ANNA-RPT-010
Revision 0

Recommendation for Upgrade of Radiation Monitoring at the Idaho National Laboratory Reactor Technology Complex

August 2007

ANNA Inc.
Bringing Solutions to Power
Portage
Longenecker & Associates
Burns and Roe
Vista Engineering Technologies, L.L.C.

ANNA-RPT-010
Revision 0

Recommendation for Upgrade of Radiation Monitoring at the Idaho National Laboratory Reactor Technology Complex

August 31, 2007

Approved by:

Lori Kostelnik, Deputy Project Manager	Date
Dan Osetek, Lead Engineer	Date
James Kriskovich, Project Engineer	Date

Prepared for the
Idaho National Laboratory under
Contract No. 00051053, Release 10

EXECUTIVE SUMMARY

Battelle Energy Alliance, LLC (BEA), managing contractor for the Idaho National Laboratory (INL), requires an evaluation of the existing radiation monitoring systems and a study to recommend cost-effective technology upgrades to address obsolescence, reliability, and maintainability for the Reactor Technology Complex (RTC) and the Advanced Test Reactor (ATR). BEA has issued Release 10 to Contract No. 00051053 to the ANNA Team to complete the evaluation. This report describes the evaluation completed by the ANNA Team and provides recommendations with a technical basis for the upgrades to the Radiation Monitoring System(s).

The radiation monitoring function at the RTC has historically been accomplished by a collection of different systems and components. Since the early days of initial operations at the RTC, several different systems have been installed, maintained, upgraded and decommissioned. Today's functional requirements are different than in past years, and future program plans for the RTC dictate new requirements for radiation monitoring. The ANNA Team has researched these current and future requirements to help guide the evaluation of radiation monitoring at the RTC and to support the recommendations for changes and improvements. It should be noted that this Study was completed while the ATR Design Basis was being confirmed (reconstituted). Some of the requirements and technical basis of the radiation monitoring equipment could change from that used to support this Study when the design basis confirmation is completed.

Within the RTC are several facilities, including the ATR. Several of these facilities include nuclear activities that require radiation monitoring. Some of the facilities are inactive, have no required function, or are scheduled for deactivation and demolition. Some of the inactive facilities still require surveillance and maintenance. Radiation monitors at the RTC include active systems, inactive but operational systems, and inactive systems removed from the facility or abandoned in place. The performance specifications of the various radiation monitoring systems were compared to the cumulative functional requirements for monitoring at the RTC to determine the potential usefulness of existing monitors to current and future operations at the RTC. The reliability and maintainability of the existing monitors was evaluated, and the availability of new improved technology was examined to support the development of recommendations for overall system improvement.

The ANNA Team completed the evaluation, developed a set of recommendations and obtained BEA review of the results in generating this report. The recommendations are based in large part on the evaluation of options, including minimal, basic, intermediate and optimal options. It was determined that only certain radiation monitors at ATR and RTC-605 should be upgraded at the present time; other radiation monitors at other RTC facilities are deemed adequate to meet current requirements. To provide the best value to current and future operations at the RTC, the ANNA Team recommends that all ATR primary radiation monitors be replaced with new equipment, intelligent radiation monitors. The principal drivers for this recommendation are maintainability, improved performance and ease of future upgrades. The old monitors are failing

at an increasing rate, replacement parts are often unavailable, and continued safe operations at the RTC are at an increased risk of interruption, suspension or termination for lack of required radiation monitor support. New technology available at a reasonable cost can provide a superior radiation monitoring function at the RTC, and especially at the ATR. Additional upgrades are recommended as optional. The auxiliary and process monitors could also be replaced with new units to improve the overall performance of the radiation monitoring system, however the additional cost should be weighed against the option of retaining the old units, run to failure and consider replacement in the future.

Also included in the ANNA Team recommendation is the replacement of the DRMS control and communications system (computers and software) with a new modern system that can provide high performance at a reasonable cost. The new system will allow Ethernet communication and control from multiple locations and the addition of automatic data backup and control at a remote location. Upgrade of the control and communications system offers significant improvement in performance, adds significant flexibility and simplifies future changes and upgrade. By upgrading to intelligent monitors with both analog and Ethernet connection, the existing system can be kept in service until the new system is fully operational and qualified. The old system can then be removed or left in place to provide supplemental monitoring and backup.

The new intelligent monitors offer improved performance through features such as automatic and frequent operational checks, automatic remote and manual calibration, and vendor support (including trouble shooting over the internet) User groups are available that include several participants that employ the same or similar monitors, offering ATR users information on performance issues and solutions to common problems that may arise.

After consultation with several commercial nuclear power plant operators and evaluation of radiation monitor vendors and their products, the most beneficial features of modern radiation monitoring systems were determined. Those features applicable to the ATR and most beneficial were included in the options evaluated for upgrade. Four options were considered, evaluated and ranked. The ANNA recommendation is based on the top ranked option.

The ANNA Team recommendation is based on a review of the technical and regulatory requirements, features available in new modern equipment, and equipment cost and potential schedule challenges. If implemented, the recommended upgrade will provide the RTC with a cost-effective, reliable system that can be operated at a high level of performance and maintained with a significantly lower level of effort.

The ANNA Team has prepared a rough cost and schedule estimate for upgrade of the Radiation Monitoring System. The cost estimate is not a detailed buildup of all associated costs of the upgrade project, but rather a rough order-of-magnitude cost based on average published costs of the recommended equipment and minimal installation time. Additional costs are anticipated for detailed engineering design, preparation of procurement specifications, revision of drawings and documents and development of supporting technical bases and

feasibility studies. The inclusion of ROM costs and schedules allows a better comparison of the evaluated Options.

Estimated cost of the minimal option, with no new upgraded monitors, is $200K. Estimated cost of the recommended option, which upgrades the 33 Primary monitors, is approximately $2.5M. Estimated cost of the Optimal option is approximately $4.9M. The procurement time for a few of the replacement units is driven by the Quality Assurance requirements and could take up to 8 months for delivery. Additional time for installation, testing and commissioning suggests that the upgrade project would require 12 to 18 months and close coordination with ATR outage schedules. A key decision on the acceptability of wireless communication in the ATR will be required to pursue the recommended option. Cost of the upgrade will increase for additional cable installation if wireless technology is not included.

CONTENTS

EXECUTIVE SUMMARY iii

ACRONYMS xi

1. BACKGROUND 1-1

2. CURRENT RADIATION MONITORING AT THE RTC 2-1

2.1 Requirements 2-1

2.1.1 Current Regulatory, Operational and Environmental Requirements 2-1
2.1.2 Future Program Requirements 2-2
2.1.3 Recommended Methods for Compliance to Requirements 2-3

2.2 Existing Radiation Monitoring 2-4

2.2.1 RMSS 2-30
2.2.2 DRMS 2-30
2.2.3 Other ATR Monitoring 2-40
2.2.4 Other RTC Monitoring 2-41

2.3 RMS Performance and Compliance to Requirements 2-43

3. MODERN RADIATION MONITORING TECHNOLOGY 3-1

3.1 Discussion of New Commercial Plant RMS 3-1

3.1.1 Commercial NPP RMS Upgrades Lessons Learned 3-1
3.2 Vendor Options and Equipment Features 3-2

3.2.1 Apantec 3-2
3.2.2 Berthold Technologies 3-3
3.2.3 General Atomics Electronics Systems Inc. 3-3
3.2.4 MGP 3-4
3.2.5 Thermo Scientific 3-4

3.3 Recommended New Technology for the RTC 3-9

3.3.1 Intelligent Monitors 3-9
3.3.2 Wireless Technology 3-9

4. COMPARISON OF REQUIREMENTS AND EXISTING MONITORS 4-1

4.1 Compliance to Current and Future Requirements 4-1

5. RECOMMENDATION 5-1

5.1 Evaluation of Options 5-1

5.1.1 Minimal Upgrade 5-1
5.1.2 Basic Upgrade 5-3
5.1.3 Intermediate Upgrade 5-3
5.1.4 Optimal Upgrade 5-4

5.2 ANNA Team Recommendation 5-12

5.3 Technical Basis for Recommendation 5-12

6. COST AND SCHEDULE ESTIMATES 6-1

6.1 Cost Estimate 6-1

6.2 Schedule Estimate 6-3

7. SUMMARY 7-1

8. REFERENCES 8-1

Appendix A—Upgrade Cost and Schedule Estimate A-1

Appendix B—Commercial Plant Contact Notes B-1

Appendix C—Commercial Plant Contact Information C-1

Appendix D—Vendor Information D-1

FIGURES

2-1. Existing RTC RMS. 2-5

2-2A. Existing mezzanine. 2-6

2-2B. Existing first floor. 2-7

2-2C. Existing first basement. 2-8

2-2D. Existing second basement. 2-9

2-3. RMS systems diagram. 2-10

2-4. Existing DRMS. 2-31

2-5. Layout of RTC-605. 2-42

4-1A. Minimal Mezzanine. 4-3

4-1B. Minimal first floor. 4-4

4-1C. Minimal first basement. 4-5

4-1D. Minimal second basement. 4-6

4-1E. Minimal RTC-605. 4-7

5-1. Minimal DRMS upgrade option. 5-2

5-2. Basic DRMS upgrade option. 5-5

5-3A. Intermediate DRMS upgrade option. 5-6

5-3B. Intermediate DRMS upgrade option with wireless variation. 5-7

5-4A. Optimal DRMS upgrade option with Ethernet cabling. 5-8

5-4B. Optimal DRMS option with wireless Ethernet. 5-9

5-5A. Optimal system with DRMS removed. 5-10

5-5B. Optimal system with wireless and DRMS removed. 5-11

TABLES

2-1. Radiation monitors that exist at the RTC 2-11

3-1. Vendor comparison. 3-5

3-2. Vendor equipment comparison. 3-6

6-1. Comparison of ROM costs for the upgrade options. 6-2

6-2. Relative schedule estimates. 6-3

ACRONYMS

ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
ATR	Advanced Test Reactor
ATRC	Advanced Test Reactor Critical Facility
BEA	Battelle Energy Alliance, LLC
CAM	continuous air monitor
DCM	Data Acquisition and Control Module
DOE	Department of Energy
DRMS	Digital Radiation Monitoring System
ECC	Emergency Communications Center
EDF	Engineering Design File
GA	General Atomics
HSIS	Hydraulic Shuttle Irradiation System
INL	Idaho National Laboratory
MDA	minimal detectable activity
NG	noble gas
NMC	Nuclear Measurements Corporation
NPP	nuclear power plant
NRC	Nuclear Research Corporation
PING	particulate, iodine and noble gas
PCB	Pressure Control Box
RAM	Radiation Area Monitor
RIA	Remote Indicator or Alarm
RCP	Radiological Control Program
RCR	Reactor Control Room

RCU	Radiation Control Unit
RMS	Radiation Monitoring System
RMSS	Radiation Monitoring and Seal System
ROM	Rough Order-of-Magnitude
RTC	Reactor Technology Complex
SC	safety class
SDD	System Design Description
SPING	stack particulate, iodine and noble gas
TEDE	Total Effective Dose Equivalent
TSR	Technical Safety Requirements
UFSAR	Updated Final Safety Analysis Report, SAR-153
WWTF (ATR)	Warm Waste Treatment Facility equipment in RTC-670
WWTF (RTC-605)	Waste Water Treatment Facility remote from ATR

1. BACKGROUND

Radiation monitoring at the Idaho National Laboratory (INL) Reactor Technology Complex (RTC) has two major purposes: (1) to identify, control and limit the release of radioactive material from nuclear facilities at the RTC, and (2) to limit personnel exposures to radioactive materials at RTC facilities.

Facilities where nuclear materials are stored or handled offer the risk of accidental exposure to personnel and the potential for release from confinement and contamination of the environment and exposure of onsite and offsite personnel. The radioactive materials at risk at the RTC are primarily fission products from irradiated nuclear fuel, radioactive isotopes used in research at the RTC and radioactive waste that is being prepared for disposal. The facilities at the RTC that provide for these functions are monitored by a variety of means to ensure safe operations, identify hazards, and mitigate the risks that may arise from the radioactive materials. Radiation monitoring is accomplished using various types of monitors arranged into a Radiation Monitoring System (RMS) to support the Radiological Control Program (RCP) or plant operations.

Although there are a few ancillary facilities at the RTC that include small quantities of radioactive materials that must be monitored, the principal source of risk associated with radioactive material at the RTC comes from operations at the Advanced Test Reactor (ATR). The ATR is a pressurized water test reactor that operates at low pressure and low temperature. The ATR has many uses including research for National Security, and has operated safely for over 40 years. The ATR facility includes a confinement structure and radiation monitoring systems to continuously maintain operations safe and minimize the risks from radioactive material release and inadvertent exposure. There are two principal radiation monitoring systems at the ATR, the Radiation Monitoring and Seal System (RMSS) and the Digital Radiation Monitoring System (DRMS).

