Revised Comments from Members of the Radiation Advisory Committee Augmented for the Review of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Revision 2, Public Comment Draft

Comments Received as of February 2, 2021

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Final comments on the assigned charge questions

Charge Question 1.1 (Associate Reviewer)
"Please identify whether the inclusion and proposed implementation of scan-only surveys (Section 5.3.6.1 and Section 8.5) is appropriate, adequate and clear, especially the discussion on sampling for scan-only measurement method validation or verification."

I feel that the current description of scan-only surveys is appropriate, adequate and clear; however, I feel that it will continue to be misinterpreted. The title, "scan-only" puts one in the mind-set that they can just scan and go. If the title "Scan-Only Surveys" was changed to "Surveys with site-specific validated scan system", I feel that the misinterpretation would be minimized.

Specific Comments

- A reference to Table 5.5 which summarizes Section 5.3.6.1 is needed.
- Page 5-42, line 20 – Sentence indicates that "…will likely require …" It would be helpful to the reader to have specific examples of when validation would be required and specific examples of when it would not be required. As currently written, it is too vague and not helpful to the reader.
- Page 5-42, line 25 - Recommend specifying the scan coverage from 10-100% rather than the use of the vague statement of "a much larger portion". The use of "much larger" is subject to interpretation.
- Page 5-43, line 3-6 – This sentence seems out of place. Obviously an important point to the "scan only" survey approach. It seems that it should be the first sentence to the sub-section. Also recommend deleting "However," and starting the sentence without an introductory clause.
- Page 5-43, line 7 – It is specified that the scan MDC should be less than 50% of the $DCGL_W$. It would be helpful to the reader to know the basis for the stated 50% reduction.
- Page 5-43, line 8 – It is specified that "some percentage" of the samples go for laboratory analysis. It is now explicit that the "scan-only" has to be accompanied with sampling and laboratory analyses. I feel that this is the reason for the misinterpretation; in Section 5.3.6.2 is titled "Scanning and Sampling". One need to read further into Section 5.3.6.2 to sort out the differences. I would be helpful to the reader to include clarification into 5.3.6 that differentiates "Scan-Only Surveys" from "Scanning and Sampling" Surveys
- Page 5-43, Equation 5-10 – It would be more accurate if "Scan Area" were relabeled "% of Scan Area".
- Page 5-43, lines 21-22 – Sentence states, "… in the surface…", do the authors mean "… <u>on</u> the surface…". It seems to me that the issue being raised here is applicable to more

than just alpha and beta radiation in the case of volumetric contamination. It seems that MARSSIM is directing the reader to determine whether there is surface or volumetric contamination at the scan survey site. The results will be impacted for alpha, beta and gamma-ray emitting radioactive materials, but will have a greater impact on alpha, beta, and low-energy gamma-ray and x-ray radiation.

Charge Question 1.4 (Associate Reviewer)

"*Is the discussion of survey requirements for areas of elevated activity technically accurate, appropriate and clear? In particular, please comment on the decision to maintain the use of the unity rule for multiple areas of elevated activity (Section 5.3.5, Section 8.6 and Appendix O.4).*"

Personally, I found the presentation in MARSSIM Rev. 2 on this topic very confusing. I am reading this section for the first time, and not reading the material leading up to Section 5.3.5. Appendix O.4 is helpful in understanding the background on the elevated activity and the advantages/disadvantages of the different approaches. The examples are helpful in understanding the process that is to be followed, but the mathematical notation is inconsistent making the equations leading up to the examples hard to follow.

Specific Comments

- Page 5-36, line 3 – Should read "…treatment of areas of elevated radioactive materials…". The adjective "elevated" is misplaced.
- Page 5-36, line 30 – It would be helpful to the reader to give a little insight into the decision on selection of a triangular or rectangular grid. There are certainly advantages/disadvantages, which should be briefly presented before sending the reader off to EPA 1994b for a detailed explanation.
- Page 5-36, line 31, Equations 5-1 and 5-2 – The notation in Section 5.3.5 is inconsistent and confusing. For example, *A* is defined as the "total area of the survey unit". But in Equations 5-1 and 5-2, the total area of the survey unit now seems to be defined as "*A* (survey unit)"
- Page 5-37, Equations 5-3 and 5-4 – "*A* (grid area)" is used in these equations and never defined. Further "*A* (grid area)" and "*A* (surface area)" are not defined in "Symbols, Nomenclature, and Notations," Page xxviii. What is defined on Page xxviii for "*A*" is overall sensitivity of a measurement, whereas "A" is area.
- Page 5-37, line 4 – "A_{EA}" is defined here and is consistent with "Symbols, Nomenclature, and Notations" on Page xxviii as area of elevated activity. I point to this as an example of good and logical notation that should be used consistently throughout Section 5.3.2 and the entire MARSSIM document.
- Page 5-37, Equations 5-5 and 5-6 – The use of "Scan MDC (actual)" and "Scan MDC (required)" is confusing in these two equations and never defined. If someone jumps to these equations and starts to apply then without reading the context for which they apply, they will come to the conclusion that Scan MDC (actual) = Scan MDC (required). To avoid the possible confusion and the poor notation I recommend that these two equations be removed. Rather than "Scan MDC (actual)" would it be clearer to the reader if it were stated "Actual scan MDC"? What about "Scan MDC (required)"?

