UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

- - - Quality Review Draft - - -
August 17, 2006

EPA-SAB-RAC-06-xxx

The Honorable Stephen L. Johnson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Subject: Review of 2005 Agency Draft entitled *"Expansion and Upgrade of the RadNet Air Monitoring Network, Vol. 1 &2, Concept and Plan"*

Dear Administrator Johnson:

The Radiation Advisory Committee's (RAC) RadNet Review Panel of the Science Advisory Board has completed its review of the Agency's draft entitled *"Expansion and Upgrade of the RadNet Air Monitoring Network, Vol. 1 &2, Concept and Plan,"* dated 2005.

The Review Panel commends the Agency for maintaining the only comprehensive United States network for monitoring radioactivity and ionizing radiation in the environment. The Review Panel concludes that the proposed expansions and upgrades significantly enhance the ability of the RadNet monitoring network to meet the mission and objectives of the EPA. However, the Review Panel presents a somewhat different view with respect to the roles of the fixed and deployable monitors in routine and emergency operations. The Review Panel believes that there should be a better balance between physical deployment schemes and modeling requirements for effective environmental assessment, data interpretation and decision-making. The Review Panel provides some guidance to the EPA for determining the locations of the fixed monitors involving the use of model constraints and meteorological forecast predictions. Most importantly, the Review Panel recommends more declustering of the fixed monitors to gain greater geographical coverage for interstate-scale monitoring.

The Review Panel's concern with under-representation of the fixed monitors in low population areas is compounded by the concern that due to limited resources, the number of fixed monitors in the near future may be less than the 180 postulated in the plan. The Review Panel makes some suggestions for leveraging resources with states and other nations.

The Review Panel discusses the flexibility of the placement of the deployable monitors in response to different types of hypothetical events. A key question pertaining to the optimal use of the deployable monitors is whether or not the monitors could be systematically deployed for "routine" monitoring to supplement the fixed monitors, thereby increasing the utility of the deployables. The Review Panel agrees that use of the deployable monitors for augmenting the fixed monitoring capability must not significantly impact their availability for an emergency or incident. The Review Panel questions whether the correct mission for the deployables has been identified. It is imperative that both the similarities and differences between the fixed and deployable systems be understood and quantified so that interpretation of the resulting data will be of high quality and consistency.

Because a large volume of data will be collected during routine operation, the Review Panel finds a need for carefully tailored decision rules (i.e. pre-existing criteria and process by which individual readings or groups of readings are identified as "elevated") used to test whether a particular set of data is above background.

The modes of data transmission from the field to a central database appear to be satisfactory, with a variety of backup systems. The evaluation and interpretation of RadNet data also involves other communication links that are critical to the process of providing high-quality information to decision makers and other stakeholders. The Review Panel finds that NAREL's plans for QA/QC are adequate. The Review Panel fully supports the need for exercises that would test the standard operating procedures for set up, siting, data transmission, data QA, data presentation, use of the data by incident management, as well as message evaluation.

The Review Panel commends EPA for including stakeholders in the Agency's ongoing planning to aid in understanding the requirements and preferences of various groups. EPA should consider developing, with the aid of social science experts, sample informational messages for release to stakeholders, including the public, in an emergency concerning the radiological aspects of specific situations.

In summary, the SAB finds that the draft dated 2005 and entitled *"Expansion and Upgrade of the RadNet Air Monitoring Network, Vol. 1 &2, Concept and Plan,"* is an important document that details a critical step in the enhancement of our national security through effective radiation monitoring and emergency response to radioactive releases.

The Review Panel appreciates the opportunity to review this draft document. The Review Panel hopes that the recommendations contained herein will enable EPA to improve the RadNet Air Monitoring Network as expeditiously as possible, thereby ensuring this essential service is available to the public. We look forward to your response to the recommendations contained in this Review.

Sincerely,

Dr. M. Granger Morgan	Dr. Jill Lipoti
Chair	Chair, RAC RadNet Review Panel
Science Advisory Board	Science Advisory Board

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1. EXECUTIVE SUMMARY

RadNet is the United States' only comprehensive network for monitoring radioactivity and ionizing radiation in the environment. Since its inception in 1973, RadNet (formerly known as the Environmental Radiation Ambient Monitoring System or ERAMS) has continuously monitored multiple media, including air, precipitation, surface water, drinking water, and milk. The Environmental Protection Agency (EPA) proposes to expand and upgrade the air monitoring component to address homeland security concerns, as well as comply with the original mission to monitor radioactivity in air and to provide information on nuclear or radiological accidents. When implementation is complete, RadNet will consist of up to180 fixed monitors augmented by 40 deployable monitors, all with near real-time monitoring capability. EPA's Office of Radiation and Indoor Air (ORIA) requested that the Radiation Advisory Committee of the Science Advisory Board review and provide advice on the expansion and upgrade of the RadNet air monitoring network.

The Review Panel concludes that the proposed expansions and upgrades significantly enhance the ability of the RadNet monitoring network to meet the mission and objectives of the EPA. However, the Review Panel presents a somewhat different view with respect to the siting, sampling, and deployment of the fixed and deployable monitors in routine and emergency operations.

For routine monitoring, EPA views the fixed monitor network as establishing baseline values; the Panel agrees with this view. The major benefit of the expansion and upgrade plan is the designation of up to 180 monitoring sites. Since acquisition of 180 fixed monitors is not projected to be completed until 2012, the Review Panel recommends that the EPA consider placing some of the deployable monitors temporarily in the locations chosen for the fixed monitors to fill in geographic sampling gaps and provide more regional baseline data.

In the event of an emergency, EPA anticipates that the fixed monitor network will mainly be used to reassure people in population centers who are not expected to be impacted by the event that no protective action is warranted. Therefore, EPA proposed placing fixed monitors in high population centers, with only a secondary concern for broad geographic coverage. The Review Panel strongly believes that in an emergency situation, the output of modeling would be more important to public safety and useful to decision-makers than the output of individual monitors. Therefore, the Review Panel recommends more declustering of the fixed monitors guided by modeling requirements, to gain greater geographical coverage for interstate-scale monitoring and providing a better understanding of the potential risks to the public.

Because both the fixed and deployable sampling monitors will be used to provide important information to decision makers, it is imperative that both the similarities and differences between these two monitoring systems be understood and quantified so that interpretation of the resulting data is of high quality and consistency. The Review Panel recommends that potential sampling biases in the fixed monitor be evaluated. The EPA should examine whether near real-time gamma exposure measurement capability should be added to the fixed monitors as is present on the deployable monitors. Consideration of cross-calibration using a series of different energy gamma emitters or against a pressurized ion chamber would add to the EPA's understanding of the performance of the monitors. The Review Panel suggests that the EPA add the capability to distinguish among alpha emitters because that may be important in assessing potential terrorist activities, as well as distinguishing alpha emissions of naturally occurring radon progeny.

The Review Panel recommends that the EPA create a simple table of radioactivity values in nanocuries (nCi) for radionuclides deposited on the filter that correspond to the selected limit on intake related to Protective Action Guidelines (PAGs). This would confirm that the Minimum Detectable Activity (MDA) is suitably lower than the PAG to permit reliable measurement results. Calculation of the MDA should be inserted into the EPA report and include a calculation of the standard deviation with counts and background counts tabulated for each region of interest.

The Review Panel believes that, in general, the proposed EPA approach for siting fixed and deployable monitors significantly enhances the ability of the RadNet monitoring network to meet mission objectives. Nevertheless, the Review Panel is concerned about the interplay between the deployable and fixed monitors. The Review Panel believes that there should be a better balance between physical deployment schemes and modeling requirements for effective environmental assessment, data interpretation, and decision making.

The Review Panel has provided some guidance to the EPA for determining the locations of the fixed monitors involving the use of models and meteorological forecast predictions. The Review Panel's concern with under-representation of the fixed monitors in low population areas was compounded by the concern that, due to limited resources, the number of fixed monitors may be less than 180. The Review Panel suggests leveraging additional monitoring stations by working with other existing systems such as those in individual states, around commercial nuclear power plants, and federal (e.g., Department of Energy) nuclear facilities. The Review Panel suggests that there should be a mechanism established for entities who wish to use their own funding to purchase stations and who agree to comply with EPA standards, to become full-fledged "members" of the network. Coordination with Canadian and Mexican authorities for coverage near the northern and southern borders of the U.S. is also needed.

The Review Panel strongly encourages EPA to optimize the fixed monitor siting plan by integrating the results of several models and performing several sensitivity analyses for different numbers of fixed monitors, siting density, and geometry of distribution. The actual physical location of the monitors can then be determined based on such practical considerations as access to electrical power, security, and availability of appropriate volunteers to maintain the system.

The Review Panel discussed the flexibility of the placement of the deployable monitors in response to different types of hypothetical events. A key question for the use of the deployable monitors is whether or not the monitors could be systematically deployed for "routine" monitoring to supplement the fixed monitors, thereby increasing the utility of the deployables. The Review Panel agrees that use of the deployable monitors for augmenting the fixed monitoring capability must not adversely impact the availability of the deployables if an emergency occurred. In view of the possibility the EPA would be requested to pre-deploy its deployable air monitors, the criteria for pre-deployment should be carefully established.

The EPA envisions using volunteers to deploy the monitors in an emergency situation. The Review Panel expressed concern about the training for these volunteers, and about their availability in a situation where there may be risks to their personal or family safety. EPA must identify and maintain a sufficient cadre of cross-trained key personnel and appropriately trained volunteers to effectively implement a response in the event that the core groups are not available.

The RadNet siting plan provides flexibility for placing deployable monitors for different types of events; however, the role of the deployables is not totally clear. Are the deployables limited to monitoring the edge of a deposition area? Are they available to provide assurance to populated areas not covered by fixed monitors? Since decision-makers will be looking for more data on impacted areas, should monitoring stations that can transmit data without unnecessary and avoidable exposure to personnel be used? The Review Panel suggests that EPA consider whether the correct mission for the deployables has been identified. The effective interplay between the fixed and deployable monitors is dependent on clarification of their respective roles.

Data that will be collected includes an estimated 35,000 data points per day related to radionuclide levels from the fixed stations alone. It is important that these data be used for rapid identification of elevated levels, while avoiding false positives that misdirect concern. The approach and frequency of data collection of near real time data appears to be reasonable for deciding during an emergency that an area is not likely to be affected by a particular event.

A process does not appear to be in place for deriving optimal decision rules for RadNet such as pre-existing criteria and a process by which individual readings or groups of readings are identified as "elevated." Careful development of decision rules will require collaboration among all agencies involved in radiological emergency response. Because a large volume of data will be collected in routine operation, careful thought needs to be given to the types of decision rules used to test whether or not a particular set of data represents an increase above background. The optimization of decision rules should also take into account the number of monitors and their physical locations, which means the rules have to change over time as the RadNet system is expanded.

The modes of data transmission from the field to a central database appear to be satisfactory. There are a variety of backup systems for communicating data including modem backup to the satellite telemetry. The Review Panel recommends that ORIA keep abreast of improvements in the technology as well as other factors that may have a detrimental or beneficial effect.

The evaluation and interpretation of RadNet data also involves other communication links that are critical to the process of providing high-quality information to decision makers and other stakeholders. Since the field stations, NAREL, IMAAC, and all of the agencies at FRMAC are part of the communication system that provides information to the public in an emergency, there is also a need to consider the communication links among these nodes as well.

Since the Review Panel proposed a revised mission for the deployable monitors, it may be necessary to have a direct read-out of radiation levels on the monitor itself, rather than relying on the download of local dose rate to a PDA.

The Review Panel found that NAREL's plans for QA/QC were adequate, but notes that the standard operating procedures should be in place and accompany all of the QA/QC plans to ensure that the data are handled reproducibly prior to any release and that information from the system is accurate and reliable. The Review Panel fully supports the need for exercises that would test the standard operating procedures for set-up, siting, data transmission, data QA, data presentation, use of data by incident management, as well as message evaluation.

The Review Panel commends EPA for including stakeholders in the Agency's ongoing planning to aid in understanding the requirements and preferences of various "customer" groups such as modelers, decision makers, and the public. EPA should consider developing sample informational messages with the aid of social science experts for use during an emergency and testing those messages during disaster drills. Information on background radiation levels and their variability also needs to be communicated to the public relative to the changes measured by RadNet. Care should be taken to avoid using unprocessed RadNet monitoring data in the estimation of the number of excess cancers that could be expected in future years among a large population potentially exposed to very low doses of radiation. Such estimations are not considered to be a responsibility of the RadNet program.

2. INTRODUCTION

2.1 Background

RadNet is the United States' only comprehensive network for monitoring radioactivity and ionizing radiation in the environment, with more than 200 sampling stations nationwide. Since its inception in 1973, RadNet (formerly known as the Environmental Radiation Ambient Monitoring System (ERAMS) has continuously monitored multiple media, including air, precipitation, surface water, drinking water, and milk. EPA is proposing a plan for expanding and upgrading the air monitoring component of RadNet. The plan is designed to go beyond the original mission of providing information on nuclear or radiological accidents. The mission now includes homeland security concerns and the special problems posed by possible intentional releases of radioactive material to the nation's environment.

EPA's plan proposes additional and updated air monitoring equipment and more monitoring stations to provide greater flexibility in responses to radiological and nuclear emergencies, significantly reduced response time, and improved processing and communication of data. The ultimate goal of RadNet air monitoring is to provide timely, scientifically sound data and information to decision makers and the public.

Formal planning for RadNet began in the mid 1990's when the Office of Radiation and Indoor Air (ORIA) initiated a comprehensive assessment of RadNet's predecessor (ERAMS) to determine if the system was meeting its objectives and if the objectives were still pertinent to EPA's mission. The first Radiation Advisory Committee (RAC) advisory, in 1995, concentrated on an ORIA proposed preliminary design for a RadNet reconfiguration plan (U.S. EPA SAB. 1996.). The second RAC advisory, in 1997, examined the reconfiguration plan for RadNet that was developed, in large part, based on the guidance from the previous advisory (U.S. EPA SAB. 1998.).

In 1999 and 2000, three events placed the RadNet national air monitoring component on emergency status and confirmed some lessons on limitations in the existing system. The three events were the Tokaimura, Japan criticality incident (IAEA. 1999) and the fires near the Department of Energy's (DOE)'s facilities at Los Alamos National Laboratory (U.S. DOE. 2000) and the Hanford Reservation (Poston et al. 2001, and Albin et al. 2002). The Tokaimura incident highlighted the fact that the existing air monitoring system was not designed to detect noble gases. The two fires underscored the limitations of having low sampling density and a relatively slow system response time. Air filters had to be shipped to NAREL for analyses. It took several days for definitive data to reach decision makers and the public.

In early 2001, ORIA began working on a new vision for a nationwide radiation monitoring system. In August of 2001, the design team announced its goals, and was well along in its planning. The terrorist attacks on the United States on September 11, 2001 expedited and strongly influenced the subsequent planning for updating and expanding RadNet. As a result, the design team decided to concentrate on the air monitoring portion of RadNet, and elected to introduce a series of deployable monitors that could be positioned in an emergency to augment the fixed monitors positioned in predetermined locations and to add real-time monitoring capability to the system.