The ATR is operated under strict regulations to ensure safety. As the facility has aged over the past 40 years it has been upgraded to meet new and improved regulatory guidance. As systems and components become obsolete, unreliable, or fail, they are replaced with new upgraded systems and components. The radiation monitoring systems at the RTC including the ATR have seen several changes and improvements since first installed several years ago. The current systems have begun to age and have experienced reliability and maintainability problems. These problems add to the cost of operations at the RTC, therefore an evaluation has been undertaken to review radiation monitoring at the RTC, determine the best path forward, and recommend the most appropriate changes to cost-effectively restore the radiation monitoring systems to the most safe and reliable condition practical.

This report describes the general configuration and condition of existing radiation monitors at the RTC and evaluates their compliance to operational and regulatory requirements. The review includes examination of current practice in the commercial nuclear industry and the offerings of vendors of new modern equipment. Finally, this report evaluates the options for future radiation monitoring at the entire RTC and recommends specific changes for improvement.

2. CURRENT RADIATION MONITORING AT THE RTC

The design and configuration of the current radiation monitoring systems at the RTC are described in several documents including some that were recently revised and a few older reports that are in the process of revision. To obtain the most accurate description of the current configuration, the documented information was supplemented with facility walk-downs and interviews of the cognizant personnel, including the designated system engineers.

2.1 Requirements

The requirements for radiation monitoring at nuclear facilities are based in federal regulations. There are requirements for the protection of workers, on-site personnel, off-site persons and the environment. The ATR also must demonstrate compliance to certain siting criteria that include limits on release of radioactive contaminants. The ATR Operations organization has established specific radiation monitoring requirements to support plant status monitoring and assist in management of plant process operation.

2.1.1 Current Regulatory, Operational and Environmental Requirements

Reactor siting criteria at 10CFR100 require that reactors limit release of radioactive material to minimize exposure to the public. The regulation at 10CFR100.11 is applicable to the license holders of commercial nuclear plants, and provides a guideline for the Department of Energy (DOE) reactors including the ATR. Reactors must be designed to limit the release of radioactive material during normal operations, operational occurrences and accidents such that no member of the public residing at or beyond the site boundary (exclusion zone) would receive a total effective dose equivalent of 25 rem. Safety analysis requirements at 10CFR830 require that DOE nuclear facilities demonstrate that facilities are designed to limit radiation exposures resulting from accidents to 25 rem whole body to the maximum exposed offsite individual at or beyond the site boundary. To meet this requirement, the ATR has implemented a safety class (SC) engineered safety feature to isolate the reactor building in the event of elevated radiation in the gaseous effluent. Designated as the RMSS, the system relies upon radiation monitors at the base of the building exhaust stack to support this function. The RMSS must meet strict quality assurance and design requirements for safety class equipment. System Design Description (SDD) 7.7.4 Revision 2 describes the various requirements applicable to the RMSS and the bases for the requirements.

Environmental regulations at 40CFR61 Subpart H require that nuclear facilities limit their emissions such that members of the public will not receive an effective dose equivalent of 10 mrem/year. The regulation prescribes methods for emission monitoring that define additional requirements for the RTC RMS. The ATR uses a stack particulate, iodine and noble gas (SPING) monitor to measure the radiation associated with airborne release from the ATR effluent. Additional radiation monitors are used to track liquid effluents at the WWTF (ATR) in the ATR 2nd Basement and at the WWTF (RTC-605) prior to discharge to the evaporation ponds. Together these monitors help INL confirm compliance to the regulatory limit.

Other facilities at the RTC must also comply with the requirements of DOE regulations. Safety basis documents for these other facilities at the RTC specify the monitoring requirements appropriate for their particular hazards. These other nuclear facilities include the Hot Cell Facility RTC-632, and the Laboratories (and RML) at RTC-604 and -661.

Occupational exposures to radiation must be kept as low as reasonably achievable (ALARA) and individual facility workers must not exceed a total effective dose equivalent (TEDE) of 5 rem annually (administratively controlled at INL to 2 rem annual TEDE). Regulations at 10CFR835 specify the requirements for radiation protection and RCP for nuclear facilities. In addition to personnel radiation exposure monitoring using personal dosimeters, radiation monitoring at the RTC includes instrumentation to measure and record the dose rate in areas where workers may encounter radiation exposure. At the ATR, the DRMS is used to meet these requirements. SDD 7.8.16 describes the DRMS and several supporting Engineering Design Files (EDFs) describe the minimum requirements and the technical bases for radiation monitoring.

To assist nuclear facility operations personnel with plant process operations and emergency actions, certain radiation monitors are needed. Some components of the DRMS and other facility radiation monitors are relied upon to meet these requirements.

Idaho State regulations also require that certain engineering activities be certified by a licensed professional engineer and that certain activities comply with the requirements of ANSI Standard NQA-1.

The methods used to demonstrate compliance to these requirements and their technical bases are discussed further in Section 2.2 and 2.3.

2.1.2 Future Program Requirements

Research programs at the RCT change periodically and the radiation monitoring required to support the programs must also change. Planned changes at the RTC were considered to help determine the appropriate changes and upgrades to the RMS. This Study considered the following planned and potential changes.

- **New Programs and Future Operations at the Hot Cells at RTC-632.** Although new programs are a possibility for the hot cells at RTC-632, there is not enough certainty to warrant planning now for any new or upgraded radiation monitoring. The existing monitors, although old and problematic, should only be required to maintain safe conditions at the facility which is in warm standby. Operations are limited as is the risk of exposure to the radiation hazard at RTC-632. The existing radiation monitors should be maintained operational to meet current requirements, or portable and temporary instruments should be provided. Changes to these monitors should be considered when new hot cell operations are planned or when the cells are decontaminated and removed.

- **New Hot Cells at the ATR.** New hot cells are also being considered to support programs at the ATR. A preconceptual design for hot cell facilities at the ATR was prepared in 2007 (Reference 12) to help with planning decisions. However, plans are still uncertain and do not warrant any commitments now to changes in the radiation monitoring at the ATR to support new hot cells.

- **Canal Extension at the ATR.** Similarly, an extension of the ATR canal was considered to support potential new programs at the ATR. The same preconceptual design of 2007 was used to aid planning, but uncertainties limit the need for changes now in the radiation monitoring to support the potential facility changes.

- **Relocation of Operations from RTC-604 and -661.** The old laboratory buildings at RTC-604 and RTC-661 are planned to be demolished in 2008. Since they currently house some programs that require radiation monitoring support, changes in the RMS should be considered. However, the

relocation of the functions is still under consideration. New replacement structures and relocation of laboratory operations are not certain. Therefore the existing radiation monitors should be maintained operational to meet current requirements, or portable and temporary monitors should be substituted as appropriate. Changes to these monitors should be considered when new operations are planned or when the existing operations are terminated and removed.

- **A New Hydraulic Shuttle Irradiation System (HSIS) at the ATR.** The new HSIS or Rabbit at the ATR is being designed and installation is planned for the near future (Reference 11). The HSIS will require radiation monitoring support, since it will transfer a capsule of irradiated material from an irradiation position in the reactor to a loading station in the canal. There is a potential for periodic changes in radiation fields in some ATR work areas, and a potential for accidental releases of radioactive materials during operation of the HSIS. Specific requirements for radiation monitoring, e.g. radiation area monitors (RAMs) and continuous air monitors (CAMs), will be necessary. Tentative monitoring to support the HSIS is included in this study; however, the EDFs that define the technical basis for radiation monitors will need to be updated to address this change in the ATR design and operations.

- **Reactivation of the ATR Pressurized Water Loop 2A.** The ATR Pressurized Water Loop 2A that has been used for research at the ATR in past years is being reactivated. Although this operation is not entirely new, the planned experiments and operations may present a change to the conditions evaluated in the analysis supporting the safety of the ATR. Confirmatory analysis for the planned operations should include evaluation of the required radiation monitoring. Tentative monitoring to support the operation of Pressurized Water Loop 2A is included in this study.

  New instrumentation for radiation monitoring may be needed to support these operations. Other new programs may be identified and planned in the future that will require radiation monitoring. Planning documents, Unreviewed Safety Question Determinations, safety analysis and updated EDFs in support of the new programs will specify the requirements for RMS changes, upgrades or additions. Changes and upgrades to the RMS at the RTC should consider the potential for these future programs. Flexibility in the RMS should be planned as part of any upgrade, to accommodate these anticipated and other potential changes and ease future expansion of the systems. This flexibility to accommodate future changes is a criterion used in this Study to evaluate RMS upgrade options and develop the recommendations.

2.1.3 Recommended Methods for Compliance to Requirements

Based on the limited review completed by the ANNA Team, the following methods are recommended to achieve compliance to the requirements for radiation monitoring at the RTC.

- The basic requirements for the RMSS are to support the RMS-1 building seal function. The necessary and sufficient radiation monitoring required to provide this function is described in SDD-7.7.4.

- The basic requirements for the DRMS are to support the RCP and to maintain personnel exposures ALARA. The necessary and sufficient radiation monitoring required to provide this function is described in SDD-7.8.4 and 7.8.16; the technical basis is presented in EDF-1977, EDF-3077 and EDF-6174.

- The DRMS radiation monitoring requirements should be supplemented to provide support for the HSIS. The technical basis for the minimum required monitoring should be developed and used to confirm the adequacy of the radiation monitors recommended in this Study.

- The DRMS radiation monitoring requirements should be supplemented to provide support for the Pressurized Water Loop 2A. The technical basis for the minimum required monitoring should be developed and used to confirm the adequacy of the radiation monitors recommended in this Study.

- The requirement for limiting emissions from the ATR such that members of the public will not receive an effective dose equivalent of 10 mrem/year should be addressed by airborne release (stack effluent) monitoring and waste water discharge monitoring. The SPING monitor is used to track airborne effluents and monitors in the WWTF at RTC-605 are used to track the liquid discharges. These monitors should be evaluated for upgrade.

- The requirements for radiation monitoring at the RTC-632 Hot Cell Facility should be met by maintaining the existing RMS (or temporary substitute instruments) until new radiological operations are initiated or until the facility is decontaminated.

- The requirements for radiation monitoring at buildings, RTC-604 and RTC-661 should be met by maintaining the existing RMS (or temporary substitute instruments) until new radiological operations are initiated or until the facilities are decontaminated.

2.2 Existing Radiation Monitoring

Figure 2-1 is a diagram of the RTC indicating the locations of facilities that require radiation monitoring or have existing monitors in place. Figure 2-2 (A-D) is a diagram of the ATR showing the locations of radiation monitors that presently exist, including monitors that may be obsolete, inoperable or abandoned in place. Figure 2-3 is a diagram of the ATR radiation monitoring systems showing the lines of communication between various components. Table 2-1 is a listing of all the radiation monitors that exist at the RTC separated into four groups corresponding to the RMSS, DRMS, Other ATR RMS, and other RTC RMS.

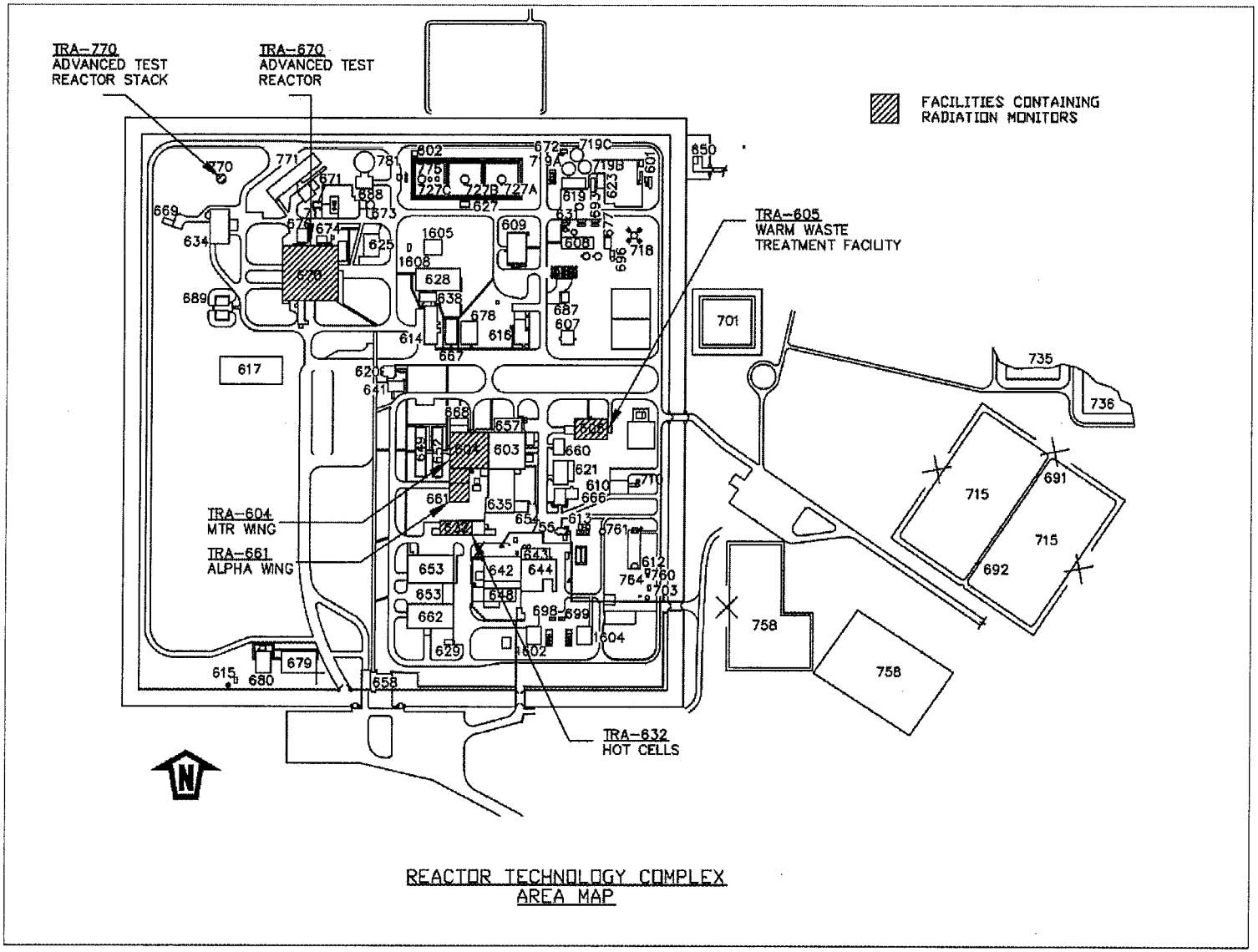


Figure 2-1. Existing RTC RMS.

