in bulk or wipe samples were consistent with those observed in exterior soils, the Be present in the facility was taken to be of natural origin and, therefore, not “contamination” in the sense of 10 CFR 850. Facilities judged not contaminated based on this evidence are designated by blue coding in the chart in Appendix 2.

Be soil data

The plot at right shows the distribution of all 37 soil Be values. The fitted middle 95% of these data extends from 0.38 to 1.86 mg/Kg [milligrams per kilograms]. There is some indication that the soil values may vary systematically from NTS Area to Area, as seen in the next plot.

In that plot, “N” indicates soil samples obtained in Areas 1, 3, and 12 to the north of the NTS; “C” indicates those obtained in Areas 5 and 6; “S” indicates those obtained in Areas 23, 25, 26, and 27; and “NLV” indicates those obtained in NLV or Nellis Air Force Base (AFB). Differences in means among these locations are highly statistically significant ($p = 0.001$), with NLV being clearly lower than N and S, and N being somewhat higher than C.



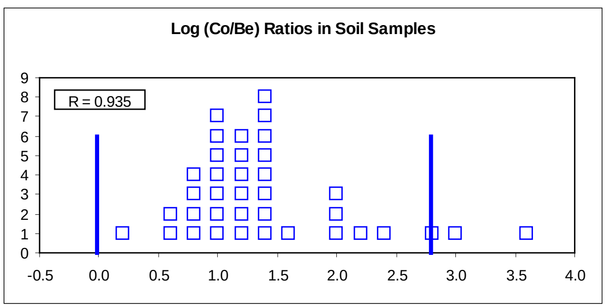


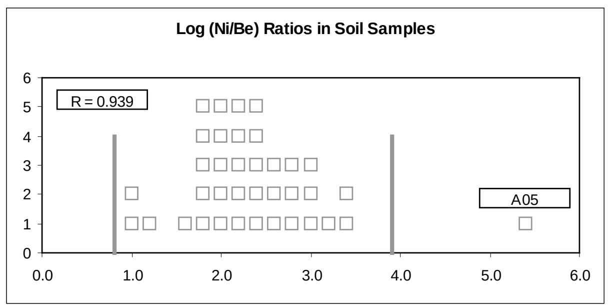
These data are mildly consistent with soil samples obtained previously from Frenchman Flat, Jackass Flat, and Yucca Flat, and analyzed by Y-12 using ICP-AES. The middle 95% of those data extend from 0.20 to 1.28 mg/Kg; the areas sampled correspond to some areas labeled "C" and "S" in the adjacent dot plot. Differences in sample preparation methods are surely involved as well.

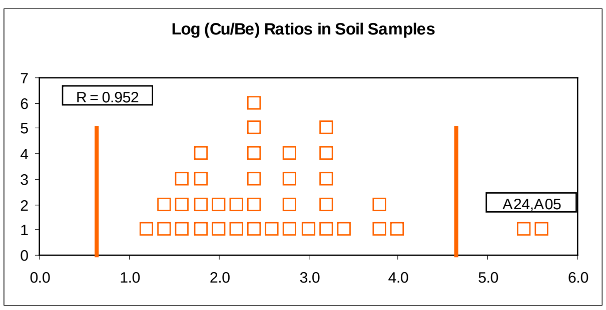
Metal Ratio Data

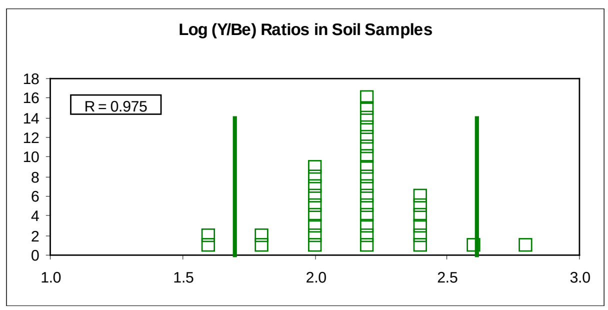
The idea here is that natural Be in soils is associated with other metals, which can also be analyzed via ICP-MS. If that association is reasonably consistent, the value of the ratio of the concentrations can provide supporting evidence that the Be concentration in a bulk or wipe sample is consistent with what one would expect based on, for example, the Y or Nb concentration in that sample. This discussion is carried out in terms of logs of ratios, as those tend to have more symmetric distributions.

