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MULTI-AGENCY RADIOLOGICAL LABORATORY ANALYTICAL PROTOCOLS (MARLAP) MANUAL: AN SAB REVIEW

REVIEW OF THE MARLAP MANUAL AND APPENDICES BY THE MARLAP REVIEW PANEL OF THE RADIATION ADVISORY COMMITTEE OF THE US EPA SCIENCE ADVISORY BOARD (SAB)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

June 10, 2003

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OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

The Honorable Christine Todd Whitman
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Ariel Rios Building, Mail Code 1100
Washington, DC 20460

Subject: An SAB Review of the Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual

Dear Governor Whitman:

The Office of Radiation and Indoor Air (ORIA) requested that the Radiation Advisory Committee (RAC) establish a panel to review the Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Manual. The MARLAP Manual is intended to provide consistent technical guidance for planning, implementing, and assessing projects that require the generation of radiological data. As such, it compliments the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) developed through a similar process during the 1990s. The MARLAP Manual was developed over as seven year period by a by a partnership of seven federal agencies, departments, and commissions, and two states.

The Panel wishes to bring to your attention that the partnership that produced this Manual, which was led by Dr. John Griggs of ORIA and involved technical staff from different government entities working together, represents the very best in government practices. Such collaboration brings collective wisdom, together with the practical application of consistent and comprehensive science methodologies, into harmony with a variety of regulatory and compliance practices. We believe that this effort deserves special mention for the common sense approach it brings to the implementation of government programs and guidelines.

Through the auspices of ORIA, the federal MARLAP Work Group posed three charge questions to the Panel regarding:

1) the effectiveness and clarity of the overall approach,
2) the technical accuracy of the guidance on laboratory operations, and
3) the technical accuracy and clarity of the guidance on measurement statistics.

The MARLAP Review Panel added a fourth charge question pertaining to:

4) the overall integration and implementation of the Manual's guidance.

The MARLAP Review Panel found the Manual to be well conceived and expects that it will be a valuable reference, particularly helpful to analytical laboratories and users of laboratory services working with radioanalytical data and protocols. The primary recommendations from the Panel involve reorganization of the Manual to make it user friendly and facilitate its intended use. The comments and recommendations offered by the Panel should be construed as constructive criticism as they are intended solely to assist in improving a document that is already very comprehensive and thorough.

In response to Charge Question #1 (relating to the effectiveness and clarity of the overall approach), the Panel finds that the performance-based, flexible approach in MARLAP is appropriate and, for the most part, presented clearly and logically in the draft MARLAP Manual. The Panel agrees with the guidance provided with regard to a graded approach for projects of different size and scope, as well as with the emphasis on data quality, that is adequate and reasonable for the decision being supported. The linkage of the planning, implementation, and assessment phases of projects involving radioanalytical data is effective. However, the Manual is consequently massive, and finding the information needed for a specific radioanalytical project is difficult at this stage, especially for a novice or infrequent user. In its attempt to make the various chapters stand alone, the MARLAP Work Group may have introduced excessive redundancy. The Panel also identified some guidance requiring greater definition and detail. The Panel recognizes that a lack of consensus between different members of the MARLAP Work Group may be inevitable, due to the multi-agency input to this document and the different governing regulatory requirements under which those agencies must operate. Nonetheless, the Panel recommends that a well-defined "consensus" solution be adopted in making recommendations to the users. In addressing these and other questions, the Panel proposes several specific suggestions for reorganizing and editing the document and improving its overall usefulness and accessibility.

In response to Charge Question #2 (relating to the technical accuracy of the guidance), the Panel finds that the document is an impressive compilation of information and recommendations that should be immensely useful to radiochemical analysis practitioners. It also finds the guidance to be, on the whole, reliable and well thought out; however, as would be expected with such a large compendium of information, some technical inaccuracies and inconsistencies are identified. The Panel includes the most important of these issues in the text of its Review Report and recommends some changes or additions to several of the chapters. It also suggests some changes in the organizational structure of the Manual to add clarity and usefulness. The bulk of the Panel's specific concerns are addressed in appendices to its report.

In response to Charge Question #3 (involving the guidance on measurement statistics), the Panel finds that statistical issues are addressed very well in the MARLAP Manual but offers several suggestions for reorganization and clarification to enhance its value, specifically for laboratory directors and staff. In particular, both the terminology used in the MARLAP Manual as well as the treatment of uncertainty propagation in measured values require some re-evaluation, and possible revision.

In response to Charge Question #4 (related to self-initiated Panel questions on the issue of overall integration and implementation), the Panel suggests that in addition to better integration with the earlier MARSSIM (2000) document, it might be useful to devote a short section at the beginning of the Manual to show how the performance-based approach is suitable for decisions regarding the cleanup of radioactively contaminated sites. Although the Panel recognizes that MARLAP is not limited to site cleanup decisions, these represent some of the most important drivers for the creation of MARLAP. The proposed new section would also help elucidate the areas of overlap between MARLAP and MARSSIM, as well as emphasize their differences in scope and coverage.

Finally, the Panel offers some suggestions beyond the charge given by the federal MARLAP Work Group, regarding implementation of the Manual's recommended protocols after its completion and release:

Due to the complexity of the issues addressed in MARLAP, the Panel recommends that EPA undertake a program to train laboratory personnel and users of radio-analytical data in much the same manner as occurred for the MARSSIM activity.

The Panel also recommends that the agencies, departments, and commissions involved in the development of MARLAP support a professional education program to generate a new generation of experts in radioanalytical techniques, to offset the trend towards a diminishing pool of available experts. Such a program might include scholarships, fellowships, research grants, and teaching grants geared to encourage students and faculty to develop and maintain proficiency in the application of radioanalytical protocols.

The MARLAP document should be maintained as a "living document" and involve an iterative process whereby user suggestions can be incorporated into future revisions.

The success of this and a previous multi-agency effort (i.e., MARLAP and MARSSIM) in addressing complex multidisciplinary environmental issues leads us to recommend that multi-agency approaches be extended to other EPA activities.

The Panel also wishes to express to you that one of its main concerns with the draft MARLAP does not involve its technical content but rather the ease and practicality of its use as a tool. User implementation of its recommendations to use a performance-based approach may be frustrated by the fact that the selection of specific radiochemical protocols is often driven by the requirements of existing methods set as standards by different organizations. Until these methods are revised, and commitments from EPA and other authoring organizations are obtained, the radiochemistry community may be in conflict over the application of MARLAP guidance. The Panel therefore encourages you to establish a time table and funding to conduct a review of your agency's existing regulations and guidance on radioanalytical protocols and to revise those documents as appropriate to reflect the MARLAP performance-based approach.

We appreciate the diligence and cooperative spirit in which this ambitious project has been undertaken and congratulate its participants. On behalf of members of the RAC and the MARLAP Review Panel, we wish to thank you for your consideration and look forward to your response.

Sincerely,

/Signed/

Dr. William H. Glaze, Chair
EPA Science Advisory Board

/Signed/

Dr. Janet A. Johnson, Chair
Radiation Advisory Committee
and MARLAP Review Panel
EPA Science Advisory Board

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ABSTRACT

The EPA Science Advisory Board's Radiation Advisory Committee and the MARLAP Review Panel (the Panel) reviewed technical aspects of the draft Multi-agency Radiological Laboratory Analytical Protocols (MARLAP) Manual dated August 2001. This document was developed collaboratively by seven federal agencies, departments, and commissions having authority for regulating radioactive materials, and two states.

The Panel finds that MARLAP effectively addresses the need for a nationally consistent, performance-based approach for planning, implementing, and assessing radioanalytical measurements to address regulatory concerns. The Manual's graded approach encourages a user to select a set of analytical procedures, with associated precision and reliability, suited to the complexity and importance of the problem being addressed. It does a thorough job of explaining how decision makers should make choices in the selection of hypotheses that help determine the confidence levels associated with the results obtained from analytical laboratories. The Manual's guidance on laboratory operations is generally technically sound although highly variable in scope and level of detail provided. Guidance on measurement statistics is also technically sound but perhaps overly detailed. The Panel recommends reorganization and a thorough technical edit of the Manual to improve its flow, add clarity and logic, and reduce redundancy so as to make it easier to use. The Panel also stresses the need to include more explicit examples to better illustrate the application of each step in the performance-based approach to activities of differing size and complexity. The Panel recommends that the EPA undertake a training program for MARLAP users and that it use the classes as a mechanism for seeking input that can be incorporated into future revisions of the Manual.

Key Words: Analytical Protocols, Protocol Assessment, Protocol Implementation, Protocol Manual, Radiological Analytical Protocols

U.S. Environmental Protection Agency
Science Advisory Board (SAB)
Radiation Advisory Committee (RAC)
Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Review Panel

CHAIR
Dr. Janet A. Johnson, Senior Technical Advisor, Shepherd Miller, Inc, Fort Collins, CO

SAB MEMBERS
Dr. Lynn R. Anspaugh, Research Professor, University of Utah, Salt Lake City, UT

Dr. Bruce B. Boecker, Scientist Emeritus, Lovelace Respiratory Research Institute, Albuquerque, NM

Dr. Gilles Y. Bussod, President, Science Network International, Santa Fe, NM

Dr. Thomas F. Gesell, Professor of Health Physics, Department of Physics, Idaho State University, Pocatello, ID

Dr. Helen Ann Grogan, Cascade Scientific, Inc., Bend, OR

Dr. Richard W. Hornung, Director, Division of Biostatistical Research, IHPHSR, University of Cincinnati, Cincinnati, OH *[Subcommittee chair: Charge Question #3: Guidance on Measurement Statistics, Measurement Uncertainty, and Detection and Quantification Capability]*

Dr. Jill Lipoti, Assistant Director, Environmental Safety, Health and Analytical Programs, Radiation Protection Program, New Jersey Department of Environmental Protection, Trenton, NJ

Dr. Genevieve S. Roessler, Radiation Consultant, Elysian, MN

CONSULTANTS

Dr. Vicki M. Bier, Professor of Industrial Engineering, College of Engineering, University of Wisconsin, Madison, WI

Dr. Stephen L. Brown, Director, R2C2 (Risks of Radiation and Chemical Compounds), Oakland, CA *[Subcommittee chair: Issues Beyond the Charge]*

Dr. Michael E. Ginevan, Proprietor, M.E. Ginevan & Associates, Silver Spring, MD

Dr. Shawki Ibrahim, Department of Radiological Health Sciences, Colorado State University, Fort Collins, Colorado

Dr. Bernd Kahn, Professor, School of Nuclear Engineering and Health Physics, and Director, Environmental Resources Center, Georgia Institute of Technology, Atlanta, GA *[Subcommittee chair:*

Charge Question #2: Guidance on Laboratory Operations]

Dr. June Fabryka-Martin, Staff Scientist, Group EES-6, Hydrology, Geochemistry and Geology, Los Alamos National Laboratory, Los Alamos, NM *[Subcommittee chair: Charge Question #1: Overall Approach for Planning and Implementation]*

Dr. Bobby R. Scott, Staff Scientist, Lovelace Respiratory Research Institute, Albuquerque, NM

SCIENCE ADVISORY BOARD STAFF

Dr. K. Jack Kooyoomjian, Designated Federal Officer, U.S. Environmental Protection Agency, Science Advisory Board (1400A), 1200 Pennsylvania Avenue, NW, Washington, DC, 20460

Ms. Mary L. Winston, Management Assistant, U.S. Environmental Protection Agency, Science Advisory Board (1400A), 1200 Pennsylvania Avenue, NW, Washington, DC, 20460

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY 1

2. INTRODUCTION AND CHARGE 5
   - 2.1 Background About the MARLAP Manual 5
   - 2.2 Charge Questions 5
   - 2.3 RAC Review Process 6
   - 2.4 Report Organization 7

3. RESPONSE TO CHARGE QUESTION #1: TECHNICAL ACCEPTABILITY, PRESENTATION, AND EASE OF IMPLEMENTING THE PLANNING, IMPLEMENTATION AND ASSESSMENT PHASES 8
   - 3.1 Overall Response to Charge Question #1 8
     - 3.1.1 Response to Charge Question #1a 8
     - 3.1.2 Response to Charge Question #1b 9
     - 3.1.3 Response to Charge Question #1c. 9
   - 3.2 Detailed Comments on Organization and Presentation of Part I 9
     - 3.2.1 Organization 9
     - 3.2.2 Presentation Style 10
     - 3.2.3 Technical Edit 12
   - 3.3 Detailed Comments on Technical Content of Part I 14
     - 3.3.1 Technical Issues 14
     - 3.3.2 Use of Examples 18

4. RESPONSE TO CHARGE QUESTION #2: TECHNICAL ACCURACY OF GUIDANCE ON LABORATORY OPERATIONS 23
   - 4.1 Overall Response to Charge Question #2 23
   - 4.2 Detailed Comments on Organization and Presentation of Part II 25
   - 4.3 Detailed Comments on Technical Content of Part II 25
     - 4.3.1 Chapter 10: Field and Sampling Issues That Affect Laboratory Measurement 26
     - 4.3.2 Chapter 11: Sample Receipt, Inspection and Tracking 28
     - 4.3.3 Chapter 12: Laboratory Sample Preparation 28
     - 4.3.4 Chapter 13: Sample Dissolution. 28
     - 4.3.5 Chapter 14: Separation Techniques 28
     - 4.3.6 Chapter 15: Nuclear Counting Instrumentation 30
     - 4.3.7 Chapter 16: Instrument Calibration and Test Source Preparation 30
     - 4.3.8 Chapter 17: Data Acquisition, Reduction and Reporting 31
     - 4.3.9 Chapter 18: Laboratory Quality Control 32
     - 4.3.10 Chapter 20: Waste Management in a Radioanalytical Laboratory 32

5. RESPONSE TO CHARGE QUESTION #3: GUIDANCE ON MEASUREMENT STATISTICS 33
   - 5.1 Overall Response to Charge Question #3 33
   - 5.2 Detailed Comments on Organization and Presentation of Chapter 19 33
     - 5.2.1 Organization 33
     - 5.2.2 Terminology 34
   - 5.3 Detailed Comments on Technical Content of Chapter 19 35
     - 5.3.1 Statistical Approximations of Uncertainty 35
     - 5.3.2 Treatment of Negative Analytical Values 36
     - 5.3.3 Use of Examples 38

6. RESPONSE TO CHARGE QUESTION #4: OVERALL INTEGRATION AND IMPLEMENTATION ISSUES . . . 39
6.1 Integration Issues . . . 39
6.2 Implementation Issues . . . 40
6.2.1 Composition of the Planning Team . . . 40
6.2.2 Availability of a Trained Workforce . . . 41
6.2.3 User Training . . . 41
6.3 Future Enhancements of MARLAP . . . 43

7. SUMMARY OF FINDINGS AND RECOMMENDATIONS . . . 49
7.1 Overall . . . 49
7.2 Charge Question #1: Effectiveness and Clarity of the Overall Approach in Part I . . . 49
7.2.1 Comments . . . 49
7.2.2 Recommendations . . . 49
7.3 Charge Question #2: Technical Accuracy of the Guidance in Part II . . . 50
7.3.1 Comments . . . 50
7.3.2 Recommendations . . . 51
7.4 Charge Question #3: Guidance on Measurement Statistics . . . 52
7.4.1 Comments . . . 52
7.4.2 Recommendations . . . 52
7.5 Charge Question #4: Overall Integration and Implementation Issues . . . 53

REFERENCES CITED . . . R-1

APPENDIX A - DETAILED DESCRIPTION OF THE SAB PROCESS AND ITS CHARGE . . . A-1
A.1 Charge Questions and Subcommittee Assignments . . . A-1
A.2 Panel Review Schedule and Process . . . A-3

APPENDIX - B - ACRONYMS AND ABBREVIATIONS . . . B-1

APPENDIX C - TECHNICAL REVIEW COMMENTS . . . C-1

1. EXECUTIVE SUMMARY

The MARLAP Manual is intended to provide consistent guidance for laboratories and users of laboratory services, for the planning, implementation, and assessment of projects entailing radioanalytical data and protocols. The MARLAP Manual was developed in partnership by seven federal agencies, departments, and commissions: the U.S. Environmental Protection Agency (EPA), Department of Energy (DOE), Department of Defense (DoD), Nuclear Regulatory Commission (NRC), National Institute of Standards and Technology (NIST), U.S. Geological Survey (USGS), and U.S. Food and Drug Administration (FDA). State participation in the development of the Manual involved contributions from representatives from the State of California and the Commonwealth of Kentucky. For the purpose of the Radiation Advisory Committee (RAC) review, this group is termed the federal "MARLAP Work Group."

The RAC finds that the development of the MARLAP Manual is an excellent example of interagency cooperation in line with a similar effort that produced the Multi-agency Radiation Survey and Site Investigation Manual (MARSSIM). Use of an interagency partnership to produce the MARLAP Manual represents the very best in government practices by involving technical staff from different government entities working together. Such collaboration brings collective wisdom and practical application of consistent and comprehensive science methodologies into harmony with a variety of regulatory and compliance practices. The RAC believes that this effort deserves special mention for the common sense approach it brings to the implementation of government programs and guidelines. The multi-agency authorship of MARLAP and the apparent consensus on a single overall "performance-based" approach gives the reader confidence in the reliability of the guidance and the logical foundation that underlies it.

Through the auspices of EPA's Office of Radiation and Indoor Air (ORIA), the federal MARLAP Work Group posed three charge questions to the RAC regarding: 1) the effectiveness and clarity of the overall approach; 2) the technical accuracy of the guidance on laboratory operations; and 3) the technical accuracy and clarity of the guidance on measurement statistics. To respond to the charge, the RAC established the MARLAP Review Panel ("the Panel") as a RAC subcommittee, augmented by consultants. Following a planning conference call, the Panel added a fourth charge question pertaining to overall integration and implementation issues.

With regard to Charge Question #1 (relating to the effectiveness and clarity of the overall approach), the Panel finds that the performance-based and flexible approach in MARLAP is appropriate and, for the most part, presented clearly and logically in the draft MARLAP Manual. The essence of a performance-based approach is the selection of radioanalytical protocols and the development of acceptance criteria for radioanalytical data based on project-specific analytical data requirements, as opposed to the use of prescribed methods. The Panel finds the guidance to be reasonable with regard to application of a graded approach for projects of different size, scope, and complexity, as well as the emphasis on data quality sufficient for the

decision being supported. The linkage of the planning, implementation, and assessment phases of projects involving radioanalytical data is effective. However, the draft Manual is consequently massive, and finding the information needed for a specific radioanalytical project may be difficult, especially for a novice or infrequent user. In its attempt to make each chapter relatively self-contained, the federal MARLAP Work Group may have introduced excessive redundancy. The Panel identified some guidelines which require greater definition and detail. Although the Panel recognizes that a lack of consensus among members of the federal MARLAP Work Group may be inevitable due to the different governing regulatory requirements for each of the participating agencies, the Panel recommends that a well-defined "consensus" solution be adopted in making recommendations to the users. To address these and other concerns, the Panel proposes several specific suggestions for reorganizing and editing the document to improve its overall usefulness and accessibility.

The Panel also recommends the inclusion of more examples to illustrate the planning process and the graded approach, so as to bring these to life for the reader. A variety of clearly presented and realistic scenarios will be critical to the success of MARLAP and should emphasize the potential benefits of planning and using a graded approach. The Panel recognizes that policies are often implied in the assumptions that are adopted as part of the planning process, and that it is difficult for a multi-agency document to address this nontechnical aspect. The Panel also recognizes the concern of the federal MARLAP Work Group that case studies or scenarios in the Manual could be interpreted by some users as setting or endorsing a precedent. Nonetheless, the Panel recommends that this concern be addressed upfront. Furthermore, to address the concern that regulatory agencies may try to apply the entire MARLAP process to situations and organizations for which a full-scale effort would not be appropriate, the Panel suggests the inclusion of more explicit guidance, including examples, on how to scale back the process to a level appropriate to the decision under consideration.

In reference to Charge Question #2 (relating to the technical accuracy of the guidance), the Panel finds that the draft Manual is an impressive compilation of information and recommendations that should be immensely useful to radiochemical analysis practitioners. The Panel also finds the guidance to be, on the whole, reliable and well thought out; however, as would be expected with such a large compendium of information, numerous technical inaccuracies and inconsistencies are identified. The Panel includes the most important of these issues in the text of its Review Report and recommends some changes or additions to the discussions in specific chapters. The Panel also suggests some changes in organizational structure so as to streamline and add clarity to the discussions, improve the logic of its flow, and in general increase its usefulness as a reference. The bulk of the Panel's specific concerns are addressed in Appendices C and D to its report.

With regard to Charge Question #3 (involving the guidance on measurement statistics), the Panel finds that statistical issues are addressed very well in the MARLAP Manual but offers several suggestions for reorganization and clarification to enhance its value, specifically for laboratory directors and staff. In particular, the terminology used in the draft MARLAP Manual

and the treatment of uncertainty propagation in measured values require some re-evaluation and, perhaps, revision.

In terms of Charge Question #4 (related to the self-initiated Panel question on the issue of overall integration and implementation), the Panel suggests that, in addition to better integration with the earlier MARSSIM (2000) document, it might be useful to devote a short section at the beginning of the Manual to show how the performance-based approach is suitable for decisions regarding the cleanup of radioactively contaminated sites. Although the Panel recognizes that MARLAP is not limited to site cleanup decisions, these represent some of the most important drivers for the creation of this Manual. The proposed new section would also help elucidate the areas of overlap between MARLAP and MARSSIM, as well as emphasize their differences in scope, coverage, and guidance.

In general, the Panel emphasizes that its comments and recommendations are intended to facilitate the use, and enhance the user-friendly construct, of an already superior product. The comments and recommendations offered by the Panel should be construed as constructive criticism intended solely to assist in improving a document that is already very comprehensive and thorough. Some of the main concerns with the draft MARLAP do not involve the technical content but rather the ease and practicality of its use as a tool. User implementation of its recommendations to use a performance-based approach may be frustrated by the fact that the selection of specific radiochemical protocols is often driven by the requirements of existing methods set as standards by different organizations. Until these methods are revised, and commitments from the authoring organizations are obtained, the radiochemistry community may be in conflict over some applications of MARLAP guidance.

The Panel emphasizes the need for a thorough technical edit, the main objectives of which should be to: 1) remove the considerable amount of redundancy, 2) ensure internal consistency among the chapters in presentation style and formatting, 3) make wider and more consistent use of effective techniques for presenting information, such as the inclusion of a Manual roadmap, reduced use of acronyms, development of a good overview figure, and reinforcement of key text information with tables and figures, and 4) verify and proof read all references, web-site addresses, equations, tables, figures, and examples. To aid in this effort, the Panel notes several presentation and formatting techniques in the draft Manual that it found to be particularly effective in emphasizing important points.

Finally, the Panel offers some suggestions beyond the charge given by the federal MARLAP Work Group regarding implementation of the Manual after its release:

1. Due to the complexity of the issues addressed in MARLAP, the Panel recommends that EPA undertake a program to train laboratory personnel and users of radioanalytical data in much the same manner as occurred for the MARSSIM activity.

2. The Panel also recommends that the agencies, departments, and commissions involved in developing MARLAP support a professional education program to generate a new generation of experts in radioanalytical techniques, to offset the trend towards a diminishing pool of available specialists. Such a program might include scholarships, fellowships, research grants, and teaching grants geared to encourage students and faculty to develop and maintain proficiency in the application of radioanlytical protocols.

3. The MARLAP document should be maintained as a "living document" and involve an iterative process whereby user suggestions can be incorporated into future revisions.

4. The success of MARLAP and MARSSIM in addressing complex multidisciplinary environmental issues leads the Panel to recommend that multi-agency approaches be extended to other EPA activities.

2. INTRODUCTION AND CHARGE

The EPA's Office of Radiation and Indoor Air (ORIA) requested that the Radiation Advisory Committee (RAC) of the Science Advisory Board (SAB) review the Multi-Agency Radiological Laboratory Protocols (MARLAP) Manual. The RAC review was initiated in August 2000 while the MARLAP was still under development, at which time the RAC initiated action to establish a MARLAP Review Panel comprised of RAC members and consultants. The draft Manual was made available to the Review Panel in September 2001. The Panel's review was completed in September 2002. Its report was adopted and approved by the RAC in November 2002 and transmitted in December 2002 for an Executive Committee review. Appendix A describes the details of the RAC review schedule and process. Appendix B defines the acronyms and abbreviations used in this report.

2.1 Background About the MARLAP Manual

The MARLAP Manual provides "guidance for the planning, implementation, and assessment of projects that require the laboratory analysis of radionuclides." The intent of the Manual is to "provide the guidance necessary for national consistency in the form of a performance-based approach for meeting a project's data requirements" and to help "ensure the generation of radioanalytical data of known quality, appropriate for its intended use." The MARLAP is not intended to be a "cookbook;" the Manual contains guidance but not specific laboratory procedures.

The MARLAP Work Group that developed the Manual consists of representatives of the Environmental Protection Agency (EPA), Department of Defense (DoD), Department of Energy (DOE), Nuclear Regulatory Commission (NRC), National Institute of Standards and Technology (NIST), U.S. Geological Survey (USGS), U.S. Food and Drug Administration (FDA), the Commonwealth of Kentucky, and the State of California.

2.2 Charge Questions

The specific charge questions posed to the RAC by the MARLAP Work Group through the auspices of ORIA were as follows:

Charge Question 1: Is the overall approach present in Part 1 of MARLAP for the planning, implementation and assessment phases of projects which require analysis for radionuclides technically acceptable?

- *1a. Is the performance-based approach presented clearly and logically?*
- *1b. Is the approach reasonable in terms of ease of implementation?*
- *1c. Does the approach effectively link the three phases (planning, implementation, assessment) of a project?*

Charge Question 2: Is the guidance on laboratory operations in the Part II chapters technically accurate? Does it provide a useful resource base of information for a laboratory's implementation of a performance-based approach?

Charge Question 3: Is the guidance on measurement statistics - specifically measurement uncertainty and detection and quantification capability - technically accurate, clearly presented, and useful for implementation by appropriately trained personnel?

2.3 RAC Review Process

The MARLAP was introduced to the RAC at its August 1, 2000 meeting in Washington, DC and the RAC conducted a planning meeting on MARLAP and other topics on December 12-14, 2000. The RAC determined that additional expertise would be needed for the review. Consequently, several consultants were added to the MARLAP Review Panel to assist in addressing the organizational aspects of the Manual as well as the accuracy of its radiochemical and statistical guidance.

The sequence and scope of the Review Panel's conference calls and meetings, and its interactions with the MARLAP Work Group (who were responsible for the Manual's content), are described in Appendix A. Two aspects of the review process are particularly worthy of the reader's attention. First, during its April 23-25, 2002 public meeting, the Panel subcommittee responding to Charge Question #1 (relating to the effectiveness and clarity of the overall approach) employed a tool that is unique to this review, at least for the RAC. In order to get a sense of how a laboratory manager or other critical users might perceive MARLAP, the Subcommittee engaged in a role-playing exercise with members of the MARLAP Work Group. This exercise was very enlightening, particularly in identifying and clarifying areas where MARLAP may be confusing and/or not a practical guide for the user. The exercise subsequently served as the basis for one of the Panel's recommendations on MARLAP training techniques.

Secondly, although not unusual among RAC reviews of EPA products, the cooperative process between the Panel and the federal MARLAP Work Group proved to be very useful. It facilitated the flow of information from the federal MARLAP Work Group to the Panel as well as providing an opportunity for the federal MARLAP Work Group to hear and understand the concerns of the Panel. Questions that might have been posed in the Panel's draft Review Report were addressed at the time they were raised, thus saving much effort and reducing the need for later corrections. The RAC very much appreciates the time and effort the federal MARLAP Work Group devoted to explaining aspects of the Manual and the rationale behind its organization. While the Panel worked in close cooperation with the federal MARLAP Work Group, that process did not compromise the independence of the peer review.

2.4 Report Organization

Responses to specific charge questions are contained in Sections 3, 4, and 5 of this report. In addition to responding to the specific charge questions, the Panel addressed several issues that went beyond the charge. These issues are presented in Section 6. Section 7 summarizes the Panel's most important findings and recommendations. Appendix C to this report compiles the Panel's comments on technical aspects of the Manual, relating to the accuracy, completeness, and clarity of MARLAP's technical discussions. Appendix D lists the Panel's editorial comments that address the need for more precise or succinct wording, additional detail in the guidance, corrected references, cross-referencing, and clarification of statements or terminology used in the Manual.

Names of subcommittee chairs and members, and a list of the MARLAP Manual chapters and appendices assigned to each Panel subcommittee, are included in Appendix A of this report.

3. RESPONSE TO CHARGE QUESTION #1: TECHNICAL ACCEPTABILITY, PRESENTATION, AND EASE OF IMPLEMENTING THE PLANNING, IMPLEMENTATION AND ASSESSMENT PHASES

Charge Question #1: Is the overall approach presented in Part 1 of MARLAP for the planning, implementation and assessment phases of projects which require analysis for radionuclides technically acceptable?

- *1a. Is the performance-based approach presented clearly and logically?*
- *1b. Is the approach reasonable in terms of ease of implementation?*
- *1c. Does the approach effectively link the three phases (planning, implementation, assessment) of a project?*

3.1 Overall Response to Charge Question #1

Compiling and organizing information and guidance related to the acquisition and use of radioanalytical analyses is a formidable but worthy task to be undertaken by a multi-agency committee. The federal MARLAP Work Group is largely successful in achieving its goal of developing a consensus document on this complex topic. Overall, the MARLAP Manual is a very impressive document with almost encyclopedic amounts of useful information. Chapters 1 to 9 in Part I are well prepared and thoughtfully organized, making this document very useful for persons needing to obtain or provide radioanalytical services for large-scale projects. The Manual does a thorough job of explaining how decision makers should make choices in the selection of hypotheses that help determine the confidence levels associated with the results obtained from analytical laboratories. Finally, the multi-agency authorship of MARLAP and the apparent consensus on a single overall approach gives the reader confidence about the reliability of the guidance.

The Panel strongly supports the graded approach advocated for the implementation of MARLAP, in which resources applied to a problem are appropriate to the size and complexity of the project. The Panel also strongly endorses MARLAP guidance that the planning process be viewed as an iterative process, rather than linear or stepwise, to ensure that the final product precisely meets all the requirements associated with data needs and a decision-based approach. An iterative process also permits the incorporation of new information as it is received, allowing the planners flexibility to modify or change earlier decisions as required, so that the most resource-effective approach to the problem can be developed and implemented.

3.1.1 Response to Charge Question #1a

With only a few reservations about explaining the context in which MARLAP will operate, the performance-based and flexible approach is well designed and appropriate, and is

presented clearly and logically in the draft document. The exposition is generally better than that typical of such large and complex draft technical documents at this stage of review.

3.1.2 Response to Charge Question #1b

Although some of the guidance in MARLAP may challenge the capabilities of those who must plan, manage, and conduct radiochemical analyses (see detailed discussion in Sections 3.2 and 3.3), the approach is reasonable, especially in light of the graded approach for projects of different scope and importance, and the emphasis on data of quality sufficient for the decision being supported rather than on specific requirements for analytical procedures or data precision and accuracy.

3.1.3 Response to Charge Question #1c.

The linkage of the planning, implementation, and assessment phases is largely effective as well. However, the Panel recommends that MARLAP provide guidance or recommendations to the end user who receives the analytical data that are generated through MARLAP, with regard to traceability, compilation and archiving of the data. For certain types of projects the assembled data may be useful in the future in the context of a different project. However, such data will be useful only to the extent that they are compiled and stored with sufficient information regarding sampling location, method, sampling time, analytical procedure, and quality assurance and control aspects. Inclusion of a statement regarding this issue could provide very timely advice to project planners and managers in the early stages of a project.

3.2 Detailed Comments on Organization and Presentation of Part I

The following comments are offered in the hope of further improvement, not as a criticism of this important effort. The comments are classified into the following categories: organization, presentation style, and the need for a thorough technical edit.

3.2.1 Organization

The organization of the draft MARLAP document is complicated, and it is not obvious how the user should most effectively make use of this thick two-volume manual. The present draft is wordy, with information being scattered and repetitive. The goal of producing stand-alone chapters is ineffective in practice because this repetition is distracting to those who are reading more than one chapter at a time, with the result that the reader very quickly loses interest. The following suggestions are made to address these shortcomings:

a) The goal should be to make Part I a stand-alone volume, replacing the goal of stand-alone chapters. The Panel envisions Part I as including the information presented in Chapters 1 to 9 and Appendices A to E.

b) Chapters should be thinned down and focused. Information in the chapters should be limited to that which the majority of users are likely to need to know, with the reader being referred to an appendix or references for extended discussions of exceptions, alternative options, or less common aspects.

c) In order to improve usability and reduce repetition, the Panel suggests that Appendix B should be incorporated in its entirety into Chapter 2. As it now stands, neither Appendix B nor Chapter 2 give the total picture, and the different numbering of steps in these two parts of the Manual adds to the confusion. If for some pressing reason the two cannot be merged, then at a minimum cross-references to appropriate sections of Appendix B should be sprinkled throughout Chapter 2 in order to tie the two together. Attachment B-1 to Appendix B also provides information that is important for understanding the underpinnings of a performance-based laboratory process; it may not need to be elevated to chapter status, but technically oriented readers should be encouraged to read it.

d) Instead of discussing all planning process options, the main body of the Manual should stick with one model (Data Quality Objectives) and discuss the alternatives only in an appendix.

e) Problems associated with navigating efficiently through the document could be minimized through the use of a decision tree to guide the user to sections that are relevant to a particular issue.

f) In the future, navigation through the document could also be made easier through the use of hyperlinks in a computerized version of MARLAP.

g) In general, the document eventually answers almost every question that occurs to the reader while reading it. However, it is so extensive that questions that arise in one section may be answered only in another section well removed from it. Although the document has extensive cross-referencing, it could do even better in that regard. Examples are provided in the specific comments compiled in Appendices C and D.

h) The utility of the Manual would benefit from the inclusion of an index similar in design, use of key words, and level of detail to the one in MARSSIM (2000).

3.2.2 Presentation Style

During one of the Panel's subcommittee sessions, a member of the federal MARLAP Work Group observed that the emphasis of key points and redundancy were already built into the document, but that key points were nonetheless still being overlooked by new readers. Why is

that the case? In its role as new readers, the Panel feels that the presentation style is often ineffective, and that it takes too long for the reader to "catch on" and to "see the big picture." The following suggestions are made to address that problem:

a) A well-written Executive Summary or Roadmap [such as the one in MARSSIM (2000)] could provide a means to unify MARLAP by using clear, simple text and figures to show the linkages among the chapters without the distracting repetition that is currently present. This summary of the major components of the MARLAP Manual should use figures and tables in the place of extensive text, as appropriate, to summarize sequential steps and/or interrelationships.

b) Acronyms are likely to be a major stumbling block at first for most readers. Although training and time may make some readers more comfortable with use of acronyms, the document is acronym-heavy and plain language should be used more often. Numerous acronyms appear to be good candidates for being dropped from the Manual and replaced with their full terms, such as ADC (analog to digital converter), AL (action level), ASL (analytical service laboratory), ATD (alpha track detector), BOA (basic ordering agreement), CC (charcoal canister), CL (central line of a control chart), COC (chain of custody), COR (contracting officer's representative), DL (discrimination limit), EDD (electronic data deliverable), GUM [*Guide to the Expression of Uncertainty in Measurement* (ISO, 1995)], and NIM (nuclear instrument module), to name but a few.

c) A good overview figure is needed at the outset, a figure that lays out the entire planning process and shows the interrelationships among the steps. Figure 1 (appearing at the end of Section 3 of this report) is a suggestion for such a figure.

d) Figures and tables should be designed so as to reinforce the text, or to help reduce the need for lengthy discussions. For example, Figure 1.1 is particularly helpful in presenting the concept of a Data Life Cycle without a lot of words. In many cases, however, the flow charts and other illustrations or tables are not always particularly useful and are sometimes even confusing, with the important ideas covered better in the text. For example, the text essentially repeats information in Table 3.1 without providing any added value. In these cases, the authors or technical editor should consider deleting one or the other. As an aside, the Panel noted that the text used in the flow charts is too small in many cases and even unreadable in a few cases.

e) The MARLAP text is clear about the very non-linear and iterative nature of the planning process, even at its first step. However, this aspect is not reinforced by the figures and tables. Figures 1.2 and 1.3 are static and linear; these figures should include feedback loops to more clearly convey the sense of the process of continual reassessing and fine-tuning the objectives and approaches. The

repeating spirals used in MARSSIM's Figure D.2, "Repeated Applications of the DQO [Data Quality Objectives] Process Throughout the Radiation Survey and Site Investigation Process" (MARSSIM, 2000) illustrate one approach for capturing this aspect in a graphic format.

f) The draft Manual's Table of Contents indicates that a glossary will be provided. In this glossary, it may be useful to place terms in italics in each definition to indicate those terms that are further defined in the glossary, as has been done in MARSSIM (2000).

3.2.3 Technical Edit

In order to make the Manual more user-friendly, efficient and effective, it should receive a thorough technical edit. The main objectives of this edit should be to remove the considerable amount of redundancy, ensure internal consistency among the chapters in presentation style and formatting, and make wider and more consistent use of effective techniques for presenting information. The Panel found the following presentation and formatting techniques to be particularly effective in emphasizing important points:

a) The boxed summaries of Recommendations at the end of Chapters 2 to 7 and Chapter 9 are useful and easy to understand. However, the number of recommendations for some chapters appears to be too few relative to the large amount of detail given in that chapter. Suggestions for additional recommendations to include in the chapter summaries are provided in Appendix C of this report (e.g., see comments for sections 2.2, 2.3.1, 2.3.3, 2.4, 2.4.1, 2.5, 2.7.1, 2.7.2 and 3.5).

b) The short discussions on uncertainty and error (MARLAP Section 1.4.7), and on precision, bias, and accuracy (MARLAP Section 1.4.8) are admirably concise and focused, saying no more and no less than is appropriate for this introduction to MARLAP terminology.

c) MARLAP Section 2.2 is another effectively written section, with just the right level of detail, good pacing, and an effective mix of presentation styles (short paragraphs, bulleted lists, boxed example).

d) The design and content of Table 2.1 effectively summarizes the planning process and the role of the radioanalytical specialist in this process.

e) Although the text in MARLAP Sections 2.5.1 to 2.5.4 covers the same topics as does MARLAP Table 2.1, it does not duplicate the table entries but rather adds value beyond the information presented in the table. The discussions largely support one another in a complementary fashion that is not overly repetitive

(although comments in Appendices C and D of this report note some discrepancies).

f) The specification of inputs and the explicit inclusion of an "Output" statement at the end of the discussion of each Analytical Planning Issue in MARLAP Section 3.3 are very helpful in understanding the value and importance of each item discussed.

g) MARLAP Section 3.3.7.1 reinforces critical but subtle guidance by including a short clear example immediately following the paragraph that describes how to establish a Measurement Quality Objective (MQO) for method uncertainty.

h) The well-designed checklist formats used in Chapters 7 and 18 are particularly noteworthy as effective ways to organize and communicate information. Section 7.4.2.2, which addresses on-site audits, is effective in telling the reader what to look for. This approach is equally useful for the laboratory and the client in that it identifies for both parties the key aspects to be examined during an audit and thus facilitates communication between them about expectations. Similarly, the chapter on Laboratory Quality Control (Chapter 18) provides succinct lists of potential causes for specific types of analytical problems, which is an effective way to convey some of the lessons learned from many years of practical experience by the MARLAP co-authors.

i) Section 8.5 guides the reader through the data verification and validation process by spelling out the criteria to be met, and the approach to first verify, and then validate, that the data meet the specified criteria. MARLAP is unusual among guidance documents on laboratory data acquisition in that it clearly distinguishes the different issues to be identified and resolved in the data validation and verification steps.

j) The format used in Chapter 18 subsections is particularly user-friendly: first defining and summarizing the importance of the issue at hand, then expanding on its subtleties in a more extended discussion, briefly mentioning excursions as appropriate, and finally ending with specific examples.

In contrast, reference citations in the document are particularly problematic in the draft Manual, for being incomplete, inconsistent, and sometimes outdated. Federal regulations cited in the text should be included in the list of chapter references so that the reader can judge their potential applicability to specific situations. For example, U.S. Department of Transportation (DOT) regulations may not be applicable to material transport on roads that are closed to public access, such as is commonly the case for some DOE laboratories. To the extent possible, cited references should refer to current editions. Reference citations that include web-site addresses (a practice which the Panel wholeheartedly supports) also need to be checked prior to publication.

For example, the web-site address listed for MARSSIM (2000) at the end of Chapters 1 and 3 is incorrect.