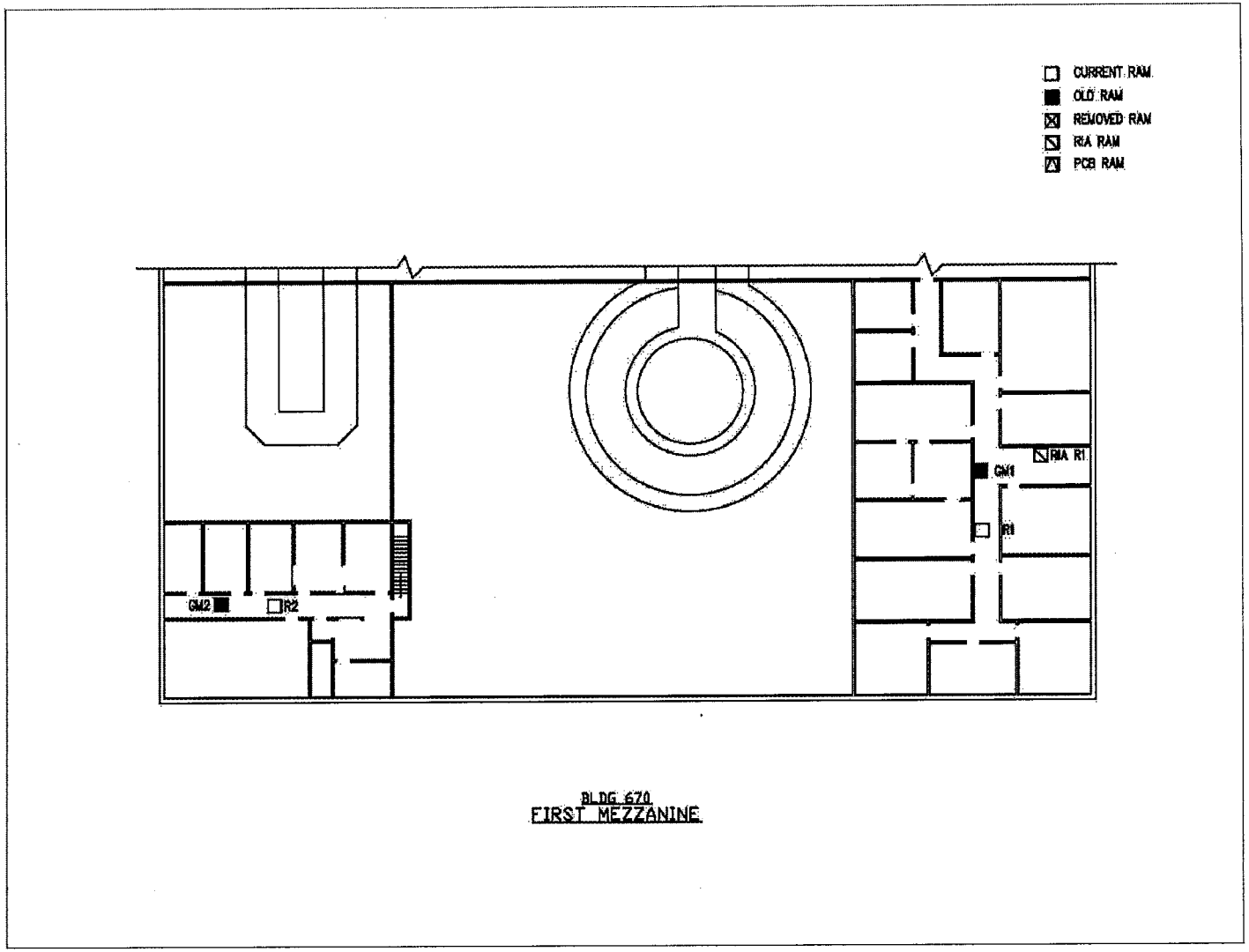


Figure 2-2A. Existing mezzanine.

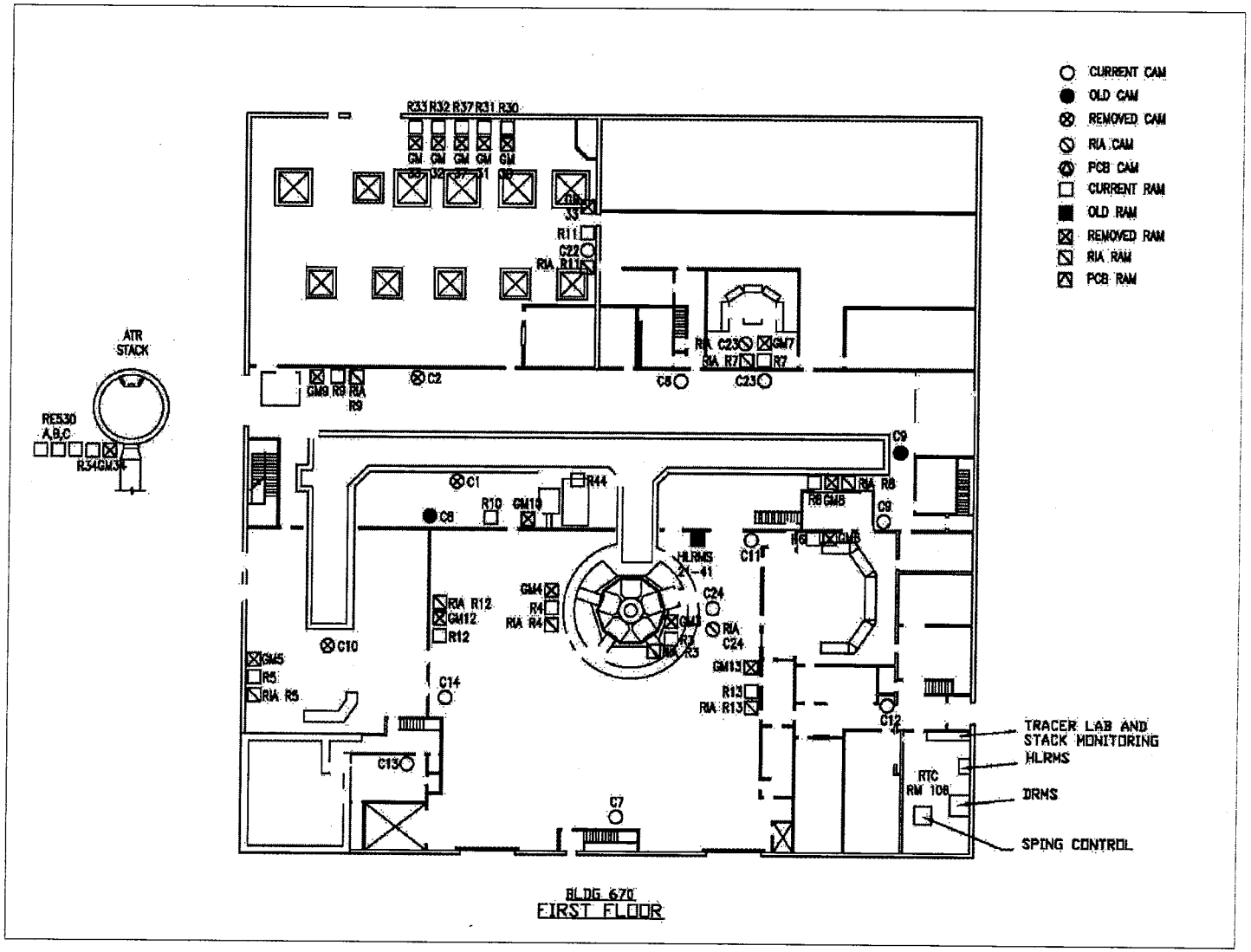


Figure 2-2B. Existing first floor.

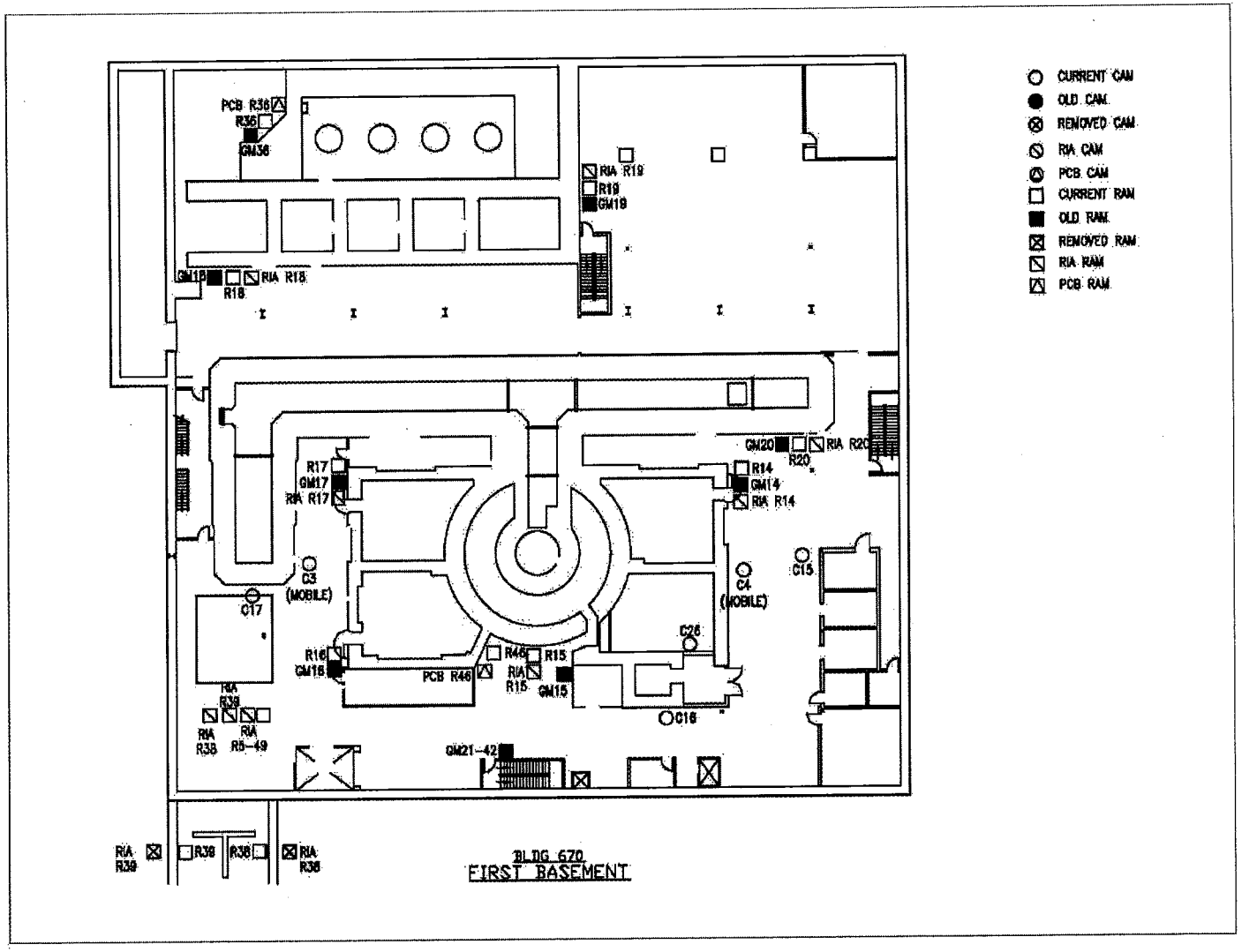


Figure 2-2C. Existing first basement.