Since use of deployable monitors had already been planned prior to September 11, 2001 and as they could be procured more quickly, the first available homeland security funding (late in 2001) was committed to their acquisition. ORIA then turned its attention to the system of fixed monitors with testing of a prototype in 2002. By 2003, EPA had decided that the prototype had demonstrated the technical feasibility of adding near real time gamma and beta monitoring capability to the fixed air monitoring stations. A proposal was submitted to the capital budget for expanding and upgrading the fixed air monitoring station component of RadNet, and, after evaluation by the Office of Management and Budget, was funded in the FY 04 budget. An actual purchase of a fixed monitor prototype was made in 2005.

The RadNet upgrade and expansion project is currently in the early implementation phase. AS of December 2005, the first prototype fixed monitor was received, tested, and installed at ORIA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama. A set of 40 deployable monitors has been acquired, 20 of which have been delivered to each of ORIA's labs in Montgomery and Las Vegas, NV. The information technology infrastructure is in place for handling real-time data.

The next steps include determining the national siting plan (where to put the fixed monitors), how to distribute and operate the deployables under emergency conditions, and the best protocols for dissemination of verified RadNet data during emergencies. EPA plans to acquire and deploy the fixed monitors at the rate of five (5) per month. EPA's Office of Radiation and Indoor Air (ORIA) requested that the Science Advisory Board (SAB) Radiation Advisory Committee (RAC) provide input for these next steps.

2.1.1 Request for EPA Science Advisory Board (SAB) Review

The EPA's ORIA requested the Agency's SAB provide advice on the National Monitoring System (NMS) upgrade, formerly known as the Environmental Radiation Ambient Monitoring System (ERAMS). The Radiation Advisory Committee (RAC) held a public conference call meeting on February 28, 2005 to receive briefings from ORIA about this request, to receive public comments and to discuss its plan for the coming year (see ***FR***, Vol. 70, No. 19, January 31, 2005, pp. 4847-4848).

2.1.2 Panel Formation

The Review Panel (Radiation Advisory Committee's (RAC) RadNet Review Panel) was formed in accordance with the principles set out in the 2002 commentary of the SAB, *Panel Formation Process: Immediate Steps to Improve Policies and Procedures: An SAB Commentary* (U.S. EPA SAB. 2002). A notice offering the public the opportunity to nominate qualified individuals for service on the Review Panel was published, where the SAB Staff Office requested nominations of experts to augment expertise to the SAB's Radiation Advisory Committee (RAC) for SAB review of RadNet's air radiation network, a nationwide system to track environmental radiation (see ***FR***, Vol. 70, No. 56, March 24, 2005, pp. 15083-15084).

The SAB Staff Office Director, in consultation with SAB Staff, including the Designated Federal Officer (DFO), the SAB Ethics Advisor, and the Chair of the SAB's Chartered Board, selected the final Review Panel. Selection criteria included: excellent qualifications in terms of scientific and technical expertise; the need to maintain a balance with respect to qualifying expertise, background and perspectives, willingness to serve and availability to meet during the proposed time periods, and the candidate's prior involvement with the topic under consideration. The final Review Panel includes persons with expertise in instrumentation, statistics, modeling, risk assessment, or risk communication as advertised in the ***Federal Register***. The Review Panel members, in addition to having new persons to serve, also include individuals who are experienced SAB consultants familiar with the Agency. The final panel determination memo was signed on November 22, 2005 and posted prior to the December 1, 2005 conference call meeting of the Review Panel.

2.1.3 Review Process and Review Documents

The RAC's RadNet Review Panel first met via conference call on December 1, 2005 to be briefed by the Agency staff on the draft document to be reviewed, to clarify the charge to the Review Panel, and to assign specific charge questions to the individual Panelists in preparation for the face-to-face meeting. The actual face-to-face meeting of the RAC's RadNet Review Panel to conduct a peer review of the Agency's draft document entitled *"Expansion and Upgrade of the RadNet Air Monitoring Network, Vols. 1 &2 Concept and Plan,"* dated October, 2005 (U.S. EPA ORIA. 2005.) was held on December 19 and 20, 2005 in the Agency's NAREL in Montgomery, AL where many of the Agency ORIA Staff implementing and managing RadNet are housed (see ***FR***, Vol. 70, No. 220, November 16, 2005, pp. 69550-69551).

The RAC's RadNet Review Panel scheduled three (3) additional public conference calls to reach closure on their draft report in critique of the Agency's RadNet draft document dated October, 2005. The meetings were held on March 20, 2006, April 10, 2006, and June 12, 2006. (see ***FR***, Vol. 71, No. 40, March 1, 2006, pp. 10501-10502). The March 20, 2006 meeting focused on the responses to charge questions 1 and 2. The April 10, 2006 meeting focused on reducing redundancy in the report, and the response to charge question 3. During the interval between the April 10 meeting and June 12, 2006, the executive summary and letter to the administrator were drafted, so that the June meeting could focus on making sure the Review Panel had reached consensus on the issues of most importance

2.2 Charge to the RAC RadNet Review Panel

The Agency's Office of Radiation and Indoor Air requested that the EPA Science Advisory Board review and provide advice on a draft document entitled *"Expansion and Upgrade of the RadNet Air Monitoring Network, (Volume 1&2) Concept and Plan,"* dated October 2005 (U.S. EPA ORIA. 2005.). EPA requested response to the following specific charge questions:

Charge Question 1: *Are the proposed upgrades and expansion of the RadNet air monitoring network reasonable in meeting the air network's objectives?*

Charge Question 2: *Is the overall approach for siting monitors appropriate and reasonable given the upgraded and expanded system's objectives?*

2a) *Is the methodology for determining the locations of the fixed monitors appropriate given the intended uses of the data and the system's objectives?*

2b) *Are the criteria for the local siting of the fixed monitors reasonable given the need to address both technical and practical issue*s?

2c) *Does the plan provide sufficient flexibility for placing the deployable monitors to accommodate different types of events?*

2d) *Does the plan provide for a practical interplay between the fixed and deployable monitors to accommodate the different types of events that would utilize them?*

Charge Question 3: *Given that the system will be producing near real-time data, are the overall proposals for data management appropriate to the system's objectives?*

3a) *Is the approach and frequency of data collection for the near real-time data reasonable for routine and emergency conditions?*

3b) *Do the modes of data transmission from the field to the central database include effective and necessary options?*

3c) *Are the review and evaluation of data efficient and effective considering the decision making and public information needs during an emergency?*

3d) *Given the selected measurements systems are the quality assurance and control procedures appropriate for near real-time data?*

2.3 Acknowledgement

The RAC RadNet Review Panel (the Review Panel) met on December 19-20, 2005 at the National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, AL, to consider the charge questions. The meeting location was important to facilitate discussion of the system since members could see, hear, and manually examine the prototype fixed and deployable monitors. Review Panel members were able to maximize the interaction with staff involved in the project at NAREL since they were all available at the meeting. This face-to-face interaction was integral to the Review Panel's understanding of the thought processes during design of the system. The hands-on aspect of being able to directly experience the fixed and deployable monitors was also essential. Review Panel members even commented on the noise associated with the monitors in operation as a consideration in establishing the siting criteria. The Review Panel wishes to express their sincere thanks to the ORIA staff in accommodating their needs during the meeting and for making it as productive as possible. The Review Panel wishes to commend ORIA on the planning that went into this meeting.

The document *"Expansion and Upgrade of the RadNet Air Monitoring Network* (*Volume 1&2) Concept and Plan,"* 2005 was well written and provided much needed background to the RAC's RadNet Review Panelists. During the meeting, the staff worked hard to augment this excellent document with additional pieces of information that the Review Panelists felt were necessary to assist with the review. The staff took extreme care to honor all the Review Panel's requests and demonstrated their patience as Review Panel members struggled to understand all that went into the decisions on equipment, siting and deployment strategies, and anticipated data uses.

3. RESPONSE TO CHARGE QUESTION 1: AIR NETWORK OBJECTIVES

<u>**Charge Question 1:**</u> ***Are the proposed upgrades and expansion of the RadNet air monitoring network reasonable in meeting the air network's objectives?***

In its briefing document, EPA stated the mission and objectives of the expanded and upgraded RadNet monitoring network as (in paraphrased form):

- Provide data on baseline levels of radiation in the environment;
- To the extent practicable, maintain readiness to respond to emergencies by collecting information on ambient levels capable of revealing trends;
- During events, provide credible information to public officials (and the public) that evaluates the immediate threat and the potential for long-term effects; and
- Ensure that data generated are timely and are compatible with other sources.

The Review Panel concludes that the proposed expansions and upgrades significantly enhance the ability of the RadNet monitoring network to meet this mission and objectives. However, the Review Panel's view of the respective roles of the fixed and deployable monitors in routine and emergency operations is somewhat different than that of EPA, and is a major factor in the responses and recommendations in this report. A number of specific issues are detailed below.

3.1 Roles of Fixed and Deployable Monitors

Current plans for the upgraded RadNet system of air monitoring instruments call for a system comprising 180 fixed monitors and 40 deployable monitors. The 40 deployable monitors have been purchased and are available for deployment from the National Air and Radiation Environmental Laboratory (NAREL) in Montgomery and the Radiation and Indoor Environments National Laboratory (RIENL) in Las Vegas. Procurement of the fixed monitors is in progress, but procurement of the full complement of 180 monitors is not projected to be completed until 2012. Both types of monitors will be needed in response to a major airborne release of radionuclides. It is planned that the deployable monitors will be used to expand the sampling network of interest around the site of a known airborne release. As discussed below, deployable monitors could also be used routinely in the near future to augment the fixed station network until more fixed sampling monitors can be obtained.

The objectives associated with the interplay of fixed and deployable monitors are specific to the two basic operational scenarios: a) "routine" and b) "emergency" (i.e., a radiological 'incident,' whether accidental or intentional). In practice, the necessary monitoring data to characterize the radiological 'environment' in these two scenarios exist at multiple levels of scale or "resolution." For the sake of simplicity, the Review Panel identifies three scales: national- or interstate-scale (multi-state; 100s to 1000s mile radius), regional-scale (10s to 100s of mile radius), and local-scale (1-10 mile radius).

a) "Routine" monitoring is predominately an interstate-scale activity. Of major importance, in routine monitoring, the measurements from individual monitors are intrinsically useful, and represent the primary data of interest. The purpose of this monitoring is to characterize, on an on-going basis, the ambient radiation environment in space and time. For this purpose, air monitoring needs to be supplemented with other existing RadNet-based media sampling, including water and milk sampling. Routine monitoring is not expected to provide the first indication of a radiological event.

b) "Emergency" monitoring requires data inputs at all three scales. Interstate- and regional-scale data are used to track transport of major releases, typically from nuclear power plant accidents or the detonation(s) of improvised nuclear device(s) (IND). Local-scale data are most relevant for smaller Radiological Dispersion Devices (RDD) events, and help determine evacuation versus shelter-in-place decisions. In addition, EPA should address the pros and cons of "routinely" pre-deploying the monitors to places where intelligence information suggests that they may be needed (e.g., Times Square NYC during New Year's eve, Super Bowl game, World Series, Olympics, Mardi Gras). For such decision-making, real-time data are critical and deployable monitors must be well integrated with fixed Networks in terms of data integration and immediate availability to the key decision making agencies, Federal Radiological Monitoring and Assessment Center (FRMAC) and the end user, Inter-agency Modeling and Atmospheric Assessment Center (IMAAC), which generates the plume projections. For small events the best interplay between monitor types would factor in all the monitors in the nation in spite of data quality variability, for state, local, utility, DOE and others.

In the event of an emergency, EPA anticipates that the fixed monitor network will be used to reassure people in population centers who are not expected to be impacted by the event that no protective action is warranted. That is, EPA views the measurements from individual monitors as the primary data of interest in an emergency, as they do for routine monitoring. As a result, EPA's fixed monitor siting approach primarily focuses on adequate population coverage, by placing fixed monitors in high population centers, with only a secondary concern for broad and uniform area or geographic coverage. The Review Panel views things differently. The Review Panel strongly believes that, in an emergency situation, the output of modeling is significantly more important and useful for decision-making than the output of individual monitors. This situation is strikingly different from the case for routine monitoring.

In the event of an emergency, EPA anticipates deploying the deployable monitors locally (and perhaps regionally) around the event site, so that deployable monitor measurements can be rapidly used to complement measurements from the fixed monitors. The Review Panel agrees that the deployable monitors (if appropriately deployed in an emergency) can provide regional trends, but believes it is unrealistic to think that the deployables can be sited with enough sampling density to provide useful local level data. Such local scale data will be provided by monitoring conducted by local, state, and other assets.

For routine monitoring, EPA views the fixed monitor network, and the deployable monitors (if pre-deployed), as establishing baseline values; the Review Panel agrees with this view. In this regard, the major benefit of the expansion and upgrade plan is the addition of up to 180 monitoring sites. Here, the fixed monitors will provide large-scale data; the deployable monitors can (if appropriately pre-deployed) fill in geographic sampling gaps and provide more regional baseline data (if some clustering of the deployables is possible).

Because of the Review Panel's view of the central importance of modeling in an emergency (a view that possibly differs from that of EPA), the geographic distribution of the fixed and deployable monitors (the "sampling" as input data to the model) becomes critical. Accordingly, some of the Review Panel's strongest recommendations below deal with more declustering of the fixed monitors and pre-deployment of the deployable monitors. As noted above, these recommendations stem from an intrinsically different view of the use of data from the fixed and deployable monitors, in both routine and emergency situations.

The Review Panel recommends more declustering of the fixed monitors to gain greater geographical coverage for interstate-scale monitoring. The Review Panel further recommends that EPA consider placing some of the deployable monitors temporarily in the locations chosen for the fixed monitors to bridge the time interval until the fixed monitors are purchased and in place.

3.2 Issues with the Monitors Themselves

Because of timing and resource issues, there are some differences in the design and operation of the fixed and deployable types of monitors selected by ORIA. The design of the deployable monitors was in response to the fires at Hanford and Los Alamos. Procurement of these monitors began before the conceptual design of the fixed monitors was complete. Additionally, practical considerations dictated that the deployable monitors be sturdy enough to withstand damage from repeated shipping and handling.

Both the fixed and deployable types of monitors are capable of sampling air at high volumetric rates (35-75 m^3/hr) through a 4"-dia. filter. The fixed stations use a polyester filter, while the deployable monitors use a glass fiber filter. The deployable monitor also has a second sampling head operated at a lower sampling rate (0.8-7 m^3/hr) utilizing a charcoal filter suitable for sampling radioactive gases, including ^{131}I. The sampling heads are located in different places in the two types of monitors. The two sampling heads on the deployable monitors are located on extensions several feet above the system's equipment enclosure, whereas the sampling head in the fixed monitor is located in the top portion of the system's enclosure along with two radiation detectors that provide periodic in-place measurements of the accumulation of radionuclides on the filter medium. These detectors are a 2"x2" sodium iodide (NaI) detector to measure gamma emissions and a 600 mm^2 ion-implanted silicon detector to measure alpha and beta emissions from radionuclides on the filter sample periodically during the sampling cycle. These radiation measurements can be transmitted via satellite to NAREL for analysis and storage.