Finally, based upon suspected errors found in some equations, the Panel recommends a rigorous check of all equations throughout the Manual in order to ensure that they are correct. Furthermore, the MARLAP Work Group is encouraged to establish a quality assurance/quality control (QA/QC) plan in order to ensure that the equations, tables, and figures do not get corrupted during the process leading to final publication.

3.3 Detailed Comments on Technical Content of Part I

3.3.1 Technical Issues

No significant technical errors were found during the Panel's review. However, the Panel recommends that the MARLAP Work Group consider addressing the following points, at least in a cursory fashion, in the Manual. Additional technical points are raised in Appendix C to this report.

a) MARLAP clearly should not be expected to cover every situation involving the collection and evaluation of radioanalytical data, but it might be useful for the Manual to state more clearly and directly the types of decisions to which it applies. Examples of topics beyond its scope include radionuclide speciation in the environment, demonstration of regulatory compliance, and evaluation of some innovative radioanalytical approach, such as for analyzing a short-lived and volatile radionuclide. The Panel refers the federal MARLAP Work Group to Table 1.1, Scope of MARSSIM, in MARSSIM (2000) as one way to convey information to the reader on the limits of the Manual's coverage. Table 1 in this report suggests the types of entries that may be appropriate for an analogous table in MARLAP.

b) Radionuclides released in the environment from a source can be present in different physico-chemical forms varying in size, valence, and charge properties. Although it is outside the current scope of MARLAP to include specific guidance on analysis of speciation and oxidation states of radionuclides, it nonetheless should discuss the significance of speciation for proper utilization of radioanalytical data. Several radionuclides (e.g., plutonium, americium and uranium) are known to coexist in multiple oxidation states which are each susceptible to different complexation and hydrolytic reactions and consequently, result in different physico-chemical properties. Thus, knowledge about the total concentration of radionuclides in environmental samples is important but may be insufficient to assess potential ecological mobility and risks to humans. Prediction of contaminant transport in the environment can be significantly improved if their physico-chemical associations are well defined. The action

level (e.g., the derived concentration guidance level [DCGL]) often, if not always, will be set under the assumption that the nuclide is in the worst possible state as far as risk is concerned (e.g., soluble if the exposure pathway is ingestion). However, if the nuclide is in fact in a different state, then its presence at levels slightly above the action level may be inconsequential. If specified as part of the analytical plan, a laboratory should report the levels of the nuclide in each of its possible states, but in practice, meeting such a request may not be feasible for many radionuclides. Protocols for sample collection and preservation and for speciation measurements are the subject of intense research at the present time. The MARLAP report should acknowledge the importance of this topic and mention the complexities associated with it. The MARLAP authors should be prepared to address the issue of speciation in further detail in future revisions; this effort may require close coordination with the MARSSIM authors on protocols for sample collection and preservation.

c) Specific examples of clearly defined DQOs and associated MQOs would be instructive, particularly for illustrating the application of a graded approach. As an example, the Manual could discuss how DQOs and MQOs would differ for analysis of tritium in a liquid sample, depending upon whether the issue being addressed involves site cleanup, drinking water standards, risk analysis, bioassay for worker exposure, leak testing, waste acceptance criteria for a specific treatment facility, effluent monitoring, background survey, or a groundwater tracer study.

d) In its discussions of DQOs and MQOs, the Panel suggests that MARLAP include some realistic examples of considerations for developing an optimized strategy using a performance-based approach. The following examples could be used to illustrate that, from the perspective of statistical power, it is often better to obtain many data of only modest quality (e.g., ±30%) than a few data of high quality (e.g., ±1%). (See comments in Appendix C relating to MARLAP Sections 2.5.4, 3.3.1, 6.4, B3.8, and C.3 for suggested locations in which to make this point)

1) Data collected for reconnaissance purposes, such as screening an area for hot spots or conducting a preliminary assessment of an area about which little is known.

2) Data collected for a purpose that does not require great precision or the prescribed use of a precise method.

3) Data collected when it is known or suspected that uncertainties related to field sampling (e.g., representativeness of the sample, sample outgassing) may overwhelm analytical uncertainties.

4) Calibrated air flow measuring devices on air sampling stations (MARLAP Section 10.5.1, line 1221) offer high precision but maintaining calibrated instruments can be labor-intensive. An alternative which may be a little less accurate, but far more reliable, is to simply measure the flow after placing a new filter on the device and then just before it is removed, and averaging the results. This average flow rate is multiplied by the run time (sampler should be equipped with a simple run-time meter) to get the total flow through the filter. The same flow rate meter, which is taken from station to station and checked frequently for calibration, provides good station to station precision in airflow.

5) Along similar lines, some guidance would be useful relating to the use of data that do not have a good QA/QC pedigree but that are otherwise believed to be credible.

e) The document makes it clear that the radioanalytical specialist is essential throughout the planning, implementation, and assessment phases. However, the skill set for this position differs from that for the generic "health physicist" as described in most job specifications. It thus may be useful for MARLAP to include a sample job specification or Statement of Work (SOW) that could be used by small radioactive materials licensees or small regulatory programs to hire a radioanalytical specialist to help with writing a project-specific SOW, evaluating the bids, and assessing the data. In addition, the Manual should note areas in which individuals with related backgrounds could also conduct some of the tasks, noting that the role of the "radioanalytical specialist" need not be filled by a single person with a specific title but rather may be jointly covered by the expertise and experience of the other team members, e.g., industrial hygienist, laboratory personnel, scientist, project manager.

f) Timely review of data packages is a very important point that cannot be emphasized enough. Without feedback from this review process, the whole process could suffer because needed changes would not be identified in a timely or effective manner. Although stated clearly in MARLAP Section 5.4.3.3, this recommendation should be reiterated in the summary section of that chapter as well as in Chapter 8.

g) The Panel agrees with the approach taken by the authors to seek and identify points on which consensus could be reached, such as an overall approach (or structure or framework) to be taken rather than details on the specific steps or the order in which they should be taken. Nonetheless, it would be useful for the Manual to openly acknowledge that many areas exist in which agency guidance or requirements are currently not uniform or consistent, such as in the establishment of action levels, reporting uncertainties, assessment of penalties if

specifications are not met by the contracted laboratory, differences in number of significant figures reported, attention given to estimating yields, and treatment of negative data.

h) There is a need to check generalizations that may not apply to a significant proportion of the target audience or to the samples with which they may be dealing, and to assess whether exceptions to these generalizations are sufficiently important to warrant at least a brief mention. Several examples are given from Chapter 11:

1) Guidance on line 207 of page 11-8 is to treat contaminated packing material and packages as radioactive waste; however the possibility that there may be non-radioactive hazardous contaminants that would require the contaminated material to be classified as mixed waste is not mentioned.

2) Similarly, page 11-6 seems to mandate a designated receiving location for all samples, and page 11-14 states that sample storage areas must be posted as Radioactive Materials storage areas. For small projects or those limited to the analysis of very low levels of radioactivity, these apparent "mandates" may not be applicable or may even be counter-productive (e.g., by storing low-level samples together with high-level samples).

3) Page 11-4 (lines 73-75) states that laboratory facilities that handle radioactive materials are required to have a radioactive materials license issued by the NRC or the Agreement State in which the laboratory operates, with the exception of certain DOE and DoD laboratories. However, it is important to make clear that the latter facilities themselves cannot handle unrestricted levels of radioactive materials. They operate under similar types of regulation-driven restrictions, which are administered internally.

i) Chapter 9 of the Manual focuses on verification, validation, and assessment of the laboratory measurements. Somewhere in that chapter, perhaps in Section 9.2, the selection of the verification, validation, and assessment personnel should be discussed. Can some of them come from the performing laboratory? From the sponsoring organization (e.g., EPA, DOE, or DoD)? From the financially responsible parties? From an outside organization contracted to do the work? What qualifications are essential?

j) The example on page 3-16 (lines 458 ff) implies that data are unacceptable if the uncertainty does not meet the à priori MQO. This is not necessarily the case. For example, if an action level is 0.1 Bq/g (as in the MARLAP example), the

uncertainty should be less than 0.01 Bq/g. However, data for a sample with a concentration of 0.02 Bq/g and an uncertainty of 0.02 Bq/g are still valid and useful even though the reported uncertainty exceeds the MQO of 0.01 Bq/g. The MARLAP should make a distinction between the à priori MQO and the validity of the actual data.

3.3.2 Use of Examples

More examples are needed to illustrate the planning process and the graded approach, so as to bring these to life for the reader. A variety of clearly presented and realistic scenarios will be critical to the success of MARLAP and should emphasize the potential benefits of planning and using a graded approach. The Panel suggests the following aspects be considered for adding more examples:

a) References to good examples of process outputs (e.g., Statements of Work) from different agencies would be helpful. Specific examples or case studies would also be helpful, such as how to analyze a volumetrically-contaminated sample (e.g., scrap metal) in order to decide its disposition. Specific scenarios or case studies could be carried through each chapter to illustrate and contrast how a particular step would be implemented in those particular cases.

b) The MARLAP process appears to be designed for, and is applicable to, large projects encompassing a team and a relatively large number of samples. However, it is not clear that it would be practical to implement for small projects. Although the document refers to a graded approach, insufficient explicit guidance is provided for small projects. The detailed process described in the MARLAP Manual requires intensive use of resources. This is appropriate for large-scale environmental projects but not for small-scale evaluations and other activities. Therefore, it would be useful if the Manual could advise users on circumstances for which a much simpler approach would be appropriate, e.g., similar to the brief example discussed in Appendix B in MARSSIM (2000), which applies to certain users of sealed sources, short half-life materials, and small quantities. The limited number of references to a "graded approach" in MARLAP (e.g., Sections 2.3.1 and 4.5.3, and the first recommendation on p. 4-18) do not provide guidance that is clear or complete. For example, the Manual could expand upon its statement in Section 2.3.1 that the concept of a graded approach extends to the representation of the planning team by using this opportunity to provide a few concrete examples of simple activities in which only a few people would need to be involved in the planning. Examples of the graded approach could also be provided in the discussion on selection of contract services (Appendix E).

c) The federal MARLAP Work Group should consider whether a simpler version of MARLAP could be prepared, that would be applicable to the $10,000 to $50,000

projects that involve taking no more than 10 to 20 samples and that cover a small area. This is an important point. Regulatory agencies may try to apply the entire MARLAP process to situations and organizations for which a full-scale effort would not be appropriate. Some "out" must be available for small projects that are being required to respond to radiological situations with minimal potential for real impact. Suppose, for example, an entity had a small site with the potential for very low levels of contamination. This type of project could be a short-term decommissioning project, involving a health physicist and a few field and laboratory personnel. The health physicist would be responsible for site safety as well as the development of the sampling and analysis plan and production of the final report. The entire budget could be expended in writing the Project Plans described in MARLAP. A simpler outline could be developed that would give reasonable assurance that the DQOs would be met but without the myriad of written plans and reviews. A limited version of MARLAP could cover the development of DQOs, sampling and analysis plans, and verification and validation of data, but would not necessarily go into great detail in the selection and evaluation of a laboratory. Contract laboratories can be selected just on the basis of past experience.

d) The Panel recognizes that policies are often implied in the assumptions that are adopted as part of the planning process, and that it is difficult for a multi-agency document to address this non-technical aspect. The Panel also recognizes the concern of the federal MARLAP Work Group that case studies or scenarios could be interpreted by some users as setting or endorsing a precedent. However, the Panel recommends that this concern be addressed upfront and that the MARLAP Work Group not be discouraged from including realistic or complex case studies or scenarios in the Manual.

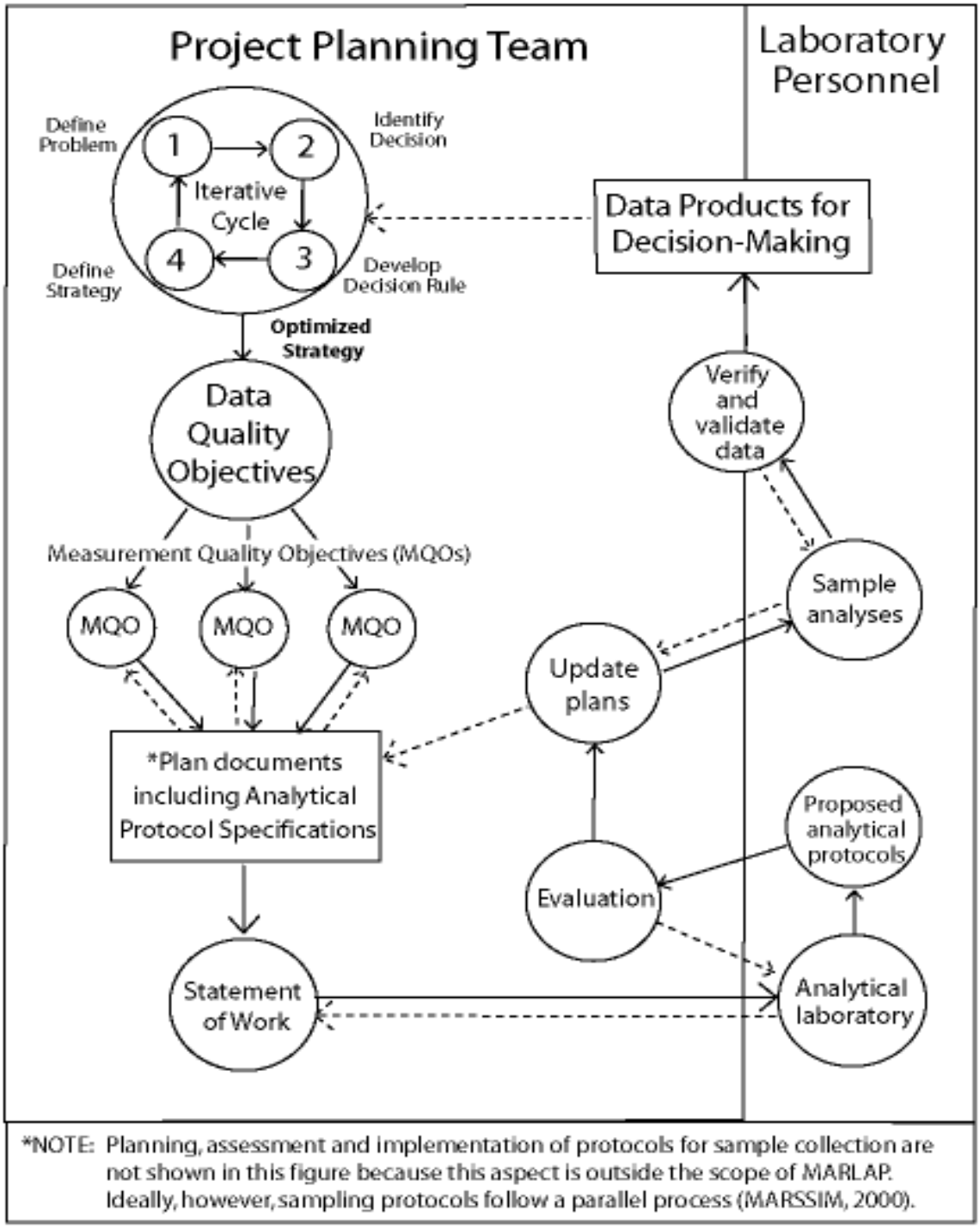

Figure 1. Schematic of the MARLAP planning, assessment and implementation process for radioanalytical analyses. Solid arrows indicate advancement to the next step, while dotted arrows indicate feedback loops to earlier steps.

Table 1. Scope of MARLAP

Topic	Within Scope of MARLAP	Beyond Scope of MARLAP
Regulatory guidance	Describes an approach that is generally consistent with those required by various federal and state agencies responsible for managing radiological contamination	• Does not establish or propose new regulations for radioanalytical protocols • Does not address how to demonstrate compliance with regulations
Applicability to specific projects	Broadly applicable to any project requiring the acquisition of radioanalytical data. Emphasizes a "graded approach" to data acquisition, in which the extent of application is based on the intended use of the data and the degree of confidence needed in the quality of the results	• Does not specify whether or not MARLAP is applicable to a specific project • Not intended to address research and development projects requiring acquisition of radioanalytical data • Would be difficult to apply to pre-existing data, in the absence of detailed information on the protocols used for sampling and analysis
Contaminants of concern	Applicable to any radionuclide for which action levels are, or can be, defined	• Does not address analytical protocols for nonradioactive chemical constituents • Does not address the determination of radionuclide speciation or oxidation state • May be difficult to apply to a radionuclide for which an action level does not exist or is irrelevant (e.g., studies of groundwater recharge and solute transport rates based on concentrations of natural atmospheric radionuclides like tritium or carbon-14)
Sampling procedures	Discusses how sampling protocols can affect the analytical results	Does not provide detailed guidance on sample collection
Types of media	Addresses analytical issues for a wide range of media typically encountered in environmental sampling studies	Does not contain guidance on sampling or analyzing fixed contamination on surfaces, i.e., radioactive contamination that cannot be readily removed from surfaces by nondestructive means such as wiping or washing
Data Quality Objectives (DQOs) and Measurement Quality Objectives (MQOs)	Presents a systematic approach for developing qualitative and quantitative statements of the analytical data requirements for a project	Does not provide prescriptive or default DQO or MQO values
Action levels	Describes how action levels are used to establish quantitative data requirements adequate to support decisions	Assumes that action levels will be provided rather than specified by MARLAP

Topic	Within Scope of MARLAP	Beyond Scope of MARLAP
Analytical procedures	Guidance given in MARLAP is performance-based and directed towards acquiring data adequate to meet a project's specific data needs. The Manual should be viewed as a toolbox with many components—some of which are discussed explicitly in MARLAP and others by reference.	• Does not contain step-by-step descriptions of analytical procedures • Does not recommend the use of specific analytical equipment or procedures • Does not include novel analytical procedures that are not yet widely accepted by the radioanalytical community • Does not establish specific procedures for sample storage and disposal • Does not contain guidance on the analysis of fixed contamination on surfaces • Provides only cursory discussions on laboratory health and safety, and waste management
Use of analytical data	Discusses how to translate a decision into a testable hypothesis with an associated decision error rate, and provides a set of statistical tests for evaluating data against the stated hypothesis	• Does not discuss how measured data are translated into doses or risks • Does not discuss how measured data are compared against release criteria for contaminated components, equipment or property • Does not recommend the use of specific hypotheses, decision error rates, or statistical tests
Non-technical issues	Recognizes that non-technical factors (e.g., costs, stakeholder concerns) can impact the selection of analytical protocols	• Does not discuss non-technical issues (e.g., legal or policy) in detail • Does not address public involvement • Does not address training issues for analytical protocols

4. RESPONSE TO CHARGE QUESTION #2: TECHNICAL ACCURACY OF GUIDANCE ON LABORATORY OPERATIONS

Charge Question #2: Is the guidance on laboratory operations in the Part II chapters technically accurate? Does it provide a useful resource base of information for a laboratory's implementation of a performance-based approach?

4.1 Overall Response to Charge Question #2

MARLAP is an impressive compilation of information and recommendations that should be immensely useful to radiochemical analysis practitioners. The document addresses the entire reach of radiochemical analysis from project design to final report of results. Each section appears to have been prepared by competent specialists in the topic, and little appears to have been ignored or misinterpreted. The MARLAP document matches the MARSSIM document for providing guidance for the laboratory analyses of field samples collected under the MARSSIM approach.

The following discussion focuses on Chapters 10 to 20 (excluding Chapter 19) of Part II because they specifically discuss the actual laboratory operations of analytical processing and measurement. Because these chapters are integrated into the entire text, some comments refer to related aspects in other chapters. On the whole, guidance in these chapters is reliable and well thought out. However, as would be expected for such a large document, the Panel found numerous errors. While many of the errors are typographical, they can be misleading, such as errors involving a chemical formula or technical terminology. Suggested corrections are compiled in Appendices C and D of this report.

The document is an encyclopedic resource. Chapters 10, 11, 12, 16, 18 and 20 are particularly well written, technically straightforward, and very useful. For the sake of clarity, Chapters 13 and 15 require more important revisions because some of the information is either incomplete, not useful or repetitious. Most of the suggested changes are organizational or editorial in nature, although they affect the technical clarity of the document and its internal consistency. Specific parts that would benefit from revisions are identified in Section 4.3 of this report.

The Panel concludes that the performance-based approach for the MARLAP document is appropriate and presented clearly and logically. The Panel suggests some reorganization of the presentation to the user, as described in recommendations provided in this review. Subject to the caveats listed in this section, Part II of the MARLAP document provides a much needed resource base for laboratory operations.

The Panel spent considerable time discussing the issue of how to report measured values that are below the minimum detectable concentration (MDC) as determined from counting

statistics or even negative (due in the latter case to the subtraction of non-negligible background concentrations). The Panel agrees with the MARLAP authors that the laboratory must report "as measured" values, whether or not negative or below the MDC, in the product intended for the scientists who will compile and statistically analyze the results for decision-making and who must evaluate the reliability of measurements near the limit of detection. The Panel was divided on the issue as to whether or not the lay public and nontechnical decision makers would be better served by tables that use "less than" values or statements of nondetectability for such measurements, in order to provide a better picture of the prevalence of results reliably different from zero. Reporting in that form will seem more familiar to many users, and doing so also eliminates the need to explain why the laboratory appears to have measured a physically impossible value. However, several Panel members strongly objected to the proposal to "dumb down" results for managers and the public. That practice increases the likelihood that the non-numeric results will be misused in further analyses and decisions, including the danger of generating mixed data sets with inconsistent treatment of low-level measurements. The Panel recommends that the MARLAP Manual address this issue in more depth and attempt to find a solution that will allow reports to the public and decision makers to be easily understood without being easily misused. A compromise solution to this quandary is proposed in Section 5.3.2 of this report.

The Panel also discussed the relationship of uncertainties in the results of laboratory analyses with the generally much larger uncertainties associated with:

a) derivation of an action level (e.g, a DCGL) from a risk-reduction policy goal, and

b) design of an effective sampling strategy to decide whether the action level is exceeded.

The federal MARLAP Work Group made it clear orally that its intent was to specify analytical procedures whose uncertainties would not add significantly to the uncertainties from other steps of the decision process. To the Panel, that intent is less clear in the written Manual, and it should be clarified there, perhaps in what is now Section B-1.3. Moreover, some Panel members are concerned that the user's interpretation of "significant" might not recognize that there are strategic tradeoffs between the precision of the analytical procedures and the coverage of the sampling plan. These two steps compete for resources; whether larger sample size with less analytical precision or smaller sample size with greater analytical precision is best for a given situation undoubtedly depends on situation-specific factors. Again, the Manual should devote greater attention to this issue, perhaps in Section B-1.3 and possibly in Section 1.4.7 as well.

In summary, guidance to the designers and managers of analytical laboratory projects should be as complete and direct as possible to avoid misuse of the MARLAP process. The Panel strongly supports the initiation and maintenance of a training program and implementation of a web site to enhance dissemination of the points raised above, as well as others.

The MARLAP Manual should emphasize the identification and treatment of data that are crucial for making decisions. Analyses that influence the overall performance results should be evaluated and, if necessary, redone prior to the completion of the decision process. Similarly, this point could also apply to the selection of the null hypothesis. This issue needs to be addressed in more detail in MARLAP. The most conservative approach may not be the optimal one. Failure to thoroughly evaluate the null hypothesis in the early stages of a project may lead to the wrong policy decisions, i.e., that a relatively "benign" site requires remediation. The Panel expects that this and other aspects of the technical implementation of MARLAP's performance-based approach will be greatly improved by user feedback as the document is tested through time.

4.2 Detailed Comments on Organization and Presentation of Part II

The Panel suggests that Part II be divided into two parts to facilitate convenient use in the laboratory. A reasonable separation may be between Chapters 10 to 14 and Chapters 15 to 20. Dividing Part II into two parts would make the document more convenient for use by radiochemists and by radiation detection and quantification users. Such a division would also help with the unwieldy physical size of the document in its present form, and in locating the needed information more quickly by the users. This suggested logical division is described in more detail below.

<u>Part IIa. Chapters 10 to 14.</u> These chapters contain information on sampling considerations, sample receipt and inspection on laboratory premises, sample preparation and pretreatment, and various separation techniques. All these topics are related and are likely to be used mainly by the radiochemistry laboratory staff (except possibly Chapter 10, Field and Sampling Issues).

<u>Part IIb. Chapters 15 to 20.</u> The remainder of the document, i.e., Chapters 15 to 20, includes information on nuclear counting, instrumentation, calibration and test sources, data acquisition and reporting, quality control, statistical considerations, and waste management. These topics are somewhat related (except Chapters 19 and 20, which are stand-alone chapters) and are likely to be used mainly by the counting laboratory staff.

Appendices should be rearranged for inclusion with the respective volumes, so as to facilitate the ease of use. At present, all appendices for Parts I and II are placed at the end of Part II.

4.3 Detailed Comments on Technical Content of Part II

Note: Additional comments related to these chapters are compiled in Appendices C and D. Some of these specifically address complexities associated with analytical methods and techniques.

4.3.1 Chapter 10: Field and Sampling Issues That Affect Laboratory Measurement

Overall this chapter is straightforward and useful. Although not necessarily a bad thing, a disproportionate amount of space is devoted to radon. It is all good information, but invites the question why there are not analogous sections such as "Selecting Tritium Sampling Methods Based on Data Quality Objectives" or for any other radionuclide as well? A table summarizing the known problems related to container and type of acid preservative for the various radionuclides, matrices, and analytical methods would be a useful addition to Chapter 10. For example, USGS documents usually indicate hydrochloric acid rather than nitric acid as a preservative for water. Is there a good reason for this? [Note: These sampling concerns could logically be addressed in either Sections 10.3.3.1 or 14.10.9.]

Several instances are noted in which the compilation of sampling methods or sampling data needs is incomplete:

Section 10.4.1. The Manual should remind users that the laboratory needs to document the amount of vegetative material removed from a sample so that environmental concentrations can be estimated appropriately for the exposure scenario(s) of interest. Also, sampling soil profiles and sediment cores for determining total inventory is an important technique that is not presented in this section of MARLAP. For example: soil at specified depths can be removed and analyzed separately. A plot of activity as a function of depth can be prepared, and the activity integrated over a particular depth of soil can be determined [c.f. DOE (1990)].

Section 10.4.2.1. This section implies total reliance on models for description of initial mixing and dispersion of radionuclides discharged to water. The use of dyes or other tracers to quantify dispersion in studies of complex situations should be acknowledged.

Section 10.4.3.2. In selecting foods and locations for food sampling, it is tempting to limit consideration of consumption habits to those of European-descended populations. The consumption and lifestyle habits of native peoples and other ethnic minorities can be quite different. MARLAP should recommend consideration of these differences. The use of inedible plants and non-game species as indicator organisms should also be mentioned in this section.

Section 10.5.4.2. Noble gases in air have also been collected for laboratory analysis by compressing air into Self-Contained Breathing Apparatus (SCBA) tanks, by collecting in impermeable plastic bladders (e.g., Tedlar) for later compression, or by cryogenic methods. Radon isotopes do not present an issue as interferents if laboratory analysis is delayed sufficiently for their decay.

Section 10.5.4.3. Electrets can also be used for monitoring tritium at relatively high levels. The use of electrets was discussed with regard to radon so a discussion of that technology in the tritium section would also be appropriate (e.g., Surette and Wood, 1993). Although mentioned earlier, the molecular sieve technique is not identified as a method for collecting tritium.

Molecular sieves are being used increasingly because of favorable properties such as less water retention following bakeout and better collection properties in environments with fluctuating temperatures.

Section 10.5.5.2. Methods for measuring radon flux should be mentioned in this section. In addition, ^{220}Rn analysis methods should be addressed. Also, it would be appropriate to note here that MARSSIM Section 6.9 provides extensive guidance on radon measurement methods and instrumentation.

Section 10.6.2. It would be very useful to indicate or reference suitable combinations of liquid scintillation fluids (cocktails) and filters for the liquid scintillation method of wipe testing.

The Panel also notes an exception to the general guidance provided on labeling of samples submitted to analytical laboratories. The statement in Section 10.2.4 (lines 173-176) provides guidance on ensuring that laboratory data are not influenced by prior knowledge of the origins of the samples. This is certainly an important consideration and needs to be discussed. However, the wording implies, perhaps unfairly, that laboratory personnel might take deliberate actions in this regard. In addition, there are many situations in which a laboratory would need to be aware of samples with relatively high levels of activity as these may require separate treatment to prevent cross-contamination, as is reflected in the statement on lines 313-314 in Section 12.2.4. The statement in Section 10.2.4 could be reworded as follows: "*The project manager needs to determine whether the sample numbering scheme is appropriate. It is advantageous to number samples to be submitted to a laboratory in such a way as to prevent inadvertent bias on the part of the analyst. However, in some cases, laboratories need to be aware of "hot" samples because these may require the use of separate areas or labware for processing (see Section 12.2.4)."*

Some technical inaccuracies in guidance or in generalizations are noted in this chapter:

Page 10-8, lines 217-219. The time to date of analysis is usually captured in pre-established holding times, not left to the judgment of field sampling personnel who make entries in the log or on the data form.

Page 10-21, lines 660-661. "*...radionuclides that are highly insoluble, such as isotopes of uranium, thorium, and plutonium..."* This is an invalid premise. Uranium is somewhat soluble and occurs dissolved in some groundwaters. Thorium and plutonium are better described as relatively immobile in the environment rather than insoluble, because thorium nitrate, for example, is certainly soluble.

Page 10-24, line 766. The statement "*...paper pulp has been shown to remove more than 95 percent of radionuclides from solution..."* seems too general. Tritium, for example, would not likely be removed by paper pulp.

Page 10-27, line 839. The following sentence is much too simplistic as guidance for selecting milk sampling sites: *"Raw milk should be obtained from the closest cows or goats downwind from a source."* For example, background sites should also be selected, and processed milk may have to be collected to fully characterize the impact on the general public. Significant iodine releases are much more likely to result from accidental exposures, which may be short term, than from continuous routine releases. Relying on a single "downwind" sampling location could potentially result in underestimating the impact of an episodic event.

4.3.2 Chapter 11: Sample Receipt, Inspection and Tracking

The relationships among various recommended documentation (e.g., bench sheets, laboratory logbook, "separate paperwork obtained before sample receipt," and "documents listing requests for specific analyses") need to be made clear. Good examples of these documents would be useful.

4.3.3 Chapter 12: Laboratory Sample Preparation

Overall, this chapter is straightforward and useful. Note that tritium may also be a problem for cross-contamination if low-level measurements are made in an environment where higher-level tritium sources are analyzed or in use. Tritium from leaking exit signs may also be a problem in certain laboratories. Similarly, background levels of radon progeny from natural sources in soil or possibly in the building's construction materials may create a problem in low-level counting laboratories. Short-lived radon decay products can become attached to surfaces, particularly where a static charge has been induced.

4.3.4 Chapter 13: Sample Dissolution.

In general, this chapter should be reorganized so as to discuss the issues from the simplest to the most complex. In addition, Section 13.6 (Special Matrix Considerations), Section 13.7 (Total Dissolution and Leaching), and Section 13.8 (Examples of Decomposition Procedures) should be presented differently. The style in these sections is inconsistent, and the text is either too general or overly specific with direct quotes from published papers. An alternative approach would be to refer the reader to specific publications for each special case.

4.3.5 Chapter 14: Separation Techniques

A table summarizing the characteristics of alpha, beta, and gamma radiation should be inserted at the beginning of Section 14.2 to illustrate that the extent of radiochemical separation is impacted, in part, by the type of radionuclide emission (e.g., see Table 2 as an example of such a table). This information relates directly to the understanding of the required chemical separation for each type of emission.

Table 2. General Characteristics of Alpha, Beta and Gamma Radiation

Characteristic	Alpha Particles	Beta Particles	Gamma Radiation (Photons)
Identity	Helium nuclei	Electrons Positrons	High-energy electromagnetic radiation (e.g., gamma or x-rays)
Mass (g)	$\sim 10^{-24}$	$\sim 10^{-28}$	0
Charge	2+	1±	0
Energy characteristic (initial emission energy)	Discrete	Continuous or discrete	Discrete
Penetrating power (relative)	1	100	10,000
Required radiochemical separation	Extensive	Modest	Minimal or not required

Section 14.10 would benefit from some reorganization and revised headings. This section would be more appropriately titled "Analysis of Specific Radionuclides," which is its subject, rather than "Radiochemical Equilibrium," which does not describe its contents. The presentation would be better balanced by placing current Sections 14.10.1 to 14.10.8 as subheadings in a new Section 14.10.1 called "Introduction" or "Overview." This overview should also include a brief explanation concerning the selection of the specific radionuclides that follow. The selection makes sense but should be justified. Finally, the analytical aspects of individual radionuclides in current Sections 14.10.9.1 to 14.10.9.12 would be renumbered as Sections 14.10.2 to 14.10.13.

The citation of references in subsections 14.10.9.1 through 14.10.9.12 is problematic for the Manual's users. Each of these 12 subsections has 8 sub-subsections, beginning with "Isotopes" and ending with "Methods of Analysis." The properties of radionuclides that permit chemical separation are discussed throughout these sub-subsections, but the references that underlie the presentation for each radionuclide are all bunched in the last sub-subsection, "Methods of Analysis." It would be far more convenient for the reader if each discussion of a property that permits separation and purification were associated with the reference on which it is based. At present, the reader who wants to follow up a particular separation has to guess which of the references are pertinent. This comment pertains to each of the 12 subsections.

Detailed descriptions of certain aspects of chemical behavior in current Sections 14.10.1 to 14.10.8 should be referred to in the specific radionuclide sections to avoid repetition concerning matters such as hydrolysis and polymerization. For specific radionuclides discussed in Section 14.10.9, extensive paragraphs that describe the occurrence, properties, and preparation of minerals and the metallic state should be deleted unless they are pertinent to the purpose at hand. Furthermore, some of the discussion on the environmental behaviors of specific radioelements such as plutonium and uranium is misleading and overly generalized (see specific comments in Appendix C of this report, relating to Section 14.10.9). For such topics, it might be best to direct the reader to appropriate up-to-date references rather than to provide detailed descriptions of aspects that are largely outside the scope of MARLAP. Similarly, the discussion of toxicity and radiotoxicity in Section 14.10.9 is not appropriate except when advising on

sample handling, in which case any warning to analysts should include specific information about use, quantity, and speciation in order to place amounts and effects in perspective. If the reference to toxicity is intended to explain the purpose or required sensitivity of an analysis, the reader should be referred to a radiation protection text. In a large tome such as this, the authors should limit themselves to pertinent information.

4.3.6 Chapter 15: Nuclear Counting Instrumentation

This chapter is a strange presentation of two writing styles: Sections 15.2 to 15.6 and Sections 15.7 to 15.10. In addition, much of the material in the first part is repeated in the second part. Although this chapter is admirably concise, it (especially Sections 15.2 to 15.7) is not consistent with the rest of MARLAP, which is much more detailed. Because of its conciseness, there is missing information in parts of the chapter. This material appears later in the chapter and even in Chapter 16 but there needs to be a better organization. The Panel learned that the reason that Chapter 15 is confusing and/or repetitive is because at least part of it was taken directly (and with permission) from an American Society for Testing and Materials (ASTM) text, but its order was reversed. This chapter needs to be rewritten. The material in Chapter 15 would be more efficiently presented if it were to describe proportional counters and scintillation counters (or even each of the various types of detectors) first and then describe specific radiation types. This reordering of material would avoid the need to repeat the description for each type of radiation.

Section 15.7 is redundant with much of the early material but is written more in the style of the rest of MARLAP. This section answers many of the questions raised in reading the earlier sections. It might be worthwhile for the earlier sections to be merged into section 15.7. Perhaps much of the overlap and difference in presentation in this chapter could be overcome by reorganizing the chapter. Starting on page 15-26, the chapter reads very well. This section should be used as a guideline for the earlier parts of the chapter. Pages 15-31 and 32 are redundant with Chapter 16 and should be deleted. On page 15-39, the writing suddenly becomes very specific and prescriptive. Consider whether some of the material in Attachment 15A, "Field Measurements," is redundant with other chapters on calibration or quality assurance.

The federal MARLAP Work Group should review Chapter 15 to be sure that the terminology used is consistent with current practices. For example, in Section 15.2 (lines 133 ff), photomultiplier tubes are referred to as "multiplier phototubes." This is not the usual terminology and is confusing to the reader.

4.3.7 Chapter 16: Instrument Calibration and Test Source Preparation

Chapter 16 seems to be straightforward and unambiguous with a good balance between the general performance and the prescriptive. There are numerous reference citations. Some of the instrument descriptions in this chapter are better than the ones in Chapter 15. There are instances of overlap with other chapters; and although this repetition probably cannot be

avoided, it is suggested that a better integration of Chapters 12, 13, 15 and 16 be sought. This may be accomplished in part by including suitable references in the chapters preceding pertinent discussions in Chapter 16. In general, a better "road map" to these chapters is required for clarity.

Chapter 16 deals with two topics, instrument calibration and test source preparation. Because instrument calibration is intimately linked to Nuclear Counting Instrumentation (Chapter 15), the question arises as to whether this topic should be included in Chapter 15 instead of Chapter 16. In contrast, test source preparation deals with converting the collected and processed samples to a suitable form for introduction to the counting instrument; hence, this topic is the bridge to Chapter 15 from:

a) Chapter 12, Laboratory Sample Preparation (for samples that need minimal preparation),

b) Chapter 13, Sample Dissolution (for samples that need moderate preparation), and

c) Chapter 14, Separation Techniques (for samples that need radiochemical preparation).

The Panel suggests that the federal MARLAP Work Group consider making Test Source Preparation a separate chapter either before or following the current Chapter 15. The common thread between the two parts of Chapter 16 (instrument calibration and test source preparation) is that both the test samples and the calibration samples should be prepared in the same, consistent manner. These two topics could be separated, with a note in the test source preparation chapter that samples need to be consistent for the calibration to apply to all the samples. A note could also be inserted in the calibration section stating that the calibration sources need to simulate the geometry and composition of the test samples. The chapter as written flows well and it currently uses some of the material already introduced in Chapter 15. At a minimum, the document should be reviewed to ensure that the wording in Chapters 12, 13, and 14 and at the beginning of the Test Sample Preparation part of Chapter 16 recognizes and facilitates the linkages described above.

It is not clear what the role for commercial, plated alpha and beta sources is, particularly for alpha spectrometry. MARLAP should discuss the considerations, cautions, correction factors, etc. should a laboratory choose to purchase commercial sources rather than custom making sources from calibrated solutions.

4.3.8 Chapter 17: Data Acquisition, Reduction and Reporting

In general, the text is very well written, with the exception of some repetitions and redundancies and editorial points as listed in Appendices C and D of this report. The Panel compliments the authors on the thorough technical job done for this chapter.

One shortcoming is that the advice to laboratories on how to check their own data is not adequate (discussed in Sections 7.3 and 7.4 and tie-in of Chapter 17 with Chapters 8 and 9). MARLAP presents consumer advice on how to verify and validate data, but provides no parallel advice to laboratories on how to check their own data. Verification is possible but not validation. MARLAP should provide advice on data verification by the laboratory as well as by the consumer.

4.3.9 Chapter 18: Laboratory Quality Control

This chapter is very well written and the presentation of the material is very accessible. The Panel compliments the authors for the thorough technical presentations in this chapter. The MARLAP authors might want to include the International Atomic Energy Agency (IAEA) along with NIST as a source of certified reference materials [IAEA Analytical Quality Control Services (AQCS), 2002].

The greatest problem resides in the presentation of the references in the text, which should be accompanied by a date of publication to distinguish these from earlier versions of the same documents. The reference section needs work and the format needs to be consistent throughout the section as well as throughout the MARLAP document (i.e., from chapter to chapter).

Attachments 18A and 18B are very useful additions to Section 18.3.2, "Statistical Means of Evaluating Performance Indicators--Control Charts." Attachment 18A serves as a guide to the various control charts and their use in the statistical evaluation of data sets. The solutions to the problems given in the section should be verified using an internal QA procedure for all statistical and numerical problems and equations throughout the MARLAP document. The only problem noted in Attachment 18B is the equation indexing. Problems and their solutions are well presented and the section is very useful as an illustration of additional statistical methods available to the user of control charts.

NOTE: The Panel's comments on **Chapter 19** are addressed under Charge Question #3 in Section 5 of this report.

4.3.10 Chapter 20: Waste Management in a Radioanalytical Laboratory

The chapter has good flow and is well written. The second paragraph in the introduction is a nice road map that tells what the chapter is all about. The chapter, out of necessity, gives general guidelines and then lists specific references to lead readers to more detailed information. Section 20.8, "Useful Web Sites," is an excellent addition to the chapter. However, just before final publication someone should verify that these sites are all still correct and active.