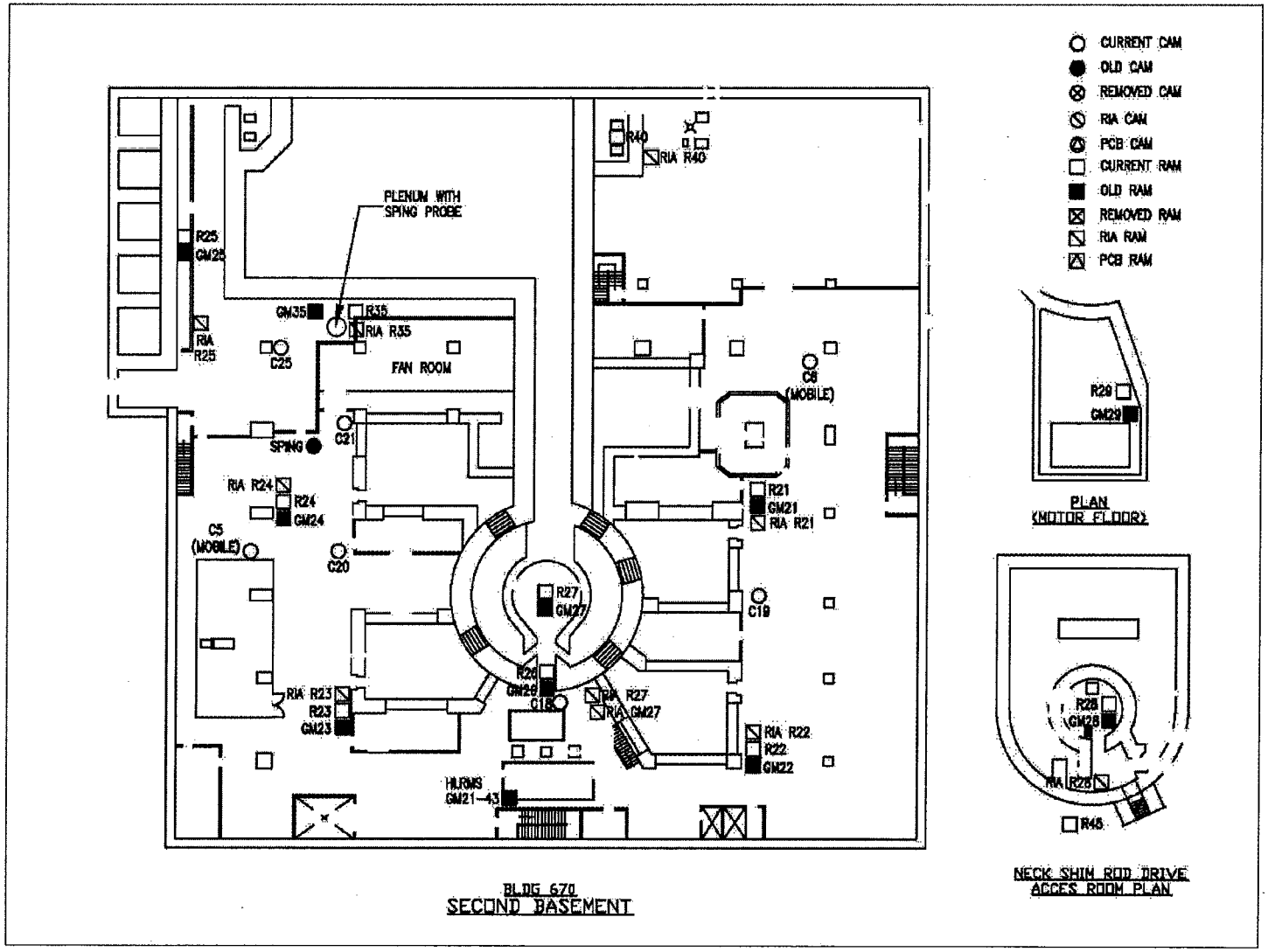


Figure 2-2D. Existing second basement.

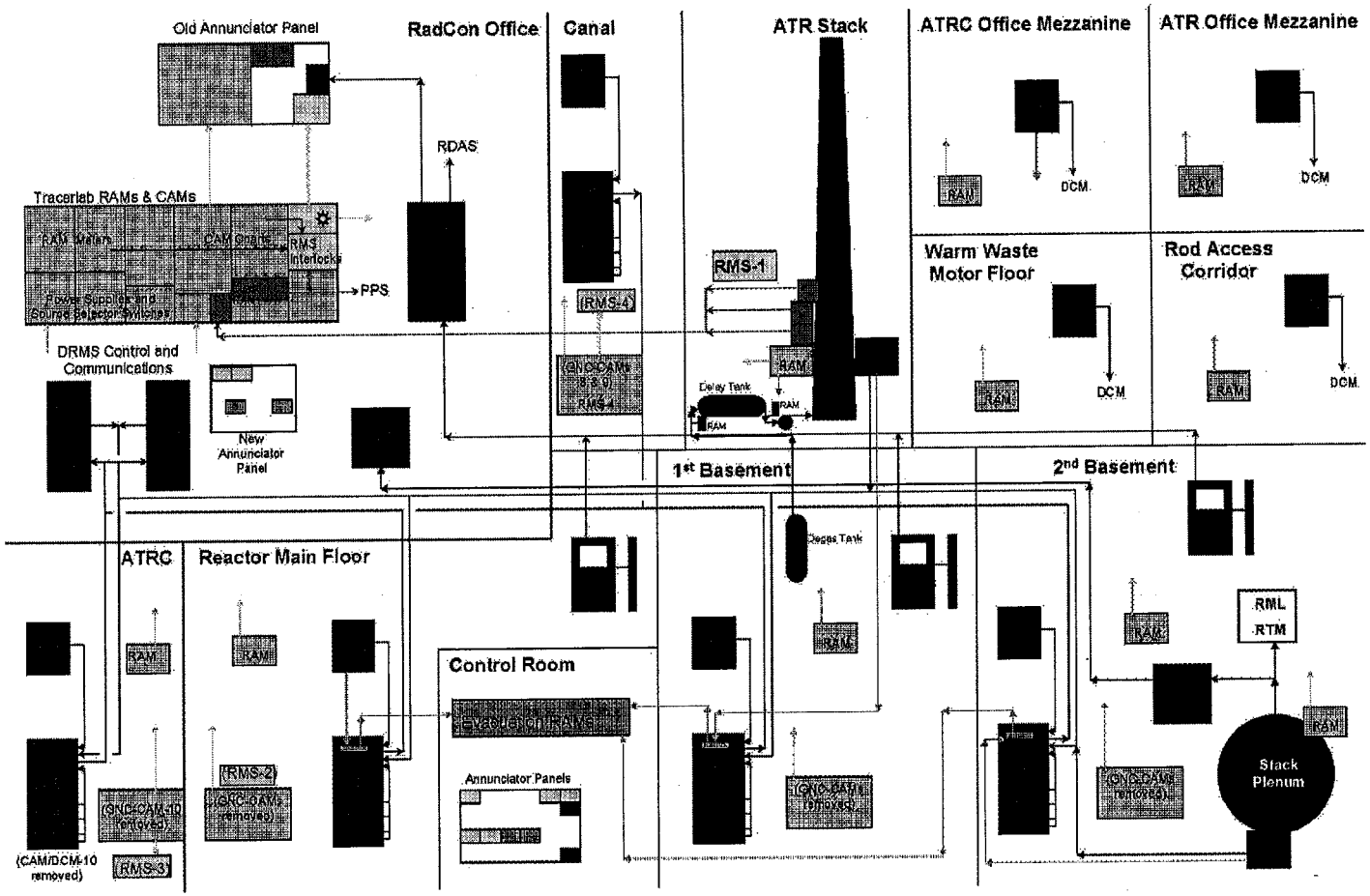


Figure 2-3. RMS systems diagram.

Table 2-1. Radiation monitors that exist at the RTC.

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status	Ancillary Components
RMSS						
RE-530A, 530B, 530C	RMSS RMS-1	Reuter Stokes	ATR Stack	Stack Breech	Active - Seal System	Components of a SC system; TSR-186 GA & MGP offers replacement instruments.
GM-23, -24, -25, -2, -5,-6, -35, CAM-7, -14	RMSS RMS-2 not operational	Tracer Lab	ATR	various	All of the equipment listed in the Monitor ID column is abandoned in place except for CAMS 7 and 14, which have been removed from the facility.	Purge system
Old CAM-10	RMSS RMS-3	General Nuclear Corporation Model 710	REMOVED	REMOVED	CAM 10 removed and wiring abandoned in place	CAM 10 is not required per EDF TRA-ATR-1408.
Old CAM-08	RMSS RMS-4	General Nuclear Corporation Model 710	ATR	Canal SW		Canal area isolation
Old CAM-09	RMSS RMS-4	General Nuclear Corporation Model 710	ATR	Canal east end		Canal area isolation
DRMS						
CAM 01	DRMS	Berthold	REMOVED	REMOVED	Unit has been removed from the plant	
CAM 02	DRMS	Berthold	REMOVED	REMOVED	Unit has been removed from the plant	

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status - June 07	Additional Requirements
CAM 03	DRMS	Berthold	ATR	First basement West - Mobile Unit	This unit is placed in standby when not being used for monitoring (DCM powered down, but checked weekly to ensure immediate availability) This unit presently has no iodine detection capability.	
CAM 04	DRMS	Berthold	ATR	First basement East - Mobile Unit	This unit is placed in standby when not being used for monitoring (DCM powered down, but checked weekly to ensure immediate availability).	
CAM 05	DRMS	Berthold	ATR	Second basement West - Mobile Unit	This unit is placed in standby when not being used for monitoring (DCM powered down, but checked weekly to ensure immediate availability).	
CAM 06	DRMS	Berthold	ATR	Second basement East - Mobile Unit	This unit is placed in standby when not being used for monitoring (DCM powered down, but checked weekly to ensure immediate availability).	
CAM 07	DRMS	Berthold	ATR	Reactor main floor South side of reactor		
CAM 08	DRMS	Berthold	ATR	Canal North		This unit should be relocated to a better monitoring position as determined in EDF-6174.

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status – Date of	Additional Requirements
CAM 09	DRMS	Berthold	ATR	Canal East		This unit should be relocated to a better monitoring position as determined in EDF-6174.
CAM 10	DRMS	Berthold	REMOVED	REMOVED	Removed from plant and wiring abandoned in place	Unit has been removed from the plant.
CAM 11	DRMS	Berthold	ATR	Reactor main floor East side of reactor	This unit has a sample line that monitors the reactor control room.	This DCM has a black-box installed to communicate with the Evacuation system 2/3 logic for the Group B Evacuation RAM-13.
CAM 12	DRMS	Berthold	ATR	Front Hall		This DCM has a black-box installed to communicate with the Evacuation system 2/3 logic for the Group A Evacuation RAM-6.
CAM 13	DRMS	Berthold	ATR	ATRC lab		This DCM has a black-box installed to communicate with the Evacuation system 2/3 logic for the Group B Evacuation RAM-2. In addition, it was requested that this unit be moved outside the lab with a sample line to the monitoring point.