Charge question 2.1 (Lead Reviewer)
"Please comment on the usefulness and accuracy of updated measurement methods and instrumentation information (Chapter 6 and Appendix H)."

I found the updated measurement methods and instrumentation information useful and for the most part accurate. However, there exists opportunities to make the information even more useful. Although MARSSIM should not be an advertising platform, it would be useful to have example manufacturer's name and model number for the instrumentation that is being discussed. If it is not appropriate for the individual instruments, then present this information generically in a table so that "*…those interested in purchasing or using the equipment are encouraged to contact vendors …*" have an idea where to go for additional information. Further, there is specific information in Appendix H description that should be properly referenced, for example Page H-10, lines 23-25. The statement was clearly the result of some literature that should be properly cited so the reader can go obtain additional information as needed. Also by including references to the scientific literature information of the manufacturers and models would be available to the reader thus getting around the issue of being a potential advertising platform.

Appendix H needs an extensive technical edit. For the most part, the descriptions of the individual instruments are good, but when compared with the other instruments there are inconsistencies. Should check that the prices given are in 2020 dollars. Some of the prices seem low and others are identical to the previous version of MARSSIM.

Specific Comments

- Page 6-1, line 16 – Punctuation is needed to clarify the double use of "and".
- Page 6-2, line 27 – "Detection capabilities" is utilized here and then "detection capability" is defined in section 6.3. Personally, I am not familiar with "capability" referring to "sensitivity". I think "capability" should be removed and only referred to as "sensitivity". At a minimum I recommend switching the order of the words, Page 6-6, line 22 should state "*The detection sensitivity (sometimes referred to as capability)*". Back on page 2-13, lines 25-29, the "detection capability" seems to be equated with the L_D, which is not correct.
- Page 6-2, line 32 – Recommend wording to be "background of the specific radionuclides of interest". "Specific" should modify radionuclides, not background.
- Page 6-6, line 21 – "Detection Capability" should be used consistently throughout MARSSIM. As previously indicated, I believe that "Detection Sensitivity" is more appropriate. Note at all of Appendix H refers to "Sensitivity"
- Page 6-8, Figure 6.1 – Is the intent of Figure 6.1 to illustrate that a = b = 0.05? That is what is implied based on the description preceding the figure. Figure 6.1 seems to

represent b < a, based on the red and blue areas, but I may have this backwards because of the different s.

- Page 6-9, Equation 6-5 - Is it clear to the reader that MDC is an *a priori* estimate of the minimum detectable concentration? Also, is it clear that Equation 6-5 only accounts for counting uncertainty and does not account for any other random uncertainties or systematic uncertainties. Further equation 6-5 only applies to detection systems that operate in pulse mode, it is not applicable to current mode detection systems, for example an ion chamber or TLD. So references to the "Currie MDA" for detection "capability" is not appropriate.
- Page 6-9, line 24-26 – As MDC is formulated, it is possible for up to 5% of the samples to later be detected above the MDC. Clarification is needed here.
- Page 6-10, line 6 and Example 1 – Clarification is needed to differentiate MDC in units of Bq/kg and MDC in units of Bq/m^2. Typically "concentration" refers to activity/mass or activity/volume. MARSSIM is using "concentration" to refer to "areal concentration", that is activity/area. I feel that if examples of what "C" is in equation 6-5, that would clear things up for the reader.
- Page 6-11, Table 6.1 (and elsewhere) – The "Currie MDC" is being referred to as the "approximate detection capability" which is not correct.
- Page 6-35, lines 28, 29 – Consider replacing "neon or helium" with "noble gas" that is more inclusive to the possible gasses used. Also consider removing the reference to "quenching agent", just simply state that a small amount of halogen is added. Methane (lines 26-27) is also referred to as a "quench agent", but the two quench agents are quenching different phenomenon. To avoid that level of detail, it would be easiest to remove the reference to the quench agent.
- Page 6-35, lines 35, 36 – Use of the descriptor "activator" is not used consistently in Chapter 6 and Appendix H when referring to scintillators, and TLD and OSL materials. One example is being highlighted here, but there are numerous. NaI(Tl) should be referred to as "thallium-activated sodium iodide". The use of " -activated" is not used consistently in these sections of the document.
- Page 6-35, lines 36 – Cadmium telluride is not a scintillator.
- Page 6-36, line 1 – Consider removing "organic" and simply refer them as "plastic scintillators". Or is MARSSIM referring to "plastic scintillators" and "organic scintillators"? Stilbene is an example of an organic scintillator.
- Page 6-36, line 9 – Reference is made to cadmium zinc telluride (CZT), but cadmium telluride is still commercially available.
- Page 6-37, line 2 – Consider adding a sentence on the sensitivity of TLDs.
- Page 6-37, line 6 – Consider talking more about the available OSL materials like is done with the TLD materials. Consider adding a sentence on the sensitivity of OSLs.
- Page 6-37, line 11 – Consider adding a sentence on the sensitivity of the EIC.