5. RESPONSE TO CHARGE QUESTION #3: GUIDANCE ON MEASUREMENT STATISTICS

Charge Question #3: Is the guidance on measurement statistics - specifically measurement uncertainty and detection and quantification capability - technically accurate, clearly presented, and useful for implementation by appropriately trained personnel?

5.1 Overall Response to Charge Question #3

The Panel finds that the issue of measurement statistics is addressed very well but could benefit from some revision in specific areas (described below) to enhance its value to laboratory directors and staff. Review comments on Chapter 19 and its attachments have been divided into four areas: organization, terminology, technical issues, and use of examples. The comments that follow represent a consensus on issues addressed by the Panel members.

5.2 Detailed Comments on Organization and Presentation of Chapter 19

5.2.1 Organization

Overall the Panel finds that too much material is included in Chapter 19, and that the material is not presented in the most logical order. The Panel suggests several changes to address these problems:

a) Divide the chapter into two sections. The simpler concepts of measurement, detection, and quantification should be discussed in the first section, followed by a section on the more complex issues regarding uncertainty evaluation and expression.

b) Provide the most important material at the beginning of the chapter. For example, there is a good discussion of counting statistics starting on page 19-44. This discussion should be moved to (or near to) the start of Chapter 19.

c) Attachment 19E contains some good examples. These examples should be brought into the body of the text in appropriate places.

d) Avoid duplication of examples (e.g., the example on page 19-121 is an exact duplicate of the one on page 19-69).5. Number the examples to facilitate reference in the text.

e) Bullet the important points in boxes. The box on the top of page 19-25 is a good example. It is, however, critical that these boxed "important points" be clear. For example, the box on 19-25 states: "*A measurement result should not be*

compared to the minimum detectable concentration to make an analyte detection decision. A detection decision may be made by comparing the gross signal, net signal, or measured analyte concentration to its corresponding critical value." This important recommendation should also be illustrated at this point by an example.

f) Eliminate Attachment 19B, "Multicomponent Analyses."

5.2.2 Terminology

The Panel finds the technical presentation to be statistically sound but too complex for the target audience of laboratory directors and staff. This chapter and several of the attachments would be more understandable to non-statisticians if an attempt were made to use more colloquial language for presentations of concepts that will be easier to understand by the target audience. For example, the presentation of statistical independence vs. correlation provided on page 19-5, lines 122-127, is unnecessarily complicated and probably not needed. Similarly, Attachment 19C on coverage factors should either be deleted or revised. As currently written, it is doubtful that anyone without a Ph.D. in statistics and experience in laboratory uncertainty analysis could implement this methodology.

Many of the terms used in the measurement statistics chapter may be commonly employed in the jargon of laboratory science, but these terms are confusing when read by statisticians. The Panel recognizes that this is a deliberate attempt to distinguish some of the less rigorous concepts involving laboratory uncertainty from those employed in a more strict statistical interpretation. Examples are "standard uncertainty" for "standard deviation" and "coverage factor" for "uncertainty interval" or "confidence interval". For example, on page 19-10, lines 240-241, a statement is made that: "*The uncertainty in x is expressed in the form of a standard deviation, called the standard uncertainty...*". However, on page 19-29, the standard uncertainty of an input estimate using the sample mean of *n* observations is given in equation 19.4 as the standard error, which is the standard deviation of a mean of size *n*. Therefore it is not clear whether the original definition of standard uncertainty is intended to mean the standard deviation of the distribution (which does not depend upon sample size) or the standard error, i.e. standard deviation of a sample statistic which does depend upon the sample size. Perhaps what should be stated is that the standard uncertainty is the standard deviation of whatever statistic is chosen as an estimator of the input parameter as actually used in the analytic method, i.e. do not use the standard error of a mean of size n if the method only uses one replicate for that input parameter.

The MARLAP Manual frequently uses the word "uncertainty" to describe the inability of any procedure to measure some value exactly. Sometimes, however, a decision depends on the true variability of values for a parameter, as with variable soil concentrations over a contaminated site. In that case, the important uncertainty may be about the value of, say, the mean, and depends on the sampling strategy as well as the analytic procedure. Moreover, the variability of measurement results over a set of nominally identical samples can be used to

characterize the uncertainty in the next measurement of a similar type of sample, and the variability of measurement results over samples taken from a site can be used to characterize the uncertainty about the mean soil concentration over that site. The federal MARLAP Work Group surely recognizes such distinctions between uncertainty and variability. The Panel recommends that the distinction be discussed early in the document, perhaps directing the reader to a more detailed discussion later, for example in Chapter 19.

Other examples include vague definitions of "Type B" evaluations and counting efficiency. Although strictly correct, the former term should not simply be defined as "*any evaluation of standard uncertainty that is not a Type A evaluation*," but rather should include a reference and a more helpful statement that Type B evaluations are typically based upon expert judgment. Similarly, counting efficiency should be defined in terms such as the ratio of analyte measured to the amount of analyte present.

The Panel realizes that the MARLAP Manual is directed at laboratory personnel who may be familiar with the terminology used in the current version. The Panel suggests, however, that statements be included to inform statisticians, who are likely to get involved, that many of the terms used are not directly translatable to corresponding statistical parameters or concepts with which statisticians may be more familiar.

5.3 Detailed Comments on Technical Content of Chapter 19

5.3.1 Statistical Approximations of Uncertainty

The Manual needs to clarify its use of statistical approximations. The discussion of uncertainty propagation in subsections 19.5.3 (Combined Standard Uncertainty), 19.5.5.1 (uncertainty propagation for nonlinear models), and 19.5.5.2 (Bias) is incomplete and potentially misleading. In particular, the methods presented are only approximate but this caveat is not always clearly stated. For example, Equation 19.11 on page 19-33, for combined standard uncertainty, is only an approximation, not equality. However, the presentation does not clearly stress the approximate nature of the formula, nor does it indicate the conditions under which this approximation would be valid. Both the use of an equal sign in the equation as well as the use of terminology such as "*the* uncertainty propagation formula" or the "*law* of propagation of uncertainty" give the impression that the relationship in Equation 19.11 is equality rather than an approximation.

In general, it would be helpful if the terminology and notation throughout Chapter 19 clearly indicated the approximate nature of most calculations. For instance, Table 19.1 shows all results as equalities, even though most formulas in the table are only approximate (except those for sums and differences). By contrast, in the last row, the table uses an "approximately equal" sign to indicate that $(\ln 10)^2$ is only *approximately* equal to 5.302. This latter result is at least accurate to four significant figures, while in some cases, the results presented as equalities might not be accurate to even a *single* significant figure.

Similar problems appear throughout Chapter 19. Admittedly, when uncertainties are small, the errors associated with the first-order Taylor polynomial are likely to be small. However, the Manual should clearly state whether a formula is an approximation when it is first introduced, and misleading notation and terminology should be avoided.

Section 19.5.5.2 is described as a discussion of bias. However, this section does not seem to use the term in the usual statistical sense, as discussed on pages 19-5 and 19-6, but rather refers to the potential inaccuracy of the Taylor polynomial approximation. Instead of providing an estimate of the error from use of the Taylor polynomial, the Panel suggests a qualitative discussion of situations in which this approximation is not accurate (e.g., when the uncertainties span a range sufficiently large that the function of interest is not approximately linear over that range).

The discussion in Attachment 19D, "Low-Background Detection Limits," should be revised to explain when someone should consider formulas A, B, and C, the Stapleton approximation, or the exact test. If MARLAP intends to suggest a preferred method, it should be clearly stated, along with recommendations for situations when one of the other methods is preferable.

The Manual should incorporate discussion on the use of Monte Carlo analysis as an alternative means for estimating total uncertainties, such as in the situation mentioned above when the Taylor polynomial approximation would be inaccurate. Section 19.5.5.1 shows how to include higher-order terms in the uncertainty propagation formula. However, the version of the uncertainty propagation formula presented in this subsection assumes that "all the input estimates x_i are uncorrelated," and no mention is made of Monte Carlo simulation as an alternative to the uncertainty propagation formula when uncertainties are substantial. The Panel believes that when uncertainties are large and it is important to have a good estimate of their magnitude, Monte Carlo analysis is generally preferable to the use of Taylor series approximations. Even a second-order Taylor polynomial can be inaccurate when uncertainties are large and the function of interest is significantly nonlinear. Monte Carlo simulation does not have this drawback and can achieve any desired level of accuracy simply by increasing the number of realizations. The Manual should note this and provide one or more references. Comprehensive references on Monte Carlo simulation include *Simulation and the Monte Carlo Method* (Rubinstein, 1981) and *Monte Carlo: Concepts, Algorithms, and Applications* (Fishman, 1996). Briefer summaries are given in *Uncertainty: A Guide to Dealing With Uncertainty in Quantitative Risk and Policy Analysis* (Morgan and Henrion, 1990) and *Statistical Models in Engineering* (Hahn et al., 1994).

5.3.2 Treatment of Negative Analytical Values

The treatment of laboratory data in Chapter 19 could benefit from a better distinction of "à priori" and "à posteriori" data analysis. In the case of "à priori"data, to which Chapter 19 is devoted, the Panel agrees with the recommendation on page 19-13 that laboratories should report negative values when they are obtained, even though such values are physically impossible. It is

clear that the measurement process itself can create negative values, even though the physical process cannot. Analytical measurement errors are ubiquitous and caused by random and systematic effects, as well as spurious errors. Whereas random errors are inevitable, and spurious errors (e.g., operator errors) can be generally avoided by good laboratory practices, systematic errors can vary greatly between laboratories. For example, systematic errors that result from an imperfect mathematical model for the relationship between the measurands and the measurable input quantities on which their values depend, can have significant effects on the measurement values obtained. Input quantities such as instrument background corrections can be optimized for a suite of analyses, but can still lead to systematic measurement errors and mathematically negative values for the measurand because instruments typically show a positive reading even for samples that are known to contain none of the element of interest. The positive background reading occurs for many reasons, including but not limited to interfering excitation energies, external radiation, instrument noise, or other problems, as discussed in MARLAP. In the case of radionuclides, an additional complication is associated with the presence of background radiation in the sample (e.g., naturally occurring radiation), a topic which is addressed in MARSSIM and other risk management documents. Therefore, even after instrument background has been subtracted out, a set of samples all having zero actual concentration will be represented analytically, in the vicinity of the detection limit, as a distribution of values, about half of which will be negative. Large negative values and/or departures from an equal distribution of negative and positive values can therefore be useful in that they are indicative of the adequacy and quality of the background correction methodology chosen by the operator. In other words, the negative values for the measurand are in part a measure of the suitability and limitations associated with the background correction technique adopted, even though the negative number is not "physically" real.

For these reasons, the Panel supports the recommendation in MARLAP that negative analytical results be reported for any and all "à priori" analytical laboratory results, and that the associated uncertainties always be included, as is the case for any measured value reported. These data need to be readily available for future reexamination, QA review, and numerical manipulations such as averaging, trending, and isopleth plotting. In addition, the Panel recommends that MARLAP authors consider extending the Manual's guidance on the reporting of negative values and values that fall within the measured uncertainty limits, by suggesting that (1) these results should be accompanied by the initials "n.d." to indicate a "nondetect," and (2) further explicatory information should be provided for negative values, such as in footnotes, because reporting of physically impossible negative values may be confusing to nontechnical audiences.

Conversely, in the case of the "à posteriori" use of analytical data, the Panel advises that the application of Bayesian statistical methods be envisioned by MARLAP and documented in future renditions of this report (Borak, 2000; Miller et al., 2000). It may be too early to judge the extent to which a Bayesian approach may be beneficial because of the paucity of peer-reviewed publications on Bayesian analysis of radioanalytical data. However, it appears to be a promising area of research, particularly for cases in which sources of uncertainty are not initially

recognized and cannot therefore be quantified using the material based on assumptions about "à priori" distributions as presented in Chapter 19. One recent example involved data generated by a whole-body bremsstrahlung counter that was used for decades (Kozheurov et al., 2002). This counter was subject to a variety of unanticipated influences, such as varying absorption of radon by different types of cloth, seasonally dependent values of radon contamination, and cesium-137 in global fallout. These various sources of uncertainty were recognized only after the collection of an extensive set of "à priori" data. Thus, it was more realistic to reëvaluate the uncertainties in the data on the basis of "à posteriori" data analysis, rather than by using the existing "à priori" uncertainty distribution assumptions.

5.3.3 Use of Examples

Much of the material presented in Chapter 19 is at the limit or beyond the comprehension of laboratory personnel, managers, and planners. Although the material is generally technically sound, it is often too complex and presented with so much mathematical content that the targeted user will have much difficulty in trying to implement the estimation procedures. While the federal MARLAP Work Group may be reluctant to provide a “cookbook” approach to every procedure, an ordered set of steps in producing each estimate should be given. After each estimation procedure is outlined, it should be followed by a numerical example in which each step is worked out with data values typical of radiological assays. The temptation to make the examples too simple should be avoided. For example, in Attachment 19E “Example Calculation,” the uncertainties for each input parameter are provided in the calculation of the combined uncertainty when it is doubtful that most laboratories would have already obtained all of these values. On the other hand, examples should not include factors that are unlikely to occur or have negligible effect. For example, is it necessary to include the effects of buoyancy during weighing and other errors associated with pipettes?

Another potential problem with the current examples is that they seem to imply that the combined uncertainties associated with radiological measurements are small, particularly when compared to uncertainties often encountered in field sampling. For example, the total combined standard uncertainty in Example 19E is only about 14% of the estimated measurand. Perhaps such a small uncertainty is typical of radiological measurements, but the Panel suspects that there may be considerably larger combined uncertainties. Examples of scenarios where one source of uncertainty may dominate and how this situation should be handled would be useful.

6. RESPONSE TO CHARGE QUESTION #4: OVERALL INTEGRATION AND IMPLEMENTATION ISSUES

Charge Question #4: What are the overall integration and implementation issues?

6.1 Integration Issues

Careful reading of the MARLAP Manual reveals considerable attention to integrating it with the earlier MARSSIM document (MARSSIM, 2000). However, it might be useful to devote a short section early in the Manual showing how the whole process is integrated for decisions regarding the cleanup of radioactively contaminated sites. Although the Panel recognizes that MARLAP is not limited to site cleanup decisions, they are probably the most important drivers for creating MARLAP. The proposed new section should also elucidate the areas of overlap between MARLAP and MARSSIM as well as their differences in scope and coverage. The addition of a table summarizing this comparison and linkage is a possible vehicle for this purpose (e.g., see Table 3 at the end of Section 6 as an example).

What is the relationship of MARLAP to other analytical planning guidance issued or required by federal agencies? Primary sources of radiochemical methods for several of the authoring organizations are listed in Table 4 at the end of Section 6. It may be useful to include an appendix in MARLAP that lists "source methods" for specific radionuclide methods, including brief descriptions of the contents of each document, similar to the compilation and description of available guidance on sampling methods in Appendix M of MARSSIM (2000).

Unfortunately, few of the method resources listed in Table 4 fully reflect the proposed MARLAP guidance. However, many of the authoring organizations for the methods are also participants in writing MARLAP. Therefore, these same organizations are well-positioned to revise these methods in a timely fashion following the finalization of MARLAP. The issue is not so much that existing guidance specifies methods incompatible with MARLAP as it is that existing guidance may be too prescriptive about procedures. Without the freedom to use the graded, performance-based MARLAP approach, laboratories may be inhibited from finding the most cost-effective methods for providing the data needed for a decision. Unless the existing guidance is revised to encourage the MARLAP approach, the radiochemistry community will not be able to enjoy all the benefits that MARLAP offers. [Note: The list in Table 4 is based principally on the public comments of Mr. Donivan Porterfield, augmented and reorganized slightly by the Panel. It's completeness and accuracy have not been assessed by the Panel, which offers it simply as a starting point for an effort by the federal MARLAP Work Group to respond to the Panel's recommendation.]

The Panel believes that it would be useful to show, perhaps through a table of connections, how the MARLAP Manual interfaces with, augments, or replaces existing guidance on radiochemical analyses. Where existing guidance appears to limit the full implementation of

MARLAP, or even to conflict with MARLAP guidance, the source agency should be encouraged to amend its published guidance or at least to acknowledge in a footnote the potential for conflicts between MARLAP guidance and published agency guidance. MARLAP may wish to recommend that those participating agencies that currently attempt to control the quality of analysis by specifying methods, as in the regulations for the Safe Drinking Water Act, use MARLAP to control by protocol instead of method, and leave method selection to the analyst. The Panel encourages each of the authoring organizations to initiate a review of its existing guidance and to withdraw or revise them if necessary to reflect the MARLAP guidance. Otherwise, a mixed message will be sent to the user community: on the one hand, advocating the right way to do radiochemical analyses, while on the other hand likely legally requiring the usage of radiochemical methods that follow outdated practices.

The documents listed in Table 4 provide a good start as references for well-established and widely-accepted analytical procedures that have been developed over the past 50 years for various radionuclides. The Panel suggests that the federal MARLAP Work Group consider including this information in the Manual, and that it expand the list to include other sources of information and references that could assist users in searching and locating individual radiochemical procedures. Some examples of such resources are (1) the Nuclear Sciences Series of monograms on individual radioelements, that is published by the National Academy of Sciences, (2) specific journal articles in *Analytical Chemistry, Health Physics, Radioactivity and Radiochemistry, Radioanalytical and Nuclear Chemistry, and Chemical Abstracts*, and (3) specific specialized books, reports, manuals and symposium proceedings of interest to radioanalytical chemists. Although MARLAP advocates a performance-based approach to analyses and is not intended to be a "cookbook" of analytical "recipes," users nonetheless will need to seek specific laboratory procedures that could best meet the given requirements of a project. If such a list were to be provided in the Manual, then a simple disclaimer may be included with it, stating that the various participating organizations consider the listed documents to be valuable information sources on specific radiochemical procedures (without sanctioning any specific method).

6.2 Implementation Issues

6.2.1 Composition of the Planning Team

Section 2.4 in MARLAP discusses the composition of the planning team. The first paragraph of that section states "*MARLAP recommends that the planning team consist of all of the parties who have a vested interest in, or who can influence, the outcome (stakeholders)*." In the following paragraph, the Manual presents a list of potential representatives that does not explicitly include the parties paying for the analyses and potentially for remedial actions afterwards (e.g., the Potentially Responsible Parties for a Superfund site). This disconnect may or may not have been intentional; the Panel can think of reasons for including and for excluding that class of stakeholders, likely depending on the specific decision for which the analyses are being conducted. The Panel strongly recommends that the issue be discussed in Section 2.4 and,

if there is consensus among the federal MARLAP Work Group, the MARLAP recommendation be made clear. In some cases, moreover, it may be appropriate to include representatives from the candidate performing laboratory(ies).

6.2.2 Availability of a Trained Workforce

The MARLAP Manual recommends that planning teams include "radioanalytical specialists." Because any individual will rarely have substantial expertise in all the areas of interest to radioanalysis (e.g., wet chemistry, spectrometry, statistics, QA/QC), the teams may need either to include several such individuals or to recruit an individual with general knowledge of radioanalytical issues AND specially trained in the MARLAP process. In doing so, the widespread use of MARLAP may create a demand for such individuals that substantially exceeds the current supply. Declining interest in nuclear power and less emphasis on nuclear weapons as the centerpiece of U.S. national security has allowed the pool of radioanalytic specialists to diminish. The MARLAP agencies may need to stimulate a new generation of such experts through scholarships, fellowships, research grants, teaching grants, or other means in order to implement MARLAP as envisioned.

A significant decline in research support for nuclear science in general and radiochemistry in particular has made it difficult to maintain the university faculty base needed to ensure a steady supply of educated nuclear scientists and radioanalytic specialists that will still be needed into the future. A decline in fundamental nuclear research, in the number of nuclear degree-granting programs and in the number of nuclear research reactors on campus facilities, as well as a decline in research support that would encourage faculty to study the nuclear science field, have all contributed to a decline in the pool of nuclear scientists and radioanalytic specialists. Many of the currently retiring generation of nuclear scientists obtained their training through Atomic Energy Commission (AEC) Special Fellowships in Nuclear Science and Engineering. DOE continues to support the training of Health Physicists through fellowships and scholarships, and also administers a "Radiochemistry Education Award Program" and other education programs through its Office of Nuclear Energy, Science and Technology (http://www.NE.doe.gov/). However, the DOE's programs focus mainly on nuclear engineering. To the best of our knowledge, there is no program today for generally trained scientists and particularly for radioanalytical personnel. This issue is being further explored by the SAB's RAC in a proposed self-initiated study on the broad topic of education and training related to guidance developed by EPA and multi-agency work groups.

6.2.3 User Training

Although the planning process is straightforward and logical, the learning curve is steep at first. Well-designed training courses would be an efficient approach to get new users comfortable with the process more quickly. In designing these courses, the Panel recommends that the federal MARLAP Work Group meet with the federal MARSSIM Work Group to find out the lessons learned by this team over the last couple years. For example, how has

MARSSIM dealt with the highly variable starting points of prior experience and expertise among the course attendees? MARLAP is more likely to succeed if separate training courses are tailored for different audiences: managers, radioanalytical specialists, laboratory personnel, perhaps auditors. However, it will also be important for the courses to overlap at least slightly in coverage so as to enhance communication among user groups by ensuring that participants speak a common language and that all see how each fits into the "big picture." The federal MARLAP Work Group could also consider offering or coordinating some of the MARLAP training through the National Environmental Laboratory Accreditation Conference (NELAC). The stated purpose of this voluntary association of State and Federal agencies, which first convened in 1995, is to establish and promote performance standards for environmental laboratory operations (EPA, 2002). NELAC provides a well-established forum for the private sector to interact with, and provide input to, regulatory agencies in the environmental arena.

Moreover, it is important to take advantage of user feedback not only on the effectiveness of training but also on MARLAP itself. Users may be able to identify requirements in MARLAP that are infeasible or counterproductive or, by contrast, identify additions to MARLAP that would result in data products better suited to the needs of specific decisions. MARLAP could then become a dynamic document that could respond to users' comments in future revisions. The MARLAP web site could serve as one place to receive suggestions for improvement, for example by offering a bulletin board. The Panel recommends that the authoring agencies commit to the implementation of training and outreach programs with the goal of achieving better use of the current version of MARLAP and improvements in future versions.

The Panel also recommends that role-playing exercises be part of the user training courses. The Panel subcommittee addressing the overall approach, i.e., responding to Charge Question #1, employed this tool at its April 24, 2002 work session. In order to get a sense of how a laboratory manager or other critical users might perceive MARLAP, the Subcommittee engaged in a role-playing exercise with members of the federal MARLAP Work Group. The scenario that was posed was based on a real situation in which elevated alpha activity had been detected in an unofficial groundwater sample collected from one of the monitoring wells adjacent to a privately-owned landfill. Subcommittee members took on the roles of the county administrator, landfill owner, a representative of the State environmental regulatory agency, and a concerned citizen from the neighborhood adjacent to the landfill. The federal MARLAP Work Group members adopted the roles of various types of "radioanalytical specialists" that included an analytical laboratory manager, an independent advisor for the county, and legal advisor to the landfill owner. The assignment to this group was to work through the MARLAP planning process described in Part I of the Manual. The radiochemical specialists were asked to direct the Panel members to the appropriate pages in the Manual that best described each step of the process.

The exercise only lasted a half hour, during which time the group was able to come to consensus on the problem definition, decision identification, data inputs, and decision boundaries. Due to lack of time, the exercise did not proceed as far as developing decision

rules, specifying limits on decision error rates, or developing DQOs, MQOs, APSs, or a SOW. Nonetheless, this cooperative exercise was invaluable for focusing attention of the group upon relevant advice provided in MARLAP. It not only facilitated the flow of information from the federal MARLAP Work Group to the Subcommittee, but also provided an opportunity for the Work Group to hear and understand the concerns of the Subcommittee, particularly in identifying areas where MARLAP guidance may be confusing, scattered, or not a practical guide for the user. Participants gained an appreciation for the critical importance of the appendices for key information needed to work through the planning process. Subcommittee members also became more cognizant of the very nonlinear and iterative nature of the planning process, even starting at its first step. The exercise raised the awareness of the MARLAP Work Group with respect to several training issues: how to conduct training, what to include in it, how important it will be, and assumptions about the prior level of knowledge of the user community. All participants appreciated the highly variable "starting points" of prior experience and expertise, and recognized the challenge of designing training that takes this variability into account. The consensus was that scenarios and training will be critical to the success of MARLAP, by illustrating the planning process, driving home the potential benefits of the process, and "bringing it to life."

Finally, user training may be enhanced through the provision of workbooks allowing trainees to work through example exercises illustrating the various major tasks of MARLAP. These examples should be neither so simple as to hide the true complexities of implementing a laboratory project within the MARLAP guidance nor so complicated that judging the adequacy of the trainee's answers would be difficult. These workbooks would not strictly be a part of the MARLAP Manual but could be considered appendages useful in training or available for reference prior to undertaking an unfamiliar type of project.

6.3 Future Enhancements of MARLAP

Many of the changes recommended by the Panel could require considerable effort to implement in full, and it is not the Panel's intent that release of the Manual be held up to do so. The value of the Manual to the user community will best be realized if it is managed as a "living document" with a mechanism in place for its ongoing maintenance and continual improvement as a multi-agency consensus product. The essence of the MARLAP Manual is to promote a flexible approach that permits a wide range of analytical procedures, from which a few are selected to meet the specific needs of a project. It is likely that different procedures will be developed to meet different DQOs, with a secondary objective of minimizing the cost of analysis. Additional analytical techniques will be developed for a variety of analytical needs, including speciation of the radionuclides of interest. Hence, a mechanism should be developed to promote the exchange of analytical procedures among laboratory personnel, perhaps using MARLAP user groups to instigate, facilitate, and document the results of such exchanges.

The following list reiterates some of the longer-term enhancements envisioned by the Panel for the Manual, as described elsewhere in this report:

a) Better integration with MARSSIM guidance on developing and implementing sampling and analysis plans,

b) Guidance on the use of Monte Carlo approaches to estimate uncertainties,

c) Guidance on the application of Bayesian analysis to à posteriori data,

d) Up-to-date and indexed list of method resources that describe advances in sampling, separation, and analytical techniques for radionuclides, including speciation and oxidation states in the environment,

e) Up-to-date list of relevant regulations and other documents issued by regulatory agencies, including web-site addresses,

f) Development of companion workbooks for target audiences,

g) Development of appendices containing examples of good planning, implementing, and reporting documents,

h) Development of a simpler version of MARLAP geared for the planning and implementation of small projects,

i) Development of a computerized version of MARLAP that includes hyperlinks for navigation, and

j) Development of updated scenarios and examples that reflect the real-world experiences of users.

Table 3. Comparison of MARLAP and MARSSIM Approaches

Issue	MARLAP	MARSSIM
Performance-based approach	Underlying basis and recurring theme throughout Part 1, involving 3 major steps: planning, implementation, and assessment. (Section 1.4.3)	Uses the data life cycle as the basis for its performance-based approach, but does not explicitly define this term
Directed planning process	Briefly describes several directed planning processes suitable for projects requiring the collection of radioanalytical data, and presents the DQO process in detail (Chapter 2, Appendix A); detailed discussion of role of radioanalytical specialist in this process (Section 2.5)	Uses the DQO process (which is one type of directed planning process) (Section 2.3.1, Appendix D)
Graded approach	Recommends the use of a graded approach (Section 2.3.1), and discusses its application to planning (Sections 4.3 and 4.5.3) and data assessment (Section 9.3)	Emphasizes the use of a graded approach for sampling contaminated areas (Section 2.2, 2.3) and provides example of a graded approach (Appendix B)
Data life cycle	Defines three phases: planning, implementation, assessment (Section 1.4.1)	Defines four phases: planning, implementation, assessment, making decision (Section 2.3, Appendix D, Appendix E)
Data Quality Objective (DQO) process	Defines 4 elements for this directed planning process in Section 2.3.3; 7 steps described in detail in Appendix B.	Defines 7 steps in the DQO process (Section 2.3.1, Appendix D)
Data verification and validation	Extensive discussion of the verification and validation process (Chapter 8)	Very brief discussions in Section 9.3. Provides example of data validation using 6 data descriptors (Appendix N)
Data Quality Assessment (DQA) process	Defines 4 steps in the DQA process: review project plan document (including DQOs), assess whether samples are representative, assess data accuracy, assess whether decision can be made (Section 9.6)	Defines 5 steps in the DQA process: review DQOs and survey design, conduct preliminary data review, select statistical test, verify test assumptions, draw conclusions (Section 2.3.3, 8.2, Appendix E)
Sampling design	Sampling design is outside scope	Extensive discussion of survey planning and design (Chapters 4-5)
Field sampling	Extensive discussion of field sampling, focusing on those issues that affect laboratory measurements, such as sample size, containers, filtering, preservation, storage, and transport (Chapter 10)	Extensive discussion of field sampling protocols, mostly focusing on field surveys (Chapter 6), but also including sampling for laboratory measurements (Chapter 7). Provides list of sources of sampling methods (Appendix M)
Radiation field equipment and measurement protocols	Brief discussion of field measurements from perspective of how conditions under which these measurements are obtained differ from those in a laboratory (Attachment 15A)	1-2 page descriptions of common types of field survey equipment (Appendix H.2) Equipment summary tables organized by type of radiation to be surveyed (Tables H.1 to H.5) Brief discussions on measurement protocols (Chapter 6)

Issue	MARLAP	MARSSIM
Radon field measurements	Brief overviews of radon sampling methods (Section 10.5.5)	Extensive discussion of radon measurement methods (Section 6.9, Appendix H.2.4, Table H.4)
Radiation laboratory equipment and measurement protocols	Major focus of Part 2, which covers sample preparation, dissolution and separation techniques, instrumentation, calibration, and data acquisition in depth (Chapters 12 to 17)	1-2 page descriptions of common types of laboratory instrumentation (Appendix H.3), Equipment summary table of systems that measure atomic mass or emissions (Table H.5)
Obtaining and evaluating laboratory services	Selecting and evaluating laboratories are covered in depth, including contractual specifications (Chapters 5 and 7; Appendix E)	Laboratory selection is briefly reviewed (Section 7.4); evaluation of laboratory services is outside scope
Action level	Discusses use of generic "action level" to formulate and test hypothesis about contamination (Appendix C)	Defines action level as the derived concentration guideline level (DCGL), which is used to formulate and test hypothesis about contamination (Sections 2.2 and 4.3)
Statistical tests for data evaluation	Detailed discussion of statistical tests suitable for testing hypotheses about contaminant (Chapter 19 and its attachments, Appendix C). Provides statistical tables (Appendix G)	Describes tests suitable for use depending upon whether the contaminant is absent or present in the background (Chapter 8, Appendix E). Provides statistical tables and brief descriptions of specific statistical procedures (Appendix I)
QA/QC for measurements	Discusses performance indicators for radiochemical and instrumentation steps of radioanalytical procedures (Chapter 18)	Brief discussion of quality assurance project plan (QAPP) and data assessment procedures (Chapter 9); discusses use of Data Quality Indicators (DQI) (Section N.6)
Decision rules and decision errors	Extensively discussed (Appendix B)	Extensively discussed (Appendix D.5 and D.6)
Reporting data	Stresses importance of reporting actual data, including negative values. Data reports should include appropriate number of significant figures, and combined or expanded uncertainties (Section 19.3.9).	Stresses importance of reporting actual data, including negative values and results with large uncertainties. Data reports should include appropriate number of significant figures, uncertainties, and applicable method detection limit (MDL). Recommends reporting results in same units as DCGL. (Section 2.3.5)
Laboratory or field health and safety	Briefly mentioned, but no extensive discussions (Sections 10.2.11 and 14.10.9)	Briefly mentioned
Laboratory waste management	Discussed in very general terms in Chapter 20	Not discussed
Regulations requiring radioanalytical data	Outside scope	Summarizes applicable regulations (Appendix C). Describes relationship of MARSSIM to CERCLA and RCRA Corrective Action process (Appendix F)

Table 4. Analytical Planning Guidance Issued or Used by Agencies and Organizations Authoring MARLAP*

U.S. Environmental Protection Agency

EPA (1976) *Interim Radiochemical Methodology for Drinking Water*, EPA 600/4–75–008 (revised), March 1976.

EPA (1979) *Radiochemical Analytical Procedures for Analysis of Environmental Samples*, March 1979.

EPA (1980) *Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4–80–032. August 1980.

EPA (1987) *Radiochemistry Procedures Manual*, EPA 520/5–84–006, December 1987.

EPA (1997) *Manual for the Certification of Laboratories Analyzing Drinking Water*, EPA 815-B-97-001, March 1997.

40 CFR 61 National Emission Standards for Hazardous Air Pollutants, Part B radiochemical methods.

U.S. Geological Survey

USGS (1976) *Selected Methods of the U.S. Geological Survey of Analysis of Wastewaters*, Open-File Report 76–177.

USGS (1977) "Methods for Determination of Radioactive Substances in Water and Fluvial Sediments", Chapter A5 in Book 5, *Techniques of Water-Resources Investigations of the United States Geological Survey*.

U.S. Department of Energy

DOE (1982) *RESL Analytical Chemistry Branch Procedures Manual*, IDO-12096, U.S. Department of Energy, Idaho Falls, ID.

DOE (1990) *EML Procedures Manual*, 27th Edition, Volume 1, HASL-300. Environmental Measurements Laboratory, New York, NY. [N.B.: As of September 2002, this reference is no longer available in hard copy but is available on CD and on the internet at: http://www.eml.doe.gov/publications/procman.cfm]

DOE (no date) *Methods for Evaluating Environmental and Waste Management Samples*.

States:

State of New York (1982) *Determination of Ra-226 and Ra-228 (Ra-02)*, January 1980, Revised June 1982. Radiological Institute Center for Research, New York State Department of Health, Albany, NY.

State of New Jersey (1980) *Determination of Radium 228 in Drinking Water*, August 1980. New Jersey Department of Environmental Protection, Division of Environmental Quality, Bureau of Radiation and Inorganic Analytical Services, Trenton, NJ.

American Society for Testing and Materials (ASTM) International:

ASTM (1994) *Annual Book of ASTM Standards*, Vol. 11.02. American Society for Testing and Materials, West Conshohocken, PA.

American Public Health Assocation (APHA)

APHA (1971, 1989, 1992, 1995) *Standard Methods for the Examination of Water and Wastewater*, 13th edition (1971), 17th edition (1989), 18th edition (1992), and 19th Edition (1995). American Public Health Association, Washington, D.C.

* Based on a list provided by Mr. Donivan Porterfield, and amended by the Panel. Most of these documents are referenced on the EPA website at http://www.epa.gov/safewater/methods/rads.html

7. SUMMARY OF FINDINGS AND RECOMMENDATIONS

7.1 Overall

The MARLAP Manual is comprehensive and provides answers--or citations to documents with answers--to virtually all of the questions that might be asked about radiochemical analyses in support of environmental decisions. Moreover, its graded and flexible approach allows a user to select a set of analytical procedures suited to the complexity and importance of the problem being addressed. The Manual in general provides a convincing rationale for its recommendations, showing how decisions can be supported with sufficient but not excessive attention to analytical precision and reliability. It does a thorough job of explaining how decision makers should make choices in the selection of hypotheses that help determine the confidence levels associated with the results obtained from analytical laboratories.

One of the major drawbacks of the draft MARLAP document is the sheer size of its two volumes. Furthermore, the individual volumes are not self-contained because all appendices have been relegated to the back of the second volume. The Panel suggests that a more efficient goal would be to reorganize Part I to include Appendices A to E, and to consider dividing Part II into two parts to facilitate convenient use in the laboratory. A reasonable separation may be between Chapters 10 to 14 (with Appendix F), which focuses on radiochemistry, and Chapters 15 to 20 (with Appendix G), which focuses on radiation detection and quantification.

7.2 Charge Question #1: Effectiveness and Clarity of the Overall Approach in Part I

7.2.1 Comments

a) The performance-based and flexible approach in MARLAP is appropriate and, for the most part, presented clearly and logically in the draft MARLAP Manual.

b) The guidance provided with regard to a graded approach for projects of different scope, as well as the emphasis on data quality sufficient for the decision being supported, is reasonable.

c) The linkage of the planning, implementation, and assessment phases of projects involving radioanalytical data is effective.

7.2.2 Recommendations

The following recommendations are listed in order of the priority placed on them by the Panel.

a) The Manual should undergo a thorough technical edit, the main objectives of which should be to (1) remove the considerable amount of redundancy, (2) ensure

internal consistency among the chapters in presentation style and formatting, (3) make wider and more consistent use of effective techniques for presenting information, (4) proofread all references, equations, tables, figures, and examples, and (5) reduce the use of acronyms.

b) Provide a well-written Executive Summary using clear, simple text, and figures to unify the document and show the linkages among the chapters.

c) A good overview figure is needed at the outset, a figure that lays out the entire planning process and shows the interrelationships among the steps.

d) More examples should be included in the Manual to illustrate the planning process and the graded approach, so as to bring these to life for the reader. A variety of clearly presented and realistic scenarios will be critical to the success of MARLAP and should emphasize the potential benefits of planning and using a graded approach.

e) To address the concern that regulatory agencies may try to apply the entire MARLAP process to situations and organizations for which a full-scale effort would not be appropriate, the Panel suggests the inclusion of more explicit guidance on how to scale back the process to a level appropriate to the decision under consideration.

f) Figures and tables should be designed so as to reinforce the text, or to help reduce the need for lengthy discussions. In particular, the very nonlinear and iterative nature of the planning process should be indicated by feedback loops in figures to more clearly convey the sense of the process of continual reassessing and fine-tuning the objectives and approaches.

g) An appendix containing good examples of process outputs (e.g., DQOs and Statements of Work) for projects differing in scope and complexity would be helpful.

7.3 Charge Question #2: Technical Accuracy of the Guidance in Part II

7.3.1 Comments

a) Subject to caveats listed in this review, Part II of the MARLAP document provides a much needed resource base for laboratory operations, and its guidance, on the whole, is reliable and well thought out.

b) Numerous technical inaccuracies and inconsistencies in the Manual are identified, as well as incomplete compilation of sampling methods or sampling data needs

and additional complexities associated with specific analytical methods and techniques. These detailed comments are listed in Appendix C.

c) Some of the main issues with MARLAP do not concern the content but the ease of its use as a practical tool. The implementation of radiochemical analyses is often driven by the requirements of existing methods set as standards by different organizations. Until these methods are revised, and commitments from the authoring organizations are obtained, the radiochemistry community may be in conflict over the application of MARLAP guidance.

7.3.2 Recommendations

As with the recommendations in Section 7.2.2, the following recommendations are given in order of priority.

a) The Panel strongly supports the initiation and maintenance of a teaching program and the implementation of a web site to enhance dissemination of guidance on issues related to MARLAP.

b) Restructuring some of the chapters in Part II could add clarity and usefulness to the document by providing more consistency in the level of detail, employing a more logical order of presentation, and inserting appropriate cross-references between chapters to reduce confusion and repetition. Discussion of limited value should be deleted, with the reader referred to specific publications (e.g., special matrices and radionuclide behavior in the environment).

c) Although the Panel agrees that the laboratory must report values "as measured" when below the limit of detection--or even negative through subtraction of background--presentations of the data annotated with qualitative indicators of non-detectability or less-than notation may be desirable to include in reports to the lay public and to decision makers. The Manual should address this issue and attempt to find a solution that would maximize lay understanding while minimizing the potential for misuse.

d) The federal MARLAP Work Group has provided guidance on laboratory analyses with the intent of ensuring that the uncertainties in their results do not contribute significantly to the overall uncertainty of the decision process, including those from the sampling design and those from translating risk-reduction policy goals to action levels. This intent should be further clarified in the Manual, and the issue of tradeoffs between sampling coverage and laboratory precision should also be discussed.

7.4 Charge Question #3: Guidance on Measurement Statistics

7.4.1 Comments

a) From a technical perspective, statistical issues are addressed very well in the draft MARLAP Manual. From a presentation perspective, however, too much material is included in Chapter 19, the material is not presented in the most logical order, the technical discussions are too complex for the target audience of laboratory directors and staff, and the terminology differs from that most commonly used by statisticians.