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status – thru '07	Additional Requirements
CAM 14	DRMS	Berthold	ATR	Reactor main floor West side of reactor		
CAM 15	DRMS	Berthold	ATR	First basement East of PPS room		EDF-6174 recommends moving this monitor to the inside wall for more representative sampling
CAM 16	DRMS	Berthold	ATR	First basement South		
CAM 17	DRMS	Berthold	ATR	First basement loop 1C		This DCM has a black-box installed to communicate with the Evacuation system 2/3 logic for the Group A Evacuation RAM-5. EDF-3077 indicates that with current experiment requirements, an iodine channel is not required for this CAM.
CAM 18	DRMS	Berthold	ATR	Second basement South		DCM has a black-box installed to communicate with the Evacuation system 2/3 logic for the Group B Stack Evacuation RAM-35.
CAM 19	DRMS	Berthold	ATR	Second basement East side by 2B-SE primary cubicle		

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status Notes	Additional Requirements
CAM 20	DRMS	Berthold	ATR	Second basement West side between 2D-SW and 2E-NW primary cubicles		This DCM has a black-box installed to communicate with the Evacuation system 2/3 logic for the Group A Evacuation RAM-23.
CAM 21	DRMS	Berthold	ATR	Second basement Loop 2E. Samples fan room air.		This DCM has a black-box installed to communicate with the Evacuation system 2/3 logic for the Group B Evacuation RAM-24. This CAM currently has a sample line that monitors the fan room.
CAM 22	DRMS	Berthold	ATR	Main floor laydown area	The original DCM was replaced with the old DCM-10 from ATRC after a lightning strike at the stack	DCM has a black-box installed to communicate with the Evacuation system 2/3 logic for the Group A Stack Evacuation RAM-34.
CAM 23	DRMS	Berthold	ATR	Canal By PCR. Samples air from the PCR.	This unit has a sample line to monitor the process control room (PCR).	A remote indicator and alarm module is installed in the Process Control Room. The RIA is mounted on the south wall of room 121.
CAM 24	DRMS	Berthold	ATR	Reactor main floor East side of reactor	If this unit is replaced by the new system, it should have a sample point approximately 8-9-ft. high for a more representative sample, as noted in EDF-6174.	
CAM 25	DRMS	Berthold	ATR	Second Basement BP Demineralizer		

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status – line 07	Additional Requirements
CAM 26	DRMS	Berthold	ATR	First Basement East – 1B Cubicle		
RAM 01	DRMS Auxiliary - Office Hallway monitor	Berthold, Model LB6500-1	ATR	2nd Floor Office Hallway (east Mezzanine)		
RAM 02	DRMS Primary - Group B Evacuation	Berthold, Model LB6500-4/LB6500-5	ATR	2nd Floor ATRC Office Area (west Mezzanine)		Group B Evacuation signal to the control room.
RAM 03	DRMS Primary - Reactor Main floor during transfer operations	Berthold, Model LB6500-1	ATR	Reactor main floor - Reactor Top during outage (reactor top east)		The present detailed operating procedures require this RAM during handling of fuel and irradiated materials on the reactor top.
RAM 04	DRMS Auxiliary - Backup for Primary RAM 03	Berthold, Model LB6500-1	ATR	Reactor Top West		RAM is an alternate RAM for handling of fuel and irradiated materials on the reactor top.
RAM 05	DRMS Primary - Group A Evacuation	Berthold, Model LB6500-4/LB6500-5	ATR	ATRC West Wall		Group A Evacuation signal to the control room.
RAM 06	DRMS Primary - Group A Evacuation	Berthold, Model LB6500-4/LB6500-5	ATR	Reactor control room		Group A Evacuation signal to the control room.
RAM 07	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	Main floor, Process control room		
RAM 08	DRMS Auxiliary - Backup for Primary RAM 44	Berthold, Model LB6500-1	ATR	Canal East		

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status, mm/dd/yy	Additional Requirements
RAM 09	DRMS Auxiliary - Backup for Primary RAM 44	Berthold, Model LB6500-1	ATR	Canal West		
RAM 10	DRMS Auxiliary Backup for Primary RAM 44	Berthold, Model LB6500-1	ATR	Canal Southwest		This location could be used for monitoring the HSIS Rabbit send/receive lines if moved west about 15 ft
RAM 11	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	Laydown area		
RAM 12	DRMS Auxiliary - Backup for Primary RAM 03	Berthold, Model LB6500-1	ATR	Reactor main floor West		
RAM 13	DRMS Primary - Backup for Primary RAM 03	Berthold, Model LB6500-4/LB6500-5	ATR	Reactor main floor East		Group B Evacuation signal to the control room.
RAM 14	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	First Basement Outside 1A Cubicle		
RAM 15	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	First Basement South		
RAM 16	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	First Basement Loop 1C		
RAM 17	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	First Basement Loop 1D		
RAM 18	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	First basement Primary Pump Motor Room Northwest		

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status Jun 07	Additional Requirements
RAM 19	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	First basement Switchgear		
RAM 20	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	First basement East, Canal Viewing Window		
RAM 21	DRMS Primary	Berthold, Model LB6500-1	ATR	Second basement East side by 2B-SE primary cubicle		
RAM 22	DRMS Auxiliary - Backup for Primary RAM 21	Berthold, Model LB6500-1	ATR	Second basement By 2C		
RAM 23	DRMS Primary - Backup for Primary RAM 24	Berthold, Model LB6500-4/LB6500-5	ATR	Second basement West, by 2D-SW		Group A Evacuation signal to the control room.
RAM 24	DRMS Primary - Backup for Primary RAM 23	Berthold, Model LB6500-4/LB6500-5	ATR	Second basement West by 2E-NW		Group B Evacuation signal to the control room.
RAM 25	DRMS Process	Berthold, Model LB6500-1	ATR	2nd basement west at Bypass Demineralizer		
RAM 26	DRMS Process	Berthold, Model LB6500-1	ATR	2nd basement Entrance Corridor		
RAM 27	DRMS Process	Berthold, Model LB6500-1	ATR	2nd basement Subpile room		
RAM 28	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	Rod access room below 2nd basement		

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status - June '07	Additional Requirements
RAM 29	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	Motor Floor below 2nd basement		
RAM 30	DRMS Process	Berthold, Model LB6500-1	ATR	Access at main floor laydown area		Detector installed in dry tube monitoring secondary coolant outlet piping at lower level
RAM 31	DRMS Process	Berthold, Model LB6500-1	ATR	Access at main floor laydown area		Detector installed in dry tube monitoring secondary coolant outlet piping at lower level
RAM 32	DRMS Process	Berthold, Model LB6500-1	ATR	Access at main floor laydown area		Detector installed in dry tube monitoring secondary coolant outlet piping at lower level
RAM 33	DRMS Process	Berthold, Model LB6500-1	ATR	Access at main floor laydown area		Detector installed in dry tube monitoring secondary coolant outlet piping at lower level
RAM 34	DRMS Primary - Stack Evacuation Channel A	Berthold, Model LB6500-4/LB6500-5	ATR Stack	Stack Breech		Stack Group A Evacuation signal to the control room.
RAM 35	DRMS Primary - Stack Evacuation Channel B	Berthold, Model LB6500-4/LB6500-5	ATR	Second basement Exhaust Plenum		Stack Group B Evacuation signal to the control room.
RAM 36	DRMS Process	Berthold, Model LB6500-3	ATR	1st basement Heat Exchanger Corridor - Degas Tank		Monitors the heat exchanger mezzanine adjacent to the degas tank
RAM 37	DRMS Process	Berthold, Model LB6500-1	ATR	Access at main floor laydown area		Detector installed in dry tube monitoring secondary coolant outlet piping at lower level
RAM 38	DRMS process	Berthold, Model LB6500-1	ATR	1st basement WWTF, E		Monitors the east ion exchange bed.

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status June 07	Additional Requirements
RAM 39	DRMS Process	Berthold, Model LB6500-1	ATR	1st basement WWTF, W		Monitors the west ion exchange bed.
RAM 40	DRMS Auxiliary	Berthold, Model LB6500-1	ATR	2nd basement Gland Seal Room		
RAM 41	NOT USED					This is a spare communication port for additional RAMs only. There are no detectors installed and no DCMs connected.
RAM 42	NOT USED					This is a spare communication port for additional RAMs only. There are no detectors installed and no DCMs connected.
RAM 43	NOT USED					This is a spare communication port for additional RAMs only. There are no detectors installed and no DCMs connected.
RAM 44	DRMS Primary	Berthold, Model LB6500-1	ATR	Canal South (tools)		Detailed operating procedures require this RAM during fuel and irradiated materials handling, and cask loading in the canal area.
RAM 45	DRMS Process	Berthold, Model LB6500-1	ATR	Below 2nd basement Lower Firewater Injection Sys		Shielded detector
RAM 46	DRMS Process	Berthold, Model LB6500-1	ATR	1st basement Lower Firewater Injection Sys	There is also RM-22 at this location that triggers the annunciator	Shielded detector

Table 1. (continued).

Monitor ID Office ATR RMS	Monitoring System	Maintenance	Location Building	Location Room	Status June 07	Additional Requirements
SPING 3-A	Stack effluent	Eberline SPING-3A	ATR	Second basement West - samples from stack plenum in 2nd basement		
RM-20-09	Delay tank inlet	Eberline RMS-II	ATR	1st basement outside canal wall west of stairwell		Argon delay tank RAM
RM-20-10	Delay tank return	Eberline RMS-II	ATR	1st basement outside canal wall west of stairwell		Argon delay tank RAM
Loop piping monitors (13)	Experiment loop process	GA-3M				There are currently 13 radiation monitors of the GA-3M model, two for each loop, except loop 1C-W which has three, and loop 2C which have been removed. These units monitor the loop purification piping and Inpile tube outlet piping, with an added unit in the 1C-W cubicle that measures ambient radiation levels within the loop cubicle. The information is used by experimenters to detect cladding defects or other releases in the experiment loop. Some may be required for Loop 2A reactivation.

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status June '07	Additional Requirements
GM-21-41	HLRMS	GA Technologies Model RD-23 per SDD-7.8.4.1, 1989.	ATR	Reactor main floor North wall near door 44	Retired by TRA-USQ-2005-097	General Atomics still makes and sells replacement monitors. Proper operation might be verified and the HLRMS function might be restored. GA also sell replacement modules that may fit the current panel in the RCT office; they are digital units with a bar/scale vertical indicator and readout with a range of 108 R/hr.
GM-21-42	HLRMS	GA Technologies Model RD-23 per SDD-7.8.4.1, 1989.	ATR	First basement South stairwell, north wall	Retired by TRA-USQ-2005-097	Same as GM-21-41
GM-21-43	HLRMS	GA Technologies Model RD-23 per SDD-7.8.4.1, 1989.	ATR	Second basement South stairwell, north wall	Retired by TRA-USQ-2005-097	Same as GM-21-41
RE-38	ATR WWTF	GA-3M	REMOVED	REMOVED	Removed from ATR	These units used to send a signal to a module (RIA-38) in panel 670-E-101. The detectors have been removed, but the modules and wiring has been abandoned inn place. DRMS RAMs 38 and 39 now serve the function of monitoring the WWTF ion exchange tanks

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status - June 2007	Additional Requirements
RE-39	ATR WWTF	GA-3M	REMOVED	REMOVED	Removed from ATR	These units used to send a signal to a module (RIA-39) in panel 670-E-101. The detectors have been removed, but the modules and wiring has been abandoned inn place. DRMS RAMs 38 and 39 now serve the function of monitoring the WWTF ion exchange tanks
RM-5-49	ATR WWTF		ATR	1st basement at WWTF pump	Operational	Monitors warm waste system and shuts down pumps if rad level exceeds 40 mrem/hr. The monitor is mounted in the same panel as RIA-38/39 (670-E-101).
GM-1	Old RMS	Tracer Lab Some indicated as Model TA-6	ATR	2nd Floor Office Hallway (east Mezzanine)	Out of service; abandoned in place. Source removed.	All old Tracer Lab monitors, unless noted otherwise, are assumed to remain in their original installed locations
GM-2	Old RMS	Tracer Lab	ATR	2nd Floor ATRC Office Area (west Mezzanine)	Out of service; abandoned in place.	
GM-3	Old RMS	Tracer Lab	ATR	Reactor main floor - Reactor Top during outage (reactor top east)	Out of service; detector removed, wiring abandoned in place.	
GM-4	Old RMS	Tracer Lab	ATR	Reactor Top West	Out of service; detector removed, wiring abandoned in place.	

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status, June 07	Additional Requirements
GM-5	Old RMS	Tracer Lab	ATR	ATRC West Wall	Out of service; abandoned in place.	
GM-6	Old RMS	Tracer Lab	ATR	Reactor control room	Out of service; abandoned in place.	
GM-7	Old RMS	Tracer Lab	ATR	Main floor, Process control room	Out of service; abandoned in place.	
GM-8	Old RMS	Tracer Lab	ATR	Canal East	Out of service; abandoned in place.	
GM-9	Old RMS	Tracer Lab	ATR	Canal West	Out of service; abandoned in place.	
GM-10	Old RMS	Tracer Lab	ATR	Canal Southwest	Out of service; abandoned in place.	
GM-11	Old RMS	Tracer Lab	ATR	Laydown area	Out of service; abandoned in place.	
GM-12	Old RMS	Tracer Lab	ATR	Reactor main floor West	Out of service; abandoned in place.	
GM-13	Old RMS	Tracer Lab	ATR	Reactor main floor East	Out of service; abandoned in place.	
GM-14	Old RMS	Tracer Lab	ATR	First basement Outside 1A Cubicle	Out of service; abandoned in place.	
GM-15	Old RMS	Tracer Lab	ATR	First basement South	Out of service; abandoned in place.	
GM-16	Old RMS	Tracer Lab	ATR	First basement Loop 1C	Out of service; abandoned in place.	
GM-17	Old RMS	Tracer Lab	ATR	First basement Loop 1D	Out of service; abandoned in place.	

Table 1. (continued).