- Page 6-44, line 18-19 – Consider reworking "…direct measurements and scanning …". Aren't large area detectors primarily (exclusively?) used for scanning?
- Page 6-45, line 18 – "Disposition survey" is used for the second time in MARSSIM here. "Disposition survey" is never defined.
- Page 6-46, Table 6.7 – The use of "Good", "Fair", and "Poor" seem subjective. Should explain the how these ratings were determined. Also should add basis for the down grading of the instruments for the scanning surveys.
- Page 6-47, Table 6.8 – The summary table is good, but may be better if it were two tables. There are advantages and disadvantages to instruments and there are advantages and disadvantages to measurement technique; it becomes very repetitive to try to address both in a single table.
    - "Hand-Held Instruments" "Direct" "Advantages", 3rd bullet – refers to the ability to efficiently measure alpha, which is inconsistent with Table 6.7.
    - "Hand-Held Instruments" "Scanning" "Advantages", 3rd bullet – refers to neutron radiation, which is inconsistent with Table 6.7.
- Page 6-48, Table 6.8 – "ISGS" "Direct" "Advantages", 4th bullet – Should refer to "Good peak energy resolution" or simply "Good energy resolution".
- Page 6-49, Table 6.8 – The use of "Laboratory Analysis" as the "Instrument" is not appropriate. Nice to have Laboratory Analyses available for comparison, but would work best as a separate table.
    - "Laboratory Analysis" "Sampling" "Disadvantages", 4th bullet – Although true, also true with hand-held instruments.
- Page 6-53, line 14 – The reference to Jenkins 1986 leads the reader to believe that there have been no new developments in the last 3+ decades. Dr. Zoltan Szabo compiled an updated list of references which is below. Should pick updated reference(s) for inclusion in the updated MARSSIM.

  American National Standards Institute/ American Association Radon Scientists Technologists (ANSI/AARST), 2014, Protocol for Conducting Measurements of Radon and Radon Decay Products In Schools and Large Buildings, ANSI/AARST MALB-2014, 34 p. https://standards.aarst.org/MALB-2014/index.html

  American National Standards Institute/ American Association Radon Scientists Technologists (ANSI/AARST), 2015, Performance Specifications for Instrumentation Systems Designed to Measure Radon Gas in Air, ANSI/AARST MS-PC-2015, 24 p. https://standards.aarst.org/MS-PC-2015/index.html

American National Standards Institute/ American Association Radon Scientists Technologists (ANSI/AARST), 2019, Radon Measurement Systems Quality Assurance, ANSI/AARST MS-QA-2019, 24 p. https://standards.aarst.org/MS-QA-2019/index.html

American National Standards Institute/ American Association Radon Scientists Technologists (ANSI/AARST), 2020, Protocol for the Collection, Transfer and Measurement of Radon in Water, ANSI/AARST MW-RN-2020, 48 p. https://standards.aarst.org/MW-RN-2020/index.html

Baskaran, M., 2016, Radon Measurement Techniques, *in*: Baskaran, M. (Ed.), Radon: A tracer of geological, geophysical and geochemical studies. Springer International Publishing, Switzerland, pp. 15-35. https://standards.aarst.org/MW-RN-2020/index.html

International Electrotechnical Commission, 2006, Radiation Protection Instrumentation - Radon and Radon Decay Product measuring Instruments - Part 1: General principles, IEC 61577-1, International Electrotechnical Commission, Geneva, Switzerland. https://standards.globalspec.com/std/380787/IEC%2061577-1

International Electrotechnical Commission, 2000, Radiation Protection Instrumentation - Radon and Radon Decay Product Measuring Instruments - Part 2: Specific Requirements for Radon Measuring Instruments, IEC 61577-2, International Electrotechnical Commission, Geneva, Switzerland. https://standards.globalspec.com/std/1694803/IEC%2061577-2.

International Electrotechnical Commission, 2014, Radiation protection instrumentation - Radon and radon decay product measuring instruments - Part 3: Specific requirements for radon decay product measuring instruments, IEC 61577-3, International Electrotechnical Commission, Geneva, Switzerland. https://standards.globalspec.com/std/9897537/ds-en-61577-3

International Organization for Standardization (ISO), 2019, ISO 11665-1:2019 - Measurement of radioactivity in the environment -- Air: radon-222, p. 33. https://standards.iteh.ai/catalog/standards/iso/950298e5-4976-418a-9b5b-d8d4aa7ad47e/iso-11665-1-2019

Subba Ramu MC, Raghavayya M, Paul AC, 1994, Methods for the measurement of radon, thoron and their progeny in dwellings, AERB Technical Manual, TM/RM – 1

Vaupotič, Janja, Smrekar, Nataša, Žunić, Z.S., 2017, Comparison of radon doses based on different radon monitoring approaches: Journal of Environmental Radioactivity, V. 169–170, P. 19-26.
https://doi.org/10.1016/j.jenvrad.2016.11.023

Vyletělová, Petra, Froňka, Aleš, 2019, Continuous radon-in-water monitoring—comparison of methods under laboratory conditions and results of in situ measurements: Radiation Protection Dosimetry, V. 186(2-3), P. 406–412.
https://doi.org/10.1093/rpd/ncz241

WHO, 2009, Radon measurements: *in* editors, Hajo Zeeb, and Ferid Shannoun, WHO handbook on indoor radon: a public health perspective, Geneva, Switzerland, p. 21-40.