7.4.2 Recommendations

The recommendations on statistical issues are presented in the order of importance.

a) Many of the terms used in the measurement statistics chapter may be commonly employed in the jargon of laboratory science, but these terms are confusing when read by statisticians. Statements should be included to inform statisticians, who are likely to get involved, that many of the terms used are not directly translatable to corresponding statistical parameters or concepts with which statisticians may be more familiar.

b) The Panel recommends that the distinctions and connections between uncertainty and variability be discussed early in the section on measurement statistics.

c) The terminology and notation throughout Chapter 19 should clearly indicate the approximate nature of most calculations and clearly state whether a formula is an approximation when it is first introduced. It should also indicate the conditions under which each approximation would or would not be valid. If MARLAP intends to suggest a preferred method, it should be clearly stated, along with recommendations for situations when one of the other methods is preferable. For example, Attachment 19D should provide recommendations regarding which of formulae A, B, C, the Stapleton approximation, or the exact test are preferred and under what conditions.

d) The Manual should incorporate discussion on the use of Monte Carlo analysis as an alternative means for estimating total uncertainties. Given recent advances in desktop computers and work stations, computational restrictions on the use of Monte Carlo methods are no longer a concern. In this case, however, the user needs to be reminded that assumptions about parameter distributions are critical.

e) The steps used for each statistical estimate should be clearly laid out in chronological order so that users of MARLAP will know how to begin and how

to progress through the estimation process. After each estimation procedure is outlined, it should be followed by a numerical example in which each step is worked out with data values typical of radiological assays.

f) The potential use of Bayesian analysis should be explored, particularly as a way to address the problem of negative values resulting from background-corrected laboratory data.

g) The current statistical examples seem to imply that the combined uncertainties associated with radiological measurements are small, particularly when compared to uncertainties often encountered in field sampling. Examples of scenarios where one source of uncertainty may dominate and how this situation should be handled would be useful.

7.5 Charge Question #4: Overall Integration and Implementation Issues

The following recommendations are given in priority order:

a) The Panel believes that scenarios and training will be critical to the success of MARLAP, by illustrating the planning process, driving home the potential benefits of the process, and "bringing it to life" for the user community. The Panel recommends that role-playing exercises be part of the user training courses.

b) The Panel recommends that the MARLAP Work Group meet with the MARSSIM Work Group to find out the lessons learned by this team over the last couple years for developing well-designed training courses.

c) The Panel recommends that the MARLAP Work Group take advantage of the training sessions to obtain user feedback not only on the effectiveness of training but also on MARLAP itself. Users may be able to identify requirements in MARLAP that are infeasible or counterproductive or, by contrast, identify additions to MARLAP that would result in data products better suited to the needs of specific decisions.

d) It might be useful to devote a short section early in the Manual to showing how the MARSSIM and MARLAP processes are integrated for decisions regarding the cleanup of radioactively contaminated sites.

e) It would be useful to show, perhaps through a table of connections, how the MARLAP Manual interfaces with, augments, or replaces existing guidance on radiochemical analyses.

f) Although it is outside the scope of the Panel's charge, the Panel recommends that each of the authoring organizations seek to establish a time frame for reviewing and revising the radiochemical method resources issued by their organizations to fully reflect the MARLAP guidance. Otherwise, a mixed message will be sent to the user community: on the one hand, advocating the right way to do radiochemical analyses, while on the other hand likely legally requiring the usage of radiochemical methods that follow outdated practices.

g) The MARLAP agencies may need to stimulate a new generation of such experts through scholarships, fellowships, research grants, teaching grants, or other means in order to implement MARLAP as envisioned. A decline in fundamental nuclear research, in the number of nuclear degree-granting programs and in the number of nuclear research reactors on campus facilities, as well as a decline in research support that would encourage faculty to study the nuclear science field, have all contributed to a decline in the pool of nuclear scientists and radioanalytic specialists. To the best of our knowledge, there is no nuclear science program today for generally trained scientists and particularly for radioanalytical personnel. This issue is being further explored by the SAB's RAC in a proposed self-initiated study on the broad topic of education and training related to guidance developed by EPA and multi-agency work groups.

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APPENDIX A - DETAILED DESCRIPTION OF THE SAB PROCESS AND ITS CHARGE

The EPA Office of Radiation and Indoor Air (ORIA) requested that the Radiation Advisory Committee (RAC) of the Science Advisory Board (SAB) review the Multi-Agency Radiological Laboratory Protocols Manual (MARLAP). The MARLAP was introduced to the RAC at its August 1, 2000 meeting in Washington, DC. The Manual was still in early draft form at that time and was not available for the RAC to study, beyond the Table of Contents.

The SAB Staff recruited Dr. Jan Johnson, Executive Committee Member of the SAB and Chair of the SAB RAC, to serve as Chair of the MARLAP Review Panel. The RAC determined that additional expertise would be needed for the review to assist in addressing the accuracy of its radiochemical and statistical guidance. Working with the Chair, other SAB members and consultants, Agency Staff, and suggestions from the public, the SAB Staff identified scientists and engineers ("Wide Cast") whose expertise appeared to be relevant to answering the questions in the Charge. Subsequently, the Chair, the Staff Director, and the Designated Federal Official (DFO) reviewed the list in some detail and identified individuals ("Narrow Cast") to contact regarding their interest and availability to participate on the Panel. Based on this information and the importance of having a balanced range of views on the technical issues represented on the Panel, the Chair and the DFO made recommendations for membership to the Staff Director, who made the final decision on the composition of the Panel. This process included assigning Lead and Associate responsibilities to specific Panel members for each of the Charge questions.

The draft Manual was made available to the MARLAP Review Panel in September 2001. The Panel completed its review in November 2002. This Appendix describes the details of the Panel's review schedule and process.

A.1 Charge Questions and Subcommittee Assignments

Members of the MARLAP Review Panel addressed the specific charge questions posed by ORIA by organizing into subcommittees for each question, and allocating specific chapters and appendices to each subcommittee.

Charge Question #1: *Is the overall approach presented in Part 1 of MARLAP for the planning, implementation and assessment phases of projects which require analysis for radionuclides technically acceptable?*

1a. Is the performance-based approach presented clearly and logically?
1b. Is the approach reasonable in terms of ease of implementation?
1c. Does the approach effectively link the three phases (planning, implementation, assessment) of a project?

Subcommittee chair: Dr. June Fabryka-Martin
Subcommittee members: Dr. Steve Brown, Dr. Bruce Boecker, Dr. Jill Lipoti, Dr. Helen GroganApplicable MARLAP chapters:
Primary review materials: Chapters 1-9; Appendices A, B and C
Secondary review materials: Chapters 11 and 18
General review: all chapters and appendices

Charge Question #2:*Is the guidance on laboratory operations in the Part II chapters technically accurate? Does it provide a useful resource base of information for a laboratory's implementation of a performance-based approach?*

Subcommittee chair: Prof. Bernd Kahn
Subcommittee members: Prof. Tom Gesell, Dr. Gilles Bussod, Prof. Genevieve Roessler[1], Prof. Shawki Ibrahim
Applicable MARLAP chapters:
Primary review materials: Chapters 10-18 and 20
Secondary review materials: Chapters 1, 2, 5, 6 and 8
General review: all chapters and appendices

Charge Question #3:
Is the guidance on measurement statistics - specifically measurement uncertainty and detection and quantification capability - technically accurate, clearly presented, and useful for implementation by appropriately trained personnel?

Subcommittee chair: Dr. Richard Hornung
Subcommittee members: Dr. Vicki Bier, Dr. Mike Ginevan, Prof. Lynn Anspaugh, Dr. Bobby Scott
Applicable MARLAP chapters:
Primary review materials: Chapter 19; Appendices B and E; Attachment B-1
Secondary review materials: Chapters 1, 3, 5, 6, 8, 17 and 18.3
General review: all chapters and appendices

Charge Question #4: The MARLAP Review Panel added this fourth charge question during a planning conference call:
What are the overall integration and implementation issues?

Subcommittee chair: Dr. Steve Brown
Subcommittee members: All MARLAP Review Panel members and consultants

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[1] Dr. Genevieve Roessler chaired this activity in the absence of Dr. Kahn at the April 23-25, 2002 meeting. She was assisted by Drs. Bussod, Gesell, and Ibrahim and others as appropriate.

Applicable MARLAP chapters: All materials, and possibly additional supplemental items from other sources.

A.2 Panel Review Schedule and Process

The RAC was introduced to the MARLAP topic at its publicly-accessible Federal Register-noticed planning meeting on August 1, 2000 and a subsequent public planning meeting on MARLAP and other topics on December 12-14, 2000. At the December 12-14, 2000 RAC planning meeting, the RAC determined that additional expertise would be needed for the review. Consequently, several consultants were added to the widecast list as candidates for the MARLAP Review Panel to assist in addressing the organizational aspects of the Manual, as well as the accuracy of the radiochemical and statistical guidance contained in the Manual. The RAC's MARLAP Review Panel held its first formal meeting on MARLAP as a public conference call on April 8, 2002. The goal of this information-gathering conference call meeting was to clarify any questions that the MARLAP Review Panelists might have, to identify any gaps in the review materials and any other information sent to the Panel, and to identify areas that the Agency and the federal MARLAP Work Group should be prepared to clarify at the face-to-face meeting. The RAC's MARLAP Review Panel added a fourth charge question during this April 8, 2002 planning conference call dealing with the topic of overall integration and implementation issues.

On April 23 through 25, 2002 the Panel convened a in the EPA Headquarters Building, EPA East Building Hearing Room 1153, Washington, DC. The federal MARLAP Work Group participating in this review included technical staff from the following agencies, departments and commissions: the U.S. Environmental Protection Agency (EPA), Office of Radiation and Indoor Air (ORIA), the Department of Energy (DOE), the Department of Defense (DoD), the Nuclear Regulatory Commission (NRC), the National Institute of Standards and Technology (NIST), the U.S. Geological Survey (USGS), and the U.S. Food and Drug Administration (FDA). State participation in the development of the Manual involved contributions from representatives from the Commonwealth of Kentucky and the State of California.

During the April 23 - 25, 2002 public meeting, the SAB's MARLAP Review Panel heard presentations from the Agency and the federal MARLAP Work Group staff on the first day. Public comments were received from Mr. Donivan Porterfield in advance of the meeting. No additional public comments were received at this meeting. The presentations were followed by detailed discussion by the MARLAP Panelists on the four charge questions in break-out sessions held in smaller rooms adjacent to or in close proximity to the EPA Hearing Room, in which all participants were invited to participate. The second day saw continued break-out session discussions, a re-convening of the MARLAP Review Panel to discuss its progress and next tasks, and the making of additional writing assignments by the subcommittee chairs. The discussion in the break-out sessions focused on key points within each charge question, as well as re-writing of the pre-meeting written comments by the Panelists to their assigned charge questions, and teaming in groups by the Panelists to develop merged language edits.

By the end of the second day, the individual comments and merged edits were discussed by the Panelists within each of the Working Groups. The third day was engaged with more refinements of the written materials and focused discussions within each of the subcommittees. The MARLAP Review Panel decided to exercise its option to conduct a planned technical editing public conference call in June 27, in which the public can follow the Review Panel's discussions on the working draft, which is not yet a public consensus report. The Review Panel anticipated that a public consensus draft would be completed at the end of August, and planned to hold a second public face-to-face meeting at the end of September to reach closure on edits to that draft report. The first "working" public draft was developed on August 29, 2002 and posted on the SAB web site (www.epa.gov/sab under "draft reports") for discussion at the MARLAP Review Panel's Sept 24-26, 2002 meeting. It is important to note that early on in the process, the MARLAP Review Panel identified the need for two face-to-face public meetings to resolve issues, have extensive discussions, and reach a point where closure could be achieved on this complex and detailed topic.

The MARLAP Review Panel held its planned second public meeting to reach closure on September 24 -26, 2002 in which the first public draft report, dated August 29, 2002 was shared with all parties and on which public comments were solicited on the August 29, 2002 public draft report. Following receipt of Panel and public comments, a revised working draft dated was prepared and the Panel convened a technical editing (non-FACA) work session on to complete the edits. Following work session, the edits were incorporated into a second public draft report dated December 18, 2002. This draft was provided to the SAB's Executive Committee and the MARLAP Review Panel, and was posted on the SAB web site (www.epa.gov/sab under "draft reports") for access by the public (including the Agency). A public closure meeting was held on January 14-15, 2003 in which the SAB's Executive Committee and the public was given an opportunity for closure comments. At the January 14-15, 2002 SAB Executive Committee meeting the public was invited to comment by the Chair of the SAB Executive Committee. The Chair of the MARLAP Review Panel conferred with the SAB Executive Committee discussants and completed the edits to this advisory, resulting in this final version being submitted to the Administrator.

NOTE: Throughout the process, the SAB has provided announcements in the Federal Register, as well as posting notices, agendas, and the publicly-available draft reports on the SAB web site (www.epa.gov/sab), along with related efforts to reach out to all potentially affected and interested parties. This also included a public conference call meeting prior to the April, 2002 face-to-face public meeting to discuss and negotiate the charge, determine if the review materials are adequate, and begin the pre-meeting review and writing process. The MARLAP Work Group also provided a URL site for the MARLAP Manual and received extensive public comments as well as comments from all the Agencies, departments and commissions involved, including review materials, appendices, background briefings and related materials.

APPENDIX - B - ACRONYMS AND ABBREVIATIONS

[**NOTE**: Bracketed references following each definition represent the location in which the acronym first appears.]

"	probability of making a Type I error, i.e., false positive [Appendix C]
"	alpha particle (type of radiation) [Table 2]
$	probability of making a Type II error, i.e., false negative [Appendix C]
$	beta particle (type of radiation) [Table 2]
F	total standard deviation [Appendix C]
F_s	standard deviation of the sampled population [Appendix C]
:m	micrometer [Section 4]
ACE	U.S. Army Corps of Engineers [Appendix C]
ADC	analog to digital converter [Section 3]
AEA	Atomic Energy Act [Appendix C]
AEC	Atomic Energy Commission (U.S.)
AL	action level [Section 3]
Am	americium, as an element or one of its isotopes (e.g., ^{241}Am) [Appendix C]
ANSI	American National Standards Institute [Appendix C]
AOAC	Association of Official Analytical Chemists [Appendix C]
APHA	American Public Health Association [Section 6]
APS	analytical protocol specifications [Section 3]
ASL	analytical support laboratory [Section 3]
ASTM	American Society for Testing and Materials [Section 6]
AQCS	Analytical Quality Control Services [Section 4]
ATD	alpha track detector [Section 3]
Ba	barium, as an element [Appendix C]
Be	beryllium, as an element or its isotopes (e.g., ^{7}Be) [Appendix C]
BOA	basic ordering agreement [Section 3]
Bq	becquerel [Section 3]
c	counts [Appendix C]
C	celsius temperature scale [Appendix C]
CC	charcoal canisters [Section 3]
CD	compact disk [Appendix C]
CDF	cumulative distribution function [Appendix C]
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act [Table 3]
cfm	cubic feet per minute [Appendix C]
CFR	Code of Federal Regulations [Appendix C]
Ci	curie [Appendix C]
Cl	chlorine [Appendix C]
CL	central line (of a control chart) [Section 3]
CLIA	Clinical Lab Improvement Act [Appendix C]

cm	centimeter [Section 4]
COC	chain of custody [Section 3]
COR	contracting officer's representative [Section 3]
cps	counts per second [Appendix C]
Cr	chromium, as an element [Appendix C]
Cs	cesium, as an element or its isotopes (e.g., ^{137}Cs)
d	disintegrations [Appendix C]
DC	direct current [Appendix C]
DCGL	derived concentration guideline level [Section 4]
DFO	Designated Federal Official [Appendix A]
DL	discrimination limit [Section 3]
DoD	U.S. Department of Defense [Section 1]
DOE	U.S. Department of Energy [Section 1]
DOT	U.S. Department of Transportation [Section 3]
dps	disintegrations per second [Appendix C]
DQA	data quality assessment [Table 3]
DQO	data quality objective [Section 3]
EDD	electronic data deliverable [Section 3]
EML	Environmental Measurements Laboratory (DOE) [Section 6]
EPA	U.S. Environmental Protection Agency [Section 1]
Eu	europium, as an element or one of its isotopes (e.g., ^{155}Eu) [Appendix C]
F	fluorine, as an element [Appendix C]
FACA	Federal Advisory Committee Act [Appendix A]
FDA	U.S. Food and Drug Administration [Section 1]
FWHM	full width of a peak at half maximum [Appendix C]
g	gram [Section 4]
Ge	germanium, as an element [Appendix C]
GEDD	general electronic data deliverable [Appendix C]
GM	Geiger-Mueller detector [Appendix C]
GUM	*Guide to the Expression of Uncertainty in Measurement* (ISO, 1995) [Appendix C]
HASL	Health and Safety Laboratory (renamed the Environmental Measurements Laboratory [EML]) [Appendix C]
H	hydrogen, as an element or one of its isotopes (e.g., ^{3}H) [Appendix C]
HPGe	high-purity germanium (semi-conductor) [Appendix C]
I	iodine, as an element or its isotope (e.g., ^{129}I) [Appendix C]
IAEA	International Atomic Energy Agency [Section 4]
IEC	International Electrotechnical Commission [Appendix C]
ISO	International Organization for Standardization [Appendix C]
IUPAC	International Union of Pure and Applied Chemistry [Appendix C]
K	potassium, as an element [Appendix C]
LET	linear energy transfer [References]
ln	natural logarithm [Section 5]

m	meter [Appendix C]
M	metal ion [Appendix C]
M	molar concentration [Appendix C]
mm	millimeter [Section 4]
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols (Manual) [Section 1]
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual [Section 1]
MCA	multichannel analyzer [Appendix C]
MDC	minimum detectable concentration [Section 4]
Mg	magnesium, as an element [Appendix C]
MQC	minimum quantifiable concentration [Appendix C]
MQO	measurement quality objective [Section 3]
MR	moving range [Appendix C]
n	neutron [Appendix C]
NaI(Tl)	Sodium Iodide (Thallium) (crystal photon detector) [Appendix C]
NAREL	National Air and Radiation Environmental Laboratory (U.S. EPA)
NBS	National Bureau of Standards (renamed NIST) [Appendix C]
NCRP	National Council on Radiation Protection and Measurements [Appendix C]
nd	nondedect [Section 5]
NELAC	National Environmental Laboratory Accreditation Conference [Section 6]
NIM	Nuclear Instrument Module [Section 3]
NIST	National Institute of Standards and Technology [Section 1]
Np	neptunium, as an element or its isotope (e.g., ^{237}Np) [Appendix C]
NRC	U.S. Nuclear Regulatory Commission [Section 1]
O	oxygen, as an element [Appendix C]
ORIA	Office of Radiation and Indoor Air (U.S. EPA) [Section 1]
OSL	optically stimulated luminescence [Appendix C]
p	used variously in MARLAP to indicate parameter, percentile, probability [Appendix C]
PDF	probability density function [Appendix C]
pH	negative log of hydrogen ion concentration [Appendix C]
P_1, P_2	photopeaks [Appendix C]
PMT	photomultiplier tube [Appendix C]
PTFE	polytetrafluoroethylene (i.e., Teflon) [Appendix C]
Pu	plutonium, as an element or as an isotope (e.g., ^{238}Pu, ^{239}Pu, ^{240}Pu) [Appendix C]
QA	quality assurance [Section 3]
QAPP	quality assurance project plan [Table 3]
QC	quality control [Section 3]
Ra	radium, as an element or its isotopes (^{226}Ra, ^{228}Ra) [Section 6]
RAC	Radiation Advisory Committee of the EPA Science Advisory Board [Section 1]
RCRA	Resource Conservation and Recovery Act [Table 3]
Rn	radon, as an element and its isotopes (^{220}Rn, ^{222}Rn) [Appendix C]
ROI	region of interest [Appendix C]
s	second (time) [Appendix C]

S	sulfur, as an element [Appendix C]
S_1	specific activity of material added to a sample for an isotope dilution analysis [Appendix C]
S_2	specific activity of material measured in a sample using isotope dilution analysis [Appendix C]
SAB	Science Advisory Board (U.S. EPA) [Section 2]
SCBA	Self-Contained Breathing Apparatus [Section 4]
SI	International System of Units [Appendix C]
SNAP	Systems for Nuclear Auxiliary Power [Appendix C]
SOW	Statement of Work [Section 3]
Sr	strontium, as an element or its isotopes (^{88}Sr, ^{89}Sr, ^{90}Sr) [Appendix C]
Tc	technetium as an element or one of its isotopes (e.g., ^{99}Tc) [Appendix C]
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material [Appendix C]
Th	thorium, as an element or its isotopes (e.g., ^{229}Th, ^{230}Th, ^{232}Th) [Appendix C]
TLD	thermoluminescent detector [Appendix C]
Type A	method of evaluation of uncertainty by the statistical analysis of a series of observations (ISO, 1995) [Section 5]
Type B	method of evaluation of uncertainty by means other than the statistical analysis of a series of observations (ISO, 1995), e.g., based on expert judgment [Section 5]
Type I	decision error that occurs when the null hypothesis is rejected when it is true. The probability of making a Type I decision error is called alpha (α). [Appendix C]
Type II	decision error that occurs when the null hypothesis is accepted when it is false. The probability of making a Type II decision error is called beta (β). [Appendix C]
u	standard uncertainty, also known as "one-sigma" uncertainty and expressed as a standard deviation [Appendix C]
U	Uranium, as an element or its isotopes (e.g., ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{238}U) [Appendix C]
UBGR	upper bound of the gray region [Appendix C]
URL	uniform resource locator (protocol for specifying a unique address of a file on a specific computer accessible by other computers) [Appendix A]
US	United States [MARLAP Roster and Executive Summary]
USGS	U.S. Geological Survey [Section 1]
x_C	critical value [Appendix C]
x_D	minimum detectable value [Appendix C]

APPENDIX C - TECHNICAL REVIEW COMMENTS

This master list of comments is intended to be limited to technical comments and some major editorial comments. Editorial comments are compiled in Appendix D. Comments compiled in this appendix are not consensus comments. They represent the opinions of individual members of the Review Panel and should not be construed as formal comments of the RAC or the SAB.

Some of the comments in this appendix have also been included in the main body of this report. In this case, they can be considered to represent the consensus of the Panel members and formal comments of the RAC and the SAB. The following criteria were used to identify these comments:

a) Does the comment relate to organization of a chapter or the MARLAP as a whole?

b) Does the comment relate to the credibility of the MARLAP or its usefulness to the user?

c) Does the author of the comment feel strongly that it belongs in the body of the report?

Review comments are listed in order of the chapter to which they pertain.

APPENDIX C—TECHNICAL REVIEW COMMENTS

Row	Section	Page	Line	Technical Review Comment
C1	Abstract	III		The abstract should summarize the scope and main points in the Manual, and shorten or cut the extensive paragraph about the process (and participants) who created it. The multiagency aspect is, of course, significant but more appropriate in an Executive Summary. It also already appears in two other places in the front matter (Notice, Acknowledgments).
C2	1.1	1-1	6	The document states that failing to remediate a radioactively contaminated site could be costly in many ways. It should also note that going too far in the remediation process is costly as well.
C3	1.1	1-1	12-14	"MARLAP provides guidance in the planning, implementation and assessment phases for those projects that require the laboratory analysis of radionuclides." This is but the first time that this sentence appears in Chapter 1; altogether it appears 6 times, which is a few times too often. Although appropriate here, some of the other occurrences should be deleted.
C4	1.1	1-1	17	Is this Volume I, as indicated on the cover, or Part I, as listed here? Personally, I vote for Volume instead of Part, particularly since Chapter 15 also has a Part I and II.
C5	1.1	1-1	24	Decide whether this should refer to Volume II, as indicated on its cover, or Part II, as listed here.
C6	1.1	1-1	29-31	Replace lines 29-31 with the following text: "…analytical procedures but rather is intended to provide information on many of the options available for analytical measurements, and …"
C7	1.2	1-2	40-56	This paragraph is about twice as long as it should be. All of its concepts are stated twice, with excessive overlap in the wording of consecutive sentences. And then the same concepts are echoed yet again in the bullets on lines 58-68.
C8	1.2	1-2	51-52	Repeat of the sentence from the previous page (lines 12-14). It could be deleted without any loss of information.
C9	1.2	1-2	52-56	All of these final sentences in this paragraph should probably be deleted for being repetitious of the first part of the paragraph.
C10	1.2	1-3	69-71	Very similar to sentences on the previous two pages (lines 12-14, 40-42 and 51-52), as well as its wording being echoed in lines 73-79. It could be deleted without any loss of information.
C11	1.3	1-3	91	It would be useful here to expand upon the relationship between MARLAP and MARSSIM, their areas of overlap as well as their differences in scope and coverage. A table might be the best way to show this comparison and linkage.
C12	1.3	1-4	103-104	Very similar to sentences on the previous three pages (lines 12-14, 40-42, 51-52, 69-71).
C13	1.3	1-4	106-108	It would be appropriate to mention here that MARSSIM does provide guidance on these issues (or make this clear in the proposed table mentioned in the comment for line 99).
C14	1.4	1-4	111	I think it would be better to move section 1.5 to precede section 1.4. Otherwise, one wades through 10 pages of discussion on terminology before finally seeing how all the pieces are supposed to fit together. A figure showing "the big picture" should also be introduced at this point. Possible contenders are Figures 1.1 or 1.3 in MARLAP, Figure D-2 from MARSSIM, or something similar to Figure 1 in the Panel's review report.
C15	1.4.1	1-4	123	Insert a new introductory sentence that clarifies the connection between MARLAP and the data life cycle, e.g., "MARLAP implements the data life cycle approach for the specific case of radionuclide data."
C16	1.3	1-4	99	It would be useful here to be more explicit about what MARLAP does and does not cover, similar to Table 1.1 in MARSSIM as an example and perhaps combined with the table suggested in the comment for line 91.
C17	1.4.1	1-5	133-135	Delete the last sentence; it is unnecessary for this discussion of the data life cycle and repetitive of numerous other occurrences of this wording in this chapter.
C18	1.4.1	1-5	136-155	This paragraph is about twice as long as it should be due to excessive and distracting overlap in the wording of consecutive sentences.
C19	1.4.1	1-5	Fig 1.1	Figure 1.1 is misleading because it implies a linear process; in reality, the data life cycle process has numerous feedback

Row	Section	Page	Line	Technical Review Comment
				loops.
C20	1.4.2	1-6	161	Delete unnecessary verbiage: "While MARLAP recommends and promotes the use of a directed planning process," This wording is a distracting echo of that used just 4 lines earlier (line 157)
C21	1.4.3	1-6	168-179	All of the ideas in this first paragraph are repeated in the second one. This first paragraph should be altogether deleted.
C22	1.4.3	1-6	173-175	Very similar to sentences on the previous 5 pages (lines 12-14, 40-42, 51-52, 69-71, 103-104)
C23	1.4.3	1-6	187-188	Delete the sentence, "MARLAP provides guidance in all three of these areas." Throughout section 1.4, the focus should be on discussing the title concept in each subsection, and that discussion should not be diluted with side comments about MARLAP.
C24	1.4.4	1-7	198-201	This phrase states that "*MARLAP does not provide general guidance on the sampling process, except for brief discussions of certain activities that affect the analytical process...*" However in later chapters, there are recommendations on sampling, e.g., the recommendation to sample milk from downwind cows in section 10.3.4.1.
C25	1.4.4	1-7	Fig 1.2	Fig 1.2 is identical to Fig 3.1 on page 3-3 and very similar to Fig 6.1 on page 6-3. Personally I like Fig 6.1 best (although I may be biased by its larger font size) because it illustrates the distinction between the analytical "process" and "method".
C26	1.4.4	1-7	Fig 1.2	Figures 1.2 and 1.3 are static and linear; these should have feedback loops to more clearly convey the sense of the process of continual reassessing and fine-tuning the objectives and approaches.
C27	1.4.6	1-8	248	Many analytical methods do not require "*...sample digestion…*" as implied here. When speaking generally of the analytical method, it would be more inclusive to refer to *sample preparation and counting.*
C28	1.4.4	1-8	229-232	This paragraph could probably be deleted.
C29	1.4.5	1-8	241-243	Replace this sentence with the shortened one: "A number of alternative protocols might be appropriate for a particular process." This is true regardless of whether or not a performance-based approach is being used.
C30	1.4.5	1-8	243-245	Delete the last sentence. It is unnecessary in this discussion on the concept of an analytical protocol.
C31	1.4.6	1-8	249-251	Delete the second and third sentences of this paragraph, along with the first word ("However") of the fourth sentence.
C32	1.4.6	1-8	255-257	Delete the last sentence of this paragraph.
C33	1.4.7	1-9	276	Suggest *expanded uncertainty*
C34	1.4.7	1-9	279-289	Here and elsewhere in the document, the word "uncertainty" is used to describe the inability of any procedure to measure some true value exactly. Sometimes, however, a decision depends on the variability of true values for a parameter, as with variable soil concentrations over a contaminated site. In that case, the important uncertainty may be about the true value of, say, the mean, and depends on the sampling strategy as well as the analytic procedure. From reading the whole Manual, I am sure the MARLAP team is well aware of the distinction between uncertainty and variability--and that variability in one parameter can lead to uncertainty about another. But perhaps it should reveal that understanding fairly early in the document, perhaps by directing the reader to a detailed discussion later, e.g., in Chapter 19.
C35	1.4.8	1-10	311	The statement that "bias . . . does not vary" seems to me not quite right. If you find out that the butcher has his thumb on the scale, that would be bias, but the amount of the overage would not necessarily be the same from package to package.
C36	1.4.9	1-11	356	I don't understand the distinction between "total uncertainty" (line 356) and "expanded uncertainty" (line 276). Are these synonymous?
C37	1.4.9	1-12	376-383	In this paragraph, the same basic concept is repeated three times, reworded each time for a different emphasis or level of detail. This repetitiveness is distracting to the reader.
C38	1.4.10	1-13	403-408	Could probably delete this paragraph because the focus is on the MARLAP process, not defining the concept of APSs.
C39	1.5	1-14	444-475	It would make sense to move this section to precede Section 1.4.
C40	1.6	1-15	477-493	Summarize the first two paragraphs in just a couple sentences with minimal detail. More detailed information should only appear in the subsections.

Row	Section	Page	Line	Technical Review Comment
C41	1.6	1-15	477-497	Delete these three paragraphs; it's all covered (or should be) in subsections 1.6.1 and 1.6.2
C42	1.6	1-15	477-576	Section 1.6 needs a thorough edit to reduce its repetitious nature by streamlining the descriptions of Parts 1 and II, and using a consistent format and level of detail for the 3 subsections. Specific suggestions are made in separate comments.
C43	1.6	1-15	494-497	I suggest deleting this paragraph and follow through by setting a goal of minimizing the extent to which information is repeated in detail throughout MARLAP.
C44	1.6	1-16	Fig 1.3	I like this figure as a roadmap to the chapters in Part I. However, it should also show key feedback loops
C45	1.6	1-16	Fig 1.3	The use of acronyms in Fig 1.3 is somewhat inconsistent. For example, in the top box, APSs is spelled out but MQOs is not. In the box for Chapter 5, shouldn't the acronym in parentheses be APSs instead of MQO?
C46	1.6.1	1-17	499	It's a minor point, but I think Chapter 1 should be considered to be part of Part I (or is it Volume I?).
C47	1.6.1	1-17	499-527	A more user-friendly format would be a short introductory paragraph, followed by bullets for each chapter, similar to the format used for Appendices A-C on lines 580-587 in section 1.6.3. Figure 1.3 should be cited early in this subsection. Otherwise, the second paragraph should be largely dropped, particularly lines 523-527; this subsection is not the place to be discussing details of MARLAP.
C48	1.6.2	1-17	529-576	Edit to make this a more user-friendly presentation with minimal repetition of information (no need to state three times that Part II does not contain step-by-step instructions!). I suggest starting the section with a succinct introductory paragraph and using bullets to describe (in a sentence or two) the contents of each chapter in Part II.
C49	2.1	2-1	26	Provide a more specific cross-reference here (Section 1.4.9 instead of to just Chapter 1).
C50	2.1	2-1	3-12	This first paragraph should be briefer and allow lines 14-25 to expand on the objectives. Suggested edit: Keep lines 3-5, delete lines 6-9, and keep the italicized text in lines 9-12.
C51	2.1	2-1	all	I like the overall format of this introductory section: a) a brief introductory paragraph that identifies the topic of the chapter and how it fits into the MARLAP process, b) an explicit but brief list of chapter objectives, c) comments about terminology used in the chapter, and d) a succinct overview of the chapter sections, with high-level cross-references if appropriate.
C52	2.5	all		I think that the discussion of the DQO process would be much clearer to the reader if Appendix B (sections B1 to B3.9) were incorporated in its entirety into chapter 2. As it now stands, neither Appendix B nor Chapter 2 give the total picture, and the different numbering of steps in these two parts of the Manual adds to the confusion. In many cases, the text in Appendix B tends to explain the process better than does Chapter 2. Specific suggestions for merging the two are provided as separate comments (see comments for sections 2.5.1, 2.5.2, 2.5.2.3. 2.5.2.4, 2.5.3, and 2.5.4). If there is some pressing reason that the two cannot be merged, then at a minimum there should be cross-references to appropriate sections of Appendix B sprinkled throughout Chapter 2 in order to tie the two together. Attachment B-1 to Appendix B also provides information that is important for understanding the underpinnings of a performance-based laboratory process; it may not need to be elevated to Chapter 3 status, but technically oriented readers should be encouraged to read it.
C53	2.1	2-2	42-48	This last paragraph seems out of place for a chapter introduction. It should be deleted or moved to merge with the introductory paragraph for section 2.3.3.
C54	2.1	2-2	44-45	I suggest deleting the name of the referenced section and the chapter in which it occurs. The section number alone is adequate. This should be a global change throughout the document (i.e., citing no more than the chapter or section number for a cross-reference).
C55	2.2	2-2	49-92	Nicely written section, just the right level of detail, good pacing, effective mix of presentation styles (short paragraphs, bulleted lists, boxed example)
C56	2.2	2-3	71	"licensees" seems to imply that the party with the financial liability would always be a licensed entity, which is probably not the case in a lot of cases. Suggest broadening term to include "responsible parties" and other words to include those

Row	Section	Page	Line	Technical Review Comment
				non-governmental organizations with a financial interest.
C57	2.2	2-3	78-79	The concept expressed in this first sentence should be included in the list of recommendations at the end of the chapter, e.g. "MARLAP recommends the collection of only those data needed to address the appropriate questions and support defensible decisions."
C58	2.3.1	2-4	104-105	The concept expressed in this first sentence should be included in the list of recommendations at the end of the chapter, e.g. "MARLAP recommends a graded approach in which the sophistication, the level of QC and oversight, and the resources applied be appropriate to the project."
C59	2.3.3	2-6	160	What is meant by the phrase, "the concern that requires streamlining"?
C60	2.3.3	2-6	173-176	The concept expressed in this first sentence should be included in the list of recommendations at the end of the chapter, e.g. "MARLAP recommends the planning team strive for consensus among the stakeholders on the project planning elements."
C61	2.4	2-7	194-195	The concept expressed in this second sentence should be included in the list of recommendations at the end of the chapter, e.g. "MARLAP recommends that the planning team consist of all of the parties who have a vested interest in, or who can influence, the outcome (stakeholders)."
C62	2.4.1	2-7	205	Shouldn't the planning team also include representatives of the parties paying for the analyses and potentially for remedial actions afterwards?
C63	2.4.1	2-7	204	At some place in this section, possibly even in the introductory sentence, mention that the graded approach applies to the team representation too, that the team might consist of just a couple people, extending up to a dozen or so, depending upon the magnitude of the problem and the complexity of the issues.
C64	2.4.1	2-8	194, 199	The concept expressed in this sentence should be included in the list of recommendations at the end of the chapter, e.g. "MARLAP recommends that the planning team include operational and technical experts, including a radionanalytical specialist."
C65	2.4.2	2-8	234	At some place in this section, mention that the role of the "radioanalytical specialist" need not be filled by a single person with a specific title but rather may be jointly covered by the expertise and experience of the other team members, e.g., an industrial hygienist, lab personnel, scientist, project manager.
C66	2.5	2-9	253-542	The process of developing DQOs as specific statements seems to fall through the cracks in that this task never gets discussed explicitly, but just implicitly. It would help a lot to have some DQO examples, similar to the example of a decision rule given in section 2.5.3 on page 2-15.
C67	2.5	2-10	284-289	The concept expressed in these sentences should be included in the list of recommendations at the end of the chapter, e.g. "MARLAP recommends that the planning team ensure that it conducts the planning process in an iterative, rather than stepwise, fashion, with the objectives of more precisely defining the decisions and data needs as the planning progresses, and using new information to modify or change earlier decisions until the team has determined the most resource-effective approach to the problem."
C68	2.5	2-10	Table 2.1	I really like this table's design and content as an effective summary of the planning process and the role of the radioanalytical specialist. Consider whether it might be appropriate to include in an Executive Summary.
C69	2.5	2-10	Table 2.1	Row 1, Column 1: replace "State the problem" with "Define the problem" in order to match the title of section 2.5.1
C70	2.5	2-10	Table 2.1	Use a consistent format for the column entries--in Row 1, Column 4, reword bullets, e.g., "Problem defined with specificity," and "Identification of the…"
C71	2.5	2-11	Table 2.1	Row 2a, Column 3, bullet 3, lines 2-3: Replace "Analytical Protocol Specifications" with "APSs"; the use of acronyms throughout this table is inconsistent (i.e., sometimes used, sometimes not)
C72	2.5	2-11	Table 2.1	Row 2b, Column 3, bullet 2: Is "alternate" the right word? Should it be "alternative," "additional", or "surrogate"?