The deployable monitor has no built-in capability for monitoring either the high volume or low-volume filters in place, so the filters must be counted and analyzed at NAREL or in a mobile laboratory brought near the area of interest. Another difference between the deployable and fixed monitors is the ability of the deployable monitors to provide measurements of the external gamma radiation field at the sampling site. Measurements from two compensated Geiger-Mueller (GM) detectors also can be transmitted to NAREL via satellite. The fixed monitor has no comparable capability for quantifying external photon radiation fields.

Because both the fixed and deployable monitors will be used to provide important information to decision makers, it is imperative that both the similarities and differences between these two monitoring systems be understood and quantified so that interpretation of the data will be of high quality and consistency. (For further discussion see Section 4.5.)

3.3 Potential Sampling Biases in the Fixed Air Monitor

The configuration of the detector and filter in the fixed monitor may result in bias in collection of larger particles due to their deposition on the detector or associated support surfaces. The EPA report should include a figure that shows, with dimensions, the locations of the two detectors relative to the filter and indicates the expected airflow path. **The impact of this geometrical arrangement on the deposition of airborne particles should be evaluated by an experienced professional using laboratory or field tests that address, among other questions***:*

- Is particle deposition on the filter uniform across the filter?

- Does a significant fraction of particles deposit on the surfaces of the two detectors thereby contaminating them?

- Are there sampling biases related to different particle-size regions?

While large particles (greater than 10 µm Activity Median Aerodynamic Diameter (AMAD)) may not be of biological significance with regard to inhalation by humans, they may be of concern for ingestion of swallowed particles and in evaluating the potential for soil and surface-water impacts. Also, depending on the type of incident that results in generation of air particulates, NAREL should consider that "hot particles" might be in the larger size range and thus would not be collected on the filter in proportion to their presence in the airborne material.

The currently designed instruments have not been tested for the collection efficiency of airborne particulates as a function of the wind speed and direction at which they arrive at the monitor. The relationship between sampling efficiency and particle size might also be affected and should be tested. A wind tunnel would be a good place to conduct such tests. It is better to know these characteristics now, than to learn that there might be a problem later. This seems to be particularly critical for the new fixed monitors where local siting criteria include, but are not limited to, allowing the monitor to be located no closer than two meters from walls, five meters from building ventilation exhausts and intakes, 20 meters from a tree drip line, and 50 meters from streets and highways. Each of these factors can impact the representativeness of the measurements to ambient air.

One of the arguments for large particles not being of major concern for RadNet is the expectation that an event resulting in the generation of airborne dust is most likely to occur at a considerable distance from the monitor. Thus, the large particles would fall out before the plume reached the detector. This would be true for most of the fixed monitors involved in a single event, but not for the fixed monitors located in the population centers in which the probability of a terrorist incident involving release of radioactive material is the greatest. In such a situation, a monitor in the vicinity of the incident is of primary importance and should be capable of representative sampling of airborne dust.

3.4 Measurement of External Photon Radiation Fields

The deployable monitors use GM detectors to provide near real-time data on gamma exposure rates, but no similar measurements can currently be made with the fixed monitors**. If it is assumed that the near real-time collection of these gamma exposure measurements is an important function of the deployable monitors, then consideration should be given to making similar gamma exposure measurements on the fixed monitors as well.** The NaI detectors on the fixed monitors can also be used as dosimeters by weighting each of the recorded regions of interest for energy response and summing the result. This capability should be further explored.

Certain quality assurance efforts are needed for the radiation exposure data collected by the GM detectors with the deployable monitors. These data may contribute significantly to the evaluation of a radiological incident and need to be accurate and credible. The following aspects should be considered:

a) Results are reported (on p.60) to be accurate within 15% at the low end of the scale at 2 μR/h, and 10% at the high end of 1 R/h. Is this information certified by the manufacturer? In any case, EPA should test reliability initially and at intervals for selected monitors by comparison to a direct exposure-rate detector such as a pressurized ionization chamber (PIC).

b) The instruments are reported to have been calibrated with ^{137}Cs and to have an energy response within 20% between 60 keV and 1,000 keV. Does the manufacturer certify this information? EPA should test instruments for energy dependence by exposing selected detectors to point or extended sources. For example, radionuclides may be selected that emit single gamma rays of approximately 30, 60, 120, 300, 600, and 1,200 keV, of which one should be ^{137}Cs at 661 keV. Such sets also can be used for intercomparison with monitors by cooperating organizations, such as state agencies.

c) Quality Control (QC) considerations for exposure-rate measurements, discussed on p.90, should include specific actions such as the ones suggested above.

d) The international unit equivalent (SI) to 1 roentgen (R) is 2.58 x 10^{-4} C/kg dry air, not 10 mSv, as shown on p.60. The decision to convert R to mSv should be left to the organization responsible for estimating radiation dose.

While ^{137}Cs may be an important gamma-emitting radionuclide in the event of a nuclear incident, ^{60}Co – with gamma photons that have twice the energy of the ^{137}Cs photons – may be of equal or greater importance in a "dirty bomb" event. It is also important to note that the GM detector response to scattered ^{137}Cs gamma radiation may be different from the response to the unattenuated ^{137}Cs radiation. **While it might be impractical to cross-calibrate each deployable system against a PIC, NAREL should consider cross-calibrating the prototype using a series of different energy gamma emitters, including naturally occurring thorium with its relatively high energy gamma ^{208}Tl decay product and uranium with its lower average energy decay products.**

While the Review Panel understands that the GM detectors are energy compensated, cross-calibration would afford a degree of assurance that the GM detectors are accurately measuring exposure when a variety of different gamma energies are present. Said another way, the EPA report should address the following aspects of detector response:

- the pattern of the energy response in the form of a curve or tabulated values from the low-energy cutoff to about 3,000 keV;

- the standard deviation of measured exposure rates for the full claimed range of 2 μR/h to 1 R/h ; and

- the response to beta-particles and associated Bremsstrahlung.

The use of the radiation measurement units sievert (Sv) and rem for the output of the GM detectors is somewhat misleading since a GM detector measures counts per unit time. With appropriate cross-calibration against a PIC, the output could be converted to roentgens. However, if the units Sv and rem are being used in the sense that they represent effective dose, the one-to-one ratio of roentgen to rem may not be appropriate. The conversion from exposure in roentgen to effective dose in Sv or rem depends on both the receptor (e.g., adult or child) and the energy of the gamma radiation. The Review Panel recognizes that the use of roentgens is because of first responder familiarity with that unit. (Further discussion on this issue is in Section 5.4.5 regarding communication of results.)

3.5 Measurements of Alpha Emitters at Fixed Monitors

The description of major components of the fixed air monitoring stations on p.25 of the EPA report includes "Instruments for measuring gamma and beta radiation emanating from particles collected on the air filter media." Measurements of alpha emissions are not mentioned on p. 25, but the detailed specification sheet provided mentions the capability to measure both low and high energy alpha particles. During the December 19-20, 2005 meeting, ORIA staff told the Review Panel that a complicated algorithm is needed to distinguish alpha emissions measured in the fixed monitor from the measurements of alpha emissions of naturally-occurring radon (Rn) progeny**. It is important that this capability be perfected because other alpha emitters besides ^{241}Am may become important in assessing potential terrorist activities.**

3.6 Need for Numerical Clarity and Transparency

3.6.1 Value of the Protective Action Guide (PAG)

In the EPA report the PAG is stated to be "the committed effective dose equivalent (CEDE) of 1 rem that results from inhaling a specified radionuclide continuously during a 4- day period", (p.24, para. 5). The measurement requirements, including the minimum detectable activity (MDA) for selected radionuclides specified in the EPA report, are related to this value.

While the instruments provide the output in roentgens (R), it is expected that EPA will do the necessary conversion to provide the information to the decision-makers in rem so that they can compare it to the PAG. The Review Panel was not asked to comment on the appropriateness of the PAG; however, it is necessary to point out that the assumptions for conversion from R to rem should be explicit in the documentation so that the conversion can be replicated at a later time.

3.6.2 Relation of the EPA-specified MDA Value to the PAG for Fixed Monitor

The MDA values (at the 95% confidence level) are given in terms of nanocuries (nCi) for each of seven radionuclides on a filter to be counted for no more than 1 hour with the specified NaI(Tl) detector and spectrometer (p. 27, para. 1). Of the seven radionuclides, ^{241}Am, ^{137}Cs, ^{60}Co, and ^{192}Ir were considered to be important because of their availability in large quantity (p.24, para. 3). An MDA value also is given for ^{90}Sr counted with the silicon detector and spectrometer (p.27, para.2).

The EPA report should include the nCi value on the filter that corresponds to the selected limit on intake related to the PAG (see part A) for each of the eight radionuclides. The purpose is to confirm that the MDA is suitably lower than specified by the PAG to permit reliable measurement results.

This information can be extracted from the two tables that were distributed by EPA staff in response to a request at the meeting. One table is a list of radionuclide concentrations (in pCi/m^3) that correspond to the PAG for 1 rem by inhalation during a 4- day period (and fractions of this PAG) for five of the eight radionuclides. The other table is a list of nCi for a 30 m^3 sample related to estimated risk per nCi inhaled given in Federal Guidance Report 13, (EPA-402-R-99-001) for all eight radionuclides (and two others). The EPA staff should decide which data set is appropriate, apply the selected factors for m^3 collected on the filter for counting and m^3 inhaled in the 4-day period, and discuss the appropriateness of the specified MDA values.

3.6.3 Calculation of the MDA Values for the Fixed Monitor

Calculation of the MDA for radionuclides detected by the NaI(Tl) detector was addressed in the document MDA *for the EPA's fixed RadNet monitors*, (WSRC. 2005) that was distributed at the meeting. The value of the MDA is related to the standard deviation, σ, by MDA = $(2.8 + 4.65\ \sigma)$/constant.

The constant relates counts accumulated for this study in 10 minutes to nCi. Values of σ were obtained by measuring the counts recorded with the detector in the regions of interest for various radionuclide standards and obtaining the counting efficiency for these measurements. The Westinghouse Savannah River Company (WSRC) report notes that the calculation of σ is more complex than shown if background peaks intrude on the regions of interest for another radionuclide, as is the case of radon progeny intruding on ^{241}Am and ^{137}Cs. The radon-progeny background on filters is stated in the EPA report to fluctuate from 0.3 to 30 nCi (p.26, para.6). The calculated MDA values based on measurements that do not include radon-progeny fluctuation range from 12.3 to 1.1 nCi for the seven radionuclides. The MDA value for ^{241}Am is above the specified MDA for the 10-min count but equals it for the expected 60-min count; the MDA for each of the other radionuclides is 1 – 3 orders of magnitude below the EPA-specified MDA value.

The calculated MDA values reported in the WSRC report should be inserted into the EPA report with an explanation of the reasons for the much larger EPA-specified MDA values (p.27, para. 1), except for ^{241}Am. One reason is the indicated radon-progeny fluctuation. The extent of increase in MDA values over those calculated in the WSRC report should be tested in a field study. Relative to the EPA-specified MDA values, however, the fluctuation appears to be significant only for ^{241}Am.

Before inserting the WSRC data in the EPA report, some improvements in the WSRC report are recommended. Calculation of σ should be explicitly shown, with counts and background counts tabulated for each region of interest. Apparent errors made in the sample calculation for ^{137}Cs should be corrected in calculations of MDA in counts per second (cps), MDA in disintegrations per second (dps), and MDA (nCi).

The MDA calculation for ^{90}Sr measured by the silicon detector should be shown for the direct beta-particle count and counter background, and for the influence of radon-progeny fluctuation. Any difference between these values and the EPA-specified MDA should be explained.

The implications of the change in the thickness (from thick to thin) of the silicon-detector window reported by EPA staff at the meeting should be discussed in the EPA report. If the alpha-particle spectra that now can be measured are useful to compensate for radon-progeny fluctuations, the appropriate calculations and test results should be presented. Conversely, any detrimental effects of cross talk on ^{90}Sr counting sensitivity should be reported.

4. RESPONSE TO CHARGE QUESTION 2: OVERALL APPROACH FOR SITING MONITORS

4.1 Response to Charge Question # 2

Is the overall approach for siting monitors appropriate and reasonable given the upgraded and expanded system's objectives?

The Review Panel concludes that the proposed EPA approach for siting fixed and deployable monitors significantly enhances the ability of the RadNet monitoring network to meet mission objectives. Nevertheless, the Review Panel is concerned about a number of specific implementation issues and underlying assumptions that are detailed below.

Given the limited resources and stemming from two seemingly contradictory drivers, there are difficulties in designing a siting plan based on population density versus one based on geographic location. The siting plan proposed is therefore the result of a compromise between monitoring people and spanning the nation, or between socio-political considerations and EPA mission requirements. This is reflected in the dichotomy between the stated RadNet objectives in the context of EPA responsibilities and the interplay and use of deployable versus fixed monitors. It is the view of the Review Panel that this results in a lack of clarity in the usage of deployable monitors.

For the purpose of clarifying key underlying assumptions the following questions must be addressed:

a) What decision-making processes and prioritizations are used to accommodate different types of events ranging from long term monitoring deficiencies in the response to catastrophic incidents?

b) Are the objectives for the usage of deployable monitors strictly identical to those for the fixed monitors?

Given that any emergency response plan or EPA decision based on RadNet will depend on analyses from models that integrate data from a wide range of sources, it is essential that the RadNet network be optimized in terms of these models. These process-oriented environmental models are typically underdetermined as they contain more uncertain parameters than the variables available to them for calibration. **Therefore the Review Panel strongly advocates the use of sensitivity analyses in the siting of monitors (both fixed and deployable**).

4.1.1 Population-based versus Geographic-based Siting

Although the siting plan is not intended to monitor a city-based incident, it has been designed to accommodate one monitor per major city. For populated Western and Eastern coastline areas this results in an anomalously high density of fixed monitors at the expense of other regions, notably the US-Canadian border, Central Northern United States, Central and Eastern Nevada and Eastern Oregon as well as the states of Vermont and Delaware. Some of these concerns could be addressed by including the results of monitoring conducted by other agencies (such as the state of Nevada) or through cooperation with the Canadian authorities**. The Review Panel believes that there should be a better balance and interplay between physical deployment schemes and modeling requirements for effective environmental assessment, data interpretation and decision making.**

Based on these considerations and the limited resources currently available, **the Review Panel suggests that:**

a) **More declustering of fixed monitors should be considered initially, particularly in the vicinity of the Los Angeles and New York metropolitan areas. Local and regional meteorological models should be used along with other considerations, to reduce the density and to redistribute fixed monitors.**

b) **Model sensitivity analyses should be performed on siting configurations and distribution densities so as to meet EPA goals and optimize the placement of fixed monitoring stations in terms of the limited resources available**.

This approach will result in better geographic coverage than is currently planned, consistent with the primary decisions for siting a 'receptor-based system' with a focus on national impact. This approach will also provide more flexibility to adapt to limited resources and the deployment of fewer fixed monitors than the 180 currently planned. Finally, this deployment scheme will better serve public safety, even in populated regions, by increasing the reliability of model results and improving predictions used by decision makers.