- Page 6-55, line 16 – Should refer to "… gathering radon and progeny …"
- Page 6-55, line 32 – "More complicated systems…" is subjective. Is the measurement more complicated, the instrument more complicated, or is the data analysis more complicated. Is "sophisticated" better description than "complicated"? Where does charcoal canisters and gamma-ray measurements fit into the scheme, "simple" or "more complicated"?
- Page 6-56, Table 6.9, 1st row – I am not aware of putting activated charcoal into liquid scintillation cocktail; the color quench must be pretty significant. "Not a true integrating device" needs clarification. This is also mentioned on Page 6-58, but without explanation.
- Page 6-56, Table 6.9 – The column "Time" is not clear; is that "total time", "sample collection time" or "count time".
- Page 6-56, Table 6.9 – Regarding the "Remarks" column, "LLD" should be replaced with "MDC". Also the MDC listed are in a variety of different units which makes it difficult for the reader to compare/contrast the different techniques quickly and easily. Consider listing the MDC is the same units for all methods. This table is another example where the use of citations to the scientific literature would greatly enhance the information contained in the table. With the citation, the reader has the option to quickly and easily getting more information on the method. The reported "LLD" values must have come from some scientific literature, that literature should be cited.
- Page 6-58, Line 27 – Consider replacing "surface barrier detector" with the much more common "ion-implanted planar silicon detector".
- Page 6-59, Line 4 – As mentioned in the previous paragraph, electrostatic attraction of radon progeny to the surface of a detector is also an option.
- Page 6-60, Line 41 – Unclear what "detect radiation directly" is referring to. Is this referring to passive radiation detection?

- Page 6-63, Line 20 – Unclear what "averages 55,000 gamma in strength" is referring to. Best to specify in SI units and include traditional units in paratheses.

- Page H-1, line 26 – There can also be market contraction, correct?
- Page H-2, lines 12-13 – Recommend deleting "in the proper direction".
- Page H-2, line 15 – Best to refer to "interchangeable detectors or probes" to use the common terminology.
- Page H-2, line 20 – As previously indicated, "planchets" appears to be a typographic error.
- Page H-3, line 5 – Should correct "primary" and "secondary" to be consistent with the name of the probe.
- Page H-3, line 13 – Should replace "only" with "primarily".
- Page H-3, line 29 – Should replace "only" with "primarily".
- Page H-8, lines 16-17 – Should include a similar sentence for other instruments or delete from here.
- Page H-9, lines 7-8 – Should delete this sentence.
- Page H-9, line 13 – "same factor~~s~~"
- Page H-9, line 19 – Is the "lower limit of detection" going to be confused with the "Currie detection limit"? I believe that this is really referring to sensitivity.
- Page H-10 – The difference between this detector and the previous one (H-9) should be clarified.
- Page H-10, line 23 – Should refer to "… gamma-ray or x-ray radiation …".
- Page H-11, line 3 – Should remove "alpha" from the secondary radiation.
- Page H-12, line 4 – Should refer to "Thallium-activated sodium iodide (NaI:Tl) …".
- Page H-12, lines 42, 43 – It appears that some of the cost estimates of the instruments have not been updated since Revision 1 (2000). This is a specific example of a potential discrepancy, but there are others. The cost estimates on all the instruments should be updated to 2020 dollars.
- Page H-13, line 4 – Should refer to "Cerium-activated lanthanum bromide (LaBr:Ce) …".
- Page H-14, line 1 – Should include CdTe detectors. Both CdTe and CZT are commercially available and utilized in research and COTS instruments. Are these detectors peltier cooled?
- Page H-14, line 35 – Should say a word or two on segmented detectors.
- Page H-14, lines 36, 37 – Clarification should be added to these costs to indicate that this is the cost of the detector without the associated data acquisition system. Should follow the example for the PIC (Page H-10, lines 34-37). Want to strive for consistency in the reporting of the costs. This is one example of the discrepancy of reporting. There are

other incidents. This becomes more of an issue when presented in Tables H.2 – H.8 where costs are presented for comparison where they are not equivalent.

- Page H-15, line 20 – "24 hours" should be replaced with "72 hours".
- Page H-15, line 30 – "Detection capability" should be replaced with "detection sensitivity".
- Page H-20, line 3 – There is no discussion of neutron detection.
- Page H-20, lines 25-26 – Unclear how increasing flight altitude would decrease the MDA.
- Page H-20, lines 26 – MDA is given units of activity/area. Although, I didn't agree this was previously referred to as MDC.
- Page H-21, lines 27-31 – Some of these TLD materials are not listed in Chapter 6. Should these lists be consistent?
- Page H-24, line 8 – What are "dry cask storage neutrons"?
- Page H-28, line 3 – Should differentiate thoron from radon. Where is thoron defined?
- Page H-31, lines 8-9 – Unclear how one would measure and external alpha emitter with an EIC to determine its areal concentration. Radiation is going to be absorbed in the detector walls.
- Page H-31, line 10 – Unclear how one would measure ^{3}H with an EIC. Same is true with ^{99}Tc. Radiation is going to be absorbed in the detector walls. The lower limits of detection are given in areal concentration.
- Page H-33, line 7 – The equipment for the laboratory is commercially available, so is the reference to the equipment being in the "testing phase" referring to the fieldable equipment? Clarification needed.
- Page H-33, line 10 – Clarification to what "nondestructive" means should be added. Laser ablation is destructive to the surface which is being ablated.
- Page H-40, line 1 – Why repeated under "Beta Particle Analysis" for Laboratory equipment. Why not use the same scheme as was done in the description of the field equipment?
- Page H-42, line 3 – Alpha should be listed as a primary mode of detection, not secondary.
- Page H-43, line 38 – The fact that the energy calibration is "not totally linear" is going to be lost with most readers of MARSSIM. As long as you have a proper energy calibration curve, the non-linearity is primarily manifested in the detector energy resolution.
- Page H-46, line 21 – Recommend clarifying what "a reasonable price" is. What is reasonable to one reader may not me reasonable to another.
- Page H-50, line 12 – Recommend updating the data to 2020. I know of a facility at University of Georgia, Athens which I thought was in place before 2012. Whenever you put together a list like this it will soon be outdated. Should also consider just deleting the reference to the number and where they are located.
- Page H-51, Table H.1, column header, 3rd column – Should be "10^{5}" not "105" atoms.