Row	Section	Page	Line	Technical Review Comment
C73	2.5	2-11	Table 2.1	Row 2c, Column 4, bullet 2: the meaning of "scale" here is not clear. How is the meaning of this bullet different from the one above it?
C74	2.5	2-11	Table 2.1	Row 3a, Column 1, bullet 3: The meaning of this bullet is not clear ("the scale of decision making"). Perhaps better to replace "scale" with "extent"?
C75	2.5	2-12	342-542	Although I have lots of questions and suggested changes to these subsections, nevertheless I find them to be useful and to add value beyond the information presented in Table 2.1. The text doesn't duplicate the table entries but the two discussions support one another. The main inconsistency is that individual items in the subsections are sometimes discussed under different elements than where they appear in Table 2.1, as pointed out in some of my specific comments on these subsections.
C76	2.5	2-12	Table 2.1	Need to indicate which element(s) result in DQOs as the output. As it is now, DQOs are not mentioned in this table until the last column of the last element, so that they appear to spring from nowhere.
C77	2.5.1	2-12		Merge Appendix section B3.1 with section 2.5.1
C78	2.5.2	2-13	364 ff, esp 376 ff	Perhaps it should be clearer that not all radiochemical analyses are undertaken with a specific decision in mind, let alone a unique action level that will drive the decision. MARLAP works better if there is, but it has much to contribute even if there isn't, as when some general characterization work is undertaken. This issue is briefly discussed on p. 7-24, lines 694 ff; a cross-reference could be added here.
C79	2.5.2	2-13	369	"operation" is somewhat confusing here as a phase of site closure. Perhaps replace it with "cleanup operation"
C80	2.5.2.1	2-13	375	Here, actions levels are discussed under "Identify the Decision." However, in Table 2.1, action levels are assigned to Row 2b, "Identify inputs to the decision," which is section 2.5.2.3 in the text.
C81	2.5.2	2-13		Merge Appendix section B3.2 with section 2.5.2
C82	2.5.2.1	2-14	392	The logic of this sentence is not quite clear as written because the information in the parentheses is not an example of reasons that the no action alternative is overlooked. Reword this line by inserting connecting words: "overlooked but may be the optimal course of action (e.g, no technology...)"
C83	2.5.2.2	2-14	401	Replace "Scale" with "Boundaries" to match entry in Row 2c of Table 2.1
C84	2.5.2.2	2-14	410-415	The topic of this paragraph and the level of detail in it seem inappropriate for this overview discussion. I suggest that it be deleted.
C85	2.5.2.3	2-15	416	Delete "and Boundaries" to match entry in Row 2b of Table 2.1. Note that 2.5.2.2 and 2.5.2.3 are reversed from the order in which these elements appear in Table 2.1
C86	2.5.2.3	2-15	416-423	The distinction between the discussions in sections 2.5.2.2 and 2.5.2.3 is blurry; these subsections overlap with one another.
C87	2.5.2.3	2-15	418	To give another common example of a statistical parameter, insert "95th percentile concentration" after "mean"
C88	2.5.2.3	2-15	419-422	Delete the first sentence ("Typically, the study boundaries…") because this topic was discussed in section 2.5.2.2. Move the second sentence ("Changing conditions…") to section 2.5.2.2.
C89	2.5.2.3	2-15	423	Discussion of the "appropriate action level" here blurs the distinction between the discussions in sections 2.5.2.1 and 2.5.2.3 because action level was discussed extensively in section 2.5.2.1.
C90	2.5.2.4	2-15	426	Explain why an estimate of the expected variability is needed. E.g., "because the uncertainty estimate is used to define the gray region and factors into the determination of decision error rates."
C91	2.5.3	2-15	438	Should a third item be added to the list of what is included in the decision rule? "(3) the decision that would be made, or the action that would be taken, based on the different possible outcomes of the analytical data."
C92	2.5.3	2-15	439	I very much appreciate the inclusion of an example at this point in the discussion, and suggest that a couple other examples of decision rules be given in this same box for other common situations, e.g., using drinking water standards and

Row	Section	Page	Line	Technical Review Comment
				waste disposal path determination.
C93	2.5.3	2-15	442	Is the word "technical" appropriate here, or should it be deleted? Same comment for its use in line 444. I don't understand its purpose in this context. Perhaps you mean "alternative measurement approaches or protocols", which is used on line 462?
C94	2.5.2.4	2-15		Create new section about a feedback loop at this point by moving Appendix Section B3.5 to chapter 2, either creating new 2.5.2.5 or renaming as new 2.5.3
C95	2.5.2.3	2-15		Merge Appendix section B3.3 and B3.4 with section 2.5.2.3 (or split 2.5.2.3 into two sections, 2.5.2.3 and new 2.5.2.4)
C96	2.5.3	2-15		Merge Appendix section B3.6 and B3.7 with section 2.5.3 (or split 2.5.3 into two sections)
C97	2.5.3	2-16	445	Insert after "radionuclide of interest": "with sufficient confidence at the action level"
C98	2.5.3	2-16	466-468	I don't understand the intent of the word "attempts" here. In fact, the first and last halves of this sentence don't make sense together. Is some text missing?
C99	2.5.4	2-17	474	Replace the last part of the sentence so that it reads "between the radioanalytical specialist and laboratory and field personnel."
C100	2.5.4	2-17	475-482	This would be a good place to point out that it may be more important and useful to obtain lots of data of only modest quality (e.g., ±30%) rather than few samples of very high quality (e.g., ±1%). For example, screening for hot spots, collecting reconnaissance data from an area about which little is known, collecting water samples for radon analyses under conditions for which where it is known or suspected that the sample may outgas highly, collecting data for a purpose for which a precise method not needed, and when field sampling uncertainties may overwhelm analytical uncertainties. (Same comment for 2:534-539, 3:107-121, 6:156-168, B:347-554, and C:140-146.)
C101	2.5.4	2-17	475	Is the "analysis design" the same as the "data collection design" on line 473? If so, then a single term should be used.
C102	2.5.4	2-17	483-498	The rest of section 2.5.4 does not follow an obvious logical progression, in terms of topics and level of discussion. The boundaries between the first two paragraphs (lines 483-498) and sections 2.5.4.1 and 2.5.4.2 are fuzzy. I suggest that the details discussed in these two paragraphs (e.g., starting with line 487) be moved into the subsections.
C103	2.5.4	2-17		Merge Appendix section B3.8 with section 2.5.4
C104	2.5.4.2	2-18	527	I don't understand what is meant by "collocated sample precision"
C105	2.5.4.2	2-18	534-539	Same comment as for section 2.5.4, lines 475-482. This is a good place to point out that it may be more important and useful to obtain lots of data of only modest quality (e.g., ±30%) rather than few samples of very high quality (e.g., ±1%). For example, screening for hot spots, collecting reconnaissance data from an area about which little is known, collecting water samples for radon analyses under conditions for which where it is known or suspected that the sample may outgas highly, collecting data for a purpose for which a precise method not needed, and when field sampling uncertainties may overwhelm analytical uncertainties.
C106	2.5.4.2	2-19	539	Should "decisions" be "criteria"?
C107	2.6.2	2-21	601	I recommend starting this paragraph with a simple definition of what chain of custody means.
C108	2.6.2	2-21	604-605	Delete this sentence about the data report; the contents of the data report are irrelevant to the discussion of the COC. Also, the phrase "not all of which can be listed here" is confusing and ambiguous because this paragraph doesn't list anything nor does it tell you whether this information is listed elsewhere in the manual or not at all in the Manual.
C109	2.6.2	2-21	605	The use of "component" here is confusing. Replace with "personnel"?
C110	2.7.1	2-21	624-627	The concept expressed in this sentence should be included in the list of recommendations at the end of the chapter, e.g. "MARLAP recommends the use of a formal change control process if updates of the original plans are found to be needed in response to new information on field conditions or other situations."
C111	2.7.1	2-22	636	The meaning of this bullet is not completely clear. Perhaps reword the last part: "for evaluating the usability of the data"?

Row	Section	Page	Line	Technical Review Comment
C112	2.7.2	2-22	658-659	The concept expressed in this sentence should be included in the list of recommendations at the end of the chapter, e.g. "MARLAP recommends that a Statement of Work be developed even if a contract is not involved, for example, when an agency employs one of its own laboratories."
C113	2.7.4	2-23	693	What does "it" refer to? Perhaps reword the second half of this sentence as: "while DQA considers the data set as a whole, including the sampling and analytical protocols used to produce them, during the assessment of data quality"
C114	2.7.4.1	2-24	704	Clarify parenthetical note by expanding it: "(as prescribed by the MQOs)"
C115	2.7.4.2	2-24	716	Reword last part: "…MQOs as the basis for assessing whether the obtained data…"
C116	End	2-25	728-733	This list of succinct recommendations is a great idea and should also mke it easier to develop an Executive Summary. Consider making this list a separate section and expanding it to be more inclusive of other key points in this chapter (as suggested in separate comments). Also I think it would be less distracting if the phrase "MARLAP recommends" were not used to introduce every recommendation, but instead was used as the introductory sentence to this compilation, e.g., "MARLAP recommends the following actions during the planning phase when a decision is to be based on the collection and evaluation of radiological data:"
C117	End	2-25	729	I suggest that this recommendation be expanded to contain a bit more information, e.g., "directed project planning process in order to provide logic and framework for defining the data needed to support an informed decision for the project."
C118	End	2-25	730-731	I suggest rewriting this recommendation to be more general: "MARLAP recommends that technical experts, and particularly radioanalytical specialists, be a part of a multi-disciplinary project planning team that includes other stakeholders as well."
C119	End	2-25	732-733	I suggest separating this recommendation into two: (1) "MARLAP recommends that the planning process rationale be documented in project plan documents." and (2) "MARLAP recommends that the outputs from the planning process be integrated with the analytical SOW and data assessment plans (e.g., for data validation, verification and quality assessment)."
C120	2.8	2-25	752	Couldn't get to the web site using this address. Replace "/filesfin.htm" with "/obtain.htm"
C121	2.8	2-26	765-766	I don't remember coming across a citation to this reference in this chapter, although I would have expected to see it cited in section 2.7.4.1
C122	2	All		Where can you find a radioanalytical specialist? I think that they are absolutely essential throughout planning, implementation, and assessment. But the skill set for a radioanalytical specialist is different than for the generic "radiation physicist" that we have in our job specs. I wonder if it would be useful for small licensees or small regulatory programs to have a job spec or a SOW to hire a radioanalytical specialist to help with writing the real SOW for the project, evaluation of bids, and assessment of the data.
C123	2.2	2-2		This section and others seem to suggest that radiological laboratory analytical data are only required to help solve problems or to conduct projects. The ongoing activities that utilize these data such as effluent monitoring and environmental surveillance activities at all of the major nuclear power, production and research sites should also be recognized as consumers of radiological laboratory analytical data .
C124	2.3.1	2-4	103-109	The limited number of references to a "graded approach" (e.g., p. 2-4, lines 103-109, Section 4.5.3, and the first recommendation on p. 4-18) do not provide guidance that is clear or complete about when to do what.
C125	3.1	3-1	20-23	Could make this paragraph more succinct with no loss of relevant information by the following changes. Replace lines 21-23 to read as follows: "this chapter provides a list of some common key analytical issues as well as a framework and broad base of information..."
C126	3.2	3-2	40	Replace "The analytical process as described in Chapter 1 includes all activities, starting with" with "The analytical process, as defined in Section 1.4.4 and illustrated in Figure 3.1, starts with"

Row	Section	Page	Line	Technical Review Comment
C127	3.3	3-2	57	Reword this reference:"discusses how some of these planning issues influence the method selection process"
C128	3.3.1	3-4	75	This section defines the target analyte list in terms of radionuclides. The statement should be broadened to include chemical contaminants as well since the planning issues are applicable to the whole spectrum of constituents of concern.
C129	3.3.1	3-4	73-74	Delete "that should be addressed…planning team"
C130	3.3.1	3-4	75	Insert a new sentence as a note? "(Note that the target analyte list may also include nonradioactive hazardous constituents, which could also influence the analytical protocols, including sample collection and waste disposal issues. However, although this issue would probably be dealt with by the same planning team, discussion of it is outside the scope of MARLAP.)"
C131	3.3.1	3-5	102 ff	This paragraph should note that under certain circumstances, a properly designed characterization survey can be used as the final status survey for areas found to be unimpacted or at contaminant concentration levels well below the DCGLs.
C132	3.3.1	3-5	102-106	Shorten the first three sentences to two sentences by re-ordering them. Start off with "A fourth source of information…study." The next sentence would then read, "This preliminary analysis may be necessary if there are little or no historical data..inadequate quality."
C133	3.3.1	3-5	107-121	Same comment as for section 2.5.4, lines 475-482. This is a good place to point out that it may be more important and useful to obtain lots of data of only modest quality (e.g., ±30%) rather than few samples of very high quality (e.g., ±1%). For example, screening for hot spots, collecting reconnaissance data from an area about which little is known, collecting water samples for radon analyses under conditions for which where it is known or suspected that the sample may outgas highly, collecting data for a purpose for which a precise method not needed, and when field sampling uncertainties may overwhelm analytical uncertainties.
C134	3.3.1	3-5	122	I appreciate the explicit description of the output from this discussion.
C135	3.3.2	3-6	132-133	It would be less distracting to the reader if the phrase "concentration range for each analyte" was shortened to "range", and if the phrase "fairly large concentration range for the radionuclide of concern" were shortened to "fairly large range". No ambiguity would result because the introductory sentence makes it clear what range is being discussed.
C136	3.3.2	3-6	135-136	The following would read more smoothly: "for the protocol selection process, thereby eliminating any analytical protocols that cannot accommodate this need."
C137	3.3.2	3-6	136-141	Write these sentences more succinctly as follows: "In addition, knowledge of the expected concentration ranges for all of the radionuclides of concern can be used to identify possible chemical or spectral interferences that might lead to the elimination of some of the alternative analytical protocols."
C138	3.3.3	3-6	147	Insert after "air particulates": "radioactive gases" [referring to radon, tritium, iodine]
C139	3.3.3	3-7	160-161	Shorten the last part of this sentence to read, "information on their chemical and physical characteristics and on possible hazards associated with them."
C140	3.3.4	3-7	165	Because there could be more than two radionuclides of concern, replace "Between" with "Among" in this section title. Consider replacing "Relationship" with "Correlation" here and throughout this section.
C141	3.3.4	3-7	166	Would "surrogate" or "indicator" be a more appropriate word than "alternative"? The term "surrogate" implies that the radionuclide to be measured is a substitute for the radionuclide of interest, although the measured radionuclide is not itself particularly of interest or concern. In contrast, the term "alternative" implies a choice among radionuclides of equal interest or concern.
C142	3.3.4	3-7	188-189	Same question as for line 166: Would "surrogate" or "indicator" be a more appropriate word than "alternative"?
C143	3.3.6	3-8	228	Provide cross-reference to sections 2.5 or 2.6 for discussing DQOs as an output
C144	3.3.7	3-9	240	A paragraph defining the "gray region" here would be helpful for readers who are not familiar with MARSSIM (or have short memories). The single statement in this paragraph and the references to the appendices are not really sufficient to

Row	Section	Page	Line	Technical Review Comment
				allow the reader to understand the MQOs.
C145	3.3.7	3-9	243	Suggest inserting "relatively" before "high decision error rate". If the LBGR allows a 5% type II error, is 6% really "high"?
C146	3.3.7	3-11	291-294	Delete this paragraph.
C147	3.3.7.1	3-11	295-442	A lot of the same material is covered in section 6.5.5, but there are no cross-references between the two to link them together. Rather than treating the topic in full in both sections, the verbiage and overlap should be minimized by one of three approaches: (1) merge Sections 3.3.7.1 and 6.5.5 together in one chapter, (2) provide the bulk of the discussion in one chapter, with a highly summarized version in the other, with cross-references to the fuller discussion, or (3) establish a clear distinction between the scope and audience of each section, winnow out the parts that are not relevent for the particular chapter, and insert cross-references into both versions where appropriate.
C148	3.3.7.1	3-12	328	Following the symbol del, insert "and is a function of the action level, background level, and adopted decision error rates"
C149	3.3.7.1	3-12	328	Replace reference to "Appendix B" with "Appendix Attachment B-1"
C150	3.3.7.1	3-13	374	Footnote 1: what does it mean in English? Provide a cross-reference.
C151	3.3.7.1	3-13	Footnote	Footnote 1: Don't think beta has been defined near this point.
C152	3.3.7.1	3-14	385	How near to zero should the LBGR be? Suggest you delete "or near" unless you define "near".
C153	3.3.7.1	3-14	395-396	Delete "this method performance characteristic..important method parameter. And last…"
C154	3.3.7.1	3-14	399-402	These two sentences are so similar in wording that it takes a couple readings to note the differences. I suggest making the distinction more clear by rewording it as follows: "MQOs for each analyte: (a) expressed as MQCs if the lower bound of the gray region is at or near zero and decisions are to be made about a sample population; and (b) expressed as MDCs if the lower bound of the gray region is zero, and decisions are to be made about individual items or samples." Note the reworded version is also stated as an item, not in sentence form, to match the format of the other output statements in this section.
C155	3.3.7.1	3-15	421-425	This sentence would read more smoothly by rewording it: "The importance of this characteristic is evaluated by the radioanalytical specialist, based upon information about the expected concentration range of the analytes of concern as well as other chemical constituents that may be present and the chemical and physical characteristics of the matrices (sections 3.3.2 and 3.3.3)."
C156	3.3.7.1	3-15	434-438	This sentence would read more smoothly by rewording it: "The importance of this characteristic is evaluated by the radioanalytical specialist, based upon detailed information about the chemical and physical characteristics of the sample. If important, then an MQO should be developed for it, and may require performance data demonstrating..."
C157	3.3.7.3	3-16	460	Does this mean that a result of 0.02 +/- 0.02 would be rejected as not meeting the MQO, even though it is below the action level with a high degree of certainty?
C158	3.3.7.3	3-16	466	I don't think that "coverage factor" has been defined yet at this point, at least not in chapter 3. Provide cross-reference.
C159	3.3.7.3	3-17	476	The example did not make sense to me. It's confusing and needs to be reviewed to make sure it accurately states the problem and the answer.
C160	3.3.7.3	3-17	487	I think 1.50 Bq/g is a typo, and that it should be "0.150 Bq/g" to agree with line 479
C161	3.3.8	3-17	496	Can you give an example of how the specification of analyses to be performed could limit the analysis options for the lab, if this constraint does not mean that a specific protocol or method has to be used? If I am understanding correctly, an example would be the following: "The analyte of concern is total uranium, but the team decides that a gross alpha measurement would be an acceptable alternate analysis and therefore specifies that analysis." But the text on lines 498-501 seems to say this example is not right either. So I'm lost here.
C162	3.3.8	3-18	501-504	Shorten this discussion after "239Pu in soil, etc." by replacing it with the following: "The project planning team may

Row	Section	Page	Line	Technical Review Comment
				decide to eliminate some analyses from consideration based on information obtained, such as the absence of…"
C163	3.3.8	3-18	508	Should "analyses" be replaced by "methods" here? If not, then I'm still lost as to the distinction between these two terms.
C164	3.3.8.1	3-18	523-557	Delete sections 3.3.8.1 to 3.3.8.3, and direct the reader back to 3.3.1 (lines 111-121) and/or to appropriate sections of Part II.
C165	3.3.9	3-19	560	Replace "determined" with "specified" and insert adjective "along with the associated sample matrices"
C166	3.3.9	3-20	568	Insert new beginning to this sentence, as follow: "Assuming that a method is not prescribed by the applicable regulations, then there are a number of sources…."
C167	3.4	3-22	646-653	Replace these 8 lines with the following: "…types of projects, as summarized in Table 3.1." Everything else is either extraneous, repetitious, self-evident from the table, or duplicates text in the subsections.
C168	3.4	3-23	667-668	Replace beginning of sentence: "Some solid samples may require preservation..to prevent sample degradation or loss of water and other volatiles." This is true for some soils and sediments as well as for biota.
C169	3.4	3-23	673-679	Delete these cross-references here, and put them in Table 3.1, Column 3. For example, list the first couple potential key issues in this column as: "Container type and material (Chapter 10); Sample preservation (Chapter 10)", etc.
C170	3.4	3-23	Table 3.1	Row for liquids, column 2. Replace last item with "Order in which sample is filtered and preserved"
C171	3.4.1.2	3-24	691 ff	See comment for page 10-30, line 950 ff, about removing vegetative matter from soil samples
C172	3.4.1.2	3-24	700-701	The sentence would read more smoothly as follows: "For soil samples, extraneous material to be removed, weighed, and then stored at the laboratory could include rocks of a certain sieve size, plant matter, debris, etc."
C173	3.4.2	3-25	708-719	Here is a place where another cross-reference could be added. The team talks later (I don't remember where) about the difference in filtration requirements between raw and finished water sampling.
C174	3.4.2	3-25	710	The relevance of section 3.3.3 is not obvious and perhaps this cross-reference should be dropped.
C175	3.4.3	3-26	743	Insert phrase in middle of sentence: "…dissolve, break, or tear during sample collection or processing, thus invalidating the sample."
C176	3.4.3	3-26	747-750	Pore size is not the only determinant of filter collection properties. Collection of very small particles occurs mostly by diffusion and particle sizes much smaller than the pore size will be collected with high efficiency on filters.
C177	3.5	3-27	769-771	The concept expressed in this sentence should be included in the list of recommendations at the end of the chapter, e.g. "MARLAP recommends that the level of specificity in the APSs be limited to those requirements that are considered essential to meeting the project's analytical data needs."
C178	3.5	3-28	807-810	Replace the four entries under "Type" with the following: "Method blank (Section 3.3.10), Duplicate (Section 3.3.10), Matrix spike (Section 3.3.10), and Laboratory control sample (Section 3.3.10)"
C179	3.5	3-28	813-821	Check all the cross-references under the column labelled "Special Requirements"
C180	3.5	3-29	831	Figure 3.3: Should the lab know what the action level is? Might they analyze or report differently depending on the value, instead of just following an approved procedure? Whatever the answer, it could be discussed nearby this Figure.
C181	3.7	3-30	864	Add to end of this line "and matrix combination"
C182	3.7	3-30	869-870	Reword this recommendation as follows: "MARLAP suggests that the MQO for the detection capability for a given analyte/matrix combination be expressed as a minimum detectable concentration (MDCs) if the lower bound of the gray region is zero and decisions are to be made about individual items or samples."
C183	3.7	3-30	871-872	Reword this recommendation as follows: "MARLAP suggests that the MQO for the detection capability for a given analyte/matrix combination be expressed as a minimum quantifiable concentration (MQC) if the lower bound of the gray region is at or near zero and decisions are to be made about a sample population."
C184	3.8	3-31	887	Couldn't get to the web site using this address. Replace "/filesfin.htm" with "/obtain.htm"
C185	3.3	All	122 ff	The clear inclusion of an “Output” statement at the end of the discussion of each Analytical Planning Issue is very helpful

Row	Section	Page	Line	Technical Review Comment
				in understanding the value (importance) of each item discussed (pp 3-2 to 3-22)
C186	3.4	3-23	Table 3.1	The text seems to be quite repetitive of the information given in Table 3.1 without giving any added value. The authors or technical editor should consider deleting one or the other.
C187	4.5.3, 4.6.1	4-11	306 ff	Table 4.2 seems to be in an awkward place in the text. In its current location, it is referred to in Section 4.5.3., which contains text relating to small projects. One must page over quite a bit to find the other, primary reference to this table in Section 4.6.1. Could the text before the table be revised to indicate that this table applies in some way to both small and large projects?
C188	4.5.1	4-7	193 ff	Table 4.1 needs a better caption to describe the purpose of the table more clearly. Perhaps it could read something like "Comparison of contents in different plan documents."
C189	5.3.5	5-4	134 ff	I wondered when QC samples should be blind to the analyst. Chapter 18 and Appendix C do discuss this issue to some extent, but maybe a specific cross-reference is needed here.
C190	5	All		On a practical problem, there is no guidance for "what do you do if no one bids on your project?" For small projects, it might not be very lucrative, so labs might not bid. What do you do?
C191	5.4.3.3	5-11	376-378	Timely reviews of the data packages is a very important point. This cannot be emphasized enough. Without feedback from this review process, the whole process could suffer because needed changes would not be identified in a timely or effective manner.
C192	5.3.3	5-3	110-111	The suggested statement “A method uncertainty of 0.5 Bq/g is required at the action level of 5.0 Bq/g” seems curious as written. Shouldn’t the emphasis be on keeping the uncertainty to less than or equal to 0.5 Bq/g? As written, it sounds like the uncertainty is required to equal a particular value.
C193	6.4	6-11	156-168	Same comment as for section 2.5.4, lines 475-482. This is a good place to point out that it may be more important and useful to obtain lots of data of only modest quality (e.g., ±30%) rather than few samples of very high quality (e.g., ±1%). For example, screening for hot spots, collecting reconnaissance data from an area about which little is known, collecting water samples for radon analyses under conditions for which where it is known or suspected that the sample may outgas highly, collecting data for a purpose for which a precise method not needed, and when field sampling uncertainties may overwhelm analytical uncertainties.
C194	6.4	6-11	159	How would one define the value of the "screening level"? I can't remember whether this issue is covered elsewhere.
C195	6.4	6-11	185	"Robustness" is used here, whereas "ruggedness" seems to be preferred elsewhere. If there is a difference, it should be explained. Also p. 6-14, line 257
C196	6.5.1	6-13	236 ff	This section seems to be addressed to the laboratory rather than to the project planners, which is unique. Probably not a key problem, but disconcerting to me.
C197	6.6.2	6-28	727 ff	Table 6.1: The basis for the numbers (e.g., "Three to five groups of two samples with concentrations within 20% of each other" or 3 concentrations levels with 7 replicates) was not clear to me. They are probably reasonable, but I'd like to know how they were established.
C198	7.1	7-1	25	The phrase “…final evaluation of the protocol’s performance…” should be re-written. The protocol doesn’t do anything. The laboratory uses the protocol in its performance.
C199	7.2.2.3	7-8	226	For biological samples, cooling or freezing may be a better method of preservation than adding biological preservatives, which is suggested here.
C200	7.4.1.1	7-24	704	Equation 7.3 is supposed to hold at the UBGR. Is this true even if the action level is not at the UBGR?
C201	8.2.2.3	8-4	124 ff	also raised the same question in my mind (cf comment for pg 5-4, line 134 ff, about when samples should be blind to the analyst)
C202	8.2.3	8-5	136-137	Regarding combination of the verification and validation steps, it is stated here that "*...they may be combined - with the*

Row	Section	Page	Line	Technical Review Comment
				verification activities constituting the bulk of the review." It is not clear why this should be the case; as described in section 8.5, validation does not appear to require significantly less effort than verification.
C203	8.2.3	8-6		Suggest that the data quality assessment portion of this flow chart (Figure 8.1) indicate that the verification and validation reports be reviewed as a part of data quality assessment phase.
C204	8.3	8-7	192 ff	This section is devoted to the validation plan. It invites the question as to whether or not there should be a verification plan and a section devoted to it.
C205	8.5	8-13	341 ff	I found the format used here, that spelled out verification and validation points very clearly, made the concepts easy to follow and understand.
C206	9.2	9-2	32 ff	How one selects the data verifiers, validators, and assessors should be discussed here. Can some of them come from the performing laboratory? From the sponsoring organization (e.g., EPA, DOE, NRC, or the Armed Forces)? From the financially responsible parties? From an outside organization contracted to do it? What qualifications are essential?
C207	9.6.4.1	9-24	645-651	Should call to Figure 18.1 as an example
C208	10.1.2	10-3	71	Suggest: "*Sample packaging, radiological surveys, shipping, and tracking; and…*"
C209	10.2.3.1	10-4	115-123	This section on containers should cross-reference section 10.3.3.1, which although titled "*Sample Acidification"* also discusses relationships among sample containers, analytes and preservation , e.g., lines 699 to 719 in chapter 10.
C210	10.2.4	10-6	173-176	"*The project manager needs to determine if a sample number scheme may introduce bias into the analysis process. That is, the lab may be aware of trends or locations from the sample identification and this could influence their judgment as to the anticipated result and thereby introduce actions on the part of lab personnel that they would not otherwise take.*" [This recommendation is short-sighted and implies that labs are not trustworthy. In particular, labs need to be aware of "hot" samples because they may use separate areas and or labware for processing. In fact in section 12.2.2, lines 146-148, it is suggested that knowledge of historical or field screening data is useful to labs in preventing cross-contamination. In section 12.2.4, lines 313-314 it is stated that: "*Operations should be segregated according to activity level. Separate equipment and facilities should be used for elevated and low-level samples whenever possible.*"]
C211	10.2.5	10-8	217-219	The time to date of analysis is usually captured in pre-established holding times, not left to the judgement of field sampling personnel who make the log or data form entries.
C212	10.2.7	10-9		We have found it useful to include a section on the chain of custody document indicating a radiation survey of the package, especially when no shipping manifest will be used (e.g., samples hand delivered to lab).
C213	10.2.11	10-13	369	Suggest adding the following sentence: "*In almost every case, field sampling personnel will be subject to State or Federal occupational safety regulations. A few of the hazards peculiar to field sampling are discussed in the following sections, but these should not be considered to be the basis of a comprehensive occupational health and safety program.*"
C214	10.2.11.1	10-13	378	add text: At a minimum, drilling rig workers should...
C215	10.2.11.1	10-13	382	Special safety precautions may also required when field personnel have to enter trenches to take samples.
C216	10.2.11.1	10-14	408	A paragraph on the hazards of ultraviolet radiation should be added along with the heat stress.
C217	10.2.11.2	10-15	461	Citation to "Department of Energy (1994)" should include a, b, c, or, d as there are four DOE (1984) references in the reference section.
C218	10.2.11.2	10-16	469	Film badges and TLDs are not the only personnel dosimeters available. The Luxel dosimeter from Landauer appears to be a good alternative. According to company's web site (http://www.landauerinc.com/prsr/products/luxelosl.htm), this dosimeter is based on optically stimulated luminescence (OSL) technology, in which the aluminum oxide detector can be restimulated numerous times to confirm the accuracy of a radiation dose. The minimal reporting level is as low as 1 mrem, with a precision of +/- 1 mrem.
C219	30.3.2.1	10-20	631	higher than what?

Row	Section	Page	Line	Technical Review Comment
C220	10.3.2.2	10-21	660-661	"*...radionuclides that are highly insoluble, such as isotopes of uranium, thorium, and plutonium...*" This is an invalid premise. Uranium is somewhat soluble and occurs dissolved in some groundwaters. Thorium and plutonium are better described as relatively immobile in the environment rather than insoluble, because thorium nitrate, for example, is certainly soluble.
C221	10.3.3.1	10-22		Somewhere in this section, or referenced from this section, it would be useful to have a table in which the known problems related to container and type of acid for the various radionuclides, matrices, and analytical methods are addressed. USGS documents usually indicate HCl rather nitric acid as a preservative for water. Is there a good reason for this? Another possibility would be to address these sampling concerns in section 14.10.9.
C222	10.3.3.2	10-24	766	The statement "*...paper pulp has been shown to remove more than 95 percent of radionuclides from solution...*" seems too general. Tritium, for example, would not likely be removed by paper pulp.
C223	10.3.4.1	10-26	825-826	What is a "...universal adapter and fill-line..."
C224	10.3.5	10-27	839	The following sentence is much too simplistic as guidance for selecting milk sampling sites: "*Raw milk should be obtained from the closest cows or goats downwind from a source.*" For example, background sites should also be selected, and processed milk may have to be collected to fully characterize the impact on the general public. Significant iodine releases are much more likely to result from accidental exposures, which may be short term, than from continuous routine releases. Relying on a single "downwind" sampling location could potentially result in underestimating the impact of an episodic event.
C225	10.3.4.1	10-27	841	Although mentioned in Table 10.1, adding formaldehyde to milk samples may require the samples, once analyzed, to be disposed of as chemical hazardous waste. This should be emphasized in the text as well as being mentioned in the table.
C226	10.3.4.1	10-27	844-847	The recommendation to add NaI to milk samples should be limited to those samples destined for analyses involving radiochemical separation of iodine. Most milk samples for iodine analyses are analyzed by simple gamma-ray spectroscopy of the milk.
C227	10.4	10-29		Sampling a soil profiles and sediment cores for measuring total inventory is an important technique and is not present. Remove soil at certain depths and do an integrated curve. And plot activity vs. depth (c.f., EML manual).
C228	10.4.1.1	10-30	950 ff	This section talks about the possible need to remove vegetative matter, rocks, and debris from soil samples before analysis. It could be clearer that the lab needs to document the weight and nature of the material removed, because the average concentration in that fraction could well be different, often lower, than in the fraction analyzed. Whether the measured concentration needs to be adjusted before comparison with an action level depends on the exposure scenario that led to the action level. For example, if exposure via soil ingestion is the dominant route, then the concentration in the fine fraction is appropriate and no adjustment is needed. If exposure via external gamma is dominant, then the DCGL would have been calculated assuming uniform distribution in soil, and use of the measured concentration in the fines would overestimate the risk; an adjustment is needed. This point is discussed a bit on page 15-71, but not enough, in my view. The same question arose when I read p. 3-24, line 691 ff.
C229	10.4.2.1	10-31	1001-ff	This section implies total reliance on models for description of initial mixing and transport dispersion of radionuclides discharged to water. The use of dye or other tracer studies for complex situations should be acknowledged.
C230	10.4.3.2	10-33	1066-1068	Use of inedible plants and non-game species as indicator organisms should be mentioned here.
C231	10.4.3.2	10-33	1073-1075	This guidance is not very useful. Most agricultural fields and gardens are fertilized, and, except for TENORM situations or gross measurements, laboratories have no difficulty distinguishing the radionuclides of concern from natural radionuclides.
C232	10.4.3.2	10-33		In selecting foods and locations for food sampling, there is often the temptation to limit consideration of consumption habits to those of European-descended populations. The consumption and lifestyle habits of native peoples and other

Row	Section	Page	Line	Technical Review Comment
				ethnic minorities can be quite different and should also be considered. It might be worthwhile to recommend this in MARLAP.
C233	10.4.3.2	10-34	1110-1113	Again, laboratories will have no difficulty distinguishing anthropogenic radionuclides from 40K or 7Be.
C234	10.4.3.2	10-35	1127-1128	Except perhaps for aesthetic reasons, why must stomach or rumen contents be collected within a brief period (two to four hours) after death?
C235	10.5.1	10-38	1221	In my experience, "reliable calibrated air flow measuring device" on air sampling stations is an oxymoron. An alternative which may be a little less accurate, but far more reliable, is to simply measure the flow after placing a new filter on the device and then just before it is removed, and averaging the results. This average flow rate is multiplied by the run time (sampler should be equipped with a simple run-time meter) to get the total flow through the filter. The same flow rate meter, which is taken from station to station and checked frequently for calibration, provides good station to station precision in airflow.
C236	10.5.3	10-39	1286	"...222Ra and 220Ra..." should be "...decay products of 222Rn and 220Rn..." Also radon decay products will always interfere with evaluation of both alpha and beta emitting radionuclides by gross particle counting unless time is allowed for them to decay or unless there are very large quantities of anthropogenic radionuclides on the filter.
C237	10.5.3	10-39	1287	A holdup time of several days, not just several hours, is required if Rn-220 decay products are of concern since Pb-212 has a half-life of 10.6 hours.
C238	10.5.2	10-39	1261-1278	Should Teflon (polytetrafluoroethylene, PTFE) fiber filters be cautioned against due to their high ashing temperatures and difficulty with digestion?
C239	10.5.3	10-39	1282-1283	Folding filters for storage makes it difficult to do gross alpha and beta measurements with a proportional counter.
C240	10.5.4.2	10-41		Noble gases in air have also been collected for laboratory analysis by compressing air into SCBA tanks, by collecting in impermeable plastic bladders (e.g., Tedlar) for later compression, or by cryogenic methods. Radon is not an issue if laboratory analysis is delayed sufficiently for decay.
C241	10.5.4.3	10-41		Electrets can also be used for tritium monitoring at sufficiently high levels. Electrets were discussed for radon so a mention in the tritium section may also be appropriate. (e.g., RA Surette et al "Evaluation of electret ion chambers for tritium measurements," Health Physics 65:418-421(1993)
C242	10.5.4.3	10-42	1377	Although mentioned earlier, molecular sieve is not identified here for collecting tritium. It is being used increasingly because of favorable properties such as less retained water following bakeout and better collection properties in environments of fluctuating temperatures.
C243	10.5.5	10-42	1382	The radon section should include a description of the methods for analysis of Rn-220 decay products and a paragraph on radon flux measurements.
C244	10.5.5	10-42	1382	It would be appropriate to note here that MARSSIM Section 6.9 provides extensive guidance on radon measurement methods and instrumentation.
C245	10.5.5.2	10-46		While not necessarily a bad thing, there is a disproportionate amount of space devoted to radon. It is all good information, but invites the question why are there not other sections like "Selecting H-3 sampling methods Based on Data Quality Objectives" (DQOs) or for any other radionuclide as well?
C246	10.6.2	10-50	1656-1658	It would be very useful to indicate or reference suitable combinations of liquid scintillation fluids (cocktails) and filters for the liquid scintillation method of wipe testing.
C247	10.7	10-53	1747	It should be noted that the reference: Department of Energy (DOE), EML Procedures Manual (HASL-300), Environmental Measurements Laboratory, is available on CD and on the internet <http://www.eml.doe.gov/publications/procman.cfm>. It is no longer distributed in paper copy. This reference should be checked in other chapters as well.
C248	10	10		Some Chapters have references cited vs bibliography. Make reference as complete as possible.

Row	Section	Page	Line	Technical Review Comment
C249	11.1	11-1	30	This statement in association with the references, which are limited to radiological guidance, suggests that radiological safety is the only kind of safety that needs to be considered.
C250	11.1	11-1	30	NRC 1998a is not listed in the references for this section.
C251	11.2.3	11-4	73-75	Page 11-4 (lines 73-75) states that laboratory facilities that handle radioactive materials are required to have a radioactive materials license issued by the NRC or the Agreement State in which the laboratory operates, with the exception of certain DOE national laboratories and DOD laboratories. However, it is important to make clear that the latter facilities themselves cannot handle unrestricted levels of radioactive materials. They operate under similar types of regulation-driven restrictions as other laboratories, that are administered internally.
C252	11.3.1	11-6	137	Page 11-6 seems to mandate a designated receiving location for all samples, and page 11-14 states that sample storage areas must be posted as radiation areas. For small projects or those limited to the analysis of very low levels of radioactivity, these apparent "mandates" may not be applicable or may even be counter-productive (e.g., by storing low-level samples together with high-level samples).
C253	11.3.2	11-8	207	Guidance on line 207 of page 11-8 is to treat contaminated packing material and packages as radioactive waste; not mentioned is the possibility that there may be non-radioactive hazardous contaminants that would require the contaminated material to be classified as mixed waste.
C254	11.3.2	11-8	183-186	This sentence, “An external exposure... ...working hours).” is redundant with a nearly identical sentence in the previous paragraph, lines 176-178.
C255	11.5.2	11-13	356-357	On these lines it is stated: "*This documentation should be compared to separate paperwork obtained before sample receipt.*" What is this separate paperwork and who provides it?
C256	11.5.3	11-14	376	Page 11-6 seems to mandate a designated receiving location for all samples, and page 11-14 states that sample storage areas must be posted as radiation areas. For small projects or those limited to the analysis of very low levels of radioactivity, these apparent "mandates" may not be applicable or may even be counter-productive (e.g., by storing low-level samples together with high-level samples).
C257	11	all		The relationships among various recommended documentation (*"Bench sheets," "laboratory logbook," "separate paperwork obtained before sample receipt," and "documents listing requests for specific analyses"*) need to be made clear. Model documents would seem to be useful.
C258	11	11		Address security issue? Might be important here as samples are open because of security and not put back in place. Samples by mail should not be irradiated.
C259	12.2.2.1	12-6	152ff	Tritium may also be a problem for cross-contamination if low level measurements are made in an environment where higher-level tritium sources are analyzed or in use.
C260	12.2.2.1	12-7	166-167	Suggest changing to read: "*The laboratory may have background levels of radon progeny from natural sources in soil or possibly in its construction materials.*"
C261	12.3.1.2	12-17	423	Shouldn't first word be "Adsorbed"?
C262	12.3.1.2	12-23	646	It is not clear why ashing at 400 to 500 C is recommended for iodine when losses are reported as low as 450 C (Table 12.3)
C263	12.3.1.3	12-25	685-716	This approach to weighing samples is certainly meticulous, but one wonders about its applicability to routine analysis of samples. If it is desired to retain this list, it would be useful to also provide an alternative, more practical, guide for weighing under less demanding circumstances.
C264	12.3.3.1	12-32	884	This subheading, “12.3.3.1 Biological Samples” is redundant with “12.3.3 Biota Samples”
C265	12.3.3.2	12-33	Table 12.4	Table 12.4 recommends "burning" as the method to ash fish, meat and flour samples. Although drying, charring and ashing are discussed at length in the text there is no discussion of burning as a sample preparation step. Also this table is

Row	Section	Page	Line	Technical Review Comment
				not cited from the text.
C266	12.5	12-34	973-974	Suggest changing to read: "Wipe samples may be digested prior to analysis, but more commonly are simply placed into a liquid scintillation vial with cocktail and counted or directly analyzed with appropriate detectors such as proportional or Geiger counters." As written, this section implies that digestion is commonly used for wipe samples and that liquid scintillation is the only method of counting. This section and section 10.6 should be checked for consistency.
C267	12.8	12-40	1139	In the section on bioassay samples, the MARLAP document should at least mention the Clinical Laboratory Improvement Act (CLIA) that requires a qualified laboratory director (generally and MD) for laboratories that perform clinical measurements. Some states have interpreted CLIA to include laboratories that analyze urine and fecal bioassay samples.
C268	12.9.1	12-46	1285-1286	A more complete and useful reference is: Department of Energy, "RESL Analytical Chemistry Branch Procedures Manual", IDO-12096, U.S. Department of Energy, Idaho Falls, Idaho (1982).
C269	12	11		Citations of references do not follow a standard style. In most cases the simple author, year method is used (e.g., line 76), in others the title is additionally given in the text (e.g., lines 233, 672-673, 1047-1048), or even the nationality and discipline of the author is provided (e.g., line 730). Sometimes a citation such as “HASL-300" is given without author or date (e.g., lines 900, 919, 1147), but is listed under “U.S. Department of Energy...” in the reference section. In this example, there are even two editions of HASL-300 listed in the references (lines 1303 and 1308) so it may be important to know which one is meant.
C270	13.1	13-1	19	insert "or mineral acids" between "with" and "water"
C271	13.1	13-1	28-30	change the order to: (1) wet ashing, acid dissolution; (2) microwave digestion; and (3) fusion methods
C272	13.1	13-2	37	insert "during sample pretreatment" after "explosions"
C273	13.1	13-2	48	add two more useful references: Sample Pretreatment and Separation by Anderson and Chapman (1987); Chemical Dissolution of Metal Oxides by Blesa, Morando and Regazzoni (1994)
C274	13.2	13-2	52	delete ", but usually the tracer is added to the sample"
C275	13.2.1	13-3	71	change "many" to "some"; change "is" to "could be"
C276	13.2.1	13-3	82	change "water" to "aqueous solutions"
C277	13.2.2	13-3	91	replace "fluxes" to "reagents"
C278	13.2.3	13-4	113	replace "all chemical species present" to "the analyte of interest"
C279	13.4.1	13-14	432 ff	Oxidation reduction potential is in all chemistry books and need not be in this Chapter. Put Table 13.3 in Appendix
C280	13.2.3	13-5	137	insert "fusion" before "fluxes"
C281	13.2.4	13-5	153	change "radionuclides" to "elements"
C282	13.2.5	13-6	158	insert "sometimes" before "required"; delete "and detection"
C283	13.2.5	13-6	171	change "issues" to "possible interactions"
C284	13.2.5	13-6	172	delete "during each step of the procedure"; redundant
C285	13.3	13-6	177	replace "small" with "an appropriate"
C286	13.2.5	13-6	166-169	delete the sentence that begins with "knowledge of the behavior …", it does not add anything to the discussion
C287	13.3	13-6	181-182	replace "wet ashing" with "acid treatment"
C288	13.3	13-7	190	add "to a small" between "ground" and "mesh"
C289	13.3	13-7	219	replace "fusions" with "During fusion, samples are heated …"
C290	13.3	13-7	188-189	delete "charring to remove organic material is not usually necessary because" and start the sentence on line 189 with "Samples with significant
C291	13.3	13-8	238	add "remove and" between "to" and "dissolve"
C292	13.3	13-8	251	replace "any" with "most"

Row	Section	Page	Line	Technical Review Comment
C293	13.3	13-9	258	Make sure that the statement about cleaning platinum crucibles in boiling HCl is correct. I think HCl can attack platinum?
C294	13.3	13-9	277	What is meant by "etc."?
C295	13.3	13-9	279	explain what is meant by "pyrosulfate fusions or reversible"
C296	13.3.3	13-13	391	replace "chromatography" with "extraction"
C297	13.3.3	13-13	392-394	other elements such as lead and polonium can also be volatilized during pyrosulfate fusion
C298	13.4.1	13-14	425 ff	Table 13.2: Can HCl alone dissolve cement?
C299	13.4.1	13-14	Table 13.3	Has the information been checked against the original reference for typing errors?
C300	13.4.1	13-17	554	insert "for use in sample treatment with HF" after "preferred"
C301	13.4.1	13-18	556	replace "boils at" with "is"; explain why "HF works most efficiently when used alone"
C302	13.4.1	13-18	561	replace "chemical reactions" with "separation methods"
C303	13.4.1	13-18	564	replace "wet ashing samples" with "sample dissolution"
C304	13.4.1	13-18	572	Can HCl dissolve cement?; insert "completely" for "not"
C305	13.4.1	13-18 & -19	582-591	The direct quote by "Sulcek and Povondra" is non-conforming with the text style
C306	13.4.1	13-19	595	delete "wet ashing" and insert "dissolution" after "samples"
C307	13.4.1	13-19	621	insert "concentrated" before "H2SO4"
C308	13.4.1	13-20	623	insert "separation" before "procedures"
C309	13.4.1	13-23	709-710	the sentence starting with "K2Cr2O7 is commonly mixed … ", is incomplete.
C310	13.6.1	13-26 & -27	831-853	this section is too general and incomplete. It is of questionable value to the reader.
C311	13.6	13-26	General	This section is not well-written and will require extensive editing. It is either too general or very specific with direct quotes from published papers. Some information is either incomplete or not useful. Also, the style is not consistent. This part should be deleted or presented differently. One way is to refer the reader to a specific publication(s) for each special matrix. This is a specific topic that requires specific information.
C312	13.6	13-26		The document should include a section on determining solubility of particulate matter in body fluids. The solubility or clearance rate from the lung is a critical factor in dose estimates.
C313	13.6.4	13-28	870-884	this information is not very useful
C314	13.6.5	13-28	885-909	this information is incomplete and the reader would be much better served if only referred to the complete reports by Gibbs et al., 1978 and Peng, 1977.
C315	13.5.2	13-29	810	replace "water" with "aqueous samples"
C316	13.7	13-29	General	This section is not well-written and will require extensive editing. It is either too general or very specific with direct quotes from published papers. Some information is either incomplete or not useful. Also, the style is not consistent. This part should be deleted or presented differently. One way is to refer the reader to a specific publication(s) for each special matrix. This is a specific topic that requires specific information.
C317	13.7.1	13-30	930-931	Why are HF and aqua regia not included? Who provided this definition? The above combination of acids can provide a very powerful acid leaching method for Pu from large size soil samples (up to 100 g). See Ibrahim et al., 1994; J. of Radioanalytical and Nuclear Chemistry, Vol. 177, No. 1, 127-138.
C318	13.8	13-32	1015	explain "red or white fuming nitric acid"
C319	14.1	14-1	3	What is meant by: The methods of …, "Collection"?
C320	14.1	14-1	3	detection of radionuclides are not similar to ordinary chemicals
C321	14.1	14-1	14	What is meant by "agency procedural manuals", can you give examples?