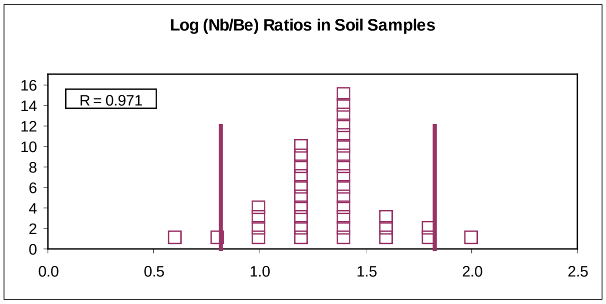
In each case, Be is the denominator of the ratio. Therefore, ratios with Be relatively high compared with the other metal(s) will have relatively low values; we will be less concerned about ratios that are relatively high. Here are plots of the distributions of these log ratios in soil data, with the middle 95% of the distributions indicated.

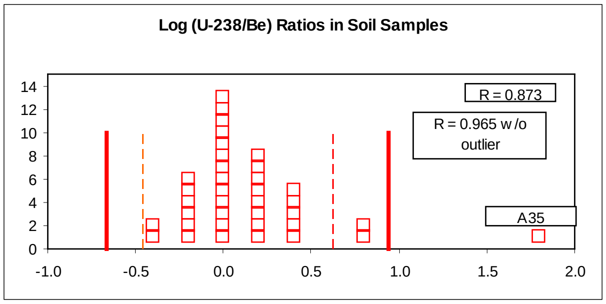












There are a few outliers in these plots with relatively low Be; those are indicated by Area. The normal probability plot correlation R is given in each plot; for U, where this is less than 0.9, computations are repeated with the outlier from Nellis AFB (with low Be compared with U) omitted.

The next table lists the means and standard deviations of the ratios along with their middle 95% intervals. The one after that gives the results of an ANOVA, testing whether the means of the ratios are the same from location to location, using the same location groups as for the Be soil concentrations themselves. Referring to both tables, we find in particular that Ni/Be is quite variable throughout the NTS (standard deviation is relatively large), but no systematic differences among location groups are found. For Co and Cu, the ratios are also quite variable (standard deviation = 0.70 and 1.00, respectively); the statistically significant differences among locations contrast the NLV locations with relatively low Be with one or all of the remaining groups of locations.

The other three ratios have rather lower standard deviation values, and hence will provide better evidence for consistency of Be with the other metals involved. Y/Be has the lowest standard deviation (0.23), and does not quite have statistically significant differences among location groups. Nb/Be and U/Be are next best; the U/Be ratios are different in NLV because of the relatively low Be found in the soil samples there.

95 Percent Intervals for log Metal Ratios

Metals	Mean	StDev	Lower	Upper
Co/Be	1.39	0.70	-0.02	2.80
Ni/Be	2.36	0.78	0.81	3.91
Cu/Be	2.64	1.00	0.64	4.65
Y/Be	2.15	0.23	1.70	2.61
Nb/Be	1.32	0.25	0.81	1.83
U/Be	0.14	0.40	-0.67	0.94
U/Be *	0.09	0.27	-0.46	0.63

Tests of Mean Ratios Among Locations

Metals	*p*	Pattern
Co/Be	0.036	N < NLV
Ni/Be	0.454	
Cu/Be	0.007	rest < NLV
Y/Be	0.062	
Nb/Be	0.048	S < C
U/Be	0.000	rest < NLV