- Page H-53, line 16 – It is not a perfect vacuum, so "all" air molecules have not been pumped out.
- Page H-54, line 2 – Is this a typographical error? Should this be "Laboratory"? We are in the laboratory section.
- Page H-55, line 4 – Should be "lanthanides" not "lanthanum".
- Page H-55, line 22 – Oxygen is also a major interferent that must be removed.
- Page H-55, line 27 – Missing a reference. Sentence reads "… has been reported by.".
- Page H-56, lines 5&6 – The instrument is commercially available. Not clear why a prove is "not available".
- Page H-57, line 2 – Recommend either adding a discussion of field usage or removing the reference to it.
- Page H-59, Table H.2, column headers, 5th column – Need to update costs to 2020. Some of these values seem to indicate only the cost of the probe, while others include the probe and the instrument to read out the signal. Would be good to present consistently, but at least clarify if it is just the cost of the probe.
- Page H-59, Table H.2, last row, 4th column – Should read "requires P-10 gas".
- Page H-60, Table H.2, 3rd and 4th rows – Should consistently populate the table. For the gas-flow proportional counter "laboratory" and "field" are given separate rows, while liquid scintillation is combined and discussed on one row.
- Page H-61, Table H.2, 2nd row – Clarification into what "low-resolution" spectrometer you are referring to would help the reader. There is an indication that sample is under vacuum, which indicates the best available energy resolution, assuming everything is operating properly.
- Page H-62, Table H.3, 4th row, 4th column – I believe that is supposed to read. The LSC process is highly selective …". This is interesting since Alpha radiation was previously indicated (Page H-42, line 3) to be a secondary radiation for alpha detection.
- Appendix H – It seems appropriate to include "Direct Ion Storage" (DIS) devices in Appendix H. TLDs, OSLs, EDs are all presented, but DIS is not. DIS devices are commercially available and are "drop in" replacements for TLD and OSL. I feel that it is appropriate to be presented in Appendix H.

Charge Question 2.2 (Associate Reviewer)
"Please comment on the usefulness and accuracy of the additional optional methodology for the use of Ranked Set Sampling for hard-to-detect radionuclides."

I feel that the Appendix E is useful for implementation of the RSS methodology. Although I am not a statistician and was not able to follow all the methodology, the description with examples were helpful in following the methodology. One reference is given to give the reader more depth into the topic. Is that one reference sufficient? It is stated (Page E-1, lines 40-42), "*Performing an RSS survey requires a much greater level of expertise in survey planning and implementation than a traditional Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) survey requires.*" It seems that Page E-1, line 40 through page E-2, Line 2 should be elevated to the first paragraph of Appendix E, maybe even the first paragraph of Appendix E.

Specific Comments

- Page E-6, line 6 – Need to insert a space between "median" and "of".
- Page E-12, lines 1,2, 4 – The extra line numbering in the document should be removed
- Page E-14, Example 3 – There is a change in notation in this example. Initially the mean is defined with the symbol "μ_{RSS}" then when calculating sample variance the mean is defined as "$\overline{X}_{RSS}$". Should use consistent notation to avoid confusion. The latter is consistent with equation E-7.
- Page E-14, lines 3-9 – The line numbering in the document should be removed

Dr. R. Craig Yoder

1) Are the revisions to MARSSIM concepts and methodologies technically appropriate, useful and clear, and do they provide a practical and implementable approach to performing environmental radiological surveys of surface soil and building surfaces?
1.3 Is the proposed implementation of the concept of Measurement Quality Objectives adequately and correctly described, including the concept of measurement uncertainty (Chapter 4 and Appendix D)? Is the proposed calculation of measurement uncertainty consistent with the concept of Measurement Quality Objectives? Is the method appropriate and practical for both laboratory and field (including scan) measurements? Please comment on the concerns of stakeholders that calculating measurement uncertainty for field measurements makes the survey process difficult to implement. In addition, please comment on whether recommendations provided by NIST, ANSI/IEEE and MARLAP for measurement quantifiability should be incorporated further into MARSSIM, Revision 2, or whether the current recommendations should be left as is (e.g., the original MARSSIM requirement that the MDC/MDA should be set at 10-50% of the action level).