Row	Section	Page	Line	Technical Review Comment
C322	14.1	14-1	32	delete "because the radiochemist detects atoms by their radiation" and start the sentence with "The success or …"
C323	14.1	14-2	44	move "(radiolysis)" to line 45 after "heat effects"
C324	14.1	14-2	53	A proposed table summarizing the characteristics of alpha, beta and gamma radiation can be inserted (see Table 2 in main body of Panel review report) to illustrate that the extent of radiochemical separation is impacted, in part, by the type of radionuclide emission. This table relates directly to the understanding of the required chemical separation for each type of emission.
C325	14.2.1	14-2	57	How is "detection of analyte, tracers, and carriers" related to "oxidation-reduction"? I don't think they are related.
C326	14.2.1	14-2	62	change "number" to "state"
C327	14.1	14-2	35-37	It gives the impression that coprecipitation is very specific and will yield "pure radionuclide, free of interfering ions". Coprecipitation is very seldom that specific. Re-word the sentence to reflect reality.
C328	14.2.1	14-2 & -3	68-70	The statement "The differences …" is not clear; give an example.
C329	14.2.2	14-4	103	Shouldn't this read U<Cl<F ?
C330	14.2.3	14-9	256	before "radiolysis products …" add "At high levels, radiolysis products …"
C331	14.2.3	14-9	265	under "notes" in Table 14.1, indicate that the color of the various chemical forms are visible only in the presence of significant amounts (mass)
C332	14.3.2	14-21	539 ff	Might be useful to provide diagrams of complexed and chelated metals--how the metal ion fits into the agent.
C333	14.8.2	14-63	1676	Table 14.1: Shouldn't radium be included in the list of exceptions for sulfates?
C334	14.8.3.1	14-68	1819	Just a quibble about solubility being dependent on particle size. I think of solubility being an inherent property of the solute in the limit of infinite time. Size affects mostly the rate of solution. While I understand the fact that molecules can redistribute from small to large particles at concentrations near saturation, I'm not sure that should be called a difference in solubility.
C335	14.10.	14-107	2955 ff	Organization and headings: Call section 14.10 "Analysis of Specific Radionuclides", which is its subject, rather than "Chemical Equilibrium", which does not describe its contents. Then, place current sections 14.10.1 to 14.10.8 as subheadings in a new section 14.10.1 called "Introduction" or "Overview". Thus, current sections 14.10.9.1 - 14.10.9.12 become 14.10.2 - 14.10.13. To new section 14.10.1, add a brief explanation concerning the selection of the specific radionuclides that follow. The selection makes sense, but should be justified.
C336	14.10.	14-107	2955 ff	The detailed descriptions of certain aspects of chemical behavior in current sections 14.10.1 - 14.10.8 should be referred to in the specific radionuclide sections to avoid considerable repetition concerning matters such as hydrolysis and polymerization.
C337	14.10.1	14-108	2978	It should be realized that carrier added to a solid may not be uniformly interchanged with the radionuclide
C338	14.10.1	14-109	3008	Were these salts mixed as solids or in solution and then the chloride was crystallized?
C339	14.10.7	14-116	3209	Add that, for accuracy, S1/S2 should be significantly larger than 1.
C340	14.10.9	14-120	3347 ff	A section on a specific radionuclide usually is read to select or evaluate an analytical method. The contents will be most useful if each brief description is paired with the reference to the detailed description. The current practice of first describing all methods and then bunching the references at the end is not helpful.
C341	14.10.9	14-120	3347 ff	For specific radionuclides, extensive paragraphs that describe the occurrence, properties, and preparation of minerals and the metallic state should be deleted. Unless they are pertinent to the purpose at hand, a reader can look for these descriptions where the author obtained them. In a large tome such as this, the authors should limit themselves to pertinent information.
C342	14.10.9	14-120	3347 ff	The authors should reevaluate use of qualitative judgements of amounts of specific radionuclides, their toxicity, and the

Row	Section	Page	Line	Technical Review Comment
				difficulty of analysis (examples are discussed elsewhere in this list of comments). The MARLAP document may somewhere have quantitative information or make reference to such information concerning amounts, doses and costs that could be used to place amounts and effects in perspective.
C343	14.10.9	14-120	3347 ff	I was surprised that Chapter 14 contained the very long sub-subsection (14.10.9) on specific radionuclides. The latter could easily have been a separate chapter or, perhaps better, an appendix. But it may actually be the section of most use to the laboratory faced with a specific type of analysis.
C344	14.10.9	Various	Various	An additional reference for the "occurrences" sections for individual radioelements is the review of speciation, solubility, and sorption characteristics of specific radionuclides provided in Sections 6.3 and 6.4 of Conca (2000), a report that was prepared in order to support the performance assessment of the proposed repository at Yucca Mountain. Radionuclides covered by MARLAP that are also in that report include Pu, Np, Am, U, Tc, I, Cs, Ra, Sr, Th, and Zr.
C345	14.10.9.1	14-121	3361	Replace "military" with "various plutonium"
C346	14.10.9.1	14-122	3394	Do rocks actually absorb Am(III), or is it adsorption?
C347	14.10.9.1	14-125	3502	It would be useful, here and elsewhere, to specify the alpha particle and gamma ray energies used for spectral analysis; if they are listed elsewhere in MARLAP, this list should be referred to for each radionuclide
C348	14.10.9.1	14-125	3509	This mixture of references is not useful; the reader will want to be referred to specific papers for the method of interest.
C349	14.10.9.2	14-125	3518	Information about the metal is not useful in MARLAP and should be deleted
C350	14.10.9.2	14-126	3527	The only aspects of interest under "Occurrence" concern (1) stable cesium in media submitted for analysis that may affect the analytical results and (2) radioactive cesium in media submitted for analysis; delete all other contents.
C351	14.10.9.2	14-128	3595	Give reference to the cited experiments
C352	14.10.9.4	14-137	3873	Add I-123, according to line 3913
C353	14.10.9.4	14-137	3873	It is not true that "Iodine is … never found in the elemental form." Brauer et al. (1976) measured the speciation of gaseous forms of iodine in the atmosphere and reported that a significant fraction was present as molecular iodine (I_2).
C354	14.10.9.4	14-137	3875	An additional fairly recent reference that may be useful is the short literature review of 129I in the hydrological environment presented by Fabryka-Martin (2000).
C355	14.10.9.4	14-140	3963	The discussion of toxicity and radiotoxicity in this paragraph is not appropriate in this context; any warning to analysts should be in specific terms about use, quantity and speciation.
C356	14.10.9.5	14-144	4088	Delete the word "compounds"
C357	14.10.9.5	14-144	4089	After "natural environment", insert "(e.g. the natural reactor at Oklo)"
C358	14.10.9.5	14-144	4103-4104	The sentence beginning with "There are minute quantities of plutonium..." is redundant and irrelevant; delete.
C359	14.10.9.5	14-144	4108-4110	Although plutonium from fallout was originated in air, over 99% now resides in soils and sediments.
C360	14.10.9.5	14-144	4109	Add that most 238Pu in the environment was due to the high-altitude burnup of a SNAP-9 satellite power source. SNAP is the acronym for "Systems for Nuclear Auxiliary Power." Details on SNAP-9 worldwide fallout and 238Pu in the environment can be found in: R.W. Perkins and C.W. Thomas (1980) Worldwide Fallout. In: Transuranic Elements in the Environment, W.C. Hanson editor.
C361	14.10.9.5	14-144	4169-4184	This discussion is much too general, inexact and most of the information presented is not supported by any literature references.
C362	14.10.9.5	14-144	4169-4184	This discussion is misleading and overly generalized. I propose that it could read something like: "Because the solubility and sorption properties of most actinides is highly dependent not only on the chemical form of the element (speciation), but also on the oxidation state, it is often difficult to predict the mobility of this element in nature, particularly in the vicinity of fuel reprocessing plants and nuclear waste sites, where the subsurface water chemistry can vary greatly and depart from natural compositions due to the presence of man-made materials (e.g., cements and acids). The behavior of

Row	Section	Page	Line	Technical Review Comment
				soluble plutonium is therefore unlikely to be similar from one location to the next. In addition, like americium and uranium, plutonium is capable of existing in multiple oxidation states simultaneously, and will tend to hydrolyze and polymerize in solution, further complicating the situation. In general, sorption of plutonium by surrounding rocks and soils is favored by water chemistries with low pH values although this is dependent also on available sorption sites (mineralogy), saturation and the presence or absence of colloidal forms. As a colloid, however, plutonium can travel rapidly and great distances through fractured rocks (e.g., contamination from underground nuclear tests at the Nevada Test Site). In conditions where plutonium occurs principally in particulate form, as a result of atmospheric testing for example, the average residence time for plutonium in waters with pH>7 appears to be proportional to the amount of suspended material. For this reason, more than 90 percent of plutonium is removed from coastal water. The residence time in mid-ocean water, where particulate matter is less, is generally much longer although concentrations can be greatly reduced by advective dispersion."
C363	14.10.9.5	14-147	4203	Table 14.20: Should second Pu+3 be Pu?
C364	14.10.9.6	14-156	4475	Same comment as given for line 3963 applies to "highly toxic" discussion
C365	14.10.9.6	14-159	4563	Replace "SO4-2" with "SO3-2"
C366	14.10.9.6	14-159	4569	Replace "BaIO3" with "Ba(IO3)2"
C367	14.10.9.6	14-159	4571	Replace "Th(C2O4)" with "Th(C2O4)2"
C368	14.10.9.6	14-160	4616	The interference is there, but can be corrected on the basis of secondary U-235 gamma rays
C369	14.10.9.6	14-160	4618	"lengthy and expensive" must be placed in context: relative to what procedure, or what are the cost and time?
C370	14.10.9.6	14-160	4624	Delete "alpha- or"; for reliable gamma counting, the radon gas must be uniformly distributed in the container
C371	14.10.9.6	14-161	4631	Insert "beta, or gamma" after "alpha,"
C372	14.10.9.7	14-162	4683	Change "90Sr" to "88Sr"
C373	14.10.9.7	14-163	4710	Should "strontium carbonate" be "divalent strontium ions"?
C374	14.10.9.7	14-164	4742	Add "to leach strontium"
C375	14.10.9.7	14-165	4770	Add extraction of strontium with di-2-ethylhexyl phosphoric acid
C376	14.10.9.8	14-168	4868	This section is incomplete, as indicated by more detailed discussions of solubilities in lines 4885, 4893, and 4950.
C377	14.10.9.8	14-168	4880	This advice depends on the amount of Tc-99 handled, hence it does not apply to environmental samples; as indicated in the comment for page 14-140, line 3963, terms like "high specific activity" need to be replaced by quantitative guidance.
C378	14.10.9.8	14-172	5005	How low is "low"?
C379	14.10.9.8	14-172	5020	Replace "beta" with "conversion electron"
C380	14.10.9.9	14-178	5211	insert "or stainless steel" after "platinum"
C381	14.10.9.10	14-181	5305	Use "1.5" instead of "twice"
C382	14.10.9.10	14-182	5320	Clarify "selectively exchange": do they selectively accumulate or release?
C383	14.10.9.10	14-183	5365	Comment is needed here on the existence and extent of organically bound tritium (mentioned in line 5381) in the environment
C384	14.10.9.10	14-184	5388	Mention here the process for oxidizing tritium to measure gaseous or organically bound tritium as tritiated water
C385	14.10.9.10	14-184	5391	State here that the purpose is to measure tritium as gas in a gas-filled proportional counter
C386	14.10.9.10	14-185	5411	Mention here use of azeotropic distillation with an organic solvent such as cyclohexane to extract tritiated water from biota samples
C387	14.10.9.11	14-186	5425	The sentence beginning with "The ^{234}U that was formed ...." is irrelevant and confusing; delete
C388	14.10.9.11	14-186	5440	Mention here that man-made U-236 can also be found
C389	14.10.9.11	14-187	5490-5491	Lines 5490-91 should read: **"For natural water compositions and under controlled conditions, although uranium**

Row	Section	Page	Line	Technical Review Comment
				metal will slowly decompose in water at room temperature, **it can do so rapidly** at 100/C."
C390	14.10.9.11	14-188	5508	In line 5508, one could insert:"As in the case of americium and plutonium, uranium is capable of existing in multiple oxidation states simultaneously and is susceptible to complexation and hydrolytic reactions, such that its properties will vary greatly with differing water chemistries. In the vicinity of nuclear waste sites, for example, where ground water chemistries may be strongly modified by breached containment canisters, the solubility and sorption of uranium in groundwater can be very complex. Therefore, knowledge of the migration behavior of this element through soils and rocks requires the use of complex physically-based models which take into account pathways and evolving water chemistries. Conversely, uranium in nature is almost entirely in the IV and VI oxidation states…"
C391	14.10.9.11	14-195	5754	more strongly than what or when?
C392	14.10.9.11	14-195	5756	Should "Absorbance" be "Absorption"?
C393	14.10.9.11	14-196	5783	Insert "or stainless steel" after "platinum"
C394	14.10.9.12	14-198	5839	Delete gamma symbol at end (less than 0.01% gamma)
C395	14.10.9.12	14-200	5895	Replace "very small quantities" with a description that places such quantities in context (e.g., quantities small compared to ...)
C396	14.10.9.12	14-200	5904	Replace "monovalent" with "tetravalent"
C397	14.10.9.12	14-200	5914	Insert "with analyses for other radionuclides" after "proceeding", if that is the intended meaning
C398	14.10.9.12	14-201	5928	"high pH (1 - 2 M)" doesn't make sense; are some words missing?
C399	14.11	14-209	6166	Are all three references to the same report in different years (lines 6171, 6175) needed?
C400	14.11	14-217	6383	Replace "submitted to" with volume and page numbers
C401	14.11	14-217	6384	This does not appear to be a readily accessible reference and should be replaced if possible. Others in this category are in lines 6388, 6429, and 6458
C402	14.11	14-218	6427	If this is more or less the same reference as on line 6424, delete it
C403	14.11	14-220	6461	Reference is incomplete
C404	14.11	14-226	6620	Move "Zolotov" to beginning of line; is this reference needed, since it is the same reference as in lines 6504 and 6526?
C405	14.10.9	14		Remove the various comments on the toxicity or hazard of a radionuclide except when advising on sample handling; if the reference to toxicity is intended to explain the purpose or required sensitivity of analysis, refer to a radiation protection text.
C406	15.1	15-1	26	Vague. States "scintillation counters". This implies complete systems but I suspect it is intended to mean "scintillation detectors" consistent with instrumentation listed as "detectors" in lines 22-25
C407	15.1	15-1	27	"Multichannel analyzers" are a readout component that might be used with any of the three preceding detectors.
C408	15.1	15-1	21-27	These lines leave a gap -- gives a variety of detectors but the only electronic package or readout instrument is the multichannel analyzer; it omits scalers and other analyzers. The electronic components or instrumentation that might be found include: (1) Simple counting systems (primarily scalers and ratemeters with simple baseline discriminators), (2) Energy-selective systems such as single-channel analyzers and the 1-, 2-, and 3-channel analyzers commonly found in the simpler liquid scintillation counting systems), and (3) Multichannel spectrometers (incorporating the MCAs of line 27).
C409	15.1	15-1	22-27	The bullets are a mixture of detectors (lines 22-25), readout instrumentation (line 27), and complete systems (line 26).
C410	15	15-1	General	Chapter 15 deals with two topics, 1) Instrument calibration and 2) test source preparation. Instrument calibration is intimately linked to Nuclear Counting Instrumentation (Chapter 15); the question arises as to whether it should be part of Chapter 15 (Nuclear Counting Instrumentation). Test source preparation deals with converting the collected and processed samples to a suitable form for introduction to the counting instrument. Test source preparation is the bridge to

Row	Section	Page	Line	Technical Review Comment
				Chapter 15 (Nuclear Counting Instrumentation) from: Chapter 12, Laboratory Sample Preparation (for samples that need minimal preparation); Chapter 13, Sample Dissolution (for samples that need moderate preparation), and Chapter 14, Separation Techniques (for samples that need radiochemical preparation). The question arises as to whether Test Source Preparation should be a separate chapter either before or following the current Chapter 15. The common thread between the two parts of Chapter 16 (instrument calibration and test source preparation) is that both the test samples and the calibration samples should be prepared in the same, consistent manner. As a minimum, the document should be reviewed to assure that the wording in Chapters 12, 13, and 14 and at the beginning of the Test Sample Preparation part of Chapter 16 recognize and facilitate the linkages described above.
C411	15	all	General	Revise the order of presentation and undertake some rewriting. We found that the chapter was confusing or repetitive because it is, in part, an ASTM text that the authors present in reversed order.
C412	15.1	15-1		Flow chart indicating steps and boxes and move boxes to connect sequences. Build a flow chart to show, and place at beginning of Chapter 15.
C413	15.1	15-2	38-39	What is the difference between the line 38 "spectrometry (Section15.5)" and the line 39 "spectrometry ... (Section 15.7)"?
C414	15.2, 15.3	15-2	44 ff	Sections 15.2 and 15.3 give similar considerations for alpha and beta, respectively, but are written in two different styles.
C415	15.2.1	15-2	58-59	"analog-to-digital converters" (line 59) are not used in "all cases" (line 58), only in those systems using multichannel analyzers.
C416	15.2.1	15-3	63	Source diameter is not an independent variable in this list; it is only important as it affects Geometry (line 62) or Self absorption (line 64). Do not hyphenate self absorption.
C417	15.2.1	15-3	71	Suggest inserting "typically" between "counters" and "have". Why "Thus" in the second sentence? This statement does not follow from the preceding one.
C418	15.2.2.1	15-3	80-88	Alpha-counting ion chambers are rather specialized (not just any old ion chamber), and are not too common (see pg 15-24, lines 731-735, discussion of gridded ion chambers, their high efficiency, and being replaced by semiconductor detectors.) This paragraph should start off by giving us a clue as to how they are used and the special considerations.
C419	15.2.2.2	15-3	89-99	This section should lead off by saying where/how this type of detector is used and in what systems.
C420	15.2.2.2	15-4	114-115	Should the efficiency for the windowless flow counter be given (as was done for window flow counter, line 120)?
C421	15.2.2.3	15-4	121-132	This section should lead off with a statement as to where/how scintillation counters are used, in what type of system.
C422	15.2.2.3	15-5	133	the statement "The counter size is limited by the multiplier phototube size" is not true. Scintillation detectors are commonly the same size as the phototube but there are detectors with light pipes connecting a large size phosphor to a smaller diameter PMT.
C423	15.2.2.3	15-5	133	Photomultiplier tubes are referred to here as “multiplier phototubes.” This is not the usual terminology and is jarring to the reader.
C424	15.2.2.3	15-5	133	The convention for using metric not withstanding, 51 mm PMTs and gas filled detectors were designed as, sold as, and commonly identified as 2-inch detectors. Therefore, in order to tie to conventional usage, I suggest using "51 mm (2 in)" -- here and elsewhere.
C425	15.2.2.4	15-5	156	line 156 mentions planchet preparation, a subject that is not really covered until Chapter 16. At the least, a cross-reference to the appropriate section(s) would help.
C426	15.2.2.4	15-5	149 ff	Sections 15.2.2.4 and 15.3.3 deal with liquid scintillation counting for alpha and beta, respectively. Much of the material is applicable to both but not mentioned in both. Suggest there either be an earlier section on liquid scintillation counting in general or make Section 15.2.2.4 more complete and refer back to this section in 15.3.3.
C427	15.2.2.4	15-5	150-157	This paragraph should include the statement that the sample-scintillator mix is placed in a vial transparent to the emitted light (glass or plastic). Vials are not mentioned until later on pg 15-9, line 265 (in the beta section). The statements in

Row	Section	Page	Line	Technical Review Comment
				lines 156 and 157 are true but not evident from the information given unless the counting vial is mentioned.
C428	15.2.2.4	15-6	160	Quenching is mentioned but not defined. (Later on pg 15-34, lines 1037- 1054 there is a pretty good description of liquid scintillation quenching.)
C429	15.2.2.5	15-6	191-193	The comparison here of the semiconductor detector to the gridded ionization chamber is valid but "gridded" and the resolution were not mentioned in the early section on ion chambers -- you have to know more than was given in the earlier section in order to be able to follow this.
C430	15.3.2	15-8	225	This statement is true if you are gross-beta counting a sample without chemical separation. However, the first paragraph of this section includes radiochemical separation. If there has been complete separation of the radionuclide of interest, gross counting is all you need! The author should have made a distinction between gross activity analysis and gross counting. Furthermore, this statement applies equally to alpha, beta, and gamma and should be in general section rather than only in this beta section.
C431	15.3.3	15-8	227	See earlier comments re overlap with Section 15.2.2.4.
C432	15.3.3	15-8	246	Again quenching is mentioned but is not really defined until later on pg 15-34.
C433	15.3.3	15-9	273	Suggest add "in the medium" after "speed of light".
C434	15.3.3	15-9	275	"wave shifters" should be "wavelength shifters".
C435	15.3.3	15-9	278	Suggest add "(see Section 20.1)" after "mixed waste".
C436	15.3.5	15-10	306-308	This is redundant with Section 15.3.1.
C437	15.3.6	15-11	323	This is in the beta section, but most of it applies as well to alpha and gamma counting.
C438	15.3.6	15-11	324	Do any modern systems still use a mechanical register? Or should this be deleted? This sounds like it was lifted from an old document.
C439	15.3.6	15-11	324, 325	A number of system components are named but I don't believe their functions have been given
C440	15.3.6	15-11	334-348	This explains the characteristics of and differences between various gas-filled detectors (which were introduced earlier). Is this necessary? If so, it should appear earlier -- before the introduction of ion chamber, proportional, and GM detectors.
C441	15.4	15-12	359	Various places in this section present materials applicable to both scintillation detectors (such as NaI) and to semiconductor detectors (such as HPGe), other parts are specific to one or the other; however, this isn't always clear to the uninitiated reader.
C442	15.4.1	15-12	361	The statement about non-destructive measurement is not always true and to a certain extent misleading. Yes, relatively non-destructive gamma measurements are made. However, in many cases the sample is processed in some fashion first: e.g., grinding, sieving, ashing, evaporation to reduce volume, ion exchange, etc. Furthermore, gamma counting is also used to count radiochemically separated portion of samples that have been destructively processed.
C443	15.4.1	15-12	371 ff	Abrupt change of thought in the middle of this paragraph.
C444	15.4.1	15-12	382 ff	At this point it would be instructive to state that photoelectric events can be used to identify and quantitate specific nuclides in a mixture.
C445	15.4.1	15-13	389	Change "In solids such as NaI(Tl) or CsI ... " to "In solids such as the scintillation detectors NaI(Tl) or CsI ... ".
C446	15.4.1	15-13	410-422	This is, for the most part, redundant with pg 15-12, lines 371-382.
C447	15.4.1	15-13	caption	Figure 15.2 caption: Add the words "from Semiconductor Detectors". (The text referring to this figure (called out on line 418) has been talking about both scintillation and semiconductor detectors, but this is very definitely a spectrum from a semiconductor detector.)
C448	15.4.1	15-14	441-444	Again a reference to gross counting which has never been well defined in either the beta or the gamma section. You have to be already knowledgeable to follow this.

Row	Section	Page	Line	Technical Review Comment
C449	15.4.1	15-15	457-474	This section introduces a number of technical terms (pulse pileup, rise time, pole zero, etc., but not enough information for them to have meaning to anyone not already knowledgeable.
C450	15.4.1	15-15	460-474	This is a laboratory manual, the most practical solution in most cases will be dilution rather than distance, collimation, or detector size. These later solutions are more like to be applied to process line monitoring or to emergency effluent monitoring than to laboratory sample analysis.
C451	15.4.1	15-15	460-474	These high count rate effects are possible for "process", some radioactive waste, and activation analysis samples, but are not likely to be a problem for general environmental samples. The reader should be given a little more guidance on when to be alerted for these effects.
C452	15.4.2	15-16	518	Abrupt jump from HPGe to NaI scintillation. In addition, this sentence doesn't read very well. It would read better if it said something like "The most widely used size of NaI(Tl) detector is the 76 x 76 mm (3 x 3 in)".
C453	15.4.1	15-16	493-496	This is specific to NaI(Tl) scintillation and a sudden switch after previous discussion and figures dealing primarily with HPGe. Similar information should be given for HPGe; especially since this is the detector of choice for resolving complex spectra.
C454	15.4.2	15-16	502-503, Fig 15.4	35% and 70% are not explained; this could easily be confused with absolute efficiency. This explanation does not occur until later on pg 15-26, lines 809-810.
C455	15.4.2	15-16	504, 505	What do "vespel well" and "Mg well" mean?
C456	15.4.2	15-16	518, 523	Suggest putting detector size in inches in parentheses following the metric size -- for same reasons given for pg 15-5, line 133.
C457	15.4.2	15-16		The line codes in the key for figure 15.4 cannot be distinguished. The position order in the key is inverted from the position order in the figure. This is an unnecessary complication for the reader and not good communication.
C458	15.4.2	15-17	540	Table 15.1: The geometries for each of these sample configurations should be more explicitly defined. I assume that the filter paper (column 2), the planchet (column 3), and the AL can (column 4) are placed directly on top of an upright detector.
C459	15.4.2	15-17	555	Table 15.1: Here the detector size is given in inches without the metric equivalent. Be consistent and also see earlier recommendations re detector size convention.
C460	15.4.3	15-18	561	how about 76 x 76 mm (3 x 3 in)?
C461	15.4.3	15-18	569	States "... gamma ray spectrometer system." However the following description is for a single channel gamma ray spectrometer system and there is no mention of the more preferable multichannel spectrometer system. Was this perhaps adapted from an out-dated reference?
C462	15.4.3	15-18	571	First column entry is for Preamplifier but second column gives description of the main amplifier. No column two entry for Preamplifier; no column one entry for main amplifier.
C463	15.4.3	15-18	560 ff	The section title says "Detector Assembly" and the first paragraph deals with the detector. However, the second paragraph deals with all the other components of the system. A more appropriate title would be "Sodium Iodide Counting System."
C464	15.4.3	15-18	572-573	Between lines 572 and 573: Column two entry for sample mounts and containers but no column one entry. (This also screws up the line numbering sequence!)
C465	15.4.4	15-19	576	"None of the configurations of germanium detector .. can be operated at room temperature ..." would be a better choice of words than "Any type of germanium ... cannot be operated at room temperature ...". This refers to configuration of germanium detector, not type of germanium. Also "No ... can" is less ambiguous than "Any ... cannot".
C466	15.4.4	15-19	590-592	These two sentences pertain to choosing between NaI and HPGe and it seems as though the statement should come earlier. However, I don't have a specific suggestion.
C467	15.4.7 to	15-20	612-629	These are three sections (15.4.7, 15.4.8, 15.4.9) on less commonly used scintillation detectors and they seem like orphans.

Row	Section	Page	Line	Technical Review Comment
	15.4.9			How about grouping all scintillation detectors together in one place and then go on to expand on the more common NaI? Or in a single section, "Other scintillation detectors"?
C468	15.4.9	15-21	629	I don't believe "photofraction" has been defined in this document. Should it be?
C469	15.5	15-21	630	The title "Spectrometry Systems" is misleading. The most common spectrometry systems were covered earlier; these are special systems.
C470	15.5	15-21	631	I dispute the statement "commonly used for gamma-ray spectrometry". Unless I've really lost touch with things, these are uncommon systems! Also "... commonly use …" should be "... commonly used …"
C471	15.5.4	15-22	661	this statement needs a reference.
C472	15.6.2	15-23	683-698	Does this section have any practical significance in this document?
C473	15.7	15-24	717 ff	Section 15.7 is redundant with much of the early material but is written more in the style of the rest of MARLAP. This section answers many of the questions raised in reading the earlier sections. It might be worthwhile for the earlier sections to be merged into 15.7. Perhaps much of the overlap and difference in presentation in this chapter could be overcome by reorganizing the chapter
C474	15.7	15-24	718 - 889	This first part of the section should have some subsections (such as for alpha, beta, and gamma) to provide more balance with existing subsections 15.7.1 and 15.7.2, which are really secondary in importance to this earlier material.
C475	15.7	15-25	752	This paragraph needs more introduction. Why is it important to know about the Heath spectrum catalogs?
C476	15.7	15-26	803, 810	Crystals in inches as well as mm?
C477	15	15-26	General	Starting from this page, the chapter reads very well. This section should be used as a guideline for the earlier parts of the chapter.
C478	15.7	15-27	828	Crystal in mm as well as in?
C479	15.7	15-28	847	This sounds like end cap specifications for a low energy detector.
C480	15.7	15-28	857, 858	76 x 76 mm (4 x 4 in).
C481	15.8	15-31	956-959	This paragraph on counter background seems to be an orphan in the Shielding section. This should go earlier in the chapter as a prelude to the various background reduction strategies.
C482	15.9	15-31	969-975	Are standards of all radionuclides available from NIST or is it necessary to go out of the country for some? (Ex. IAEA)
C483	15.10.1.1	15-32	983 ff	This section is redundant with Chapter 16. It should be deleted.
C484	15.10.1.1	15-32	988-989	What is the relevance of this cesium-137 gamma radiation to alpha detection?
C485	15.10.1.1	15-33	1002, 1014	Paragraphs starting lines 1002 and 1014 are redundant.
C486	15.10.1.1	15-34	1049	This diagram is not very clear. What do the underlined spaces and the vertical lines mean? Are some arrow heads missing?
C487	15.10.1.1	15-34	1059	Should be "calibration, attenuation . . ."
C488	15.10.1.1	15-34	1037-1048	Here is the definition of quenching that should be moved to earlier in the chapter.
C489	15.10.1.4	15-37	1124 ff	line 1124 ff introduces the control chart, but it is not fully discussed with an example until Section 18.3.2. Probably should be a early cross reference, especially to the example chart on p. 18-7.
C490	15.10.1.4	15-39	1183 ff	The writing suddenly becomes very specific and prescriptive.
C491	15.10.2.1	15-40	1232-1240	"Gross" activity measurement is a little better described here. (See comments for page 15-8, lines 225-226, and for page 15-14, lines 441-444)
C492	15.10.3.1	15-47	1431	Equation 15.1 needs a lead in.
C493	15.10.3.1	15-47	1431-1450	And what are you supposed to do with the results of these equations? (eqns 15.1 to 15.3)
C494	15.10.4.1	15-52	1586, 1588	Shouldn't "234U" be "233U"? Spike is 233U (line 1585).
C495	15.10.4.3	15-54	1651	neutron flux is in "n", not "ng". Is the notation "n/cm2/s" consistent with the rules for this publication?

Row	Section	Page	Line	Technical Review Comment
C496	15.10.4.3	15-54	1662	neutron flux is in "n", not "ng". Is the notation "n/cm2/s" consistent with the rules for this publication?
C497	15	All		In this chapter, wouldn't it be more efficient to describe proportional counters and scintillation counters (or even each of the various types of detectors) first and then go to specific radiation types, and thus avoid having to repeat the description for each type of radiation?
C498	15A	All		Is any of this redundant with other Chapters on calibration of QA?
C499	16	All		Chapter 16 addresses standard reference materials (usually solution standards) which are used to make up instrument calibration standards. Also important are the matrix-specific reference materials that are used to check for recoveries from various matrices and to QA for matrix-specific effects in sample preparation, dissolution, and separation. A cross-reference should be made here to Section 18.4.4, which discusses these materials.
C500	16	All		It is not clear what is the role for commercial, plated alpha and beta sources, particularly for alpha spectrometry. What are the considerations, cautions, correction factors, etc. if a laboratory chooses to purchase these sources rather than custom making sources from calibrated solutions?
C501	16	All		Chapter 16 seems to be straight forward and unambiguous with a good balance between the general performance and the prescriptive.
C502	16	All		Some of the instrument descriptions in this chapter are better than the ones in Chapter 15.
C503	16	All		There are a number of instances with overlap with other chapters; however, this probably cannot be avoided.
C504	16	All		Integrate with chapters 12 – 15 by suitable references in these preceding chapters to the pertinent discussions in chapter 16.
C505	16	All		I was surprised that the topic covered by Chapter 16 (which includes advice on test source preparation) was discussed after the topics in Chapter 15 (which covers counting after the source has been prepared)
C506	16	All		Chapter flows well as written, so leave chapters as they are but do better road map on what this section is all about and how the Chapters 15, 16 are interrelated.
C507	16.2.2	16-3	76	Is there another word that can be used instead of "Correspondence"? (congruity, harmony, harmonization, etc.?) It is a perfectly good word for what it is meant here, but it conjures up the image of mail or e-mail.
C508	16.3.3	16-6	161	Show how this scattering/self-absorption factor is used (give a correction equation?).
C509	16.4.1.2	16-11	311-318	If this is not mentioned in Chapter 15, it should be.
C510	16.4.2	16-11	333-335	Redundant with what is (or should be) in Chapter 15; but that's probably alright.
C511	16.5.1	16-14	413-414	Insert "such as 89Sr and 90Sr" just after "... not accompanied by a gamma ray". Delete "89Sr and 90Sr" from their present position and leave the rest of the radionuclides where they are.
C512	16.5.2	16-15	462	Shouldn't "aliquant" be "aliquot"? (same question arises in other parts of this chapter)
C513	16.5.2.1	16-16	500-507	Quenching was discussed in Chapter 15, but this is a much better description.
C514	16.5.2.1	16-17	530	Should "... channels ratio" be "... channels ratio method"?
C515	16.6.1	16-18	557-562	Here is some bridge material from Chapters 12 and 13.
C516	16.6.1	16-19	589-597	More bridge material from earlier chapters.
C517	16.7.5	16-27	844	Why isn't radon in this list?
C518	16.7.5	16-27	844	Add the isotopes of Rn to the list of radioactive noble gases.
C519	16.7.5	16-27	851, 852	"Media" should be "medium" (singular); insert "or" before "peroxide"; substitute for the final clause "with the medium then analyzed by scintillation spectrometry".
C520	16.7.5	16-28	890	Another instance of non-SI units (cfm)
C521	17	All		Many of the terms and acronyms were poorly explained.
C522	17	All		Many of the units associated with terms from the equations are inconsistent from one equation to the next.