Monitor ID	Monitoring System	Monitor Type	Location Building	Location Room	Status - June '07	Additional Requirements
GM-18	Old RMS	Tracer Lab	ATR	First basement Primary Pump Motor Room Northwest	Out of service; abandoned in place.	
GM-19	Old RMS	Tracer Lab	ATR	First basement Switchgear	Out of service; abandoned in place.	
GM-20	Old RMS	Tracer Lab	ATR	First basement East, Canal Viewing Window	Out of service; abandoned in place.	
GM-21	Old RMS	Tracer Lab	ATR	Second basement East side by 2B-SE primary cubicle	Out of service; abandoned in place.	
GM-22	Old RMS	Tracer Lab	ATR	Second basement By 2C	Out of service; abandoned in place.	
GM-23	Old RMS	Tracer Lab	ATR	Second basement West, by 2D-SW	Out of service; abandoned in place.	
GM-24	Old RMS	Tracer Lab	ATR	Second basement West by 2E-NW	Out of service; abandoned in place.	
GM-25	Old RMS	Tracer Lab	ATR	2nd Basement west at Bypass Demineralizer	Out of service; abandoned in place.	
GM-26	Old RMS	Tracer Lab	ATR	2nd Basement Entrance Corridor	Out of service; abandoned in place.	
GM-27	Old RMS	Tracer Lab	ATR	2nd Basement Subpile room	Out of service; abandoned in place.	

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status	Additional Requirements
GM-28	Old RMS	Tracer Lab	ATR	rod access room below 2nd basement	Out of service; abandoned in place.	
GM-29	Old RMS	Tracer Lab	ATR	Motor Floor below 2nd basement	Out of service; abandoned in place.	
GM-30	Old RMS	Tracer Lab	ATR	Access at main floor laydown area	Detector head removed	
GM-31	Old RMS	Tracer Lab	ATR	Access at main floor laydown area	Detector head removed?	
GM-32	Old RMS	Tracer Lab	ATR	Access at main floor laydown area	Detector head removed?	
GM-33	Old RMS	Tracer Lab	ATR	Access at main floor laydown area	Detector head removed	
GM-34	Old RMS	Tracer Lab	ATR Stack	Stack Breech	Out of service; abandoned in place.	
GM-35	Old RMS	Tracer Lab	ATR	Second basement Exhaust Plenum	Out of service; abandoned in place.	
GM-36	Old RMS	Tracer Lab	ATR	1st basement Heat Exchanger Corridor Degas Tank	Out of service; abandoned in place.	
GM-37	Old RMS	Tracer Lab	ATR	Access at main floor laydown area	Out of service; abandoned in place.	

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status – June '07	Additional Requirements
Other RTC RMS						
RM-5-28	Warm Waste Treatment Facility (WWTF) process monitoring,	GA-3M	TRA 605	1 × Cub #1	Abandoned in place	A portable RAM monitors the sample sink area.
RM-5-29	Warm Waste Treatment Facility (WWTF) process monitoring,	GA-3M	TRA 605	1 × Cub #2	Abandoned in place	A portable RAM monitors the sample sink area.
RM-5-30	Warm Waste Treatment Facility (WWTF) process monitoring,	GA-3M	TRA 605	Valve Nest	Abandoned in place	A portable RAM monitors the sample sink area.
605-ERM-ChA and 605-ERM-ChB	ERM	Bicron 3H3/L3 Detector, Ortec 9305 Pre-amp, 556 Power Sup, 436 Discriminator, 871 Contr-timer, 449 Ratemeter	TRA 605	SW Quadrant		SDD 8.9.7 describes the system; (drawing 634656)
HC-RAM-1	Hot Cell 632 gallery RAM	AX-300A, GP-100c probe,	Hot Cells at RTC-632	North wall, Cell #1 Gallery	Detector is removed and a portable RAM is monitoring this location	Old Tracer Lab RAMs are still in place; detectors have been removed.
HC-RAM-2	Hot Cell 632 gallery RAM	AX-300A, GP-100c probe,	Hot Cells at RTC-632	North wall, Cell #2 Gallery		Old Tracer Lab RAMs are still in place; detectors have been removed.
HC-RAM-3	Hot Cell 632 gallery RAM	AX-300A, GP-100c probe,	Hot Cells at RTC-632	Center of 632 near ratemeters	Detector is removed	Old Tracer Lab RAMs are still in place; detectors have been removed.

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status, Turn On	Additional Requirements
HC-RAM-4	Hot Cell 632 gallery RAM	AX-300A, GP-100c probe, ADM-600A Ratemeter	Hot Cells at RTC-632	North wall, Cell #3 Gallery	Controlled by ADM-600	Old Tracer Lab RAMs are still in place; detectors have been removed.
HC-RAM-5	Hot Cell 632 gallery RAM	AX-300A, GP-100c probe, ADM-600A Ratemeter	Hot Cells at RTC-632	South wall, Cell #3 Service area	Controlled by ADM-600	Old Tracer Lab RAMs are still in place; detectors have been removed.
HC-RAM-6	Hot Cell 632 gallery RAM	AX-300A, GP-100c probe,	Hot Cells at RTC-632	South wall, Cell #2 Service area		Old Tracer Lab RAMs are still in place; detectors have been removed.
HC-RAM-7	Hot Cell 632 gallery RAM	AX-300A, GP-100c probe,	Hot Cells at RTC-632	South wall, Cell #1 Service area	Detector removed	Old Tracer Lab RAMs are still in place; detectors have been removed.
HC-CAM-1	Hot Cell 632 air monitor	Kaman Sciences Corp.	Hot Cells at RTC-632	Cell 1 and 2 Service Area		CAMs 2 and 7 draw air through the filters via a vacuum pump located in the cell 2 filter mezzanine, the same pump used to draw air from the exhaust ducts through the PING monitor. CAM-1 and CAM-5 have pumps. The
HC-CAM-2	Hot Cell 632 air monitor	Kaman Sciences Corp.	Hot Cells at RTC-632	Cell 1 Gallery		
HC-CAM-7	Hot Cell 632 air monitor	Kaman Sciences Corp.	Hot Cells at RTC-632	Office Gallery between Cell 2 and 3		

Table 1. (continued).

Monitor ID	Monitoring System	Manufacturer	Location Building	Location Room	Status – Line 6P	Additional Requirements
HC-CAM-15	Hot Cell 632 air monitor	Kaman Sciences Corp.	Hot Cells at RTC-632	Cell 3 Service Area		electronics for these units contain a mixture of modules, all with Model 220 Alarm Modules, Model 203 Digital Alarming Rate Meters, Model 210 Amplifiers, and Esterline/Angus Chart Recorders. CAM-7 and CAM-15 have a Model 355 HV Power Supply and Tennelec Model TC-910 Power Supply, while CAM-1 has a TC-948 HV Power Supply and a TC-910 Power Supply, and CAM-2 has a TC-948 HV Power Supply and a Model 354 Power Supply.
HC-Crit 1-4	Hot Cell criticality monitors	GA-3M	Hot Cells at RTC-632		Out of Service since 1992	
HC-PING	Combined Stack	Eberline	Hot Cells at RTC-632	Near RAM monitoring panel	Out of service	The detectors and electronics are out of calibration and are secured. The unit is used for sample collection only, with filters removed periodically for analysis at RML for permitting purposes.

2.2.1 RMSS

The RMSS provides the ATR confinement isolation to limit the release of airborne radioactivity to the environment. The RMSS is composed of three channels of instrumentation that monitor the inlet to the exhaust gas stack and an actuation system that provides a signal to stop fans and shut dampers in the heating and ventilating system when measurements of radiation levels in the main exhaust stream exceed preset limits. This system is discussed in the Updated Final Safety Analysis Report (UFSAR) Section 6.2.2.5 and in Chapter 7 (Instrumentation and Controls). The SDD for the RMSS is SDD-7.7.4.

The original RMSS included four functions: RMS-1, RMS-2, RMS-3 and RMS-4.

- **RMS-1**: Seal (limit all airflow in and out of) the gastight area of the ATR
- **RMS-2**: Purge (reduce airflow in) the gastight area while maintaining exhaust flow via the ATR stack
- **RMS-3**: Restricts airflow in and out of the ATR Critical Facility
- **RMS-4**: Restricts airflow out of the Canal Area.

RMS-1 and RMS-4 are functional. RMS-2 has been disabled. RMS-3 has been disabled by the removal of (old) CAM-10 from the ATRC area.

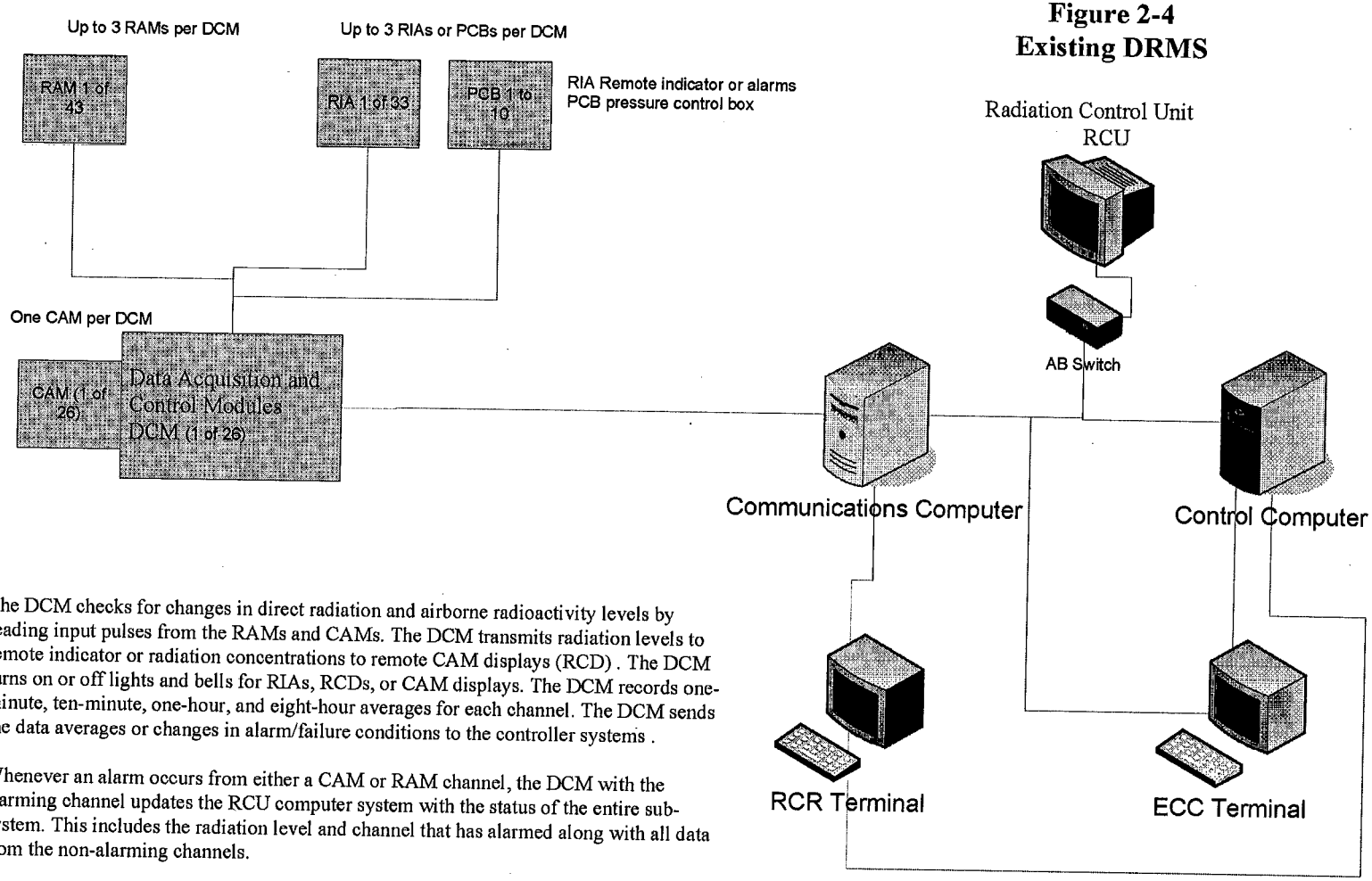
As listed in Table 2-1, several radiation monitors support the RMSS. The three monitors on the stack effluent (RE-530A, B, and C) are used in 2 out of 3 logic to actuate the RMS-1 function, isolation of the air tight space of the ATR confinement building. The radiation monitors that support the RMS-2 function have been removed or abandoned in place, effectively disabling this function. The RMS-3 function has been disabled. CAM-10 has been removed and is no longer required. A portable CAM is used to monitor in accordance with the RCP when radiation work is planned for the ATRC area. The RMS-4 function is supported by the older GNC CAMs 8 and 9.

RMS-1 is a SC design feature and therefore the system components that support this function are part of a SC engineered design feature. This system supports Technical Safety Requirements (TSR) specified in the ATR TSR (TSR-186-3.2.2). These components, the RE-530 radiation monitors and the components that make up the RMSS must be maintained to stringent quality assurance requirements.