4.1.2 Fixed versus Deployable Monitor Networks

It is unclear whether the proposed use of deployable monitors is predicated solely on the RadNet objectives outlined for the deployment of fixed monitors, for the collection of environmental data within the context of a National scope, and for the sole purpose of monitoring, assessment and baseline data collection. Given the urgent need for the monitoring of radioactivity on a national scale, and possible limitations associated with the number of fixed monitors installed in the near-term, it appears that at least some of the deployable monitors could be pre-deployed (i.e., in the absence of an event) to fill coverage gaps identified through modeling. Put another way, the deployable monitors could be used in the interim to provide some routine monitoring coverage until all the fixed monitors (i.e., 180 fixed monitors) are available and installed.

The Review Panel suggests that the discussion on monitor siting address the degree to which the use of deployable monitors fulfill EPA's new monitoring responsibilities as outlined in the post 9/11 *National Response Plan, Nuclear/ Radiological Incident Annex* (U.S. DHS. 2004). Specifically the mission of the RadNet Air Network includes providing "data for radiological emergency response assessments in support of homeland security and radiological accidents." This objective is vague and brings into question whether use of the deployable monitors is at the discretion of the EPA or under the more broad authority of the Department of Homeland Security (DHS). Under most emergency circumstances, EPA is not the lead but a supporting organization to the Coordinating Agency (CA). Therefore, EPA may not have the authority to make the decision to use the deployable monitoring stations for filling in gaps in the fixed system sites without consultation with the CAs. If the monitors were in use at locations around the nation, they would not be immediately available for use in an emergency, but would need to be recalled and subsequently redeployed. **The Review Panel recommends that EPA work with partner agencies to clarify issues of chain-of-command and assess whether some deployable monitors could be used to fill coverage and time gaps.** The Review Panel believes that integration of the two separate systems comprising the deployable and fixed monitoring networks can be better defined. Planning for the integration of the fixed and deployable monitors should be in consultation with the Federal Radiological Monitoring and Assessment Center (FRMAC) and the IMAAC

4.2 Response to Charge Question # 2a

Is the methodology for determining the locations of the fixed monitors appropriate given the intended uses of the data and the system's objectives?

The Review Panel strongly suggests that the declustering of fixed monitors within high density population areas be more aggressive and involve the use of general model constraints, historical meteorological data, and timely meteorological forecast predictions. To this end the Review Panel supports the use of sensitivity analyses and confirmatory transport modeling proposed by EPA, in conjunction with Westinghouse Savannah River Company, the US Weather Bureau, IMAAC and/or other partners.

Overall, the Review Panel considers that the methodology for determining the locations of the fixed monitors is appropriate with some reservations: There appear to be a few gaps in the proposed siting methodology for fixed monitors, resulting from (1) the apparent lack of recognition of local and regional meteorological constraints; (2) large geographic areas without coverage; (3) deficiencies in siting scenarios in the context of uncertainty in the near term number of operational fixed monitors; (4) the need for greater clarity in RadNet mission priorities; and (5) the lack of data integration with other entities conducting monitoring .

4.2.1 Meteorological Constraints

The proposed EPA scheme for adapting fixed monitor locations to both population density and land coverage achieved about 50% population coverage and about 82 % land coverage. With the constraint of 180 independent stations, this scheme appears satisfactory as an initial siting basis. However, meteorological and natural background radiation conditions (e.g., radon) may demand adjustments to this distribution as experience is gained (i) through the actual operation of the system, (ii) its deployment over a number of years, and (iii) results from preliminary models are considered. The data from the RadNet Air Monitoring Network should eventually be combined with a standard US Weather Bureau computer code for projecting variations in the local geological and meteorological conditions in the area of the monitor and regional atmospheric conditions and trends. Meteorological monitoring associated with the fixed monitor network is desirable in some cases, and should be decided on a site-specific basis, based on two considerations: (a) no "canyon effect" exists, and (b) no alternative "close" meteorological monitoring exists (where "close" still needs to be defined). In this way, elevated radiation conditions and their atmospheric transport could then be predicted and their significance assessed with respect to natural and/or man-made anomalies.

4.2.2 Uncertainty in Number of Near-term Fixed Monitors

Given the limited resources and possible limitations on the number of fixed monitors deployed in the near-term, it appears that scenarios with less than 180 fixed monitors need to be examined in terms of their immediate impact on system response. In addition at least some of the deployable monitors could be used to fill coverage gaps in routine monitoring identified through modeling. This approach has the advantage of being more flexible and responding to changing environmental conditions. It requires a thorough study of costs and of the added complexity in the event that deployable systems are required elsewhere in response to an unanticipated radiological incident.

4.2.3 Mission Priority

In keeping with EPA responsibilities and the continuity of the RadNet mission, the most important function of the fixed monitors is the continued and improved routine evaluation of the ambient radiation environment. In the context of the new RadNet network, this involves continued coordination of the air monitoring network with the other current EPA networks involving water and milk monitoring, even in the light of a later evaluation and update of those systems. This again emphasizes that population density is not necessarily the main driver but that isolated areas that involve many rural communities also support the monitoring infrastructure of the nation. In view of the resource limitations to the new RadNet system, ORIA should not lose sight of the basic EPA function that involves tracking the transfer of ambient airborne radiological conditions to the nation's food supply.

4.2.4 Integration with Existing Networks

Even though RadNet is a receptor-based system, it should strive to leverage additional monitoring stations by integrating with other existing systems, such as those in individual states and around nuclear power plants and other source areas. Moreover, **there should be a mechanism established for entities to become full-fledged 'members' of the network**. **This could include States and/or cities that wish to use their own funding to purchase stations and agree to comply with certain EPA standards.** The inclusion of state and nuclear facility air monitoring networks has the potential of adding several thousand monitors (in contrast to the extensive discussion about declustering and utilizing deployables which would pertain to 70 sites at best.) However, this would take considerable effort including arranging for participation by the operating groups, operator training, cross-calibration, a notification system after an incident, means of transporting air filters quickly to Montgomery, a feedback system for guidance, changes, questions, etc.

There also appears to be a lack of coordination with Canadian monitoring networks. Specifically, the US southern border appears to be well covered by the proposed siting plan, whereas monitors along the northern Canadian border appear scarce. Health Canada maintains monitoring stations in Edmonton, Calgary, Saskatoon, and Regina and perhaps elsewhere, but the EPA does not appear to have engaged Health Canada and there is no mention of the monitoring capabilities or planned joint coordination efforts between the US and Canada.

4.3 Response to Charge Question #2b

Are the criteria for the local siting of the fixed monitors reasonable given the need to address both technical and practical issues?

Ideally, the siting plan would evolve from modeling considerations, rather than from subjective and arbitrary ones. Given the current approach to siting, at a minimum, sensitivity analyses and post-hoc confirmatory modeling (i.e., siting plan calibration and validation) should be used for local siting of the fixed monitors. The sensitivity analyses will help focus limited resources on those siting configurations that are optimal to RadNet objectives, and help identify to which variables the models are most sensitive and less certain in terms of their formulation and/or parameterization for a given siting geometry. The analysis will also help reduce uncertainty by identifying any potential interactions or variables that exert the greatest influence on the dependence of model outcomes and interpretation.

Additionally, siting criteria based on a combination of "population" and "cluster density" – as EPA is proposing – may or may not make sense depending on the answers to two additional considerations:

a) Whether or not other fixed and deployable monitoring networks will complement RadNet (e.g., Radiological Emergency Response Team (RERT)) and provide similar and/or compatible data; and

b) What sampling requirements are necessary for the mathematical models to best estimate environmental distributions in space and time. For example, the models may require or be optimally served by more uniform geographic sampling, or conversely, require a non-uniform sampling scheme that is driven by geographic/geologic and meteorological factors (in three dimensions) rather than population or sampling density.

In either case, there are complex and non-intuitive issues involved in siting monitors, and the plan cannot be evaluated in a vacuum. In planning the distribution of fixed monitors, EPA assumed that:

- Modelers and planners require a well-spaced network that includes 'non-zero' readings in contaminated areas and 'zero' readings in non-contaminated areas in order to validate model predictions.

- Decision makers may request monitors where large population centers are located, as well as other areas that would contribute to population exposure (e.g., food production sites).

- The public may also request that monitors be located in their area although other relevant concerns include agriculture (monitoring of areas that are otherwise unpopulated or geographically "uninteresting"), business and tourism areas, and border areas that anticipate plumes from other countries.

In order to satisfy these assumptions, EPA took an approach that is both population-based and geographically-based,

i) start with the largest cities (population-based);

ii) remove the "over" clustering of monitors in certain areas; and

iii) fill in the gaps (geographically-based).

In addition to the criteria above covered in the RadNet draft document, the Review Panel strongly encourages that several additional criteria be considered. They are:

- **<u>Model Requirements</u>**. Given that the models will be used for rapid decision-making and analysis, it follows that criteria satisfying required model inputs be prioritized so that the model results are quantitative and their predictions are robust.

- **<u>Operational Security.</u>** Siting protocols should be prioritized in terms of monitoring station security and operation requirements

- **Location requirements.** In view of the role of possible monitoring obstructions, consider different sampling environments (e.g., monitors at different elevations sampling different plume horizons).

- **Integration with Other Resources**. The effective use of other existing resources could benefit rapid detection and analysis of a radioactive plume.

4.3.1 Model Requirements

Given the importance of models in integrating and understanding complex time-dependent data, their requirements represent a crucial input to the siting of the monitors. Models may best be served by input data that require more uniform geographic sampling, or a non-uniform sampling scheme that is driven by geographic/geologic and meteorological factors in three dimensions, rather than by a population or sampling density scheme. For quantitative analysis and understanding of the network data, optimal siting is therefore the product of simulation requirements, anticipated scenarios, and variations within each. In practice, the sampling requirements are also model specific and, as different models come into play, optimizing the siting plan involves integration of several results that together stochastically predict the space and time distribution of a radioactive plume in three dimensions.

The following approach is offered by way of example:

Step 1: Model three to five different, plausible scenarios, using one or more mathematical models, including any used by IMAAC. The initial tests should involve a dense monitoring coverage or over-sampling (e.g., simulating the availability of input from thousands of monitors), thereby establishing the 'ground truth' distribution in space and time.

Step 2: Use a preferred model to simulate a case with 180 monitoring stations as proposed in the RadNet siting plan and vary the siting density distribution using proposed EPA siting plan(s).

Step 3: Perform a sensitivity analysis in which a number of monitors are "removed" from a "preferred RadNet siting configuration" to evaluate the effect of reducing the total number of stations from 180 to [180 – 20] or [180- 40].

Step 4: Using a realistic number of monitoring stations, change the geometry of their distribution so as to capture model sensitivity to site geometry and distribution.

Step 5: Compare all model run results. This sensitivity analysis could render (i) the optimum deployment for 180 fixed monitors; (ii) provide a comparison of the preferred monitor distribution to an optimal siting scenario involving a greater or ideal number of monitors (>>180); (iii) optimize the use of a resource-limited monitor sampling scheme (<180 stations); (iv) help in the design of deployable stations' placement either as temporary stations to offset perceived coverage gaps or for use in rapid deployment scenarios and their effective integration with other networks, including fixed RadNet monitors; and (v) provide a defense in depth for the EPA's siting protocol and justification for any required modifications (e.g., additional stations).

4.3.2 Practical Issues

The approaches discussed above focus on the selection of 180 "optimum" sites (or geographic sites throughout the country) without regard to either technical or practical issues, but based only on sampling considerations, either from a population- and clustering-basis, or in the context of modeling. The actual selection of sites, however, must also be driven by technical and practical issues. These include:

a) the availability of and access to the appropriate electrical power;

b) an accessible and secure place to site the system; and

c) the availability of specifically trained volunteers to maintain and "operate" the system.

4.3.3 Location Requirements

A key issue that needs further specification and refinement is the physical location of the fixed monitors, especially with regard to the immediate terrain and monitor location requirements and the potential impact of siting on the air monitoring results. In urban environments a rooftop location may be the preferred location and could potentially be standardized to avoid the "canyon effect" that might otherwise be present, especially in large cities. The Review Panel suggests that the "two-meter rule" be reviewed in the context of tall buildings or large vertical structures, and, if necessary, amended or redefined.

4.3.4 Coordination with Other Resources

A complete inventory of all existing, functional radiation equipment should be performed by EPA to determine available non-EPA resources, which may include the environmental radiation equipment at nuclear power plants, resources at universities, federal, state, industrial and medical facilities, including laboratories. Thereby, in the event of a major incident within a given region the EPA could rapidly assess national needs and enlist these resources for extended coverage. International resources (e.g., Canada, Mexico, Atlantic and Pacific nearest neighbors) should also be assessed.

4.4 Response to Charge Question #2c

Does the plan provide sufficient flexibility for placing the deployable monitors to accommodate different types of events?

A key question is whether or not the monitors can be systematically deployed for "routine" monitoring to supplement the fixed monitors, thereby increasing their utility, and still be as readily deployable in an emergency.

This question requires resolution of the apparent discrepancy noted earlier between the stated RadNet objectives and the interplay and use of deployable versus fixed monitors. Both the RadNet draft document and the EPA RadNet presentations bring uncertainty as to the ultimate objectives for the usage of deployable monitors. EPA's plan currently does not include using the deployable monitors (i.e., in the absence of an emergency). To the degree to which deployable monitors are actually a response to EPA's new monitoring responsibilities as outlined in the post 9/11 *Nuclear/Radiological Incident Annex* (U.S. DHS. 2004), then the flexibility of the deployment depends on the ability to adapt to rapid response times and deployment requirements. This can only be accomplished if the siting is 'pre-planned' by incident type, regardless of location. This in turn requires that the deployment scenarios be tied to 'realistic' model renditions of different scenarios and that both model and siting plan be responsive to the input of new incident boundary conditions in a timely and effective way. At present, this is not the case and the Review Panel urges the EPA to take measures in this direction and lead the way to the use of the RadNet results.

Other considerations are the practical deployment requirements within the framework of limited resources:

- deployable monitor storage,
- pre-deployment,
- personnel training,
- flexible response to incident scenarios, and
- other concerns.

4.4.1 Deployable Monitor Storage

The EPA proposes to house the deployable systems in ORIA's two main environmental radiation laboratory sites (Las Vegas and Montgomery). EPA believes that it is important to do so in order to provide continuing maintenance and to deploy the monitors with trained staff. Alternatively, it may be more sensible to store the systems at a more diverse set of regional locations, where they could be potentially deployed more rapidly in the event of an emergency

4.4.2 Pre-Deployment

Under certain circumstances and in response to a DHS request, if a pre-deployment option for the deployable stations were envisaged, it would drastically change the nature of the RadNet mission and transform it into an event detection and early warning response system. Prior to large gatherings of people (e.g., political or sports events) the EPA may be asked by the DHS to pre-deploy the monitors. Fairly routine pre-deployments have positive and negative aspects. On the positive side, pre-deployment enables operators to become familiar with shipping and setting up the monitors. It also increases the probability that they will be in place when needed. On the negative side, apart from the cost, routine pre-deployment increases the probability that the monitors will be in some other location when they are needed to be used post-event or need to be re-deployed due to environmental changes. **In view of the possibility that the EPA could be requested to pre-deploy its deployable air monitors, the Review Panel recommends that the criteria for pre-deployments be clearly addressed and carefully established**.