Row	Section	Page	Line	Technical Review Comment
C523	17	All		Several Figures are unclear due to small font size or poor contrast (fig 17.3, Fig 17.4, Fig 17.5).
C524	17	All		On another note, I found the text to be very well written with the exception of some repetitions and redundancies. I would like to compliment the author(s) on a thorough job for this Chapter.
C525	17	All		There appear to be typos in some of the equations. In any case, all equations need to be thoroughly checked throughout the document.
C526	17	All		Many of the references both in the text and in the Reference section are incomplete, missing or wrong. All references should be thoroughly checked and a format common to the entire MARLAP manuscript should be adopted.
C527	17.1	17-2	46	Change of text: '…assist in the data validation process (Chapter 8). Support material can include information on…'
C528	17.2	17-2	54	Addition of text: 'Data acquisition in this context, refers to the process of collecting the basic information produced by nuclear…'
C529	17.2	17-2	61	Deletion of text: '…transferred to the next data-reduction step. Electronic transfer should be employed as…'
C530	17.2.1.1	17-4	118	I initially stumbled on "proportional" because I tend to think of uncertainty as relative (e.g., percent uncertainty) and wanted to insert "inversely". I now recognize that the statement is accurate, but maybe you want to add "absolute" before "uncertainty" on line 117, and even add a sentence: "The relative uncertainty is therefore inversely proportional to the square root of n."
C531	17.2.1.3	17-6	159	Addition of word: 'The output of some instruments is very basic, primarily counting data, i.e., total counts or counts per…'
C532	17.2.2	17-7	191	Change of text: 't{sub c} = real time (actual clock time) of counting…'
C533	17.3.1	17-9	Figure 17.1	Gamma-ray spectrum: index the photopeaks P1 and P2 as referred to in the text, lines 266-267.
C534	17.3.1	17-11	Figure 17.2	Gamma-ray analysis sequence: enlarge figure so that the entire width of the page is taken advantage of. This will allow to represent the boxes labeled "Report", "Calculate Uncertainty", Concentration", Resolve", etc… as larger, and dispose of flow chart in a clearer way.
C535	17.3.1.1	17-12	309-310	Addition of text: 'As previously stated, the photopeak has a basic Gaussian shape; in reality it is a histogram with a Gaussian-like shape, unless interference effects are present as in a multiplet.'
C536	17.3.1.4	17-14	386	Addition of text: '…normally quoted in terms of its full width at half maximum or FWHM (c.f., Chapter 18, section 18.5.3.2.). For a discussion…'
C537	17.3.1.4	17-16	Figure 17.3	Low-energy tailing: Clean-up this figure so that the information beneath the spectrum is clearly visible and highlighted, i.e., "FWHM", "DC", etc…Increase the font size of the abcissa and ordinate headers.
C538	17.3.1.5	17-17	Figure 17.4	Photopeak baseline continuum: Increase the overall size of figure or increase the font size of the text.
C539	17.3.2	17-24	606	Addition/modification of text: '…counts, a region of interest or ROI-type analysis is usually performed. However, peak fitting programs are…'
C540	17.3.3.8	17-32	829	On pages 17-6 and 17-7, the notation C(sub net) is used for the difference of C(sub G) and C(sub B). Why not here (Eqn 17.21) and in the next two equations (17.22 and 17.23)? Or do I misunderstand?
C541	17.3.3.8	17-32	833	Change of units : "epsilon{sub q} = the radionuclide quench corrected counting efficiency (cps/dps)" [instead of "c/d"]
C542	17.4	17-33	857	Change of units: 'epsilon = the gross or radionuclide counting efficiency cps/dps) ' [instead of "c/d"]
C543	17.4	17-34	Equation 17.26	Equation 17.26: The second term of the equation [Summation] m^{2i} u^{2} (a{sub i}) appears to be incorrect and should read: [Summation] m^{i} u^{2} (a{sub i}) (I.e., the m term should be raised to the power of i, not 2i)
C544	17.5.2	17-38	Table 17.1	Units For Data Reporting: Generalize this type of Table so that can be used throughout the MARLAP document. In this way, where applicable, similar data can be captured everywhere, for each MARLAP Chapter.
C545	17.5.2	17-38	Table 17.1	An attempt at respecting the same "Title" format as the Figures in this Chapter and indeed throughout the document would also be preferable: e.g., Table 17.1-Units for data reporting
C546	17.5.4	17-39	989 ff	Shouldn't the output charts of spectrometers also be provided on request? I'd like to see visually what was counted as a

Row	Section	Page	Line	Technical Review Comment
				peak and what was not.
C547	17.8.1	17-41 to -42	1039-1082	Cited References. Several references cited in the text, are not in this section but are mistakenly cited in the section 17.8.2 Other Sources. These need to be taken out of the latter and included in the former section (i.e., 17.8.1).
C548	17.8.1	17-41 to -42	1039-1082	Nearly all references are incomplete and some do not even have publication dates let alone page numbers.
C549	17.8.1	17-41 to -42	1039-1082	The format of the reference sections is variable to non-existent. Suggest that a common format be adopted for all references throughout the MARLAP document.
C550	17.8.1	17-41 to -42	1039-1082	Suggest that all references in text be accompanied by the date of publication to distinguish various publications.
C551	17.8.2	17-42 to -44	1083-1134	Several References in this "Other Sources" section are cited in the text and should be transferred to section 17.8.1. These are cited in comments for lines 1091, 1104, 1106, and 1122.
C552	17.8.2	17-43	1091-1092	Debertin, K. and Helmer, R.G., 1988…This reference belongs between lines 1045 and 1046 of section 17.8.1.
C553	17.8.2	17-43	1104-1105	This reference belongs between lines 1057 and 1058 of section 17.8.1.
C554	17.8.2	17-43	1106-1107	Holm, E., Rioseco, J., and Garcia-Leon, M., 1984…This reference is incorrect in the section. The correct reference is cited in section 14.11, p. 14-212, lines 6248-6249,
C555	17.8.2	17-43	1106-1107	This reference belongs between lines 1060 and 1061 of section 17.8.1.
C556	17.8.2	17-44	1122	Reference belongs between lines 1079 and 1080 of section 17.8.1.
C557	18	All		This Chapter was very well written and the presentation of the material was very accessible. Again, I would like to compliment the author(s) on a thorough job for this Chapter.
C558	18	All		The greatest problem resides in the presentation of the references in the text, which should be accompanied by a date of publication to distinguish these from earlier versions of the same documents. Reference section needs work and the format needs to be consistent throughout the section as well as throughout the MARLAP document (i.e., from Chapter to Chapter).
C559	18	All		Check Figures and Tables for typos
C560		All		All equations in this Chapter are straight forward and appear to be correct, however the indexing of the equations should be modified from: (1), (2), (3), etc… to: (18.1), (18.2), (18.3), etc, to match other Chapters.
C561	18.4.1	18-12	321	Addition of text: '…should be checked, and batches identified by serial number. When a sudden, significant increase in the blank occurs in conjunction…'
C562	18.4.1	18-12	Figure 18.2	Three general categories of blank changes: Add under the heading RAPID CHANGES a bullet for INTRODUCTION OF NEW REAGENT BATCH OF DIFFERENT COMPOSITION.
C563	18.4.1	18-12	Figure 18.2	Under the heading HIGH VARIABILITY one could add SAMPLE HETEROGENEITY.
C564	18.4.4	18-18	509-533	In addition to NIST, another widely-used supplier of standard reference materials is the International Atomic Energy Agency (IAEA). Examples of the materials available from this agency include IAEA Analytical Quality Control Services (AQCS) Reference Materials for the Determination of Radionuclides: a) Biological Materials of Marine Origin (fish and shellfish); b) Biological Materials of Terrestrial Origin (milk and diary products, grass, other vegetation, bone); c) Non-biological Materials of Marine Origin (sediments), and d) Non-biological Materials of Terrestrial Origin (soil and lake sediments) [IAEA-AQCS, 2002]..
C565	18.4.4	18-19	550	Insert at end of first sentence "or in the sample preparation process"
C566	18.4.4	18-20 & 21	Table 18.2c	Uncertified Massic activities….: Need to specify under the heading Half Life whether the values are in minutes, hours, or days for the elements 129I, 155Eu, 210Pb, 234U, 235U, 237Np, 238U, and 241Am.
C567	18.4.4	18-20 &	Table 18.2c	An attempt at respecting the same "Title" format as the Figures throughout the MARLAP document would also be

Row	Section	Page	Line	Technical Review Comment
		21		preferable.
C568	18.4.4	18-20	Tables 18.2a, b, c	All need to have the uncertainty changed from "Mean +/- 2s{sub m}" and "Half-Life +/- 1s" , changed to either "Mean +/- 2s{sub m}" and "Half-Life +/- 2s" or "Mean +/- 1s{sub m}" and "Half-Life +/- 1s" (i.e., should be consistent in size of uncertainty used in all columns of all tables)
C569	18.4.5	18-23		Figure 18.4: Suggest removing "Excursions" from title box for consistency with other charts.
C570	18.5.3.2	18-35	1030	Would this be clearer if you inserted "the energy at" before "the most probable peak height"? Or do I misunderstand?
C571	18.5.4.2	18-40	1181	Addition of text: '…electroplated sources, crosstalk may be as low as 1 percent for betas in the alpha channel and 3…'
C572	18.5.6	18-41	Table 18.5	Instrument calibration: example frequency and performance criteria: Under the heading Performance Criteria, under Initial Calibration, one needs to replace the uncertainty (2s) by uncertainty (2s).
C573	18	18-55 to -57	1642-1710	Cited Sources, Section 18.7.1: Many of the references are incomplete and some do not even have publication dates let alone page numbers. The format of the reference section is variable. Suggest that a common format be adopted for all references throughout the MARLAP document. Suggest that all references in text be accompanied by the date of publication to distinguish various publications. Several references in this section are not referred to in the body of the text and need to be moved to section 18.7.2 Other Sources.
C574	18.7.2	18-57 to -58	1711-1723	Other Sources: Many of the references are incomplete and some do not even have publication dates let alone page numbers.
C575	18.7.2	18-57 to -58	1711-1723	The format of the reference section is variable. Suggest that a common format be adopted for all references throughout the MARLAP document.
C576	18.7.2	18-57 to -58	1711-1723	Several references in this section are missing and are located in the other section (i.e., section 18.7.1), see above.
C577	18A	18-59		As in Chapter 18, the indexing of the equations needs to be modified so as to be similar to that used in other Chapters. Otherwise these sections are very well presented.
C578	18A	18-70	1955-1996	Many of the references are incomplete and some do not even have publication dates let alone page numbers.
C579	18A	18-70	1955-1996	The format of the reference section is variable. Suggest that a common format be adopted for all references throughout the MARLAP document
C580	18A	18-70	1955-1996	Suggest that all references in text be accompanied by the date of publication to distinguish various publications.
C581	18B	18-71		With the exception of the equation indexing there are no problems with the References either in the body of the text or in the Reference section itself. The Problems and their solutions are well presented and the section is very useful as an illustration of additional statistical methods available to the user of control charts.
C582	18A	18-59		Attachments 18A and 18B are very useful additions to Section 18.3.2. Statistical Means of Evaluating Performance Indicators-Control Charts. More specifically attachment 18A served as a guide to the various control charts and their use in the statistical evaluation of data sets. I did not take it upon myself to verify the solutions to the problems given in the section and suggest that this be done using an internal QA procedure for all statistical and numerical problems and equations throughout the MARLAP document.
C583	18B	18-71		Attachment 18B. No comments for this Attachment. With the exception of the equation indexing there are no problems with the References either in the body of the text or in the Reference section itself. The Problems and their solutions are well presented and the section is very useful as an illustration of additional statistical methods available to the user of control charts.
C584	19	All		The reference "Borak, Thomas B (editor), 2000. Application of Probability and Statistics in Health Physics" could be cited as a general supplementary reference for Chapter 19 (Measurement Statistics) of MARLAP. The book contains useful information on uncertainty analysis, Monte Carlo methods,

Row	Section	Page	Line	Technical Review Comment
				Bayesian statistics, etc.
C585	19.2.1	19-3	62	Page 19-7 makes it clear that "distribution function" is the same as "cumulative distribution function" (CDF) for those of us who are used to the more complete wording. Maybe it should be said here, too.
C586	19.2.1	19-3	89 ff	The discussion of mode seems incomplete. If mode means most likely value, then every point in a rectangular distribution would be a mode. To me, mode means a local peak in the density function. Then it is then easy for a function to be multi-modal without the peaks all being the same height.
C587	19.2.1	19-4	95	The median is unique except for the case where you have two non-overlapping segments. That is, if the likelihood is positive everywhere, the median is unique. Do we really need this sentence?
C588	19.2.1	19-4	95	How can the median not be unique? Isn't it where the monotonic CDF crosses 50%? Of course, a distribution could say that no values between x and y are possible, and that x just happens to be at the 50% mark of the CDF, but is that realistic for radioanalytic measurements?
C589	19.2.1	19-5	106-111	What do these lines mean? Correlated with respect to what?
C590	19.2.1	19-5	122-127	Use language that is more colloquial, with presentations of concepts that will be easier to understand by the target audience. For example, the presentation of statistical independence vs. correlation provided on page 19-5 lines 122-127 is unnecessarily complicated and probably not even necessary.
C591	19.2.2	19-6	158	Mode is non-rigorous - it is really a local maximum of the PDF - which is how we get multi-modal distributions.
C592	19.2.2	19-6	147-148	Estimator is defined as follows: "A random variable whose value is used to estimate an unknown parameter p is called an estimator for p". The definition as presented implies that only random variables are estimators. It would seem that some estimators may be deterministic.
C593	19.2.2	19-6	149-151	Related to the expectation value, it is stated that "_X, is a measure of the center of its distribution" referring to the distribution of random variable X. For discrete distributions, this definition is problematic. Consider for example a random variable X that takes on a value of 1 with probability p (where 0<p<1) and takes on a value of 0 with probability 1-p. In the case where p=0.6, _X = 0.6(1) + 0.4(0) = 0.6; a value not found among the values for X (only values of 0 or 1 can occur). Thus 0.6 does not represent the middle of the distribution for actual values taken on by X.
C594	19.2.2	19-6	149-151	"Expectation" is used instead of "expectation value". It seems that expectation value would be more appropriate.
C595	19.2.2	19-7	160-162	The definition for the "probability density function" as presented seems to exclude discrete distributions. The presented definition also does not help with distributions that cannot be adequately characterized using formal mathematical expressions (e.g. formal distribution functions such as normal and lognormal). It would be helpful to add a general definition of the "probability density" as it relates to discrete and continuous random variables. It would also be helpful to add definitions of unimodal and multimodal distributions.
C596	19.2.2	19-7	165-166	Random variable is defined as follows: "A random variable is the numerical outcome of an experiment which produces varying results when repeated." Random variables are not restricted to experiments.
C597	19.3.1, 19.3.2	19-8	181-237	Edit sections 19.3.1 and 19.3.2 for brevity and clarity
C598	19.3.3	19-10	261	Type A and B: all that is not A is B - nice definition. For type B you make a best guess?
C599	19.3.3	19-10	241 ff	I don't fully appreciate the difference between u and sigma. Is the point that the uncertainty u describes your lack of confidence in a specific measurement while sigma describes the variability of the measurement process? Perhaps a few more words on this point.
C600	19.3.8	19-13	333-334	I've always been a bit uncomfortable about the notation y +/- u for environmental measurements. It seems to imply a symmetric distribution, where the probability of an outcome less than y-u is exactly the same as the probability of an outcome more than y+u. But that doesn't hold for asymmetric distributions, does it? Although I know I am battling

Row	Section	Page	Line	Technical Review Comment
				decades or even centuries of tradition, maybe we should ask for a little more explanation.
C601	19.4.2	19-19	521 ff	I continue to find the issue of the MDC vs. the critical value difficult to understand intuitively. For example, I don't understand why the distribution on the right of Figure 19.3 shows more dispersion than the one on the left. I still struggle with the difference between the critical value and the MDC, although I do understand that the former is based on alpha and the other on beta. It might be clearer to say (if true!) that the critical value is more important when the null hypothesis is that the sample is not contaminated, while the MDC is more important when the null hypothesis is the opposite.
C602	19	19		Another relatively powerful test for normality is discussed in: Dallal, G.E. and L. Wilkinson. 1986. An analytic approximation to the distribution of Lilliefors test statistic for normality. American Statistician. 40: 294-296
C603	19	19		Overall impression of Chapter 19 main body - it is idiosyncratic. That is, it goes into great detail on stuff that may or may not be important and uses very general forms of equations that may not apply to the real world. A lot of effort goes into "uncertainty" calculations - but unless we assume normality it is hard to see what to do with the results. I'd like to see it start with counting statistics (page 19-44) and then proceed through a series of problems that treat typical or important cases, with generalizations left to footnotes or appendices.
C604	19.4.2	19-20, 19-22		Not real clear. What they want to say is that if the true analyte concentration is zero or "background," then counts greater or equal to Xc will be observed with probability (1-<alpha>). The minimum detectable value Xd is that amount of analyte which will yield a measurement less than Xc with probability <beta> or less. If this is right (I'm pretty sure it is), then these three pages are way too long.
C605	19.4.3	19-22	587-615	Do we really need to know about ISO versus IUPAC? This seems to beg for an appendix.
C606	19.4.6	19-25	670	One good idea that deserves expansion is putting important points in bulleted form in boxes. The box on the top of page 19-25 is a good example. It is, however, critical that these boxed "important points" be as clear as possible. That is, the box on 19-25 states: "A measurement result should not be compared to the minimum detectable concentration to make an analyte detection decision. A detection decision may be made by comparing the gross signal, net signal, or measured analyte concentration to its corresponding critical value." This is an important recommendation that should be illustrated at this point by an example.
C607	19.5.2.2	19-31	810	Why is Equation 19.8 needed? If the distribution is uniform, a probability interval (1-<alpha>) is defined by 2a x (1-<alpha>).
C608	19.5	19-33	847 ff	Equation (19.11) on page 19-33, for combined standard uncertainty, is only an approximation, not an equality. Admittedly, the text does state that "the variance of *y* is *estimated* using the [uncertainty propagation] formula" (emphasis added), but the presentation on this page does not clearly stress that the formula is an approximation, nor does it indicate the conditions under which this approximation would tend to be valid. In fact, both the use of an equal sign in Equation (19.11) and the use of terminology such as "*the* uncertainty propagation formula" or the "*law* of propagation of uncertainty" give the impression that the relationship in Equation (19.11) is an equality rather than an approximation. The report eventually clarifies the situation somewhat on page 19-38, where it states, "The formula is derived from a linear approximation of f (i.e., a first-order Taylor polynomial)." However, the report should state this whenever the formula is first introduced.
C609	19.5.3	19-35	874	Looks like more appendix material. Would most users have a clue about the example? Moreover, is the resulting uncertainty useful? That is, is the result normal? If not what do we do with a variance or standard error?
C610	19.5.5.1	19-38, 19-39		Why? What are they trying to say? Is it important? Will anybody use it? What problem does it solve?
C611	19.6.2	19-44	1040	It is important to get the most important material in at the start. For example, there is a nice discussion of counting statistics starting on page 19-44. This should be at or near the start of Chapter 19.

Row	Section	Page	Line	Technical Review Comment
C612	19.6.2	19-46	1084 ff	If it is clearly Poisson with a low mean, the distribution is skewed; what's the point in estimating the standard deviation?
C613	19.6.5	19-52	1219	What do we mean by "counting efficiency"? I assume it is the number of particles detected over the number actually emitted, right?
C614	19.6.9	19-58, 19-59		On pipettes etc, how often is this material (the math) actually used?
C615	19D.2	19-121	2557	The example on Page 19-121 is an exact duplicate of the one on page 19-69, line 1634. Throughout the chapter, it would be helpful to number the examples to avoid duplication and facilitate reference in the text.
C616	19E	19-135		Section 19E needs to be brought forward
C617	19F	19-149		On a technical note, for normality testing the authors might want to look at: Looney, S.W. and T.R. Gulledge. 1985. Use of the Correlation Coefficient with Normal Probability Plots. American Statistician. 39: 75-79. This is an update of the earlier paper they discuss in goodness of fit testing.
C618	19	19-1		Most of the material on the subject of "measurement statistics" is contained in Chapter 19. This Chapter starts out with a very clear presentation, and with very clear recommendations and examples. However, the clear recommendations and examples fade later in the chapter, just when the material becomes more difficult and when clear recommendations and examples are needed.
C619	19	19-1		In some cases the material appears to be arcane and takes on the appearance of material written by a bunch of statisticians with no reality checks by persons who work in radiochemical laboratories. One of the things that strikes me as unchecked against reality is the indication that a correction for buoyancy is needed when weighing material on a laboratory scale. There are other examples of details included in the material that appear to be unrealistic in terms of having any real impact upon measurement uncertainty. At the same time other sources of uncertainty, especially those that cannot be defined ahead of time, are not treated well.
C620	19	19		Lower case p is used for parameter, percentile, and probability at various points. You could consider other choices that would reduce the potential for confusion, such as Greek letters for parameters, Roman letters for estimators, and pr for probability.
C621	19	19		The general impression of our team was that the technical presentation, while statistically sound, might be too complex for the target audience of lab directors and staff. We have several suggestions that might help to make this chapter and several of the appendices more understandable to non-statisticians.
C622	19	19		Overall the reviewers feel that there is too much material for one chapter in chapter 19. We suggest dividing the chapter into two sections, one on measurement, detection and quantification, the other on uncertainty evaluation and expression.
C623	19	All		Essentially all of Chapter 19 is devoted to the use of "a priori" data; further, the name Bayes is mentioned only once. It seems to me that, in reality, there can be many sources of uncertainty in analytical procedures that are not recognizable in advance and cannot be quantified using the material in Chapter 19. Thus, it is perhaps more realistic to use "a posteriori" data and Bayes Rule to derive realistic limits of minimum detection, etc. This has been the subject of recent literature; the absence of any information on this technique is a serious omission in MARLAP.
C624	19C	19-105		Eliminate or revise attachment 19C on coverage factors. As currently written, it is doubtful that anyone without a Ph.D. in statistics with experience in laboratory uncertainty analysis could implement this methodology.
C625	19D	19-109		Revise attachment 19D to explain when someone should consider formulas A, B, and C, the Stapleton approximation, or the exact test. Does MARLAP have a preferred method? If so, it should be clearly stated, along with recommendations for situations when one of the other methods is preferable.
C626	19D	19-109		Attachment 19D has a lot of interesting material on "Low-Background Detection Limits." This is interesting, but there are many options given on how to calculate the detection limits, and no recommendations are given. This is a specific

Row	Section	Page	Line	Technical Review Comment
				example of where recommendations would have been useful.
C627	19.3.8	19-13	357-360	I am not entirely comfortable with the recommendation on page 19-13 that laboratories should report negative values when they are obtained, even if physically impossible. I understand the rationale for this, i.e., that laboratories should provide as much information as possible (to allow a complete evaluation), rather than censoring their results. However, reporting of physically impossible negative values can also be confusing. This is one of the advantages of Bayesian statistics, namely, with a non-negative prior distribution, one can ensure that the posterior distribution will take on only non-negative values. I do not have any strong ideas about how to solve this problem, since I realize that there are many obstacles to adoption of Bayesian analysis for these purposes, but just wanted to point out my discomfort. One way around the situation might be to recommend that labs report negative values when obtained, but clearly state that they are physically impossible, and provide guidance for how they should be interpreted, e.g., "the presence of negative values indicates that the uncertainties in the measurement are large relative to the amount of radioactivity, if any." This may help to reduce the likelihood of misinterpretation by users of laboratory results without much knowledge of statistics or radioactivity.
C628	19.3.10	19-15	386-442	Much of the terminology for measurement uncertainty presented in Section 19.3.10 (e.g., "standard uncertainty," "expanded uncertainty," "coverage factor," "Type A," "Type B") seems non-standard and confusing to me. For example, "standard deviation" seems clearer than "standard uncertainty"; "upper and lower confidence limits" seems clearer to me than "expanded uncertainty" (which somehow gives the impression that the uncertainty has been exaggerated, or expanded beyond its actual measured extent!); and "subjectivist and classical statistical methods" seems clearer to me than "Type B and A evaluations." However, I recognize that the terminology used here may be standard in metrology, which is not my field
C629	19.3.10	19-15	386-442	A simple figure or example accompanying this list of definitions would help the reader to understand the nuances among the different terms used for measurements, estimates, errors, and uncertainties. For example, describe the analysis for a soil sample associated with a site cleanup. Different types of measurements and estimates associated with the results could include the following: raw counts/minute (measurand and input estimate) and sample weight (measurand and input estimate), leading to a calculated sample activity in cpm/g (input quantity), and associated dose estimate (output quantity). A list of the potential errors associated with the dose estimate could include (a) counting error? (the definition on lines 391-392 is a bit ambiguous about whether or not this term is to be used), and (b) measurement error, which includes (b1) spurious error, due to (b1a) random error, (b1b) malfunction, or (b1c) similar types of events, as well as (b2) systematic errors. The example should include specific and realistic descriptons and numerical values for each one of these types of errors and for the uncertainties associated with each one, and then calculate the standard, combined, expanded, and total propagated uncertainties, along with the relative uncertainty for at least one of these categories.
C630	19.4.1	19-18	492-493	Page 19-18 states, "The significance level <alpha> is usually chosen to be 0.05." This is certainly a true statement, and if laboratories are going to choose a significance level on their own (e.g., because the customer for the test does not specify a significance level), that is the value I would want them to use. However, sophisticated users of laboratory services may occasionally want to specify another significance level, because of the relative importance of type I versus type II errors. For example, in some situations, it may be particularly important to detect contamination if it is present, in which case a user may be willing to accept a higher significance level than 0.05. The report should perhaps note that fact.
C631	19.4.1	19-18	497-500	The report defines the term "blank" informally at the bottom of page 19-18, but it should also be included in the summary of terms related to detection and quantification capability in Section 19.4.7. The discussion may also need to be expanded and clarified, as the report uses a variety of terms, such as "blank signal," "instrument blank," "blank measurement," "blank material," "blank count," and the like. I had to figure some of them out from context, and the definitions may not

Row	Section	Page	Line	Technical Review Comment
				always be clear to people who are not familiar with the terms. For example, some readers could misinterpret a "blank count" as referring to an observed count of zero (e.g., no radioactivity detected), rather than a count from a sample that contains none of the substance being analyzed (whether zero or not).
C632	19.5.2.1	19-30	790-797	On page 19-30, Section 19.5.2.1 discusses the computation of experimental covariance for evaluations of Type A. However, Section 19.5.2.2 contains no comparable discussion of covariance for Type B evaluations. I recognize that estimating covariance or correlation subjectively is an extremely difficult task. However, if correlation is important enough to be worth discussing for evaluations of Type A, it is presumably also important for Type B evaluations. One good reference on the subject is "Assessing Dependence: Some Experimental Results," by R. Clemen, R. Winkler, and G. Fischer, Management Science, 46 (2000), 1100-1115.
C633	19.5.3	19-33	848-856	Equation (19.11) on page 19-33, for combined standard uncertainty, is only an approximation, not equality. The report eventually admits this on page 19-38, which says, "The formula is derived from a linear approximation of f (i.e., a first-order Taylor polynomial)." Therefore, it is exact only for simple additive functions (or for multiplicative functions when the factors are independent). In other cases, the analyst would need to know the entire distribution of the input variables (not merely their standard deviations) to find the standard deviation of the result. When the first-order Taylor polynomial is not sufficiently accurate, analysts can use Monte Carlo simulation to propagate uncertainty. The report should probably note this (at least in a footnote), preferably with one or more references. Admittedly, when uncertainties are small, the errors associated with the first-order Taylor polynomial are likely to be small. However, the report should clearly state that the formula is an approximation when it is first introduced, and the terminology "law of propagation of uncertainty" should be avoided if possible. I also strongly recommend using an "approximately equal" sign instead of an equality sign to avoid confusion
C634	19.5	All		The discussion of uncertainty propagation in subsections 19.5.3 (Combined Standard Uncertainty), 19.5.5.1 (uncertainty propagation for nonlinear models), and 19.5.5.2 (Bias) is both incomplete and potentially misleading. In particular, the methods presented are only approximate, but this is not always clearly stated. The report also does not give references to approaches that would be more generally applicable when the approximate methods presented here are not appropriate.
C635	19.5	All		Similar problems of notation (presenting approximations as equalities) appear throughout Section 19. Admittedly, when uncertainties are small, the errors associated with the first-order Taylor polynomial are likely to be small. However, the report should clearly state that the formula is an approximation when it is first introduced, and misleading notation and terminology (such as referring to the formula as the "*law* of propagation of uncertainty") should be avoided if possible
C636	19.5.3	19-34		It would also be helpful if the terminology and notation clearly indicated (both in these subsections and throughout Section 19) the approximate nature of most of the calculations. To give an indication of the nature of the problem, consider Table 19.1, which presents applications of the uncertainty propagation formula to various mathematical expressions. The table shows all of the results as equalities, even though the uncertainty propagation formula is only approximate for all applications shown in the table except to sums and difference. By contrast, in the last row, the table uses an "approximately equal" sign to indicate that (ln 10)^2 is only *approximately* equal to 5.302. This latter result is at least accurate to four significant figures, while in some cases, the results presented as equalities might not be accurate to even a *single* significant figure!
C637	19.5	19-35	783-1023	I agree with Rick Hornung's observation that in the examples presented here, "the uncertainties for each of the input parameters ... are already provided." In my view, this is a serious shortcoming. Methods for subjectivist (i.e., Type B) evaluations of uncertainty are a whole subfield of Bayesian statistics and decision analysis; I can provide some references on request.
C638	19.5	19-35	783-1023	The examples in this section also all involve extremely small uncertainties. These may well be representative of the

Row	Section	Page	Line	Technical Review Comment
				uncertainties arising from lab work, but that is not clear, and someone knowledgeable about radiological laboratory measurement should assess the reasonableness of the uncertainty estimates used in the examples. My own personal suspicion is that while statistical uncertainties (e.g., variability between replications of the same measurement) may tend to be small, that will not always be the case (e.g., with poor laboratory procedure). More significantly, I would expect that systematic error (or "bias" -- for example, due to use of inappropriate laboratory methods, contamination of samples, etc.) would tend to be much larger than statistical variability, and probably larger than the uncertainties given in many of the examples in this section.
C639	19.5.3	19-35	874-904	Similar to the case for Equation 19.11, the example on page 19-35 appears to compute the output estimate A as a function of the mean values of the various input parameters. Again, this is an approximation based on a first-order Taylor polynomial. In fact, assuming that the mean of a function is equal to the function of the mean is one of the most common and most serious fallacies of novices in probability. This is acknowledged only several pages later (on page 19-40), and in a rather roundabout way (i.e., "If f is nonlinear, its nonlinearity may also tend to bias the output estimate y"). This vague explanation may lead to confusion about the use of the term "bias" on page 19-41. As before, the report should clearly state that the formula is an approximation when it is first introduced, and I would recommend using an "approximately equal" sign instead of an equality sign here (and throughout the report, when presenting approximations).
C640	19.5	All		Experience in situations where the uncertainties are substantial has made some committee members leery of first order error propagation. When uncertainties are large and it is important to have a good estimate of their magnitude, it is preferable in our view to develop a good description of the process generating the uncertainty and the error distributions involved, and then do a Monte Carlo analysis. In Section 19.5.5.1, the report does show how to include higher-order terms in the uncertainty propagation formula. However, the version of the uncertainty propagation formula presented in this subsection assumes that "all the input estimates x{sub i} are uncorrelated," and no mention is made of Monte Carlo simulation as an alternative to the uncertainty propagation formula when uncertainties are substantial and the approximations given here are not valid.
C641	19.5.5	All		Even a second order Taylor polynomial can be inaccurate when uncertainties are large and the function of interest exhibits significant nonlinearities. In such cases, the analyst needs to know the entire distribution of the input variables (not merely their marginal variances) to find the variance of the result. Analysts can use Monte Carlo simulation to propagate uncertainty in such cases, and in principle can achieve any desired level of accuracy by increasing the number of simulation replications. The report should note this (at least in a footnote or an appendix), and should provide one or more references. In fact, the discussion of second order Taylor polynomials could also go in an appendix, and in any case second order Taylor polynomials should not be featured more prominently in the discussion of uncertainty analysis than Monte Carlo simulation.
C642	19.5.5.2	All		Section 19.5.5.2 claims to be a discussion of bias. However, this section does not seem to be using the term in the usual statistical sense, as discussed on pages 19-5 and 19-6, but rather refers to the potential inaccuracy of the Taylor polynomial approximation. Moreover, the estimate of bias given by Equation (19.18) appears to be itself a Taylor polynomial approximation. Rather than providing an estimate of the bias from use of the Taylor polynomial, the committee would prefer a qualitative discussion of situations in which this approximation is not accurate (e.g., when the uncertainties span a range sufficiently large that the function of interest is not approximately linear over that range). The report should also recommend the use of Monte Carlo simulation in such cases.
C643	19B	19-97		Appendix 19B should be eliminated.
C644	19B	19-97		It seems to me that some of the potentially most useful information relates to the use of vectors and matrices to examine larger bodies of data and to use least-squares approaches. However, this material is not well developed; specifically, a

Row	Section	Page	Line	Technical Review Comment
				good example of these techniques should be given.
C645	20	All		Should a reference be made as to where the CFRs are to be found?
C646	20	All		I am impressed with the Chapter. However, I must add that I am not an expert in Waste Management. The Chapter has good flow. The second paragraph in the introduction is a nice road map that tells what the Chapter is all about. The Chapter, out of necessity, gives general guidelines and then lists specific references to lead readers to areas for more detailed information.
C647	20	All		Hyphens. The new rule with regard to hyphens is to use fewer of them, especially on "non" words. Therefore, I recommend taking out the hyphens of the following words: nonradioactive (lines 28, 92, 93, 97, 145, 152, 153), multiservice (line 26), degreasers (Table 20.1, row 3), biphenyls (Table 20.1, row 14), nonhazardous (lines 123, 137), microscale (line 130), reuse (line 140)
C648	20.6.1	20-10	275	should this be rewritten since October 2001 has passed?
C649	20.6.2.4	20-12	337	Think you mean "airborne radioactivity", not "radiation".
C650	20.8	20-16	451	The section, 20.8, Useful Web Sites, is an excellent addition to the Chapter. (However, just before final publication someone should check all of them to be sure they are all correct and active.)
C651		All		The appendices are inconsistent in how sections are numbered: e.g., A.12.6, D2.6
C652		All		There is not adequate advice to laboratories on how they check their own data Chapter 7.3 and 7.4 and tie in Chapter 17 with Chapter 8, 9. Consumer advice is present on how to verify and validate data, but no parallel advice to labs on how to check their own data. Verification is possible but not validation. What advice do we give to the lab to verify data? Set up Quality Assurance and/or Quality Control and reporting format criteria. Page 17.39 talks about data packages.
C653		All		Another potential problem is that many of the manual's chapters are written as if directed toward project managers in the sponsoring organization, while others are written as if directed toward the laboratory personnel, cautioning them about mistakes the sponsors could make (e.g., Chapter 11).
C654		All		The document would benefit from an index
C655		All		Use of traditional units in parentheses is uneven - RAC should decide to recommend this practice, or not, and then suggest that use or no-use be applied uniformly
C656		All		Use the same reference format throughout the text.
C657		All		Sometimes text is too specific and as the information is often not complete anyway, and it is stated in the MARLAP document that the intention is not to provide guidance in sampling, there should be some rewrite.
C658		A11		Throughout the document, the words radioactivity or isotope(s) are used when radionuclide(s) is the appropriate term.
C659	B3.1	B-4	96	The recommendation to show a "site conceptual model" presumes that the decision relates to the remediation of a site, which isn't always the case. Maybe add "and appropriate" after "possible". Also, at the end of this subsection it might be useful to add an example "concise description".
C660	B3.3	B-6	155	Remove "compatible" or "in complete agreement".
C661	B3.6	B-9	247	"exits" should be "exist". Also, I would prefer a more concrete example of the decision rule.
C662	B3.7	B-9	258	Might follow this sentence with a cross reference to B-1.4, where the choice of the null hypothesis is discussed.
C663	B3.7	B-10	298-299	Is it an "action limit" or "action level"?
C664	B3.8	B-12	347-554	Same comment as for section 2.5.4, lines 475-482. This is a good place to point out that it may be more important and useful to obtain lots of data of only modest quality (e.g., ±30%) rather than few samples of very high quality (e.g., ±1%). For example, screening for hot spots, collecting reconnaissance data from an area about which little is known, collecting water samples for radon analyses under conditions for which where it is known or suspected that the sample may outgas highly, collecting data for a purpose for which a precise method not needed, and when field sampling uncertainties may

Row	Section	Page	Line	Technical Review Comment
				overwhelm analytical uncertainties.
C665	B-1.4	B-18	507-508	I don't see why the project planning team is more likely to discover a mistake in a high reading than a low one if they are indeed wedded to a null hypothesis that contamination exists.
C666	B-1.6	B-21	606	It is easy to read this section as saying that one defines the gray region in terms of the MDC. I think it is really the other way around, as suggested in Appendix C: One uses the decision parameters to define the gray region and then calculate what MDC is needed to support it. Maybe a cross reference to Appendix C here.
C667	C.3	C-4	97	It was not entirely clear to me whether the sigma squared sub s here is the variance of the distribution or the variance on the mean of the distribution. I suspect that it is the latter because the decision regards the sample mean. In any event, some clarification is in order.
C668	C.3	C-4	110	It is not clear to me that one CAN control sigma sub s. The statement would still be true, but is "easier" the right word? What did the writer have in mind?
C669	C.3	C-5	140-146	Same comment as for section 2.5.4, lines 475-482. This is a good place to point out that it may be more important and useful to obtain lots of data of only modest quality (e.g., ±30%) rather than few samples of very high quality (e.g., ±1%). For example, screening for hot spots, collecting reconnaissance data from an area about which little is known, collecting water samples for radon analyses under conditions for which where it is known or suspected that the sample may outgas highly, collecting data for a purpose for which a precise method not needed, and when field sampling uncertainties may overwhelm analytical uncertainties.
C670	D2.7.1	D-13	366	According to your convention, shouldn't "false positive" be "Type II error"?
C671	F	All		This appendix is thought-provoking and is a step toward quantifying uncertainty in sub-sampling, despite the disclaimers.
C672	F.3.2	F-6	152-159	Sections of Chapter 12 , which have more detailed descriptions of equipment used to mix and grind solid samples and methods for decontamination should be cross-referenced from here.
C673	G	G-1		The table of contents indicates that a glossary will be provided. As this is being done, it may be useful to place in bold font, terms in each definition that are further defined in the glossary.
C674		All		The boxed Summaries of Recommendations seemed useful and easy to understand. However, it was not clear to me whether there were too few of them relative to the large amount of detail given in each chapter.
C675		All		Overall, Chapters 10-18 and 20 and the associated appendixes represent an enormous effort and supply a vast amount of information on radioanalytic laboratory procedures in support of environmental health decisions. No important area of concern appears to me to have been overlooked. The advice given is well supported by extensive citations to the scientific literature and bibliographic compilations of related documents and sources. The chapters are generally well organized and the exposition is generally clear; typographic and grammatical errors are minimal. Whatever concerns I have about these chapters tend to be minor, and I consider none to be fatal.
C676		All		I am somewhat concerned that some of the chapters may not be as usable and user-friendly as others. Contrast, for example, Chapter 18 on Laboratory Quality Control with Chapters 13-15 on the details of laboratory procedures. Chapter 18 is quite specific in its advice for maintaining quality through performance indicators, and maintains a consistent format for describing each indicator. Chapters 13-15, especially 15, tend to be more encyclopedic and descriptive, without as much clearcut advice. Although I understand that the MARLAP team deliberately avoided making specific recommendations for choice of analytic procedure, a choice that I support, I wonder whether a laboratory tasked with analyzing a specific set of samples will easily find the information it needs in these comprehensive chapters. Perhaps what is needed is a section on "how to use this document" where a laboratory would find directions on how to find the critical information for its needs. For example, if it receives samples of soil thought to contain radium-226 and uranium 238 and 234 as nuclides of concern, along with suspected non-radioactive metals as well as some other nuclides that might cause

Row	Section	Page	Line	Technical Review Comment
				interferences, and the soil is described as having likely having certain characteristics such as particle size distribution, moisture and organic content, pH, etc., then how do they find advice on how to prepare the samples, dissolve and separate them as necessary, and count or otherwise analyze them? What are the principal errors that are most likely for this kind of sample and analytes?
C677		All		Many of the references to analytical methods appear to be old (1950s and 1960s). They may be valid and the best available information but it seems odd that there is not more recent information.
C678		All		We suggest that Part II be divided into two volumes to facilitate convenient use in the laboratory. A reasonable separation may be between chapters 10 – 14 plus 20 and 15 – 19. The former chapters pertain mostly to chemistry and the latter, to radiation detection.
C679		All		We suggest that the format for reporting environmental radionuclide data should depend on the end use of the data and the necessary transmission of information to the reader. Specifically, care should be taken in reporting radionuclide concentrations that are negative due to subtracting the radionuclide background, or are below the level of detection as determined from counting statistics. Such numbers should be reported for subsequent use in compiling or averaging the data, or for evaluating the reliability of measurements near the limits of detection. For use in describing environmental contamination to the public, the facility operator, and regulators, such numbers should be replaced by "less-than" values or a statement of non-detectability.
C680		All		Cite the original reference for a method as the method is discussed instead of combining all references at the end of the subsection.
C681		All		With respect to Charge Question # 3: As nearly as I can tell, the material is technically accurate. However, I think the material could be more clearly and usefully presented. Lacking a more clear presentation, I doubt that "appropriately trained personnel" can implement much of the material.
C682		all		Another aspect that I believe to be very important is that of establishing criteria for the rejection of analytical results when samples are processed as batches. That is, criteria for when the entire batch of results should be rejected based upon information for quality control samples and blanks processed with a particular batch. This is a very important subject for contracting (Appendix E) and for laboratories themselves when processing batches of samples for, for example, the analysis of 239,240Pu. I think this subject should be dealt with much more extensively.