2.2.2 DRMS

The requirements for radiological monitoring at the ATR are based in the RCP as noted in the UFSAR. The RCP is an administrative control included in the ATR TSR-AC-5.7.9. The DRMS has evolved over time and has been changed and upgraded as monitoring needs at the ATR have changed. The SDD for the DRMS is presently being revised, therefore the description of the system has been developed from historical documents and information collected from the ATR staff. Table 2-1 includes a summary of the various monitors that make up the current DRMS. Figure 2-4 illustrates the basic components of the existing DRMS.

Figure 2-4
Existing DRMS



The DCM checks for changes in direct radiation and airborne radioactivity levels by reading input pulses from the RAMs and CAMs. The DCM transmits radiation levels to remote indicator or radiation concentrations to remote CAM displays (RCD) . The DCM turns on or off lights and bells for RIAs, RCDs, or CAM displays. The DCM records one-minute, ten-minute, one-hour, and eight-hour averages for each channel. The DCM sends the data averages or changes in alarm/failure conditions to the controller systems .

Whenever an alarm occurs from either a CAM or RAM channel, the DCM with the alarming channel updates the RCU computer system with the status of the entire sub-system. This includes the radiation level and channel that has alarmed along with all data from the non-alarming channels.

The RCU turns on an annunciator to alert personnel that an alarm has occurred and updates all applicable display screens.

Figure 2-4. Existing DRMS.

The primary function of the DRMS is to provide information on the radiation dose rate levels, airborne radioactive particulate levels, radioiodine levels, and radioactive noble gas levels in the ATR facility. Total system information, from 26 local Data Acquisition and Control Modules, is available at two Radiation Control Unit (RCU) color display terminals located in the RCT Office in ATR (Room 106), and two remote terminal computers located in the Reactor Control Room (RCR) and the Emergency Communications Center (ECC). The main purpose of the DRMS is to detect, indicate, and record radiation levels. Part of the indication function is the ability of the system to alarm when abnormal levels occur at designated points in the ATR building during normal reactor operation, shutdown and maintenance activities. Local information is available at each of the 26 DCMs via a LCD screen and their associated audible and visual Indicators on the top of the CAM housing or nearby at a location suitable for the operations being conducted. The main components in the DRMS are 4 personal computers (2 main and 2 remote) 26 DCMs, 43 RAMs (33 with remote indicator and alarm modules, 10 with pressure control boxes), 26 CAMs (22 with local alarm and 4 with local alarm and indication). Hardware for communication to 2 annunciator interface panels and 4 H&V relay panels is provided in the original layout, but is not implemented in the final (current) design.

The CAMs of the DRMS provide indication of airborne radioactive material, by sampling the local atmosphere and measuring the radiation associated with noble gases, iodine and particulates. Certain CAMs include only the particulate and iodine functions.

RAMs provide indication of a radiological release and/or loss in shielding, by measuring gamma radiation levels in selected areas. Both CAMs and RAMs alarm so that personnel can evacuate the immediate area, but the instruments described here provide no other function to mitigate the event in progress.

When originally installed, the Tracerlab radiation and airborne radioactivity monitoring system of instruments was deployed in a manner that provided some level of monitoring for each major workspace within the facility. This was presumably to support the experimental nature of activities within the facility.

Further research of design specifications found no specific references to documentation that supports the basis for the original monitoring, instrument placement, instrument monitoring requirements, or the minimum requirements for facility operation. It appears that when the DRMS was installed in 1993, the monitoring equipment was selected and placed based on previous fixed instrument locations. The system design description for the DRMS 7.8.16 was similarly void of references as to basis, placement, and monitoring requirements.

In 1998, a Conceptual Design Document was prepared to upgrade the DRMS and to move the functions from the older original RMS system to the DRMS system. The upgrade included removing the older original RAMs and CAMs, upgrading some CAMs to include pulse counters added to generate new signals. The conceptual design also recommended changing the three RMSS RAMs at the stack breech with new monitors. The upgrade was not completed.

The existing radiation monitoring system and the specification of which monitors are required for personnel protection is outlined in SAR-153 Advanced Test Reactor Upgraded Final Safety Analysis Report, Section 12.5 and 15.11.1. Additional work described in recent EDFs (reference EDF-6174, -3077, -1977, and -1408) has provided the current technical basis for most monitors. Several of the CAMs and RAMs in the current DRMS are required to meet the requirements derived in these EDFs; the remaining monitors without a specific technical basis (including some of the old Tracer Lab units) are available as backup and to provide useful supplemental information. Table 2-1 includes a listing of the monitors that

are included in the DRMS. The categories primary, auxiliary, and process are used to describe the function of the various radiation monitoring instruments distributed throughout the plant. Primary monitors are required to meet specific RCP requirements, auxiliary monitors provide useful or backup information, process monitors support plant operations with equipment status information.

2.2.2.1 CAMs

2.2.2.1.1 Primary CAM—A CAM that is required to warn personnel and allow worker evacuation from the area such that the dose limits of SAR-153, Section 15.0.14 is not exceeded. Eight DRMS CAMs as described below are considered Primary CAMs.

EDF-6174, Air Flow Study of the Advanced Test Reactor Building TRA-670 (October 2005) presents the results of the ATR building air flow tests during normal and off normal conditions. One purpose of the testing was to support optimum placement of CAMs.

The technical bases derived in the EDF supports the following DRMS radiation monitors.

A single primary CAM (1) should be placed on the north east side of the reactor top approximately 5-6 ft from the posted Contamination Area to monitor conditions at the reactor vessel and supporting systems, experiment in-pile tube seals and vent piping, the working canal, and the experiment transfer station. A secondary (auxiliary) CAM (1B) should also be located on the south east side of the reactor top as a backup monitor. These CAMs must be capable of monitoring for particulate and iodine and should be capable of monitoring for noble gas to assist in quantifying the noble gas activity measured by the iodine monitor.

A second primary CAM (2) should be located at the southwest Section of the Canal area, sampling 6-7 feet high at the northwest end of the Arc Saw 480 volt cabinet to monitor for radioactive contaminants from stored components and spent fuel, from experiments and associated hardware, and operation of equipment such as the Arc Saw. The use of remote sample points may be required to obtain air samples from optimum locations. This CAM must be capable of monitoring for particulate and iodine and should be capable of monitoring for noble gas to assist in quantifying the noble gas activity measured by the iodine monitor.

A third primary CAM (3) or sample point should be located in the vicinity of the capsule storage rack with suction approximately level with the canal platform mid-rail. This CAM must be capable of monitoring for particulate and iodine and should be capable of monitoring for noble gas to assist in quantifying the noble gas activity measured by the iodine monitor.

A fourth primary CAM (4) should be placed at the north side of the canal as a secondary monitor sampling approximately 2 feet above and adjacent to the parapet at a position opposite the shield booth. Existing CAMs cannot adequately monitor these locations. This CAM must be capable of monitoring for particulate and iodine and should be capable of monitoring for noble gas to assist in quantifying the noble gas activity measured by the iodine monitor.

A fifth primary CAM (5) should be located in the First Basement directly across from the MICE primary cubicle door to monitor for airborne radioactivity from the MICE experiment. This CAM must be capable of monitoring for particulate and iodine and should be capable of monitoring for noble gas to assist in quantifying the noble gas activity measured by the iodine monitor.

A sixth primary CAM (6) should be located between the 1D and 1C cubicles with sample points just south of each cubicle door and approximately 4 feet above the floor to monitor those two cubicles.

This CAM must be capable of monitoring for particulate and iodine and should be capable of monitoring for noble gas to assist in quantifying the noble gas activity measured by the iodine monitor. Monitoring of the Pump Room and the Switchgear Room is not required due to the lack of a source term.

A seventh primary CAM (7) should be located in the Second Basement just south of the 2B secondary cubicle door to monitor for airborne radioactivity from the 2B cubicle and the AGR-1 experiment in the 2C secondary cubicle. The seventh CAM must be capable of monitoring iodine and should be capable of monitoring for particulate.

An eighth primary CAM (8) should be located just north of the 2E primary cubicle with a sample point approximately 4 feet above the floor to monitor conditions in that cubicle. The eighth CAM must be capable of monitoring for particulate and iodine and need not be capable of monitoring for noble gas.

Continuous monitoring of the sub-floors is not required.

The following CAMs are tentatively identified as the best choice to meet these requirements for Primary CAMs.

1. For Primary CAM-1, CAM-14 should be relocated to the specified northeast location, 5-6 feet from the working area. CAM-14 provides the required particulate, iodine and noble gas monitoring. For Secondary CAM-1B, CAM-7 is presently located on the south side of the reactor deck working area. CAM-7 should be relocated to the specified SE location. CAM-7 provides the required monitoring to meet the requirements of the secondary (primary backup) CAM specified in EDF-6174.

2. CAM-8, -9, -23 or an available mobile CAM should be used for the 2nd, 3rd, and 4th primary CAMs specified in EDF-6174. These CAMs must be capable of monitoring for particulate and iodine and should be capable of monitoring for noble gas.

3. CAM-15, -16, -17, -21, -26 or a mobile CAM should be designated as the 5th primary CAM required by EDF-6174. These CAMs must be capable of monitoring for particulate and iodine and should be capable of monitoring for noble gas.

4. CAM-18, -19, -20, -25 or a mobile CAM should be designated as the 7th and 8th primary CAMs. The seventh CAM must be capable of monitoring iodine and should be capable of monitoring for particulate. The eighth CAM must be capable of monitoring for particulate and iodine and need not be capable of monitoring for noble gas.

2.2.2.1.2 Auxiliary CAMs—CAMs that warn personnel of abnormal radiation levels in occupied areas in support of the ALARA program. Some of these CAMs may act as supplemental monitoring if a primary CAM is out of service, but do not carry out the functions of the primary CAM. There are 14 (26-9-3) additional CAMs in service (or standby) at the ATR. Although not specifically required to meet the requirements of the UFSAR, these instruments provide additional information on facility status and can serve as backup to Primary CAMs, when appropriately configured. All operating CAMs not designated as primary serve as auxiliary CAMs. Existing CAMs and their present locations are listed in Table 2-1; existing CAM locations are illustrated on Figure 2-2 (A-D).

2.2.2.2 RAMs

2.2.2.2.1 Primary RAM—A RAM that is required to warn personnel and allow worker evacuation from the area such that the dose limits of SAR-153, Section 15.0.14 are not exceeded. All

evacuation system RAMs as described below are considered Primary RAMs. Some Primary RAMs are also used to backup other Primary RAMs.

EDF-1977, Radiation Monitoring Requirements for the Advanced Test Reactor (August 2002) presents the results of an evaluation of potential radiation fields that could develop in different areas of the ATR. One purpose of the evaluation was to determine the type and placement of RAMs to support the RCP.

The technical bases derived in the EDF supports the following DRMS radiation monitors.

2.2.2.2.2 Evacuation System RAM—A RAM that provides a signal for activation of an alarm warning operations personnel that an abnormal radiation condition exists that has the potential for high personnel exposures and may warrant an evacuation of the facility. The Shift Supervisor then initiates an evacuation only if data supports that course of action. The RAMs associated with the Evacuation System are arranged in two groups, each group with its own two-of-three logic bus, which provide redundant alarm capability for the same areas of the plant. Two of the three signals in the same group must be received to activate the alarm. The associated RAMs are selected for their different locations based on the assumption that simultaneous alarms from two RAMs that are isolated by distance and by facility structure indicate an event that involves a source of radiation that is affecting a large area of the facility.

- RAMs 5, 6, and 23 (Group A Evacuation)
- RAMs 2, 13, and 24 (Group B Evacuation).

Where the RAMs monitor the following areas:

- RAMs 2 and 5 monitor the ATR Critical facility (ATRC),
- RAMs 6 and 13 monitor the ATR Reactor Main Floor and control room, RAMs 23 and 24 monitor the west side of the second basement.

In addition, two RAMs that monitor the ATR stack effluent at the stack breech and plant exhaust plenum each provide a signal to the pulse counter in their respective DCM that sends a signal to the control room to activate the evacuation system alarm under a one-of-two logic.

- RAM 34 (Stack Evacuation Channel A, monitoring the stack breech)
- RAM 35 (Stack Evacuation Channel B, monitoring the exhaust plenum).

Evacuation involving these RAMs is based on the assumption that a release of radioactive material is already in progress and data may suggest an evacuation of personnel from the facility. These two RAMs are cited as backup indication and alarm for the RMSS stack monitors (TSR-186-3.2.2 Condition B).

2.2.2.2.3 Other Primary RAMs—Additional required Primary RAMs were identified in the EDF as follows:

- RAM 3 (Monitors Reactor Top East during transfer operations)

- RAM 4 (Backup for RAM 3)
- RAM 12 (Backup for RAM 3)
- RAM 13 (Backup for RAM 3 and part of the Group B Evacuation)
- RAM 44 (Monitors full or partial draining of the canal during operations)
- RAM 8 (Backup for RAM 44)
- RAM 9 (Backup for RAM 44)
- RAM 10 (Backup for RAM 44)
- RAM 21 (Monitors adjacent to the 2B Primary Cubicle)
- RAM 23 (Monitors adjacent to the 2D Primary Cubicle and part of the Group A Evacuation)
- RAM 24 (Monitors adjacent to the 2E Primary Cubicle and part of the Group B Evacuation)
- RAM 22 (Backup for RAM 21)
- RAM 23 (Backup for RAM 24 and part of the Group A Evacuation)
- RAM 24 (Backup for RAM 23 and part of the Group B Evacuation).