4.4.3 Personnel Training

Ideally, the large number of deployable monitors permits rapid deployment and operation of field monitors to adequately monitor specific situations where and when required. Since the tactics and location of a radiological based terrorist attack may not be known, the deployable monitors must permit rapid response to a given situation in 'real time.' However, there are several indications that deployment and activation of the RadNet monitors will take several days. For example, in relation to the use of deployable monitors the EPA states that the "information concerning the exact location of each monitor relative to buildings, terrain level changes, other obstacles, along with a description of the surface terrain (for surface roughness determination), will need to be relayed to meteorologists so they can determine the value of the data prior to use." In addition, EPA relies on volunteers to deploy the monitors and bring flexibility to the deployment scenario.

The Review Panel suggests however, that without prior training or experience of volunteer personnel, it is difficult to imagine the success of this enterprise in the context of a national emergency, where potential risks to personal and family safety are to be envisioned. EPA needs to clarify how, without specific training, these volunteers will know how to adequately provide the required terrain descriptions in a timely and accurate manner before starting the sampling activities; and assure themselves of the robustness of the Agency's deployment plan. **The Review Panel lacked the information necessary to determine whether or not the numbers of cross-trained key personnel and specifically trained volunteers will be sufficient to affect a response in the event that the core groups are not available for whatever reasons. The Review Panel recommends that the approaches EPA proposes to use to identify, credential, and maintain the "volunteer" operators be described and training exercises be implemented.**

4.4.4 Flexible Response to Incident Scenarios

The overall plan for the deployment of the RadNet deployable monitors appears to rely on the expectation of a single radiation incident and does not consider multiple near-simultaneous incidents in the same or geographically-separated locales. Based on the history of the 9-11 attack, where three or four entities in different locations across the U.S. were targeted simultaneously, the single incident assumption is inadequate. Simultaneous, coordinated dirty bomb or nuclear device attacks on several cities (e.g., Boston, New York, Miami, Chicago, and Los Angeles) are as plausible as a single event scenario. ORIA should therefore revisit its fixed and deployable siting plans and determine the effectiveness of the proposed methodology if only five to ten deployable stations are available for deployment at each of several locations instead of the 20 to 40 monitoring stations per site they depict in the Report. **Plans for storing, deploying and siting the deployable monitors should include sufficient flexibility to effectively respond to simultaneous potential or real radiological events in a timely manner and in the absence of viable infrastructure (e.g., appropriately and adequately trained support personnel, communication equipment, electrical power, transportation routes and modes.)**

As discussed in the Charge Question 2b answer, the deployment and siting of deployable air monitoring stations would be greatly improved by a modeling exercise where the siting is closely tied to model scenarios involving different types of incidents (e.g., dirty bombs versus nuclear devices), as well as different types of locations (e.g., large cities versus industrial or military centers).

4.4.5 Other Concerns

The RadNet siting plan provides flexibility for placing deployable monitors for different types of events; however, the role of the deployable monitors is not entirely clear. These monitors are flexible, well-designed systems, but the various locations in which they will be placed relative to a contaminated plume need better definition. There are also some practical operational issues that need resolving.

a) Are the deployables for monitoring the edge of a plume, or are they to provide assurance to populated areas not covered by fixed monitors that they have not been affected?

b) How (and by whom) will the siting of the deployable monitors be determined in response to an unexpected incident?

c) In practice, how long will it take to deploy the monitors relative to the start of an event, and how does this lag time influence the desirability of pre-deployment?

d) Are the deployable monitors considered fixed stations once positioned or will they be remobilized to track possible contaminant plume movements?

The air concentration and external gamma radiation data from the RERT teams and the deployables should be integrated. These should be the easiest data to integrate since they are collected by the same organization and provide an extra safeguard to the operators. In the early phase of an incident, the deployable monitors are to provide gamma radiation and airborne radioactive particulate data to modelers to assist in validation of model output or adjustment of input parameters. However, the deployment scheme is to place the monitors outside the contaminated area. To assist the modelers, the monitors may have to be placed inside the plume to measure gamma or airborne levels above background values.

The scheme for siting deployable monitors is to put them where they will measure background or pick up resuspension. Decision-makers will be looking for more data on the impacted areas, particularly from monitoring stations capable of transmitting data electronically to the emergency operation center without unnecessary and avoidable exposure to personnel. The Review Panel suggests that EPA clarify the role of the deployable monitors.

Finally, the RadNet report should also reference and when possible follow the guidance provided by the *Environmental Engineering Committee's Modeling Resolution* (U.S. EPA SAB. 1989.) and the *Guidance on the Development, Evaluation, and Application of Regulatory Environmental Models and Models Knowledge Base* (U.S. EPA SAB. 2006. *Quality Review Draft*: February 24, 2006. (NOTE: I will insert final, approved REM Guidance Review Panel report citation here and any other appropriately designated area of this report such as references cited when available. - - - KJK). Even though these reports do not specifically address the use of model sensitivity analysis in the optimization of the design for siting monitoring instruments, many fundamental model requirements are presented in the context of data integration and interpretation in the context of a regulatory decision making environment and information dissemination.

4.5 Response to Charge Question #2d

Does the plan provide for a practical interplay between the fixed and deployable monitors to accommodate different types of events that would utilize them?

While the Review Panel's view of the expanded and upgraded RadNet Air Network's capabilities to meet EPA objectives is essentially consistent with EPA objectives, the Review Panel's view of the respective roles of the fixed and deployable monitors is significantly different than that of EPA. This is a major factor in determining what constitutes an effective interplay between fixed and deployable monitors.

Concerning the interplay between fixed and deployable monitors, EPA proposes, in essence, to treat the data from the two types of monitors in a similar fashion. Yet, the fixed stations do not include exposure rate measurements, and the deployable monitors do not include gamma spectrometry. In addition, the collection filters (for air sampling) are different on the two types of monitors. These differences lead to a number of issues and fundamental questions.

a) How will the fixed and deployable data be integrated (e.g., in the context of modeling), especially given the different gamma-ray detectors?

b) How will cross-calibration of the systems, considering the use of different air sampling filters, be accomplished? Are there plans to calibrate both systems against each other at the same site?

c) Why is exposure rate measured on the deployable, but not on the fixed, monitors?

d) What is the purpose of the exposure rate monitoring on the deployable monitors?

Finally the EPA needs to address the following foreseen shortcomings in the RadNet program in the near term: (1) shortage of fixed monitoring stations and (2) scenario dependence of the balance and interplay between fixed and deployable stations.

5. RESPONSE TO CHARGE QUESTION 3: OVERALL PROPOSALS FOR DATA MANAGEMENT AND COMMUNICATION

Charge Question 3: *Given that the system will be producing near real-time data, are the overall proposals for data management appropriate to the system's objectives?*

3a) Is the approach and frequency of data collection for the near real-time data reasonable for routine and emergency conditions?
3b) Do the modes of data transmission from the field to the central database include effective and necessary options?
3c) Are the review and evaluation of data efficient and effective considering the decision making and public information needs during an emergency?
3d) Given the selected measurements systems are the quality assurance and control procedures appropriate for near real-time data?

5.1 Issues with Data Analysis and Management

A fundamental issue raised by the briefing document is the need for and use of "zero" readings. A closely related issue is the portrayal of 'not distinguishable from background' values and their dissemination to incident commanders, policy makers, and the public. **The Review Panel recommends the use of PAGs, not simply MDAs, for definition of trigger levels.**

EPA staff explained that hourly data for the ten regions of interest of the gamma-ray spectrometer, and ^{90}Sr data from the alpha/beta particle spectrometer from 180 fixed sampling stations, will be transmitted by telemetry to a central group for collection and analysis. The resulting radionuclide concentration data will be stored, promptly distributed to appropriate government agencies, and made available to the public.

Two important aspects of evaluating these estimated 35,000 data points per day related just to radionuclide levels are:

a) rapid identification of elevated levels to identify locations of concern; and

b) avoidance of false positives that misdirect concern.

The EPA report should consider limiting the information distributed by the central analysis group to measurements that exceed a critical value predetermined for each radionuclide. For example, the critical value should be selected to be significantly greater than the 2 σ MDA, but well below the limit on intake by inhalation. By selecting a 2 σ limit, 2.3% of null values – about 800 data points per day – would randomly exceed the limit thereby becoming the focus of concern. This leads to the suggestion that a data-pattern recognition program should be instituted and controlled by an experienced radiological professional at the central location since even at the 3.1 σ limit, or 0.1% of null values (about 3 per day), the limit is exceeded. One of the important reasons why an experienced professional is needed to examine the raw data, is that a computerized analysis of the regions of interest (ROI) for the sodium-iodide detector and spectrometer will fail spectacularly when radionuclides other than the specified ones appear in the mix on the filter. For example, fission products or one of the many activation products beyond the ones listed on p.27 of the EPA document could add counts to each of the ROI. These would be reported as Bq/L for the corresponding radionuclide, while the actual radionuclides of concern would not be reported.

5.2 Response to Charge Question #3a

Is the approach and frequency of data collection for the near real-time data reasonable for routine and emergency conditions?

The answer to this question depends to some extent on how the data will be interpreted in relation to the multiple objectives outlined for RadNet. During an emergency, **the approach and frequency of collection of near real time data appear to be reasonable for deciding that an area is not likely to be affected by a particular event or events.** The data in this case would be used by a decision maker in determining whether a PAG might be exceeded with a recommendation for evacuation. The decision would revolve around a relatively high exposure rate compared to the normal exposure rate so the outlined approach and frequency appear to be reasonable. As emphasized in the ORIA presentations, the primary objective is to identify areas that do not need to be evacuated during an emergency based upon a PAG. The frequency of data collection appears to be reasonable for what is needed in an emergency.

The same approach and frequency of data collection need to be applied for routine monitoring as well as during an emergency situation so that 1) the system is continuously monitored and always ready for emergency operations, and 2) baseline data are available for comparison. For these purposes the approach and frequency of near real time data collection appear to be reasonable. However, if routine collection is also used to detect events, then a better analysis is needed. Because a large volume of data will be collected in routine operation, decision rules used to test whether a particular set of data represents an increase above background will need clarification. Decision rules could be defined as pre-existing criteria or processes by which individual readings or groups of readings are identified as "elevated". During routine operation of the fixed monitors, consideration should be given to how frequently false positives can be tolerated given that they would trigger an immediate data review. Immediate data reviews require a commitment of valuable human resources that can commit to capricious schedules that involve any hour of the week, night or day.

Hypothetically, if there were eight Regions of Interest (ROI's) for 24 hours each day and 180 monitors, it would require performing about 35,000 statistical tests per day with perhaps 35 significant per day at the p=0.001 level, or 1 in a thousand, level. This number is excessive and probably much greater than could be accommodated by review. **Careful development of decision rules will require much thought and collaboration among all members of the**

RadNet team and their partner agencies. In developing these rules it is also necessary to balance data information needs against the desire to detect a plume from a monitoring station. It would be tragic to set decision rules for triggering a review at too high a level and to miss the early evidence of an event. The optimization of decision rules should also take into account the number of monitors and their physical locations. This means that the rules would have to change over time as the RadNet system is expanded. There does not appear to be a process in place for deriving optimal decision rules for RadNet.

When an actual event occurs, a different type of decision criterion is needed as it now becomes important to detect a different type of event that addresses the question "when does the monitor detect the plume?" rather than "does a plume exist?" At this stage the concern is not about false positives but about false negatives. At the same time, filters will be counted more frequently and more detailed data on spectra will become available which will alter how decisions are made. At later stages of the emergency, decision rules designed specifically for areas along the boundaries of the plume will be needed. There are a number of additional uses outlined for RadNet such as identification of resuspension events that will require different decision rules.

Another issue that should be considered when designing decision rules is the type of terrorism events that might occur. Most of the events considered seem to center around single large releases or explosions. Some actual terrorism events in this country involving nonradioactive materials have used contamination over a longer period of time at lower concentrations (e.g., chlordane in Wisconsin – see Wisconsin DNR no date. http://dnr.wi.gov/environmentprotect/pbt/chemicals/chlordane.htm#innovative). Although it is hard to imagine an event of this type involving an airborne release that would be dispersed over a wide enough area that RadNet could detect, it probably deserves consideration when decision rules are developed. For example, could an actual event be missed because an adjustment was made for an apparent "trend" in background?

5.3 Response to Charge Question #3b

Do the modes of data transmission from the field to the central database include effective and necessary options?

Generally, the modes appear to be satisfactory. There are a variety of backup systems for communicating data including modem backup to the satellite telemetry. Since all of the systems appear to be based on existing technology, the Review Panel recommends that ORIA keep abreast of improvements in the technology and utilize them as the systems are deployed. Some panelists considered that it is premature to conclude that the data systems are appropriate because it appears that they have been tested for only a few days. Modifications to the systems should become clearer once there has been additional testing of multiple data streams over longer time periods.

Even though a communication technology may not change in terms of its technical specifications, other factors may have a detrimental or beneficial effect on the existing technology. An example of such a situation would be that as a communication technology becomes more popular, the existing infrastructure may be inadequate to sustain the volume of use during an emergency. Also there should be an ongoing evaluation of the degree of independence between alternative communications methods—are infrastructure changes causing two previously independent communication methods to become dependent on the same resources?

The present plan offers several modes of data transmission as a solution to the problem of potential failure of one or more communications links. There is a need to consider how decisions should be made when data transmission is incomplete due to partial failure of all the communication methods. If only partial information is received from the field stations, how will the available data be prioritized? Should decision rules be changed when data are incomplete or data variability is larger than anticipated?

The charge question deals with the transmission of data from the field to the central database at NAREL. **The evaluation and interpretation of RadNet data also involves other communication links that are critical to the process of providing high-quality information to decision makers and other stakeholders. The vulnerability of these communication links should also be considered in any evaluation of the RadNet system.** Effective interpretation of RadNet data requires modeling at a center remote from NAREL—what alternative communication methods are available to link to this center? Similar concerns arise over communication of results to decision makers since for many scenarios the decision makers are likely to be located at the site of the emergency where communication methods may not be working. FRMAC and coordinating agencies also need to have alternative communication methods. Also if the field stations, NAREL, modeling center, FRMAC, agencies, and decision makers are identified as a communications system to provide information to the public in an emergency then there is a need to consider not only the communication links between the parts of the system but also the need for alternative sites such as the modeling center to preserve the communication system to the public.

The Review Panel expressed some concern with regard to the operators being a weak link in some aspects of the transmission of data. While understanding the plan to use non-radiological personnel for such tasks, it is believed that there are sufficient trained radiation safety personnel available to be able to use some of them for this role. For example, there could be many volunteers from the Health Physics Society who are unlikely to have a formal role in an emergency and who would be willing to help. In addition, radiation safety staff from other, unaffected States may be called upon through mutual aid agreements. This becomes important if the role of the deployable monitors is revised in line with other Review Panel recommendations. If the deployables are used in areas where there are measurable radiation or contamination levels, non-radiological personnel may not respond appropriately.