Response.

The use of Measurement Quality Objectives (MQO) is an appropriate and useful concept to include in the MARSSIM document; however, the description and treatment of measurement uncertainty does not conform to the recommendations provided in NIST Technical Note 1297 and the ISO Guide to the Expression of Uncertainty in Measurement, references cited in the MARSSIM draft and concepts employed in MARLAP. Specifically the main body of the Draft does not describe nor discuss Type A and Type B components of uncertainty as well as the terms standard uncertainty, combined standard uncertainty and expanded uncertainty. Better incorporation of the NIST and ISO approaches to measurement uncertainty would aid in the rigor of the thought processes and terminology involved in MQO planning and instrument performance needs. The parameters of Type A components of uncertainty (e.g. standard deviation) are derived from statistical methods. In contrast, the parameters of Type B components arise from non-statistical means, usually from expert or experiential knowledge. Note that Type A and Type B components are distinctly different from random and systematic uncertainties or errors that are prevalently used in the Draft. Paragraph 2.3 in the NIST Technical Note provides more clarity in the distinctions. The MARLAP document better conforms to the NIST and ISO concepts and terminology; although there are a few instances in which a term is not in exact agreement with the definitions used by NIST and the ISO which both refer to the definitions presented in the ISO International Vocabulary of Basic and General Terms in Metrology (often denoted as VIM).

The Measurement Quality Objectives should employ exact terminology to avoid confusion as to whether a statement of measurement uncertainty is referring to the standard uncertainty, combined uncertainty or expanded uncertainty, and if the latter, the coverage factor, k, used. Many calibration factors from secondary standards laboratories are expressed with an expanded uncertainty with a coverage factor of 2. The MQO should require a statement of the

known influences affecting measurements and whether these influences are Type A or Type B components of uncertainty and the means by which their quantitative parameters (estimates of the standard deviation) were derived.

Section 6.4.4 of the MARSSIM Draft states the terms measurement uncertainty and standard deviation are used interchangeably. This can lead to confusion because measurement uncertainty may be expressed as a combined uncertainty or expanded uncertainty. The use of standard deviation may imply a confidence interval that is not intended.

If the approach to measurement uncertainty follows that of the NIST and ISO citations made in the MARSSIM document, then they should be applicable for both field and laboratory measurements. Note that the MARLAP document that addresses laboratory measurements has attempted on conform to the NIST and ISO recommendations. The Introduction to the ISO Guide explicitly states that the approach is applicable to industrial, commercial, health and safety, and regulatory purposes. Adherence to the NIST and ISO guidance further aids in the recognition and treatment of the various influences leading to uncertainty in measurement. For example, calibration uncertainty can include many sources of error as traceability is established through various steps of comparisons from a secondary standards laboratory to the field environment where the ability to exactly reproduce the original laboratory calibration may be compromised.

Offering a comment about whether to set the minimum detectable concentration/activity (MDC/MDA) between 10% and 50% of the UBGR (upper bound of the grey region) requires an understanding about the rationale to depart from the MARLAP approach in which the MDC, the MQC and the method uncertainty are separate considerations (MARLAP Chapter 3, page 3-18). MARSSIM states its intention to combine detection and quantification concepts in what appears to be an attempt to address measurement uncertainties that have not been formally identified or considered, i.e. a desire to introduce conservatism with little quantitative basis. An MDC should be evaluated with all known sources of uncertainty being properly quantified and combined into an appropriate expanded uncertainty. Equation 6-5 (Section 6.31.) treats the calibration factor as if it had no uncertainty and disregards uncertainty sources that arise from adjusting a laboratory calibration to a field calibration. The example is too rudimentary and omits the need to consider more than just counting uncertainties. A more complete example could be presented in Appendix O. A similar situation exists in the discussion of surveyor efficiency in Section 6.3.2.1 (page 6-17). The example states that surveyor efficiency can range between 0.5 and 0.75. The MARSSIM guidance suggests the use of a constant of 0.5 as a matter of conservatism with no uncertainty consideration. If the NIST and ISO measurement uncertainty approach had been implemented, then the surveyor efficiency would be better expressed as 0.625 with an uncertainty of 0.1 or 0.14 assuming a Type B uncertainty with a triangular or rectangular distribution respectively. The rationale for combining the concepts of detection and quantification into a requirement that the MDC be less than 50% of the UBGR must be included in either Chapters 4 or 6. What were the measurement uncertainty assumptions that led to the requirement and does this requirement apply to all measurement methods? The definition of the MDC requires estimated knowledge of the distribution of possible values centering around the MDC or the expanded uncertainty with a stated coverage factor. Whether the underlying combined uncertainty (after dividing the expanded uncertainty by the coverage factor) satisfies

the need for the MQC should be a separate consideration. The relative standard deviation at the MDC must have an estimate that can be judged as sufficient or not on its own merits. Combining detection with quantification could obscure an effective assessment of the key sources of measurement uncertainty. The manual should give due consideration regarding the overall definition of MDC or MDA because the manual references many measurement methods that do not follow the normal counting statistics used in the rudimentary examples given in Chapter 6. Such methods include the dose integrating technologies of TLD, OSL and electrets as well as other methods listed in Appendix H such as x ray fluorescence analysis, mass spectrometry and phosphorescence analysis by laser.