APPENDIX D—EDITORIAL REVIEW COMMENTS

Row	Section	Page	Line	Editorial Review Comment
D1	TOC	X		Typo in title for section 2.5?: Should this be "Directed"?
D2	List of figs	XLI	Fig. 14.4	Missing first word of figure caption ("The")
D3	List of figs	XLI	Fig. 14.1	Figure 14.1 caption includes a mysterious superscripted number (1)
D4	Acronyms	XLVII		I like the format of this list, in which bracketed numbers indicate the first chapter in which the acronym appears.
D5	Acronyms	XLVII		Proposed additions to acronym list: parameter symbols, at least the most common ones (alpha, beta, del, sigma). Also ACE, Bq, NIM, MCL [2:289], GEDD [17:1031], E, U, Q, J, R [8:264-276]
D6	Acronyms	XLVIII		Check whether the I in ERPRIMS stands for anything (a logical guess would be "Information").
D7	Acronyms	XLVIII		ESC actually first appears in Chapter 2, on page 2-5, lines 119-120
D8	Acronyms	XLVII		I think some of the acronym definitions should probably be capitalized instead of all lower case. Examples: SAFER, ESC, DQO. Seems to be a bit arbitrary as to when an acronym's definition is capitalized and when it is not (e.g., SOW but not RFP or RFQ).
D9	Acronyms	XLIX		MDC actually first appears in Chapter 2, on page 2-16, line 451
D10	Acronyms	LI		I suggest that the definition of TPP be followed by "[process] (ACE)"
D11	1.1	1-1	6	Change "its" to "their"
D12	1.2	1-2	56	Change "its" to "their"
D13	1.4.1	1-5	Fig 1.1	Note that QC, which appears in Fig 1.1, has not yet been defined for the reader at this point.
D14	1.4.1	1-5	Fig 1.1	The font in Fig. 1.1 is uncomfortably small for us post-40-yr-old readers.
D15	1.4.4	1-7	221	Delete phrase, "It should be noted that"
D16	1.4.4	1-7	228	Delete "for the various activities."
D17	1.4.4	1-7	Fig 1.2	Note that QA/QC, which appears in Fig 1.2, has not yet been defined for the reader at this point.
D18	1.4.4	1-7	Fig 1.2	The font in Fig. 1.2 is uncomfortably small for us post-40-yr-old readers.
D19	1.4.4	1-8	232	Missing period
D20	1.4.5	1-8	237	Delete "the relevant activities, such as"
D21	1.4.5	1-8	240-242	Delete the sentence starting with "A written procedure…" This is an unnecessary detail.
D22	1.4.7	1-8	258-305	This section was well-written.
D23	1.4.7	1-8	260	Awkward wording: "generally the word always refers to…." Delete either "generally" or "always".
D24	1.4.7	1-9	276	Typo: "expanded"
D25	1.4.7	1-9	292	Replace "since" with "because". "Since" is used to refer to passage of time (although I know this rule of thumb is commonly ignored).
D26	1.4.7	1-10	301	Replace "since" with "because".
D27	1.4.8	1-10	306 ff	This is a wonderful discussion on precision, bias, accuracy, uncertainty, etc.
D28	1.4.8	1-10	306-348	This section was well-written.
D29	1.4.8	1-10	309	Replace "since" with "because".
D30	1.4.8	1-10	323-324	Delete "depending on one's point of view"
D31	1.4.8	1-10	324	Correct section reference to "1.4.7"
D32	1.4.8	1-10	326-332	Suggest deleting these last 3 sentences. They are a bit confusing and seem an unnecessary level of detail for this discussion.
D33	1.4.8	1-10	328	Replace "is" with "are"
D34	1.4.8	1-11	335	Replace "since" with "because".

Row	Section	Page	Line	Editorial Review Comment
D35	1.4.9	1-11	352-354	Replace semi-colons with commas.
D36	1.4.10	1-12	387	Replace "since" with "because".
D37	1.4.10	1-12	387-389	Delete the second half of this sentence because this is the subject of the following paragraph that starts on line 396; no need to state it twice. Deleted part: ", and since most projects require that a number of different analyses be performed, several APSs will normally be developed for a particular project."
D38	1.4.10	1-13	399-402	Delete the sentence starting with "However, the level of specificity.." because this was discussed in the previous paragraph on lines 391-392. Move the following sentence about the one-page form to the end of the previous paragraph (line 395). Delete the last sentence; it's already been said.
D39	1.4.11	1-13	410-412	Delete the first sentence, and replace "The" with "MARLAP's" in the second.
D40	1.4.11	1-13	416	Delete left parenthesis
D41	1.4.11	1-13	417	Missing period
D42	1.6.1	1-17	500	Replace the last part of the first sentence so that it reads "an overview of the directed planning process and its outputs."
D43	1.6.2	1-18	550	Need to correct the title listed for Chapter 10
D44	1.6.2	1-19	550	Need to correct the title listed for Chapter 10
D45	1.6.3	1-19	578	Delete "to both Part I and Part II of the manual" and replace "several" with "the following"
D46	1.6.3	1-19	579	Delete the last sentence.
D47	1.6.3	1-19	583	Replace "Data Quality Objectives" with "DQO" to match the title that appears in the Table of Contents and at the beginning of this Appendix
D48	1.6.3	1-19	587	Should "select" be "selected"?
D49	1.6.3	1-19	588-594	Note that the bullets for Appendices D through G don't describe their contents except by restating the titles; I suggest just listing the titles alone.
D50	1.7	1-20	605	Couldn't get to the MARSSIM web site using this address. Replace "/filesfin.htm" with "/obtain.htm". Consider including in the reference list, the date when the web site was most recently confirmed as being accurate.
D51	1.7	1-20	607	Capitalize the first letter in "Available". Verify the web site address.
D52	1.4.1	1-5	Fig 1.1	I liked this Figure 1.1 because it clearly presented the concept of a Data Life Cycle without a lot of words.
D53	2.1	2-1	11	Replace "of" with "on"; replace "achieve" with "support" (to match the use of this word on line 4).
D54	2.1	2-1	13	Refer to plural: "objectives" and "are"
D55	2.1	2-1	20	Add some punctuation to this phrase, e.g. "…experts--in particular, radioanalytical specialists--in the planning…"
D56	2.1	2-1	24	Spell out SOW
D57	2.1	2-1	25	Delete "--DQA"
D58	2.1	2-1	26	Use the present tense instead of the future tense by replacing "will use" with "uses".
D59	2.1	2-2	31-33	Move the second sentence to the end of the paragraph. Delete the name of the referenced chapter; the chapter number alone is adequate.
D60	2.1	2-2	31-41	Use the present tense instead of the future tense throughout this paragraph (i.e., delete the word "will")
D61	2.1	2-2	44	Typo, should refer to Section 1.4.1, not 1.4.7
D62	2.1	2-2	45-47	Delete the parentheses and replace the left-hand parentheses with the word "because".
D63	2.2	2-3	75	Insert comma after "stakeholders"
D64	2.2	2-3	81	Define QC
D65	2.2	2-3	84	Replace "is" with "are"
D66	2.3.2	2-4	113-131	The titles of these ASTM references are slightly different from those listed in the reference section, e.g., "Guide" on line 118 but "Guidance" on line 745; "Characteristics" on line 123 but "Characterization" on line 748; the word "for"

Row	Section	Page	Line	Editorial Review Comment
				following "Guide" on lines 747, 738, and 743 but missing from lines 123, 128, and 131; and the location of the procedure number with respect to the title.
D67	2.3.2	2-5	139, 142	Need to indicate 2000a and 2000b to distinguish these two EPA references.
D68	2.3.2	2-5	143	Acronym ACE used here; Chapter 4 uses "USACE"
D69	2.3.2	2-6	152	Need to specify either 2000a or 2000b to identify which EPA reference is meant here
D70	2.3.3	2-6	176	Insert "only": "If only a cursory job…"
D71	2.3.3	2-7	190-191	I suggest deleting the name of the referenced chapter. The chapter number alone is adequate.
D72	2.4	2-7	195	Insert commas: "who have a vested interest in, or who can influence, the outcome"
D73	2.5	2-9	252	Typo in title for section 2.5?: Should this be "Directed"?
D74	2.5	2-9	263	Insert "(APSs)" at end of sentence.
D75	2.5	2-10	276	Replace "lab" with "laboratory"
D76	2.5	2-10	277	Insert comma after "design"
D77	2.5	2-10	289	Hyphenate "resource-effective"
D78	2.5	2-10	Table 2.1	Row 1, Column 3, bullet 2, line 3:replace "is" with "are" ["the underlying data that are…"]
D79	2.5	2-11	Table 2.1	Row 2a, Column 3, bullet 1, line 2: insert comma after "measured"
D80	2.5	2-11	Table 2.1	Row 2b, Column 2, last line:replace "is" with "are" ["if new data are needed"]
D81	2.5	2-11	Table 2.1	Row 2b, Column 4, bullet 4, line 1: delete premature period
D82	2.5	2-11	Table 2.1	Row 3a, Column 3: make the format of these bullets consistent with other entries in this column: "Identify potentially…" and "Estimate measurement uncertainties…" Note that "uncertainties" should be plural here because "protocols" is plural.
D83	2.5	2-11	Table 2.1	Row 3b, Column 3, bullet 2, line 4: Insert comma after "protocols" and insert "if" after "or": "protocols, or if the…"
D84	2.5	2-11	Table 2.1	Row 3b, Column 4, bullet 2, line 1: Replace "Define" with "Definition of"
D85	2.5.1	2-12	347	Replace ""making a decision" with "needing a decision to be made"
D86	2.5	2-12	Table 2.1	Row 4, Column 1: Use lower case for all words but the first one, to match format of the other rows in this column.
D87	2.5	2-12	Table 2.1	Row 4, Column 3, bullet 3, line 1: would read more smoothly if "Method requirement" were replaced by "Methods required"
D88	2.5	2-12	Table 2.1	Row 4, Column 3, bullet 6, line 1: replace "quality control" with "QC"
D89	2.5	2-12	Table 2.1	Row 4, Column 3, bullet 9, line 2: Replace "Analytical Protocol Specifications" with "APSs"
D90	2.5	2-12	Table 2.1	Row 4, Column 4, bullet 3: Replace "Analytical Protocol Specifications" with "APSs"
D91	2.5.1	2-13	354	Replace "projects's" with "project's"
D92	2.5.2.1	2-13	378	Replace "criteria" with "criterion" to match rest of the list in this sentence
D93	2.5.2.1	2-13	379	Replace "the type of medium" with "a specific type of medium"
D94	2.5.2.1	2-14	388	Delete "probably". Insert hyphen in "radionuclide-specific"
D95	2.5.2.1	2-14	389	Insert "(MCL)" after "Maximum Contaminant Level" (and add it to the list of acronyms)
D96	2.5.2.1	2-14	393	Delete "of the directed planning process"
D97	2.5.2.1	2-14	398	Delete "of Chapter 3"
D98	2.5.2.1	2-14	400	Replace "Analytical Protocol Specifications" with "APSs"
D99	2.5.2.2	2-14	402	Reverse order of words: "team should define clearly…"
D100	2.5.2.2	2-14	403-404	Replace "The scale" with "The spatial and temporal boundaries" and delete "based on the spatial and temporal boundaries"
D101	2.5.2.2	2-14	407	Insert comma after "shape"

Row	Section	Page	Line	Editorial Review Comment
D102	2.5.2.3	2-15	423	Delete "(e.g., mean concentration)"; repetitive of its appearance on line 418
D103	2.5.2.3	2-15	423	Insert "statistical" after "appropriate"
D104	2.5.2.4	2-15	425-426	The second half of this sentence would read more smoothly if it were revised to read, "…a list of the specific data requirements (number, type, quality)."
D105	2.5.3	2-15	444	Change the colon to a semi-colon
D106	2.5.3	2-15	444	Replace "will" with "must"
D107	2.5.3	2-16	445-446	I suggest deleting the name of the referenced chapter. The chapter number alone is adequate.
D108	2.5.3	2-16	457	Replace "decisions" with "decision"
D109	2.5.3	2-16	458	Capitalize the first letter in "See"
D110	2.5.3	2-16	460	Should it be "maker's" instead of "makers' "? I've seen it both ways in this chapter (e.g., maker in row 1, column 4 of Table 2.1 and on line 722)
D111	2.5.3	2-16	464	Replace "Type I or Type II" with "decision"
D112	2.5.4	2-17	476	Insert "and" after "number of samples required"
D113	2.5.4	2-17	476	Replace "Analytical Protocol Specifications" with "APSs"
D114	2.5.4	2-17	477-479	Replace the long parenthetical reference with a shortened version: "(see sections 2.5.4.1 and 2.5.4.2 below)"
D115	2.5.4	2-17	496	The sentence would read more smoothly by shifting the location of "which" and deleting the comma: "to identify which portions of the analytical protocols potentially have…"
D116	2.5.4.1	2-18	507-508	I suggest deleting the name of the referenced chapter. The chapter number alone is adequate.
D117	2.5.4.2	2-18	526	Replace "lab" with "laboratory"
D118	2.5.4.2	2-18	533	Should "select" be "selected"?
D119	2.5.4.2	2-18	535	Insert apostrophe in "analyte's"
D120	2.5.4.2	2-19	542	Replace "Appendix D, Section 2.7" with "Appendix Section D2.7"
D121	2.6	2-19	544-545	Replace "their priority of concerns" with "its prioritized concerns"
D122	2.6	2-19	547	Replace "They have" with "It has"
D123	2.6	2-19	556	Should the order be reversed to "a decision and an action"?
D124	2.6.1	2-20	569-570	Replace "Analytical Protocol Specifications" with "APSs"
D125	2.6.1	2-20	571	Insert comma after "data"
D126	2.6.1	2-20	582	Replace "Analytical Protocol Specifications" with "APSs" in 2 places on this line
D127	2.6.1	2-20	585-586	Replace "Analytical Protocol Specifications" with "APSs"
D128	2.6.1	2-20	587-588	I suggest deleting the name of the referenced chapter. The chapter number alone is adequate.
D129	2.6.1	2-20	589	Replace "Analytical Protocol Specifications" with "APSs"
D130	2.6.2	2-21	605	Replace "lab" with "laboratory"
D131	2.7.1	2-22	602-603	Replace "Analytical Protocol Specifications" with "APSs"
D132	2.7.1	2-22	633	Insert "statistical", i.e. "the stastical parameter"
D133	2.7.1	2-22	642-643	I suggest deleting the name of the referenced chapter and appendix. The chapter number and appendix letter alone are adequate.
D134	2.7.2	2-22	655	Delete comma after "agreement"
D135	2.7.2	2-22	659	Replace "labs" with "laboratories"
D136	2.7.3	2-23	678	Delete comma after "as well as"
D137	2.7.4.1	2-24	709-710	I suggest deleting the name of the chapter. The chapter number is sufficient.
D138	2.7.4.2	2-24	714-715	I suggest deleting the name of the chapter. The chapter number is sufficient.

Row	Section	Page	Line	Editorial Review Comment
D139	2.7.4.2	2-24	716	Delete "planning process statements of the"
D140	2.7.4.3	2-24	723	Use lower case for "DQA process" because it is lower case elsewhere in this paragraph
D141	2.7.4.3	2-24	724	I suggest deleting the name of the chapter. The chapter number is sufficient.
D142	2.7.4.3	2-24	725	Insert "the" in "the DQA process"
D143	2.8	2-26	762, 767	Need to indicate 2000a and 2000b to distinguish these two EPA references.
D144	3.1	3-1	14	Replace "only should contain" with "should contain only"
D145	3.1	3-1	16-19	Delete the last two sentences because they repeat concepts already stated in the previous paragraph.
D146	3.1	3-1	20	Delete the word "key" here.
D147	3.2	3-2	42	replace semi-colons with commas
D148	3.2	3-2	44	Delete sentence "Figure 3.1…"
D149	3.2	3-2	48	Insert comma: "planning issues, depending"
D150	3.3	3-2	56	Delete "of Chapter 6" because this is self-evident from the section number
D151	3.3.1	3-5	112	Line 113 belongs in the same paragraph as the sentence that precedes it ("Gross alpha…studies.") Either append it to the preceding paragraph, or use the preceding sentence as the start of a new paragraph.
D152	3.3.1	3-5	116	Reword the beginning of this bullet as "Ability to detect the presence" in order to match the format of the preceding bullets
D153	3.3.2	3-6	131-132	On line 131, delete "and". On line 132, insert a new item so that the beginning of this line reads:"studies, and preliminary survey or characterization results, if availalble"
D154	3.3.2	3-6	134	Delete "concentration"
D155	3.3.2	3-6	142-143	Delete the second occurrence of "the expected concentration range of". Replace line 143 with the following "for any constituent with the potential for causing chemical or radiological interference."
D156	3.3.3	3-6	146	Delete "For many projects" so that the sentence starts with "Typical matrices" Delete "may"
D157	3.3.3	3-6	158	Should refer to Section 3.4, not 3.5
D158	3.3.3	3-6	159	Delete "of Chapter 6"
D159	3.3.3	3-7	160	Delete "any"
D160	3.3.3	3-7	162	Delete "As previously noted,"
D161	3.3.3	3-7	164	Replace "lists" with "list"
D162	3.3.4	3-7	169	Delete "to measure"
D163	3.3.4	3-7	170	Insert "that" or "the one" in the phrase: "One of the best known and easiest relationships to establish is that between" or " the one between"
D164	3.3.4	3-8	192-193	Shorten by stating:"A list of known or potential radionuclide relationships, based upon parent-progeny relationships, previous study results, or process knowledge."
D165	3.3.6	3-8	210-211	Replace "The list should" with "The list is likely to"
D166	3.3.6	3-8	214-216	Shorten these two sentences to read as follows: "Where this is significant uncertainty about the presence or absence of specific radionuclides, the most conservative approach is to leave them on the analyte list, even when there is only…"
D167	3.3.6	3-8	221	Replace "provides" with "results in a list containing"
D168	3.3.7	3-9	235	Insert "(MQOs)" at end of sentence.
D169	3.3.7	3-10	266	Move the last sentence to second place, following the italicized first sentence.
D170	3.3.7	3-10	272-273	Replace the second occurrence of "the method performance characteristics" with "them"
D171	3.3.7	3-10	280	Replace both occurrences of "since" with "because"
D172	3.3.7.1	3-12	339-345	Thank you for providing such a clear example!

Row	Section	Page	Line	Editorial Review Comment
D173	3.3.7.1	3-12	352, 354	It would be more user-friendly if more distinctly different formats could be used for the subheadings and the Output paragraphs.
D174	3.3.7.1	3-13	364	Italicize or underline "individual items or samples" to emphasize the distinction between this paragraph and the one that starts on line 376
D175	3.3.7.1	3-13	374	Insert "(MDC)" after "concentration"
D176	3.3.7.1	3-14	376	Italicize or underline "sampled population" to emphasize the distinction between this paragraph and the one that started on line 364
D177	3.3.7.1	3-14	386	Insert "(MQC)" after "concentration"
D178	3.3.7.1	3-14	387	Insert comma after ""gray region"
D179	3.3.7.1	3-14	389	Replace "since" with "because"
D180	3.3.7.1	3-14	393	Insert comma after ""example"
D181	3.3.7.1	3-14	396	Replace "overemphasis on establishing" (which does not sound quite right) with "establishment of"
D182	3.3.7.1	3-15	423	Suggest adding "and radioactive" between "chemical" and "constituents".
D183	3.3.7.1	3-15	406	Typo? Replace "activity" with "analyte"
D184	3.3.7.1	3-15	410	Replace "since" with "because"
D185	3.3.7.1	3-15	413	Insert word: "This precaution"
D186	3.3.7.1	3-15	413	Replace "prevent" with "minimize the potential for"
D187	3.3.7.1	3-15	418	Delete the second occurrence of "the concentration of" in this sentence
D188	3.3.7.1	3-16	440	Insert proper reference citation after AOAC: "(Youder and Steiner, 1975)"
D189	3.3.8	3-17	495	Replace "determine" with "specify"
D190	3.3.8	3-17	498	Delete second occurrence of "analytical" on this line.
D191	3.3.8	3-18	522	Replace "analysis" with "analytical"
D192	3.3.12	3-22	638	Typo: "parentheses" (I.e., plural)
D193	3.4	3-23	654	Insert "Common" at the beginning of the caption for Table 3.1
D194	3.4	3-23	665-666	Replace semi-colons with commas
D195	3.4	3-23	666-667	Delete sentence "In general, most solid samples…in the laboratory."
D196	3.4.2	3-25	709	Replace "..; this is discussed in Chapter 10" with "(see section 10.3.2)"
D197	3.4.3	3-26	953	Replace "where" with "if"
D198	3.6	3-27	792	Replace "if it exists" with "if they exist"
D199	3.5	3-28	803-804	Correct section references to "3.3.7" (in 4 places on these two lines)
D200	3.5	3-28	807-810	Correct the four entries under "Evaluation criteria" to refer to "Section 8.5.2"
D201	3.5	3-28	807-810	Correct the four entries under "Frequency" to refer to "Section 3.3.10"
D202	3.5	3-29	828	Insert comma after "analyte" in Row 2 of "Analysis Limitations"
D203	4.1	4-1	6	Insert (APSs) after "Analytical Protocol Specifications"
D204	5.3.5	5-4	136	Think you mean Appendix C
D205	6.1	6-1	30	"panning" should be "planning". Or perhaps you are talking film criticism.
D206	8.2.3	8-5	140	No comma needed after "Although".
D207	8.5	8-14	380	Excess verbiage. Suggest deleting "reliably identify analytes".
D208	9.2	9-3	71	"rational" should be "rationale".
D209	10.1.1	10-2	41	add comma ...to ensure that modifications, discrepancies and...
D210	10.3.2	10-19	581	correct text: “involve s” should be “involves”

Row	Section	Page	Line	Editorial Review Comment
D211	10.3.2.1	10-19	611	Last word should be "turbidity".
D212	10.3.2.2	10-21	653	modify text: Should read: ...advantage of filtering in the field is that acid...
D213	10.3.3.1	10-23	725	modify text: loss of radionuclide from the sample.
D214	10.3.5	10-28	895	Typo: 201/202Th should probably be 228/230/234Th
D215	10.4	10-29	918	Should be "appropriate" without a "d".
D216	10.5.4.1	10-40	1327	Given in traditional units (microCi/mL); should also be in SI.
D217	11.1	11-1	5	Suggest: "...topics are presented sequentially in this chapter..."
D218	11.1	11-1	26	Suggest: "Other relevant issues, including the laboratory's radioactive materials license conditions..."
D219	11.1	11-1	27	Missing part of word at end of line. Should this be "tracking activities"?
D220	11.2.1	11-3	33	Suggest: "...should know the approximate numbers..."
D221	12	12	General	Overall this chapter is also straightforward and useful.
D222	12.3	12-13	lowest diamond	Figure 12.2: To be consistent, "aliquot" should be "aliquant".
D223	12.3.1.3	12-25	705	Should "off" be "of"?
D224	13.1	13-1	26	insert "such" between "ensure" and "exchange"
D225	13.1	13-1	31	delete the first sentence
D226	13.2.1	13-3	74	insert "For example", before "the solubility product constant … "
D227	13.2.3	13-4	111	change "isotope" to "isotopic"
D228	13.2.3	13-4	123	delete the period after "acids"
D229	13.2.3	13-5	126	add a period before "dissolution"
D230	13.2.3	13-5	133	insert "metal" after "soluble"
D231	13.2.3	13-5	136	delete the second "oxidation"
D232	13.2.4	13-5	147	change "cation" to "cations"
D233	13.2.5	13-6	170	change "the method" to " a given separation method"
D234	13.3	13-9	261	replace "for fusions" with "in fusions"
D235	13.3.1	13-11	332	replace "is" with "could be"
D236	13.3.2	13-12	352	delete "rather"
D237	13.4.1	13-17	546-553	this paragraph is an exact duplicate of the one above (lines 538-545)
D238	13.4.1	13-20	638	insert "also" after "they"
D239	13.5.2	13-25	804	delete "However, " and start the sentence with "Waste is minimized …"
D240	13.6.3	13-27	864	replace "see" with "observe"
D241	13.7.2	13-31	963	Change heading to "Total Dissolution" (i.e., delete "through Fusion"). Add new paragraph at end of Section 13.7.2: "Total dissolution is feasible by dissolution in nitric and hydrofluoric acids at elevated temperature and pressure. Microwave ovens and Parr bombs are used to achieve these conditions."
D242	13.7.2	13-31	994	Delete extraneous "a" from the sentence "The analyst must consider whether a this sample is representative."
D243	13.9.1	13-36	1114	replace "or" with "from
D244	14.1	14-1	8	delete "in one reference document"
D245	14.1	14-1	13	replace "employed" with "provided"
D246	14.1	14-1	16	change "afford" to "give" or "provide"
D247	14.1	14-1	20	replace "found" to employed
D248	14.1	14-1	30	delete "for the practicing radiochemist"

Row	Section	Page	Line	Editorial Review Comment
D249	14.1	14-2	35	"their" should be "its".
D250	14.1	14-2	37	change "behavior" to "nature"
D251	14.1	14-2	48	delete "modern" and insert "also" after "should"
D252	14.2.3	14-6	183-187	Redundant, see priority rules on p. 14-5.
D253	14.2.3	14-7	205	replace "be obtained" by "occur"
D254	14.2.3	14-7	214	define "M" as the "metal ion"
D255	14.2.3	14-7	218	combine both sentences
D256	14.8.7	14-90	2450	second column: "Sarge" should be "Large".
D257	14.10.1	14-108	2975	Should be "cesium isotope"
D258	14.10.1	14-109	3009	Insert "to attempt " after "employed"
D259	14.10.1	14-109	3020	this paragraph should be shifted down behind line 3045
D260	14.10.5	14-114	3153	Move "many" to the front of this sentence
D261	14.10.8	14-118	3280	Move "Earths" to left border
D262	14.10.8	14-119	3299	Replace question mark with page numbers
D263	14.10.9.1	14-120	3353	Delete last "a" on line
D264	14.10.9.2	14-127	3565	Delete "and" after "solutions"
D265	14.10.9.2	14-128	3587	Delete "a" before "hydrocarbons"
D266	14.10.9.3	14-130	3663	Replace "principle" with "principal"
D267	14.10.9.3	14-135	3826	Correct typos in "kaolinite", "bentonite", "montmorillonite"
D268	14.10.9.4	14-137	3893	Delete comma after "Chernobyl"
D269	14.10.9.4	14-138	3907	Delete "for" after "analyzed"
D270	14.10.9.4	14-140	3988	Check reference whether the last line on this page in Table 14.19 should be moved to this line
D271	14.10.9.4	14-141	3995	This information should be added to the box at line 3989
D272	14.10.9.4	14-141	4002	Fix typo in the word "state" after "oxidation"
D273	14.10.9.4	14-141	4007	Move "-1" to exponent in second "I"
D274	14.10.9.4	14-143	4056	Insert "on" after "remain"
D275	14.10.9.5	14-144	4086	Insert comma after "94"
D276	14.10.9.5	14-147	4180	Correct the spelling of "coastal"
D277	14.10.9.5	14-151	4303	Correct verb: "have, not "has"
D278	14.10.9.5	14-151	4307	Correct verb: "are", not "is"
D279	14.10.9.5	14-152	4347	Correct typo: "carbamylphosphine"
D280	14.10.9.5	14-152	4351	correct typo: "affect", not "effect"
D281	14.10.9.5	14-153	4374	Correct typo: "electrodeposition"
D282	14.10.9.6	14-154	4431	Insert comma after "part"
D283	14.10.9.6	14-157	4523	Delete "their"
D284	14.10.9.6	14-159	4595	Correct verb: "absorb", not "absorbs"
D285	14.10.9.6	14-160	4626	Delete "however" and begin a new sentence
D286	14.10.9.7	14-169	4888	Correct spelling: "principal"
D287	14.10.9.8	14-169	4891	This heading is "Solubility of Compounds" for other radionuclides
D288	14.10.9.8	14-171	4960	Delete "to" at end of line
D289	14.10.9.8	14-173	5025	correct typo: "exchanged" instead of "exchange"

Row	Section	Page	Line	Editorial Review Comment
D290	14.10.9.8	14-173	5029	Correct typo: "called" instead of "call"
D291	14.10.9.10	14-181	5287	Correct typo: "release" instead of "releasing"
D292	14.10.9.10	14-181	5296	Correct verb: "are" instead of "is"
D293	14.10.9.11	14-192	5638	First word is "from" (sp.)
D294	14.10.9.11	14-194	5700	Correct typo: "used" instead of "use"
D295	14.10.9.11	14-194	5712	correct typo: "carbamylphosphine"
D296	14.10.9.11	14-195	5739	Add comma after "acid"
D297	14.10.9.11	14-195	5747	Insert period after "acid"
D298	14.10.9.11	14-196	5764	Correct typo: "exists" instead of "exist"
D299	14.10.9.12	14-199	5865	Delete comma after "mercury"
D300	14.10.9.12	14-199	5884	Delete either "is" or "becomes" after "metal"
D301	14.10.9.12	14-203	6006	Correct typo: "used" instead of "use"
D302	14.10.9.12	14-203	6007	Correct typo: "from" instead of "form"
D303	14.10.9.12	14-203	6011	Correct typo: "tracer" instead of "tracers"
D304	14.10.9.12	14-204	6031	Correct typo: "from" instead of "form"
D305	14.11	14-205	6068	correct typo: "Health"
D306	14.11	14-208	6157	Correct typo: "Horwitz"
D307	14.11	14-214	6300	Correct typo: "Nuclear"
D308	14.11	14-216	6365	Delete this duplicate of the reference on line 6363
D309	14.11	14-221	6497	Correct typo: "Nuclei"
D310	15.2.2.3	15-5	129	Correct typo: "vent" should be "event"
D311	15.3.3	15-9	274	the comma should be a dash.
D312	15.3.6	15-11	324	Insert a comma after "power supply".
D313	15.4.1	15-15	461	"... the data is …" should be "... the data are…"
D314	15.7	15-24	731	Delete hyphen from ion-chambers.
D315	15.7	15-27	839	Plural "minutes" should be singular "minute".
D316	15.7	15-27		Figure 15.7: Vertical axis label and peak label are illegible
D317	15.7	15-27		Figure 15.8: Vertical axis label and peak label are illegible
D318	15.7	15-28	863-864	Incomplete sentence; I suspect one or more lines or line segments got left out.
D319	15.10.1.1	15-33	1014	Need "is" between contamination and dominated.
D320	15.10.1.1	15-33	1029	"a-producing" should be "alpha-producing" (Greek letter OK).
D321	15.10.1.1	15-34	1044	"if" should be "in".
D322	15.10.1.1	15-34	1051-1052	"effected" should be "affected" (two places).
D323	15.10.1.2	15-35	1076	Put comma after second "sample".
D324	15.10.1.2	15-35	1077	Put semicolon or dash after "made".
D325	15.10.1.2	15-35	1082	Put semicolon after "available".
D326	15.10.1.3	15-36	1113, 1117	For consistency, "P10" should probably be "(super 10)P".
D327	15.10.1.4	15-37	1129	"ore" should be "or".
D328	15.10.2.2	15-41	1267	Change "large" to "larger"
D329	15.10.2.2	15-41	1267	Insert "to" after "rise".
D330	15.10.3.1	15-46	1413	"See page 51…" should be "See page 15-51 …"

Row	Section	Page	Line	Editorial Review Comment
D331	15.10.3.1	15-46	1413	"... list items …" should be "... list of items …"
D332	15.10.3.1	15-46	1419	NIM should be defined in "poorly conditioned NIM power"
D333	15.10.3.1	15-47	1443	End this line with a colon as a lead in to eqn 15.2?
D334	15.10.3.4	15-50	1522	75 x 75 mm (3 x 3 in)
D335	15.10.3.5	15-51	1566	"nim" should be "NIM"
D336	15.10.4.2	15-53	1626	"signal" should be "signals" to match "they" in line 1627.
D337	15.10.4.3	15-55	1672	"Neutron Activation analysis method was employed…" should be either "The Neutron Activation Analysis method was employed…" or "Neutron Activation Analysis was employed…"
D338	15A.2	15-64	1909	insert "a" after "as".
D339	16.3.4	16-8	232-234	uses "inch" to describe planchet size. I'm OK with that, but it's not SI.
D340	16.5.2.1	16-17	524-526	Shouldn't "aliquant" be "aliquot"? (same question arises in other parts of this chapter)
D341	16.7.1	16-20	615	Insert "alpha" between High-resolution and spectroscopy.
D342	16.7.3	16-25	771	Shouldn't "aliquant" be "aliquot"? (same question arises in other parts of this chapter)
D343	17.1	17-2	40, 988	Correction of reference: '(ANSI 42.23, 1996; p.38):'
D344	17.2.1	17-3	88	Addition of letter s : '…parameter adjustments may be required for some or all of the samples received. The number of…'
D345	17.2	17-3	62, 63	Addition of comma and modification of text: "…often as possible, to avoid the inherent errors associated with manual transfer. On the other hand, electronic transfers need to be scrutinized, so as to assure that the data are not corrupted. Following this procedure, the next step in the data reduction process may be performed manually, i.e., with a calculator."
D346	17.2.2	17-7	192	Deletion of superscript 2: "This calculates the radionuclide concentration at the time of sample collection. It compensates…"
D347	17.2.2	17-7	194	Addition of superscript 2: "…counting, when the counting duration is a significant fraction of the half-life2. For long-lived…'
D348	17.3	17-8	215	Deletion of letter s: '…for these purposes and can be applied to the analysis of a wide range of radionuclides. Energy…'
D349	17.3	17-8	228	Deletion of letter d: '…Sanderson, 1992). A method of performance…'
D350	17.3	17-8	229	Change in reference: 'ANSI N42.14 (1991).
D351	17.3.1	17-9	258 ff	Deletion of letter m: '…Gilmore and Hemingway, 1995...' (lines 258, 314, 320, 326, 343, 363, 368, 403, 515, 522, 541)
D352	17.3.1.8	17-20	504	Deletion of word is: '…time, and (2) true coincidence summing, due to the simultaneous emission of gamma-rays by a…'
D353	17.3.1.8	17-21	509	Addition of comma , (2x): 'having a count in both full-energy peaks, a count will occur somewhere else in the spectrum, equal…'
D354	17.3.1.8	17-21	511	Addition of comma : '…interactions, e.g., photoelectric with Compton, and Compton and Compton. Since this occurs…'
D355	17.3.1.8	17-21	522	Correction of reference: '…If unknown, the resolving time can be estimated by a method similar to that described in Gilmore and Hemingway (1995).'
D356	17.3.2	17-23	582	Deletion of letter s: '…to have alpha spectrometry software to identify radionuclides, subtract background, perform…'
D357	17.3.2	17-27	683	Deletion of letter n: 'The FWHM of a given peak may depend greatly on the source preparation. However, since a…'
D358	17.3.3.1	17-29	746	Correction of references: '…developed over the years (Holm et al., 1984; Harvey and Sutton, 1970).'
D359	17.3.3.3	17-30	773	Deletion of word of: '…decay pulse are the basis for discrimination alpha particles from beta and gamma radiation in…'
D360	17.3.3.8	17-32	824	Addition of comma , : '…counter efficiency4. If the internal (standards addition) method is used, the data generated by the…'
D361	17.5.4	17-39	988	Correction of reference: '(ANSI 42.23, 1996; p.38):'

Row	Section	Page	Line	Editorial Review Comment
D362	17.8.2	17-43	1104-1105	Harvey, B.R., and Sutton, G.A., 1970… This reference is full of typos.
D363	17.8.2	17-44	1122	Quittner, P., 1972…This reference is incomplete (needs page numbers).
D364	18.1	18-1	11	Correction of reference: "…laboratory. General requirements for testing laboratories can be found in ISO/IEC 17025 (1999)."
D365	18.3.2	18-6	156	Correction of reference: '…almost any distribution (ISO 8258, publication date). However, when data obtained from radiation counters are…'
D366	18.3.2	18-6	164	Correction of reference: '…ASTM D6299 (2000). Standard Practice for Applying Statistical Quality Assurance Techniques to…'
D367	18.3.2	18-6	166	Correction of reference: '…ASTM E882 (publication date). Standard Guide for Accountability and Quality Control in the Chemical…'
D368	18.3.2	18-6	169	Correction of reference: '…ISO 7870 (publication date). Control Charts—General Guide and Introduction.'
D369	18.3.2	18-6	170	Correction of reference: '…ISO 7873 (publication date).. Control Charts for Arithmetic Average with Warning Limits.'
D370	18.3.2	18-6	171	Correction of reference: '…ISO 7966 (publication date). Acceptance Control Charts.'
D371	18.3.2	18-6	172	Correction of reference: '…ISO 8258 (publication date). Shewhart Control Charts.'
D372	18.3.2	18-7	173-174	Correction of reference: '…American Society for Testing and Materials (ASTM) MNL 7. 1990. Manual on Presentation of Data and Control Chart Analysis ASTM Manual Series, 6th Edition, 1990.'
D373	18.5	18-25	711	Correction of reference: '…specific techniques, see Chapters 15 and 16 as well as ASTM standard practices (e.g., ASTM D3648, (1995), for…'
D374	18.5.1	18-26	756	Correction of reference: '…performed on a real time basis. See ASTM E18 (publication date), ANSI N42.12 (publication date), and NELAC (2000) Quality…'
D375	18.5.2	18-28	813	Correction of reference: '…instrument dead time is not significant and gain shifts do not occur (ANSI 42.23, 1996). For detection…'
D376	18.5.2	18-28	830	Correction of reference: '…fraction of the emissions from the source actually reach the detector (ANSI N15.37, 1981).'
D377	18.5.2	18-29	835	Correction of reference: '…sample container, detector housing and shielding (NCRP 58, 1985).'
D378	18.5.6	18-41	1216	Change to "readers" to agree with "their".
D379	18.5.6	18-42	1218	Correction of reference: '…given in ASTM E181 (publication date) and ANSI N42.12 (publication date).'
D380	18.5.6	18-43	Table 18.5	Instrument calibration: example frequency and performance criteria: At the base of the Table, on the bottom left, Sources should read: ASTM E181 (date of publication); ANSI N42.12 (date of publication).
D381	18.6.7	18-54	1615	Correction of reference: '…service. Ordinarily, ASTM E617 (1997) Class 1 or 2 weights are used to perform the daily calibration…'
D382	18.6.7	18-54	1631	Correction of reference: '…specified in ASTM E542 (2000). Typically calibrations use volumes of water and are gravimetrically…'
D383	18.7.1	18-55	1643-1645	American National Standards Institute/International Standards Organization/American Society for Quality Control (ANSI/ISO/ASQC) A3534-2. (publication date).
D384	18.7.1	18-55	1649-1650	American National Standards Institute (ANSI) N1.1. (1976).
D385	18.7.1	18-56	1679-1680	International Standards Organization (ISO) 7873. (publication date).(date).
D386	18.7.1	18-57	1701-1702	National Bureau of Standards (NBS). 1964.
D387	18.7.1	18-57	1703-1704	U.S. Environmental Protection Agency (EPA). 1977.
D388	18.7.1	18-57	1705-1707	U.S. Environmental Protection Agency (EPA). 1980.
D389	18A	18-61	1768	Correction of reference: '…moving range (ASTM D6299, 2000,; ASTM E882, publication date). The moving range

Row	Section	Page	Line	Editorial Review Comment
				(MR) is the absolute value of…'
D390	18A	18-65	1838	Correction of reference: '…Analysis (ASTM MNL7, 1990), as well as many other references.
D391	18A	18-65	1855	Correction of reference: '…give no more than 1 percent Poisson counting uncertainty (ANSI N42.23, 1996). In other words, at…'
D392	18A	18-70	1955-1956	American National Standards Institute (ANSI) N42.23, 1996. Measurement and Associated Instrumentation Quality Assurance for Radioassay Laboratories. 1996.
D393	18A	18-70	1958-1960	American Society for Testing and Materials (ASTM) D6299, 2000.
D394	18A	18-70	1961-1962	American Society for Testing and Materials (ASTM) E882, (publication date)
D395	18A	18-70	1963-1964	American Society for Testing and Materials (ASTM) MNL 7, 1990.
D396	19.3.1	19-8	206	What's a "GUM"? Add to Glossary?
D397	20.2	20-1	26	multiservice
D398	20.2	20-1	28	nonradioactive
D399	20	All		Good flow, well written etc
D400	20.2	20-2	Table 20.1	row three, degreasers; row 14, biphenyls
D401	20.4	20-4	92	nonradioactive
D402	20.4	20-4	93	nonradioactive
D403	20.4	20-4	97	nonradioactive
D404	20.4	20-5	123	nonhazardous
D405	20.4	20-5	130	microscale
D406	20.4	20-6	137	nonhazardous
D407	20.4	20-6	140	reuse
D408	20.4	20-6	145	nonradioactive
D409	20.4	20-6	152	nonradioactive
D410	20.4	20-6	153	nonradioactive
D411	20.6	20-7	180	should AEA be written out?
D412	20.7.1	20-14	393	Somehow what was supposed to be a comma came out "B".
D413		All		Some of the tables are cut in the middle because of placement on the page. Presumably this will be addressed in the final version of the document.
D414		All		Text in some of the flow charts is too small in many cases and unreadable in a few cases
D415		All		The arrow symbol (-->) throughout the entire report is too small in size.
D416	B3.2	B-5	125	Comma after (TEDE) should be a semicolon.
D417	B3.7	B-11	306	Suggest inserting "is understood as" before "making".
D418	F	All		This appendix is thought-provoking and is a step toward quantifying uncertainty in sub-sampling, despite the disclaimers.