The Review Panel believes that the revised mission of deployable monitors as proposed in this report has a number of other impacts. It makes it important to have a direct read-out of radiation levels on the monitor itself. Similarly, there is likely to be more need for electrical generators than has been planned for up to this point as well as a greater need for security of the deployables once positioned.

The Review Panel believes that having only one person from each lab responsible for twenty systems is too few. The Review Panel suggests that having a ratio of four lab experts for twenty systems would be preferable.

5.4 Response to Charge Question #3c

Are the review and evaluation of data efficient and effective considering the decision-making and public information needs during an emergency?

5.4.1 Review and Evaluation of Data

NAREL staff's presentations to the Review Panel on methods to provide Quality Assurance/Quality Control (QA/QC) of the data showed that the plans for ensuring the quality of the data were adequate. In addition, the automatic and computerized methods currently in place to determine if the equipment is working properly and that data are accurate were well thought out. Given that any incident response plan or EPA decision based on RadNet will depend on analyses from models that integrate data from a wide range of sources, it is essential that the RadNet network be optimized in terms of these models. These process-oriented environmental models are typically underdetermined as they contain more uncertain parameters than the variables available to them for calibration. **Therefore the Review Panel strongly advocates the use of sensitivity analyses in the siting of future monitor stations (fixed and deployable).** This represents a necessary step to optimize the value of collected monitoring data to the decision makers.

The Review Panel notes that standard operating procedures (SOP) should be in place and accompany all the QA/QC plans to ensure that the data are handled reproducibly prior to any release and that information from the system is accurate and reliable. The QA/QC system should be tested over an extended period of time with "dry runs" to determine if the methods can ensure that the equipment is operating correctly at both the fixed and deployable monitors.

In the rare case when one of the fixed stations has a reading that is outside the predetermined range of acceptability, everything possible must be done to expedite the QA/QC process to validate the readings. Even in an emergency, it is essential that the appropriate QA/QC be completed before release of data. The timetable for releasing the data should not be compressed in any way that may jeopardize data quality.

The air monitoring and data management/transmission system have only recently been delivered to NAREL and have not been completely tested. The discussion of data in the Concept and Plan document is brief and provides only a conceptual plan for data management. The Review Panel did not see complete raw data sets or data in the form that will be provided to users, including the public. The NAREL proposal for data management appears to be adequate, but it cannot be conclusively stated that it is appropriate to the system's objectives until the data management procedures are developed and tested.

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5.4.2 Communication to Decision Makers and the Public

Part of the stated mission of the RadNet Air Network is to protect the public health and the environment by providing information to public officials and the general public about the impacts resulting from major radiological incidents/accidents and on baseline levels of radiation in the environment. As EPA staff noted in documents and presentations provided to the Review

Panel, to convey technical information accurately, the manner in which the data is presented must be tailored to the nature of the event and the diverse needs and levels of technical expertise of users. Various groups will need information of varying types at different times and with differing amounts of context and explanation, after completion of the appropriate quality assurance and control review.

The Review Panel commends EPA for including stakeholders in the Agency's ongoing planning to aid in understanding the requirements and preferences of various "customer" groups such as modelers, decision makers, and the public and encourages outreach activities. EPA should also consider developing, with the aid of social science and communication experts, sample informational messages for release to stakeholders, including the public, in an emergency concerning the radiological aspects of specific situations. Such sample messages should be tested during disaster drills.

In an emergency, the EPA's primary responsibility is to assist other government agencies by providing accurate and reliable data from RadNet and other sources that can be used as a basis for decision making. First, EPA must convey the data to the National Atmospheric Release Advisory Center (NARAC) Inter-Agency Modeling and Atmospheric Assessment Center (IMAAC) at Lawrence Livermore National Laboratory as soon as possible so that models can be run to help understand the distribution and direction of the plume and the resulting dose levels. As soon as the data have been conveyed to IMAAC and properly evaluated, it is the responsibility of IMAAC to convey the results along with all other information on the event to Federal Radiological Monitoring and Assessment Center (FRMAC). FRMAC, rather than EPA, has the initial responsibility for releasing information to the public. **It is important that the flow of data from the event to the public be restricted to this line of communication (EPA to IMAAC to FRMAC), so that the messages the public receives are consistent, accurate and useful as possible.** For example there should not be one message reporting activity in disintegrations per minute and another suggesting some type of radiation dose. EPA documents that the Panel reviewed noted that all data would be coordinated through the FRMAC to develop a single common operating picture, as required by the National Response Plan (NRP). EPA could, however, also provide important assistance during the development of the message by contributing its own expertise in message development and its understanding of the data and the historical context. After communication from FRMAC has occurred, with the agreement of that agency, EPA should then make every effort to rapidly supply the validated raw data in a form that is easy for the public to understand.

Immediately following the recognition of a radiation incident, local Incident Command center will be established to direct local responders in the rescue and treatment of people who are directly affected and to protect the public who are not affected. Incident Command will make decisions on the basis of the information at hand. These decisions must be informed by data that describe the nature and significance of any potential radiation exposure. Very early qualitative data will be collected locally and provide information for early decisions but historical and quantitative data collected by EPA, including RadNet data, should be forwarded through channels as soon as possible. Because data need to be reviewed to assure quality, there will be some delay. Everything possible should be done during emergencies to minimize the time necessary to review the data and forward it to inform local Incident Command as soon as possible.

5.4.3 Units for Communication

The Review Panel was concerned that in the preparation of documentation, such as the *"Expansion and Upgrade of the RadNet Air Monitoring Network Concept and Plan,"* the appropriate international units to express activity, radiation exposure, dose and risk were not used. This may be related to the fact that international units were adopted and came into wide spread use after much of the monitoring data were derived by the systems that have been replaced by RadNet. The Review Panel considered a strong recommendation that all data should be re-evaluated using the appropriate S.I. units with the corresponding older units in parenthesis. However, convincing arguments were presented that instrumentation commonly used by first responders does not use (appropriate) S.I units, nor is their training presented in these units. The Review Panel was convinced that clarity of communication and comprehension was more important than international conformity at this time, so the recommendation has been softened to suggest that S.I. units may be presented in parentheses in preparation for a transition in the future.

5.4.4 Communicating Risk

Great care needs to be taken in converting raw data from counts per minute, to exposure, dose, and risk. Raw counting data are very site, detector, nuclide, isotope, particle size, chemical form and population specific. Thus, without much additional information and analysis, the raw data (counts per minute) **cannot and must not** be used to make even the crudest estimates of risk. In conveying the raw data to the public, it is important that the message does not convey an improper perception of the risk from any event. For example, Figure B.1 page B-2 in the report records the level of activity as Monthly Maximum Gross Beta Concentration (pCi/m^3) over a 13 year period. It shows that the activity during this time varies by more than 100,000 times. Conveying such raw data to the public would suggest that the risk had changed by a very large amount. Historical data suggest that these large changes in activity in the air have resulted in non-detectable changes in the frequency of cancer among the U.S. population. This finding relates to the high frequency of spontaneously or naturally-occurring cancer (all types) in the population (approximately four in ten persons will develop some form of cancer during their lifetime) and the relatively low additional risk of cancer associated with exposure to ionizing radiation.

5.4.5 Other Factors that Complicate Accurate Communication

The difficulty in communicating raw data from RadNet is further complicated by the wide range of background radiation and radioactive materials in the environment. **Information**

on background radiation and its variability also needs to be communicated to the public relative to the changes measured by RadNet. It is important for information on the range of background radiation to be quantified and made available with any report to the public.

The difference between "calculated risk" based on estimates of radiation doses to populations or individuals and "measured increases in cancer frequency" based on observations of the number of cancer cases in epidemiological studies following low dose radiation exposures of large populations needs to be further established and discussed in a framework that the public can understand. The magnitude of the risk of radiation-induced cancer compared to the risk of developing cancer in the absence of prior radiation exposure (i.e., spontaneously) needs to be *correctly and clearly* communicated using appropriate language in any releases to the public. **Care should be taken to avoid using unprocessed RadNet monitoring data in the estimation of the number of excess cancers that could be expected in future years among a large population potentially exposed to very low doses of radiation. Such estimations are not considered to be a responsibility of the RadNet program.**

5.4.6 Preparing for Communication in an Emergency

The Review Panel recommends that ORIA develop standard informational messages for use in press releases and emergency broadcast messages. These statements should be part of any exercise with RadNet participation. These statements need to be related to exposure, activity, dose and risk utilizing a range that would encompass those typically found from hypothetical data. **Social scientists and communications experts must carefully review such statements to be sure that the messages are understandable and accurate.**

The messages derived for use in exercises also need to be discussed with decision makers associated with the area where the exercise is conducted. These decision makers should include individuals such as Governors, City Managers, Mayor, Media managers, Chief of Police and Fire Chief. The decision makers should be asked to respond to the information provided and let EPA, IMAAC, and FRMAC know what information they need to make decisions and how the data and messages supplied would influence the decisions that they must make in the time of a real event or emergency. Studies of this type will help to develop useful, understandable and accurate messages that can be used to convey the data derived from RadNet following an event involving RDDs or improvised nuclear weapons.

It will be especially important to have these messages developed well ahead of time and defined for rapid use in the case of a real event. Such messages will need to be modified to be specific for each real event. They must provide a foundation that will help the public understand if they were exposed, the levels of the exposure, the radiation doses associated with the exposure and the level of damage or risk associated with the exposure. This will provide a rational basis for any action or sacrifice that the public is asked to make by the decision makers.

5.5 Response to Charge Question #3d

Given the selected measurements systems, are the quality assurance and control procedures appropriate for near real-time data?

It is EPA policy that all EPA environmental programs observe 48 CFR 46.202-4 (48 CFR 46.202-4. 2000). *Quality Assurance for the Federal Acquisition regulations System*, EPA Order 5360.1 A2 (U.S. EPA. 2000), *Policy and Program Requirements for the Mandatory Agency-wide Quality System*, and comply fully with the American National Standard ANSI/ASQC E4-1994 (ANSI/ASQC E4-1994.1995). Standards 48 CFR 46 and ANSI/ASQC E4-1994 provide the regulatory and operational basis for EPA QA/QC procedures and are appropriate and adequate to support the RadNet Air Monitoring Network. However, given the extensive array of requirements and activities provided in these regulations and standards, important issues regarding the RadNet Air Monitoring Network arise include the following:

- The specific EPA QA System established will assure that environmental data from the RadNet Air Monitoring Network are of adequate quality and usability to support all federal, state, and local requirements.

- All organizations and individuals under direct contract to EPA for RadNet Air Monitoring services, equipment, products, deliverable items, personnel training, and work are in full conformance with 48 CFR 46 and ANSI/ASQC E4-1994.

- EPA has audited supporting organizations and suppliers and documented that the required quality and performance of these services, products, deliverable items, personnel training, personnel training, and work are adequate.

- Periodic audits and assessments (as confirmatory documents available to interested parties) of the effectiveness of each quality system component associated with the RadNet Air Monitoring Network demonstrate conformance to the minimum specifications of ANSI/ASQC E4-1994.

Because the integrity and accuracy of the data measured, gathered, processed and disseminated are essential to the successful mission of the RadNet Air Monitoring Network, a controlled testing and periodic assessment of the overall performance of the system is essential for national security and confidence in the network.

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APPENDIX A – BIOSKETCHES

U.S. ENVIRONMENTAL PROTECTION AGENCY
SCIENCE ADVISORY BOARD
RADIATION ADVISORY COMMITTEE (RAC) RadNet REVIEW PANEL

Dr. Bruce B. Boecker:

Dr. Bruce B. Boecker: is a Scientist Emeritus of the Lovelace Respiratory Research Institute, Albuquerque, New Mexico. He is a Diplomate of the American Board of health Physics, a Certified Health Physicist, and a Fellow of the Health Physics Society (HPS). He has served on numerous committees especially for the National Council on Radiation Protection and Measurements, NCRP, International Commission on Radiological Protection, ICRP, and the National Academy of Science/National Research Council, NAS/NRC, dealing with the intake, internal doses, bioassays, epidemiology, radiobiology and risk of radionuclides. He has been elevated to honorary member of the NCRP. He was a consultant to develop a Federal strategy for research into the biological effects of ionizing radiation. He currently serves as a Technical Staff Consultant with the NCRP dealing with various Homeland Security topics. Dr. Boecker's research interests have been mainly in two broad areas, namely (1) inhalation toxicology and (2) dose-response relationships for long-term biological effects produced by internally deposited radionuclides. He has been particularly involved in the conduct of animal experimentation to develop information to support predictions of consequences of accidental exposure of man or to establish standards to ensure the safe and orderly conduct of activities that might result in release of toxic agents to man's environment. His personal research efforts have been associated primarily with the radiobiology and toxicology of airborne material associated with different activities in the nuclear fuel cycle. This research has spanned broadly from studies of aerosol characteristics as they may influence patterns of deposition, retention, and dosimetry on through to risk assessments for different nuclear energy systems. Dr. Boecker holds a Ph.D. and M.S. in Radiation Biology from the University of Rochester and a B.A. in Physics from Grinnell College.

Dr. Antone L. Brooks:

Dr. Antone L. Brooks is a radiation biologist, Senior Scientist and Professor of Radiation Toxicology in the Environmental Science Department at Washington State University. Dr. Brooks received an associate's degree in Chemistry from Dixie Junior College in St. George, Utah, a B.S. in Experimental Biology and an M.S. in Radiation Biology from the University of Utah in Salt Lake City. He received his Ph.D. in Physical Biology and Genetics from Cornell University in Ithaca, New York. Dr. Brooks has conducted extensive research on health effects of radiation exposure from both external radiation sources and internally deposited radioactive materials. He has used both molecular, cell and whole animal research to help define these effects. His current research is focused at developing a scientific basis for radiation risk estimates following low-dose radiation exposure. He has done extensive work to define energy barriers for radiation-induced cellular effects, has characterized cell and molecular responses that result in bystander effects, adaptive responses and genomic instability. His current focus is to understand how these new observations result in paradigm shifts that may impact the shape of radiation dose-response relationships in the low dose region. A major current focus is developing better tools to communicate the results of radiation science including a web site, http://lowdose.tricity.wsu.edu. Dr. Brooks has served as a member of the NAS BEIR VI Committee on Health Effects of Exposure to Radon. He is a member of the National Council on Radiation Protection and measurements (NCRP) and is on the Board of Directors of the NCRP. He is currently serving on the EPA Science Advisory Board (SAB) as a member of the Radiation Advisory Committee (RAC). He is a member of the Editorial Board of the International Journal of Radiation Biology and the International Journal of Low Radiation.