It is recommended that the MARSSIM draft explicitly define the terms repeatability and reproducibility as they appear to be used interchangeably. The VIM and the NIST and ISO documents make distinctions between the two concepts as they are important considerations in measurement uncertainty.

1) Are the revisions to MARSSIM concepts and methodologies technically appropriate, useful and clear, and do they provide a practical and implementable approach to performing environmental radiological surveys of surface soil and building surfaces?

1.5. Is the discussion of the use of MARSSIM surveys for addressing sites containing discrete radioactive particles technically sound and appropriate, and is the description accurate? In particular, please comment on the rule-of-thumb for determining when use of MARSSIM may not be appropriate for survey units containing discrete radioactive particles (Section 4.12.8 and Appendix O.5).

Discrete radioactive particles have an extremely small size and contain enough activity that survey units containing discrete radioactive particles generate impractical survey designs under MARSSIM. Over MARSSIM's twenty-year history, several sites have attempted to utilize MARSSIM to address discrete radioactive particles, with predictably extreme survey designs as a result. In addition to being impractical, designs for discrete radioactive particles violate some of the assumptions commonly made during modeling, which includes parameters based on an areal source of radioactive material, e.g., length of the area of the elevated activity in the direction of overland flow. While modeling is outside of the scope of MARSSIM, it is nonetheless required that survey designs match the assumptions made during modeling, otherwise, the survey design does not meet the requirements of the action level.

To set a limit for determining when areas of elevated activity are too small to use the traditional MARSSIM methodology, the MARSSIM Workgroup used a traditional rule-of-thumb for instrumentation. When the length of the area of elevated activity is less than three times the distance to the detector, the area of elevated activity is viewed by the detector as a point source instead of as an areal source. These point sources will need different receptor modeling and release requirements, and hence different survey designs than traditional areal sources.

At this time, MARSSIM does not provide guidance on designing discrete radioactive material surveys. It is the intention of the revision that additional information provided should prevent MARSSIM from being applied inappropriately to survey units involving discrete radioactive particles.

Response

The statement that the MARSSIM guidance for elevated areas of residual radioactive material is inappropriate seems correct but it is not clear that the rule-of-thumb will achieve the intent of avoiding use of the MARSSIM guidance in some situations. How are either *d* or *L* to be measured or estimated? Given the size and unknown location of the particle, it appears that *d*, the distance between the source and detector, would be difficult to establish; particularly with instruments that present several or more square centimeters of active detection area. Would *d* be defined at the central point of the detector where one might expect a maximum response or at some edge of the detector where the particle might first be detected? How would *L* be defined? Is it the distance between when the signal from the instrument exceeds some threshold count

rate? If so what reference area might be used to establish such a threshold given that the particle may be present in an area containing dispersed, elevated residual radioactive material?

Equation 4-26 and as repeated as O-5 may not lead to the avoidance of the MARSSIM guidance for EMC areas. For example, assume a distance, *d*, of 1 cm. Assume that the discrete particle can be detected at a distance of 5 cm in all directions in the plane of scanning. This would relate to a value of *L* of 10 cm such that *d* would have to exceed 30 cm to avoid using the MARSSIM guidance. If this is the correct interpretation, would it be the intent to use MARSSIM guidance in this situation? It would seem reasonable that any small area expected to have a discrete particle be remediated before all of the extensive survey planning for EMC areas. I assume that any potential for discrete particles would place an area into Class 1 and therefore require a 100% survey.

If discrete radioactive particles might be encountered based on historical analyses or preliminary surveys, then the Measurement Quality Objectives should anticipate both the measurement of areal and point sources. This naturally leads to establishing separate measurement detection limits and measurement uncertainty requirements that may have an effect on the selection of instrumentation and scanning procedures. Discrete radioactive particles pose a difficult problem and more discussion in MARSSIM would be beneficial.

3) Is the information in MARSSIM, Revision 2 clear, understandable and presented in a logical sequence? How can the presentation and content of material be modified to improve the understandability of the manual?

3.3 Please comment on the effectiveness of the new organization of Chapter 4 (Considerations for Planning Surveys) to improve the understandability of the Chapter. Earlier reviews of Chapter 4 provided evidence that the fundamental organization of Chapter 4 made it difficult to find and understand vital information. After discussing the challenge with experts in training and explaining the material, Chapter 4 was completely rewritten or reorganized in an attempt to improve understandability without changing the fundamental purpose of or material in the Chapter. In an effort to streamline the presentation of material in Chapter 4, some information was moved to Appendix O.

Response.

The response to the general question must be prefaced initially with reference to Chapter 1.3 of the MARSSIM that describes the intended audience; namely, “a technical audience having knowledge of radiation health physics and statistics, …”. Exact terminology should be used as much as possible and avoid such statements as found in the opening paragraph in section 4.1.3 indicating the chapter will use informal definitions. If terminology will be unfamiliar to the technically trained audience then an explanation should be provided regarding the need for unfamiliar terms and their specific meaning. Several terms used throughout the manual have multiple meanings and the context not always clear as to which meaning is intended.