Dr. Gilles Y. Bussod:

Dr. Gilles Y. Bussod is Chief Scientist with New England Research, Inc. in White River Junction, VT, and an Adjunct Professor in Earth Sciences at The University of Vermont in Burlington, VT. He also holds an appointment as Professor Candidat aux Universités de France, a Doctorate in Geophysics from the Université de Paris VII, France, and a PhD in Geology from the University of California, Los Angeles. He has recently served on the Faculty of Science at the International Research Center of the Catholic University of Leuven, Campus Kortrijk in Belgium and was employed as President of Science Network International, Inc., in Santa Fe, NM. Previously he was a staff Hydrogeologist and Geochemist at Los Alamos National Laboratory, Los Alamos, NM, and a Science Fellow at both the Bayerisches Geoinstitut in Bayreuth, Germany, and the Lunar and Planetary Institute, Houston, TX. He also served as a National Laboratory Representative to the Middle East, and a Delegation Member to the U.S. Secretary of State Madeleine Albright, at the Economic Summit Conference in Doha, Qatar. As the Los Alamos National Laboratory Project Leader and technical manager for the Yucca Mountain Project, he received several Achievement Awards and Patents. Dr. Bussod's research is centered on Environmental Restoration of contaminated DoD and DOE sites, specializing in the design and implementation of integrated laboratory and field studies on radionuclide transport, the remobilization of "legacy waste" in the environment, and the effect of subsurface heterogeneities on modeling transport phenomena and upscaling. He was PI for the Underground Unsaturated Zone Transport Test, Busted Butte, NV, and The Cerro Grande Subsurface Remediation Project, Los Alamos, NM. He holds authorship or co-authorship in over 60 publications involving geochemical flow and transport and related phenomena, as well and over 30 invited oral presentations dealing with unsaturated zone modeling, high pressure and high temperature research in experimental rock physics and petrology, novel drilling methods, rock melting drilling systems, deformation mechanisms, energy extraction techniques, high pressure experimental seismic velocity measurements and related topics.

Dr. Brian Dodd:

Dr. Brian Dodd is originally from the U.K. where he worked at Imperial College and the Royal Naval College in Greenwich. He and his family moved to the USA in 1978, taking up citizenship in 1993. Until February 2004, Dr. Dodd was Head of the International Atomic Energy Agency's Radiation Source Safety and Security Unit, managing the IAEA's efforts in dealing with orphan sources and the potential use of radioactive sources for radiological terrorism. He is currently 'retired' form the managerial burdens of work, but is still pursuing the technical aspects as BDConsulting in Las Vegas. Prior to joining the IAEA he was at Oregon State University for 20 years, most recently as the Director of its Radiation Center a well as a Professor of Health Physics and Nuclear Engineering. Dr. Dodd has been involved with the Health Physics Society for many years, including terms of office on the Board of Directors and as treasurer. He is currently (2005-6) the President-Elect of the HPS as well as Treasurer of the International Radiation Protection Association. His fields of expertise include safety and security of radioactive sources, transportation of radioactive material, emergency response, training and research reactors. Brian Dodd has authored or co-authored a number of IAEA/UN publications on security of radioactive sources, safe transport of radioactive materials, management of radiation protection, quality aspects of research reactor operations and related topics. He has authored or co-authored over 100 publications in technical journals, conference proceedings, reports and others dealing broadly with the above topics. Dr. Dodd has a B.S. in Nuclear Engineering and Ph.D. in Reactor Physics from Queen Mary College, London University.

<u>Dr. Shirley A. Fry:</u>

Dr. Shirley A. Fry is a self-employed consultant in radiation health effects. She holds a medical degree from the University of Dublin, Trinity College, Ireland, and a master's degree in epidemiology in the School of Public Health, University of North Carolina, Chapel Hill. She was on the staff of the Medical Sciences Division (MSD) of Oak Ridge Associated Universities (ORAU) from 1978 until her retirement in 1995. At ORAU she was member of MSD's Radiation Emergency Assistance Center/Training Site's (REAC/TS) clinical staff, teaching faculty and response team (1978-1995); director of its Center for Epidemiologic Research (1984-1991) and its assistant director (1991-1995). Subsequently she was a member of the Scientific Advisory Council and later the scientific director of the International Consortium for Radiation Health Effects Research, a Washington, DC.-based consortium of research groups at academic institutions in the US, Belarus, Russian Federation and Ukraine established to conduct collaborative epidemiological studies among groups potentially exposed to radiation as the result of the 1986 Chernobyl reactor accident. She continued a part-time association with ORAU until November 2005. Her areas of scientific interest are in the acute and chronic health effects of radiation, specifically in the long term follow-up of individuals and populations previously accidentally exposed or at risk of occupational exposure to radiation, including workers employed by US Department of Energy, its predecessor agencies and their contractors, and in the US radium dial painting industry. Dr. Fry is the author or co-author of a number of publications on topics relating to these groups. She has served on national and international committees concerned with radiation health effects, including the Institute of Medicine' Medical Follow-up Agency (IOM/MFUA's) Committee on Battlefield Exposure Criteria and the National Academies of Sciences/ National Research Council 's Board of Radiation Effects Research (NAS/NRC's BEAR) Committee on the Assessment of the Scientific Information for the Radiation Exposure, Screening and Education Program, the Health Studies Group of the

US/USSR Joint Commission on Chernobyl Nuclear Reactor Safety and the International Agency for Research on Cancer's International Study Group on Cancer Risk Among Nuclear Workers.

Dr. William C. Griffith:

Dr. William C. Griffith was trained as a biostatistician and has collaborated for over three decades in studies of the dosimetry and health effects of radiation and other toxicants. His work has included design, data collection and analysis of laboratory and field based studies. In particular he has extensive experience in estimation of doses from internally deposited radionuclides and estimation of dose response in terms of age specific incidence rates and prevalence. He has also been active in translating his experience into models that are useful for health protection through is participation in committees of the National Council for Radiation Protection. More recently he has analyzed how these models are applied in environmental cleanup of the Department of Energy's Hanford site, and he has worked extensively with committees of the Hanford Advisory Board. Most recently he has been funded as part of the Department of Energy's Low Dose Radiation Program to translate laboratory results into mathematical models that will be useful for future regulation of radiation. Dr. Griffith also has experience in the study of non-radioactive toxicants. He was part of the team at the Lovelace Inhalation Toxicology Research Institute that was the first to prove that diesel exhausts are pulmonary carcinogens in laboratory animals. For the last five years at the University of Washington he has been Director of the Risk Characterization Core for the Child Health Center funded by the Environmental Protection Agency and the National Institute of Environmental Health Science. As director he has designed and developed statistical methods for analysis of a community based randomized intervention to test the effectiveness of educating farm workers about how they can decrease the accidental exposures of their children from pesticides they bring home on their clothes. Dr. Griffith has also collaborated with EPA Region 10 by lecturing frequently on how to apply statistical methods to superfund cleanup decisions. This year he organized 8 workshops on the application of new genomic and proteonomic methods in collaboration with EPA-ORD for EPA regions, state and tribal environmental offices.

Dr. Helen A. Grogan:

Dr. Helen A. Grogan is a member of the SAB's Radiation Advisory Committee. She is employed as an independent consultant who has her own consulting firm, Cascade Scientific, which has been subcontracted by Risk Assessments Corporation (RAC) to work on a variety of projects, including an independent assessment of the risks to the public from the 2002 Cerro Grande Fire for the New Mexico Environment Department, development of a risk-based screening for historical radionuclide releases to the Columbia River from the Hanford Nuclear Facility in Washington under contract to the Centers for Disease Control and Prevention (CDC), and two dose reconstruction projects (Rocky Flats near Denver, CO and Savannah River in So. Carolina). Her work for the Rocky Flats site emphasized quantifying cancer risk and its uncertainty following exposure to plutonium from inhalation and ingestion. Dr. Grogan is currently working with other RAC contractors on the RACER project to develop a process and tool that can be used to guide the efforts to reduce public health risk and ecological impact from radionuclides and chemicals originating at the Los Alamos National Laboratory. Dr. Grogan has assisted in the development of an International Features Events and Processes (FEP) database for the Nuclear Energy Agency (NEA) Organization for Economic Cooperation and Development (OECD) in France to be used in the performance assessment of radioactive waste disposal systems. In addition, she was also involved with the Swiss National Cooperative for the Disposal of Radioactive Waste (Nagra), specifically in modeling the biosphere for repository performance assessment, and in development of scenario analyses for the Nagra Kristallin I and Wellenberg projects and development of supporting data bases that identify important phenomena (FEPs -features, events and processes) that need to be accounted for in repository performance assessment. She was actively involved in the Biospheric Model Valuation Study - Phase I and II BIOMOVS study (Biospheric Model Validation Study), which is an international cooperative effort to test models designed to quantify the transfer and accumulation of radionuclides and other trace substances in the environment. Dr. Grogan's doctoral thesis title is "Pathways of radionuclides from soils into crops under British field conditions." She has authored or co-authored several dozen publications, and technical reports dealing with the role of microbiology modeling the geological containment of radioactive wastes, plant uptake of radionuclides, laboratory modeling studies of microbial activity, models for prediction of doses from the ingestion of terrestrial foods (with a focus on radionuclides), long-term radioactive waste disposal assessment, modeling of radionuclides in the biosphere, quantitative modeling of the effects of microorganisms on radionuclide transport from a High Level Waste repository and related topics. She received her Bachelor of Science Degree in Botany with honors from the Imperial College of Science and Technology at the University of London, and her Ph.D. from that same university.

Dr. Richard W. Hornung:

Dr. Richard W. Hornung is a member of the Radiation Advisory Committee (RAC) since FY 2001. He recently (2005) became Director of Biostatistics and Data Management of Cincinnati Children's Hospital Medical Center, Division of General and Community Pediatrics. He headed the Statistical Working Group of the RAC's Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Review Panel. He served as a consultant to the RAC (March, 1999), and participated in the SAB's advisory on Radon Risk. He was Senior Research Associate and Director of the Division of Biostatistical Research and Support in the Institute for Health Policy and Health Services Research at the University of Cincinnati Medical Center in Cincinnati, Ohio. He has served since 1996 as a member of the White House Committee on Revisions to the Radiation Exposure Compensation Act. Since 1990, he has served as an advisor on the National Research Council. He received numerous awards, including the U.S. Public Health Service award for "Sustained High Level Performance in the Field of Biostatistics." He was a consultant to the National Academy of Science Committee on the Biological Effects of Ionizing Radiation (BEIR IV). He is a reviewer for a dozen scientific journals. His peer-reviewed publications deal with exposure assessment methods, lung cancer risk in Uranium miners, dose assessments, dose reconstruction, development of models for use in estimating exposures to a number of pollutants, including diesel exhaust, benzene, ethylene oxide, lung cancer in shipyard workers and other related topics. In the area of radiation research, he is currently funded under contract to the University of Kentucky to serve as the scientific director of an occupational epi study of workers at the Paducah Gaseous Diffusion Plant. He is also funded by NIOSH as the biostatistician on a study of radiation related cancers among residents living near the Fernald plant in Southwestern Ohio. Dr. Horning has a B.S. in Mathematics from the University of Dayton, an M.S. in Statistics from the University of Kentucky, and a Ph.D. in Biostatistics from the University of North Carolina.

Mr. Richard Jaquish:

Mr. Richard Jaquish has over 40 years experience in environmental radiation surveillance. He was the Director of the Technical Support Laboratory of the EPA National Environmental Research Center in Las Vegas which provided laboratory services for the analysis of samples from underground nuclear testing and plowshare programs. Analytical procedures were developed for unique radionuclides and media resulting from nuclear tests. In 1980 he became a senior research engineer with Battelle Memorial Institute in Richland, WA where he was manager of the environmental radiation program for the Hanford site. He was later the manager of the Office of Hanford Environmental that managed the programs in environmental surveillance, groundwater monitoring, meteorology, and wildlife resources. In 1995 he took a position with the Washington Department of Health as an advisor in environmental radiation and Hanford cleanup activities.

Hands on monitoring experience in unique environments included six months of monitoring radioactivity in Antarctica, monitoring fallout in Eskimos in Alaska, and regularly serving on a flight crew for aerial monitoring of radioactive plumes on and around the Nevada Test Site. He was a regular member of emergency response teams at Battelle and the State of Washington and responded to several unusual occurrences including the 2000 Hanford fire.

Mr. Jaquish served two terms on the American Public Health Committee on Laboratory Standards and Practices. He was a member of the National Council on Radiation Protection and Measurements (NCRP) Committee 64 (1994-2000) on Environmental Radiation and Waste Issues and is currently a member of NCRP Committee 64-22 that is preparing a guide on "Design of Effective Effluent Monitoring and Environmental Surveillance Programs." Mr. Jaquish has a B.S. degree in Civil Engineering from Washington State University and an M.S. in Engineering and Applied Physics from Harvard University. He has over 20 publications in environmental radioactivity.

Dr. Janet A. Johnson:

Dr. Janet A. Johnson is currently employed by MFG, Inc. in Fort Collins, CO as a Senior Radiation Scientist with expertise in health physics, radiation risk assessment, and environmental health. MFG, Inc., a Tetratech Company, provides environmental engineering consulting services to industry including the mining sector. She holds a BS in Chemistry from the University of Massachusetts, an MS in Radiological Physics from the University of Rochester School of Medicine and Dentistry, and a PhD degree in Microbiology (Environmental health) from Colorado State University. Dr. Johnson was formally employed by Colorado State

University as Interim Director of Environmental Health Services in Fort Collins, Colorado. She is a certified industrial hygienist (CIH, radiological aspects) and is also certified in the comprehensive practice of health physics by the American Board of Health Physics. She is an active member of a number of radiation and health-oriented professional organizations, and is a Fellow of the Health Physics Society (HPS), as well as a former member of the Board of Directors of the HPS. She has served on the Colorado Radiation Advisory Committee since 1988 and was a member of the Colorado Hazardous Waste Commission (1992-1997). Dr. Johnson's primary consulting work focuses on the mining industry with emphasis on uranium recovery facilities. She is also involved in developing technical basis documents for the National Institutes of Occupational Safety and Health (NIOSH) dose reconstruction project under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA). Dr. Johnson is a former chair of the Radiation Advisory Committee. In addition, she chaired the ERAMS II advisory (EPA-SAB-RAC-ADV-98-001, August 28, 1998).

<u>Dr. Bernd Kahn:</u>

Dr. Bernd Kahn is Head of the Environmental Radiation Branch since 1974 (formerly the Environmental Resources Center) and now Professor Emeritus of the Nuclear and Radiological Engineering and Health Physics Programs at Georgia Institute of Technology (GIT). He received his B.S. in Chemical Engineering from Newark College of Engineering (Now New Jersey Institute of Technology), M.S. in Physics from Vanderbilt University and Ph.D. in Chemistry from the Massachusetts Institute of Technology. He was Adjunct Professor of Nuclear Engineering at the University of Cincinnati (1970-1974), Chief of the Radiological & Nuclear Engineering Facility at the U.S. EPA's National Environmental Research Center (1970-1974), undertaking research in environmental, medical, and biological radiological programs, including studies of radioactive fallout in food, radionuclide metabolism in laboratory animals, and 90Sr balances in human infants; an Engineer/Radiochemist with the U.S. Public Health Service (1954-1970), evaluating the treatment of low-and intermediate-level radioactive wastes; and a Health Physicist and Radiochemist with Union Carbide Corporation (1951-1954).