Secondly, the Manual has been purposely presented in a modular form with attention to an order aimed at completing a survey plan (Page 1-7, lines 12-21). As implemented, the modules lead to extreme repetition making the manual perhaps twice as long as necessary. This

might be avoided with an explanation about what a module is expected to achieve in terms what a reader will learn. The large number of instances in which a reader is referred to other Chapters and Appendices tends to fragment the manual, particularly when the different sections vary little in content Each module be explicit, distinct and detailed. The introduction to each module should state the material to be presented and any Chapters or other references the reader requires as prerequisite information.

Finally, the Manual is a draft document but it is not clear the extent to which the authors believe the document is near final form. It is clear the Manual has been drafted by multiple persons as different writing styles are apparent. For example the introduction to Chapter 4 begins with “You will be introduced…” that is a different voice perspective from the remainder of the manual. In addition the depth of the treatment of the subjects sometime varies out of sequence. For example, Chapter 2 appears to be an overview of the structure of the Manual but detail information such as Table 2.3 that would be better located in subsequent chapters where more detail is expected. Chapter 2 provided more detail about the survey types than Chapter 4 intended to discuss common planning issues among the survey types.

The titles of Chapters 4 and 5 do not adequately distinguish the subject matter in each. The introduction for each chapter leads the reader to conclude their intent is very similar but their content is quite different. Is Chapter 4 to be an introduction to Chapter 5? Section 4.1.1 indicates, in a poorly phrased first sentence, that the chapter is intended to present planning considerations common to all survey types but in section 4.1.2 (Scope), line 20-21 indicates the chapter is to focus on planning the FSS. Is the Chapter to address common issues or those specific to the FSS?

Section 4.2 is entitled Data Quality Objectives Process and begins by listing seven steps of the process that the reader expects to be expounded upon in the following subsections. However, the subsequent subsections do not follow from the process steps listed. Instead, the topics switch to Planning Phase and Quality System. Note that Section 3.2 refers to a DQO process for an Historical Site Analysis listing three inputs to the DQO process. In addition, Chapter 2.3 discusses design phases in different terms. Clearly an intent exists to distinguish the process for selecting the components of the objectives from the objectives themselves but the distinction often appears subtle.

Section 4.3 introduces the different survey types that were previously introduced in Chapter 2 with Figures 2.4 through 2.8. These figures are repeated as Figures 5-1, 5-2 and 5-3 and would be better placed into Section 4.3, if they need repeating. There is no need to provide a brief paragraph and then refer the reader to a later chapter when an earlier chapter has discussed the concept. This defeats the concept of modularization. Identify in one section the types of surveys, describe their purposes, how they are to be planned including cautions should data or information acquired in the preliminary surveys be intended for use in the FSS.

Figures 4.1 and 4.2 should not be separated by 31 pages. It is difficult to combine the flows. The title for Figure 4.2 refers to Field Survey Design but there is no formal term called field survey. It would appear that all of the surveys presented in chapter 4 are field surveys so the term Field could imply a specific type of survey apart from the four presented or be an unnecessary adjective. Figure 4-1 addresses the FSS design prior to Figure 4-2 that addresses the

more general case applicable for the preliminary survey types. A reverse order should be considered.

Sections 4.4 on the Unity Rule and 4.5 on Radionuclides could be combined into a single section. Both address the same issue of accounting for the risk from mixed radionuclides and. equations 4-3 through 4-5 are closely associated with equations 4-6 through 4-8. A precautionary statement should be added to Equation 4-3 that the dose or risk endpoints must be identical and able to be summed.

Figure 4.1 contains boxes that refer to incorrect section references. For example, the box titled Radionuclides refers to Section 4.3 but Section 4.3 addresses survey types. The other boxes have similar errors. Such errors make reviewing the manual difficult given the fragmentation and repetition of the subjects.

The rationale for setting the MDC at less than 50% of the UBGR should be presented in Section 4.8.3, page 4-28 because there is no discussion of this requirement in Chapter 6.3 to which the reader is referred.

Section 4.12 would be more appropriate as an Appendix.

The following is a list of other observations:

- Page 5-36 references Section 4.2.5 but that section does not exist.
- Appendix A.2.1 and A.2.2 do not refer the reader to the appropriate sections in Chapter 4.
- The figure on page A-10 is labeled as Figure A.1 but a Figure A.1 exists on the earlier page A-3. The editors should verify sequencing of tables and figures with the text.
- Figures 2-5 and 3-1 include a step to assess whether the site poses an immediate risk to human health and the environment. The process flow is to inform the regulatory authorities when the site does not pose a threat. Is this intended? All immediate threats should be conveyed to regulatory authorities as is required by all regulations that pertain to licensee obligations to report dangerous conditions. The figures also show that when an immediate threat is found, the next question is does the site contain residual radioactive material in excess of background. It should be obvious that any site posing an immediate threat will have radioactive material above background. The affirmative response to this question is to document findings of non-impacted classification and release. A decision tree leading to the release of a site posing a health threat is illogical.

3.4. Please comment on the effectiveness of moving derivations from Chapter 5 to Appendix O to improve the understandability of the Chapter.
In an effort to streamline the presentation of material in Chapter 5, some derivations of key concepts were moved to Appendix O.

Response.

Moving derivations from Chapter 5 to Appendix O is supported and improves the presentation of material.