Dr. Kahn has served on a number of committees, panels and commissions, including the National Research Council committees on decontamination and decommissioning of uranium enrichment facilities, buried transuranic waste, single shell tank wastes, Panel on Sources and Control Technologies, Committee on Nuclear Science, and Subcommittee on the Use of Radioactivity Standards. Dr. Kahn served on the U.S. EPA SAB's Radiation Advisory Committee, having been on the RAC reviews of both ERAMS I and ERAMS II, the predecessor systems to RadNet, as well as the MARLAP review on laboratory radiation measurement protocols. He has served on the National Council on Radiation Protection and Measurements (NCRP) Scientific Committees as Chair of the Scientific Committee 64-22 for Effluent and Environmental Monitoring, Chair of the Task Group 5 on Public Exposure from Nuclear Power, member of the Scientific Committee 84 on Radionuclide Contamination, member of the Scientific Committee 64 on Environmental Issues, member of the Scientific Committee 63-1 on Public Knowledge About Radiation Accidents, member of the Scientific Committee38 on Accident-Generated Waste Water, member of the Scientific Committee 18A on Radioactivity

Measurement Procedures, and member of the Scientific Committee 35 on Environmental Radiation Measurements.

Dr. Kahn is widely published with over 160 publications on the topics of radiation measurements, monitoring and protocols, fate of radionuclide discharges, critical pathways for radiation and population exposure, radiochemical analyses for environmental studies, airborne radiation in buildings , emergency response to accidents involving radioactive materials, airborne fallout, sources, fate and occurrences and health effects of radionuclides in the environment, surveillance of radionuclides in the food chain, integrated environmental measurement, germanium detectors and other devices, decommissioning procedures and radiation-related topics.

Dr. Jonathan M. Links:

Dr. Jonathan M. Links is Professor of Environmental Health Sciences at the Johns Hopkins Bloomberg School of Public Health, with joint appointments in Radiology and Emergency Medicine at the Johns Hopkins School of Medicine. He is a medical physicist, with a B.A. in Medical Physics from the University of California, Berkeley, and a Ph.D. in Environmental Health Sciences (with a concentration in Radiation Health Sciences) from Johns Hopkins University. Dr. Links' expertise is in radiation physics and dosimetry, medical imaging instrumentation, radiation-based biomarkers, and terrorism preparedness and response. Dr. Links is a member of the Delta Omega National Public Health Honor Society, and is a past president of the Society of Nuclear Medicine, a 16,000 member professional medical society. Dr. Links is currently Director of the Johns Hopkins Center for Public Health Preparedness, and is Baltimore City's radiation terror expert, working with the Health, Fire, and Police Departments. He is a current member of the EPA SAB's Radiation Advisory Committee.

Dr. Jill A. Lipoti:

Dr. Jill A. Lipoti was recently reappointed by the Administrator to serve a second two-year term as Chair of the SAB's Radiation Advisory Committee (RAC). She was appointed (2005) as Director, Division of Environmental Safety & Health for the New Jersey Department of Environmental Protection (NJ DEP) in Trenton, NJ. From 1989 until late 2005, she held the position of Assistant Director of Radiation Protection Programs of the NJ DEP. This program administers licensing and inspection of radiation sources, certification of technologists, radon public awareness, certification of radon testing and mitigation firms, low level radioactive waste siting issues, nuclear emergency response, oversight of nuclear power plant activities for environmental releases, and non-ionizing radiation. She has publications and proceedings in a broad range of topical areas, such as diagnostic radiology quality assurance, certification of radiation risks from high-dose fluoroscopy, nuclear power plant and X-Ray program redesign, reduced emissions from mammography, public confidence in nuclear regulatory effectiveness, the linear non-threshold regulation, similarities and differences in radiation risk management, partnerships between state regulators and various other organizations, electromagnetic fields from transformers located within buildings, community Right-to-Know, identifying individuals susceptible to noise-induced hearing loss, community noise control, and a variety of other topics.

Dr. Lipoti holds numerous appointments to boards and councils. She has served as Chairman of the Conference of Radiation Control Program Directors (1997-98), the Board of Directors and Chair of the Environmental Nuclear Council (1992-95), Chair of the Transportation Committee (1991-93). Dr. Lipoti is a member of the National Council on Radiation Protection and Measurement (NCRP) and serves on the Board of Directors. She is a member of the Health Physics Society She has served as a member of the Technical Electronic Products Radiation Safety Standards Committee for the U.S. Food and Drug Administration (FDA).

Dr. Lipoti has provided expert testimony on a variety of radiation-related topics. She has provided comments on the revised oversight program for nuclear power plants, and orphan source recovery, and licensee's accountability programs before the U.S. NRC. She has also provided comments to various Congressional committees and subcommittees, such as comments on the Radon Disclosure and Awareness Act in a joint hearing before the United States House of Representatives Subcommittee on Transportation and Hazardous Materials and the Subcommittee on Health and the Environment, and comments on the Indoor Radon Abatement Reauthorization Act of 1993 in a hearing before the U.S. Senate Committee in Environment and Public Works, Subcommittee on Clean Air Nuclear Regulations.

Dr. Lipoti holds a Ph.D and M.S. in Environmental Science from Rutgers University, and a B.S. in Environmental Science from Cook College in New Brunswick, NJ.

Dr. Gary M. Sandquist:

Dr. Gary M. Sandquist is currently a Professor of Mechanical Engineering and former Director of the Graduate Nuclear Engineering Program at the University of Utah. Previously he was a Distinguished Visiting Professor in Physics and Civil and Mechanical Engineering Departments at the U.S. Military Academy at West Point, where he supported and trained Army personnel in Functional Area 52 activities (Nuclear operations). He has a B.S. in Mechanical Engineering, M.S. in Engineering Science, Ph.D. in Mechanical and Nuclear Engineering, MBA, was a Post Doctoral Fellow at MIT, and served a Sabbatical at Ben Gurion University in Beer Sheva, Israel. He is a Registered Professional Engineer in Utah and New York (Mechanical) and California (Nuclear), a Board Certified Health Physicist, a Diplomate in Environmental Engineering, a Certified Quality Auditor, and a retired U.S. Naval Reserve Commander with an Intelligence Designator. The Reactor Supervisor and U.S. Nuclear Regulatory Commission (NRC) Licensed Senior Reactor Operator for a TRIGA research reactor, he served as a short mission expert in nuclear science and safeguards for the International Atomic Energy Agency (IAEA) and as Technical Training Director for the joint DOE, EPA, DRI Community Radiation Monitoring Program at the Nevada Test Site. Dr. Sandquist's principal scientific interests include risk assessment; radiation transport, analytical detection and measurement; assessment and decontamination of chemical and radioactive hazards; design and execution of characterization and final status surveys using Multi-Agency Site Survey and Investigation Manual (MARSSIM); and design and operation of heating, ventilation and air-conditioning (HVAC) systems. He is a

Fellow of the American Society of Mechanical Engineering (ASME) and American Nuclear Society (QUANS). He has authored or co-authored 500 publications including 5 books and book chapters, 180 refereed papers, 325 technical reports, developed 17 major technical computer codes and participated in over 200 technical meetings, conferences, workshops and government hearings.

Dr. Richard J. Vetter:

Dr. Richard J. Vetter is Radiation Safety Officer for Mayo Clinic and Professor of Biophysics in the Mayo College of Medicine in Rochester, Minnesota, and Director of Safety for Mayo Foundation. His major areas of interest include biological effects and dosimetry of ionizing and nonionizing radiation and public policy of radiation applications. Dr. Vetter is certified by the American Board of Health Physics and the American Board of Medical Physics. He is former Health Physics Society President and has served as Editor-in-Chief of the Health Physics Journal, as well as the Board of Directors of the Minnesota Safety Council. He currently serves as a member of the National Council on Radiation Protection and Measurements Board of Directors and a member of the Nuclear Regulatory Commission Advisory Committee on Medical Use of Isotopes. He is a member of the American Association of Physicists in Medicine, the Radiological Society of North America, the Society of Nuclear Medicine, the American Academy of Health Physics, and the International Radiation Protection Association. He has served in numerous capacities on the Mayo Clinic Activities, such as the Radiation Safety Committee, the Mayo Foundation Radiation Safety Committee, the Safety Council, and the Foundation Environmental Health and Safety Committee. He has participated in a number of professional activities at the state level, such as the Governor's Task Force on Low Level Radioactive Waste. He is or has been a reviewer for the American Council on Science and Health, the Health Physics Journal, Radiation Research and numerous other publications. He is author or co-author of more than 200 publications in health physics and related areas. He received his B.S. and M.S. in Biology from South Dakota State University in Brookings, SD and his Ph.D. in Health Physics from Purdue University in West Lafayette, IN.

Ms. Susan Wiltshire:

Ms. Susan Wiltshire is a former Vice President of the consulting firm JK Research Associates, Inc. Her areas of expertise include radioactive waste management, public involvement in policy and technical decisions, and risk communication. She has planned and facilitated citizen involvement, moderated multi-party discussions and assisted with the peer review of technical projects and written and spoken extensively about the public's role in the formulation of public policy. Ms. Wiltshire's wrote the 1993 version of the League of Women Voters'"A Nuclear Waste Primer," the 1985 revision of which she coauthored.

Ms. Wiltshire has served on a number of committees of the National Academies National Research Council including the Board on Radioactive Waste Management, the Committee on Technical Bases for Yucca Mountain Standards, and the Committee on Risk Perception and Communication. She chaired both the Committee to Review New York State's Siting and

Methodology Selection for Low Level Radioactive Waste Disposal and the Committee on Optimizing the Characterization and Transportation of Transuranic Waste Destined for the Waste Isolation Pilot Plant. Ms. Wiltshire is a Vice President and member of the Board of the National Council on Radiation Protection and Measurements (NCRP) and serves as Chairman of that organization's Committee on Public Policy and Risk Communication. She is a former member of the U.S. Environmental Protection Agency Advisory Committee on Radiation Site Cleanup Regulation and its committee on the Waste Isolation Pilot Plant (WIPP), which she has chaired.

Ms. Wiltshire served two terms as member and Chairman of the elected Board of Selectmen, the chief executive body of the Town of Hamilton, Massachusetts, and of the Town's appointed Finance Committee. She is former Chairman of the Board of Northeast Health System, Beverly, Massachusetts and of Beverly Hospital. Ms. Wiltshire was formerly President of the League of Women Voters of Massachusetts. She graduated Phi Beta Kappa with High Honors from the University of Florida, receiving a BS in Mathematics.

APPENDIX B –ACRONYMS

AL	Alabama
Am	Chemical symbol for americium (^{241}Am isotope)
AMAD	Activity Median Aerodynamic Diameter (Reference to particle size)
AMADF	Activity Median Aerodynamic Diameter Factor (Reference to particle size)
ANSI	American National Standards Institute
ASQC	American Society for Quality Control (also American Society for Control of Quality (ANSI/ASQC)
Bq	Symbol for Becquerel, SI unit of radioactivity (1 Bq equivalent to 2.7 E-11 Ci in traditional units)
C	Chemical symbol for carbon (^{14}C isotope)
CA	Coordinating Agency
CEDE	Committed Effective Dose Equivalent
CFR	Code of Federal Regulations
Ci	Symbol for curie, the traditional unit of radioactivity (1 Ci is equivalent to 3.7E10 Bq in SI units)
Co	Chemical symbol for cobalt (^{60}Co isotope)
cps	counts per second
Cs	Chemical symbol for cesium (^{137}Cs isotope)
d	day
DFO	Designated Federal Officer
DHS	Department of Homeland Security (U.S. DHS)
dia	diameter
DOD	Department of Defense (U.S. DOD)
DOE	Department of Energy (U.S. DOE)
dpm	disintegrations per minute
dps	disintegrations per second
EPA	Environmental Protection Agency (U.S. EPA)
ERAMS	Environmental Radiation Ambient Monitoring System (Predecessor to RadNet)
FR	Federal Register
FRMAC	Federal Radiological Monitoring and Assessment Center
GM	Geiger-Mueller (Detector)
Gy	Gray
hr	hour
I	Iodine
IMAAC	Inter-Agency Modeling and Atmospheric Assessment Center
IND	Improvised Nuclear Device(s)
Ir	Chemical symbol for iridium (^{192}Ir isotope)
keV	kiloelectron volts
kg	kilogram
MDA	Minimum Detectable Activity
MGBC	Maximum Gross Beta Concentration
MMGBC	Monthly Maximum Gross Beta Concentration

mm^2	square millimeter
m^3	cubic meter
mS	milliSievert
µ	micro
µm	micrometer
µR	micro Roentgen
NaI	Sodium Iodide
NaI (TI)	Sodium Iodide Thallium (Crystal/Detector)
NARAC	National Atmospheric Release Advisory Center
NAREL	National Air and Radiation Environmental Laboratory (U.S. EPA/ORIA/NAREL, Montgomery, AL)
NIST	National Institute of Standards and Technology
NMS	National Monitoring System
NRP	National Response Plan
nCi	Symbol for nanocuries, traditional units of radioactivity (1 nCi is equivalent to 37 Bq in SI units)
NYC	New York City
ORIA	Office of Radiation and Indoor Air (U.S. EPA/ORIA)
p	probability
PAG	Protective Action Guide
pCi	Symbol for picocuries, a traditional unit of radioactivity (1 pCi is equivalent to 37 mBq in SI units)
PDA	Personal Digital Assistant
PIC	Pressurized Ionization Chamber
QA	Quality Assurance
QC	Quality Control
QA/QC	Quality Assurance/Quality Control
R	Roentgen
RAC	Radiation Advisory Committee (U.S. EPA/SAB/RAC)
rad	Traditional unit of radiation absorbed dose in tissue (a dose of 100 rad is equivalent to 1 gray (Gy) in SI units)
RadNet	Radiation Network, a Nationwide System to Track Environmental Radiation
RDD	Radiological Dispersion Device
R & D	Research and Development
rem	Radiation equivalent in man; traditional unit of effective dose equivalent (equals rad x tissue weighting factor) (100 rem is equivalent to 1 Sievert (Sv))
RERT	Radiological Emergency Response Team
RIENL	Radiation and Indoor Environments National Laboratory (U.S. EPA/ORIA/RIENL, Las Vegas)
R/h	Roentgen per hour; traditional measure of exposure rate
Rn	Chemical symbol for radon
ROI	Region(s) of Interest; indicates regions of the energy spectrum which are summed to determine whether there is some unusual contribution to the background for specific ranges of energy
SAB	Science Advisory Board (U.S. EPA/SAB)

SI	International System of Units (from NIST, as defined by the General Conference of Weights & Measures in 1960)
SOP	Standard Operating Procedures
Sr	Chemical symbol for strontium (^{90}Sr isotope)
Sv	Sievert, SI unit of effective dose equivalent in man (1Sv is equivalent to 100 rem in traditional units)
Th	Chemical symbol for thorium
Tl	Chemical symbol for thallium (^{208}Tl isotope)
TR	Toxicological Review
US	United States
WSRC	Westinghouse Savannah River Company (contractors for Savannah River)
σ	Standard Deviation

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