In summary, to support EDF-1977 the following 20 unique Primary RAMs are required for operation of the ATR.

RAM 2	RAM 13
RAM 3	RAM 21
RAM 4 *	RAM 22 *
RAM 5	RAM 23
RAM 6	RAM 24
RAM 8 *	RAM 34
RAM 9 *	RAM 35
RAM 10 *	RAM 44
RAM 12 *	

2.2.2.2.4 Auxiliary RAM—RAMs that warn personnel of abnormal radiation levels in occupied areas in support of the ALARA program. Some of these RAMs may act as supplemental monitoring if a primary RAM is out of service, but do not carry out the functions of the primary RAM, such as initiation of an evacuation signal. Such (auxiliary RAMs that can support primary RAM monitoring) RAMs are marked with an asterisk (*).

ATR Office Area Second Floor

- **RAM 1:** Office/Hallway monitors for radiation levels in occupied areas to detect abnormal exposure rates to unmonitored personnel and maintain radiation exposure to office workers ALARA.

ATR Main Floor

- ***RAM 4:** Reactor Top West Side monitors for abnormal radiation levels during fuel and test handling evolutions to maintain radiation exposure to reactor top workers ALARA.

- **RAM 7:** Process Control Room north of canal warns operators in the control room of abnormal radiation levels resulting from canal operations in order to maintain exposures ALARA.

- ***RAM 8:** Canal East warns operators in the control room of abnormal radiation levels resulting from canal operations in order to maintain exposures ALARA.

- ***RAM 9:** Canal West warns operators in the control room of abnormal radiation levels resulting from canal operations in order to maintain exposures ALARA.

- ***RAM 10:** Canal Southwest warns operators in the control room of abnormal radiation levels resulting from canal operations in order to maintain exposures ALARA. (Note this location could be used for monitoring the HSIS Rabbit send/receive lines if moved west about 15 ft.)

- **RAM 11:** Laydown Area warns personnel of abnormal radiation levels resulting from movement of materials or from canal operations in the adjacent room.

- ***RAM 12:** Reactor Main Floor West warns personnel of abnormal radiation levels resulting from movement of materials or from operations or maintenance within the main floor area.

ATR First Basement

- **RAM 14:** East outside the 1A primary cubicle monitors for abnormal radiation levels resulting from movement of materials or from operations of the MICE Facility in order to maintain exposures ALARA.

- **RAM 15:** South outside the Outer Shim Corridor monitors for abnormal radiation levels resulting from movement of materials or from operations of the Pump Test Loop in order to maintain exposures ALARA.

- **RAM 16:** West outside the 1C primary cubicle monitors for abnormal radiation levels resulting from movement of materials or from operations of the 1C-W loop in order to maintain exposures ALARA.

- **RAM 17:** West outside of the 1D primary cubicle monitors for abnormal radiation levels resulting from movement of materials or from operations of the 1D-N loop in order to maintain exposures ALARA.

- **RAM 18:** Primary Pump Motor Room Northwest monitors for abnormal radiation levels resulting from movement of materials or from reactor plant operation in order to maintain exposures ALARA.

- **RAM 19:** Northeast in the Switchgear Room monitors for abnormal radiation levels resulting from movement of materials or from reactor plant operation in order to maintain exposures ALARA.

- **RAM 20:** East, Canal Viewing Window on South wall of the Canal monitors for abnormal radiation as a result of loss of shielding at the canal viewing window in order to maintain worker exposures ALARA.

ATR Second Basement and Sub floors

- ***RAM 22:** West outside the 2C primary cubicle monitors for abnormal radiation levels resulting from movement of materials or from operations of the 2B-SE loop in order to maintain exposures ALARA.

- **RAM 28:** South in the Rod Access Room monitors for abnormal radiation levels resulting from plant operations to allow entry at power for routine maintenance in order to maintain worker dose ALARA.

- **RAM 29:** South in the Warm Waste Pump Motor Floor monitors for abnormal radiation levels resulting from plant operations to allow entry for routine operations and maintenance in order to maintain worker dose ALARA.

- **RAM 40:** Northeast in the Gland Seal Pump Room monitors for abnormal radiation levels resulting from plant operations to allow entry for routine operations and maintenance in order to maintain worker dose ALARA.

In summary, the following 13 unique Auxiliary RAMs for the ATR are needed to maintain worker dose ALARA.

RAM 1	RAM 18
RAM 7	RAM 19
RAM 11	RAM 20
RAM 14	RAM 28
RAM 15	RAM 29
RAM 16	RAM 40
RAM 17	

2.2.2.2.5 Process RAM—A radiation detection instrument that monitors a system for abnormal radiation fields that result from primary boundary leakage, reverse flow to support systems, transient radiation during process operation or that monitors areas that are normally inaccessible during reactor operation. These instruments warn operations personnel of abnormal radiation conditions within plant piping systems or adjacent to plant process equipment. They can be used for data prior to entering a cubicle or a measurement parameter to key operator action during a process. In some instances, this

includes portable RAMs, which are placed throughout the ATR at the discretion of Radiological Control Management. These instruments are not required for protection of personnel in the context of EDF-1977.

ATR Main Floor

- **RAM 30:** Lay down area north, detector installed in instrument tubes monitor the secondary cooling system outlet from the heat exchangers to warn operations personnel of abnormal radiation levels associated with a potential primary to secondary leak. The areas monitored are not occupied during reactor operation.

- **RAM 31:** Lay down area north, detector installed in instrument tubes monitor the secondary cooling system outlet from the heat exchangers to warn operations personnel of abnormal radiation levels associated with a potential primary to secondary leak. The areas monitored are not occupied during reactor operation.

- **RAM 32:** Lay down area north, detector installed in instrument tubes monitor the secondary cooling system outlet from the heat exchangers to warn operations personnel of abnormal radiation levels associated with a potential primary to secondary leak. The areas monitored are not occupied during reactor operation.

- **RAM 33:** Lay down area north, detector installed in instrument tubes monitor the secondary cooling system outlet from the heat exchangers to warn operations personnel of abnormal radiation levels associated with a potential primary to secondary leak. The areas monitored are not occupied during reactor operation.

- **RAM 37:** Lay down area north in, detector installed instrument tubes monitor the secondary cooling system outlet from the heat exchangers to warn operations personnel of abnormal radiation levels associated with a potential primary to secondary leak. The areas monitored are not occupied during reactor operation.

ATR First Basement

- **RAM 36:** Northwest Heat Exchanger Room upper mezzanine adjacent to the primary coolant system degas tank. His unit monitors an area that is not occupied during reactor operation. It tracks radiation increases during startup and can be used for information if an entry is made at power to inspect for leaks.

- **RAM 38:** Southwest Warm Waster Treatment Facility. These units monitor the east resin bed of the ion exchangers for treatment of liquid waste. Increased radiation levels during operation and back flush of the bed can result in radiation levels exceeding 1000mrem/hr. Monitor tracks the increase in radiation and help to determine when the bed should be changed. Information from this monitor is used prior to entry into the tank rooms.

- **RAM 39:** Southwest Warm Waster Treatment Facility. These units monitor the west resin bed of the ion exchangers for treatment of liquid waste. Increased radiation levels during operation and back flush of the bed can result in radiation levels exceeding 1000mrem/hr. Monitor tracks the increase in radiation and help to determine when the bed should be changed. Information from this monitor is used prior to entry into the tank rooms.

- **RAM 46:** South by the upper fire water injection system. This unit monitors the piping for abnormal radiation due to back leakage from the reactor vessel. The detector is shielded from the surrounding area to discriminate against background radiation.

ATR Second Basement

- **RAM 25:** Northwest by Bypass demineralizer valve corridor. This unit monitors for abnormal radiation levels during transfer of resin to check for blockage in the system and to maintain worker doses ALARA.

- **RAM 26:** South Subpile room. This unit monitors the Subpile room outer corridor, an area that is not occupied during operation. This unit can be tracked for increases in radiation levels during startup, but is not for monitoring of personnel.

- **RAM 27:** South Subpile room. This unit monitors the Subpile room central cubicle, an area that is not occupied during operation. This unit can be tracked for increases in radiation levels during startup, but is not for monitoring of personnel.

- **RAM 45:** South by the entrance to the Rod Access Room lower fire water injection system. This unit monitors the piping for abnormal radiation due to back leakage from the reactor vessel. The detector is shielded from the surrounding area to discriminate against background radiation.

In summary, the following 13 unique Process RAMs for the ATR are needed to warn operations personnel of abnormal radiation conditions within plant piping systems or adjacent to plant process equipment.

RAM 25	RAM 36
RAM 26	RAM 37
RAM 27	RAM 38
RAM 30	RAM 39
RAM 31	RAM 45
RAM 32	RAM 46
RAM 33	

All of these monitors communicate to data recording and alarm equipment in the RCT office (room 106) in ATR. The current Berthold equipment is linked to the DRMS control and communication system (RCU), and much of the old Tracer Lab equipment is linked to old chart recorders and other data storage units. Several of the monitors are also linked to annunciators and other relay equipment that support alarms and data readout in the main reactor control room.

2.2.3 Other ATR Monitoring

Stack effluent is monitored with an Eberline SPING-3A. This monitor draws a sample from the ATR exhaust plenum and measures the radiation associated with the particulate, iodine and noble gas fractions. This system provides supplemental information for quantifying the release of radioactive material from the ATR, and is used primarily to support the environmental monitoring requirements (40CFR61) and the RCP.

The radiation entering and exiting the Argon Delay Tank is monitored by two Eberline RMS-II RAMs. This information supports plant operations with data on potential release of radiation in the gaseous effluent from the ATR.

Loop piping monitors are used to track radiation in the experiment coolant loops as an aid to operations and experimenters. There are currently 13 radiation monitors of the GA-3M model, two for each loop, except loop 1C-W which has three, and loop 2C which have been removed. Each system includes a detector, a remote indicating and control module, and a remote alarm and indicating panel, except 1C-W, for which the alarm and indicating panels have been removed. These units monitor the loop purification piping and Inpile tube outlet piping, with an added unit in the 1C-W cubicle that measures ambient radiation levels within the loop cubicle. The information is used by experimenters to detect cladding defects or other releases in the experiment loop.

Three high level radiation monitors (GM-21-41, -42, -43) are still installed in the ATR. Although retired per TRA-USQ-2005-097, these General Atomics (GA) Technologies Model RD-23 monitors (per SDD-7.8.4.1, 1989) could be reactivated using components available from GA.

There are two old monitors that were removed from the ATR Warm Waste Treatment Facility (WWTF) that each consisted of a detector (RE-38, 39) and a remote indicating and control module (RIA-38, 39). The detectors were mounted on the walls of the east and west ion exchange cubicles, but have since been removed. The RIAs are mounted in panel 670-E-101 near the WWTF, along with a data recorder/strip chart that recorded both channels. The RIAs and associated wiring to the detectors is abandoned in place. DRMS channels 38 and 39 now serve the function of monitoring RAMs on WWTF ion exchange tanks.

There are 37 old Tracer Lab RAMs abandoned in place in the ATR at essentially the same locations as the current DRMS RAMs. These monitors are out of service. A few of the heads (detectors) have been removed to accommodate the newer Bertold units.

All of these monitors will be considered in the development of recommendations for upgrade of the RMS.

2.2.4 Other RTC Monitoring

There are additional radiation monitors used in other buildings at the RTC that need to be considered in the overall upgrade project. Also listed in Table 2-1, these monitors serve the RCP at these other facilities, including a few that are scheduled for D&D or anticipate future programs.

The Hot Cell Facility at RTC-632 is in warm standby (safe shutdown mode); the radiation monitors used to support the RCP at the facility are operational, but aging and nearing obsolescence. Monitors HC-RAM-1 through HC-RAM-7 measure the radiation fields in the operating galleries and service areas of the hot cells. These monitors are located strategically at the east, west and center of the north and south walls, to monitor the radiation from the three principal hot cells. The seventh monitor is located in the center of the facility near the ratemeters that provide readout and record the radiation levels of all seven monitors. Four CAMs monitor for airborne radioactivity in the facility from the east and west service and gallery areas. A PING installed to monitor the combined stack discharge of the three cells is in operation as a sampling media only. The electronics and detectors are currently out of calibration and have been secured.

Waste water discharged from the ATR is routed through the old Waste Water Treatment Facility at RTC-605. Figure 2-5 is a diagram of the WWTF (RTC-605) showing the locations of radiation monitors

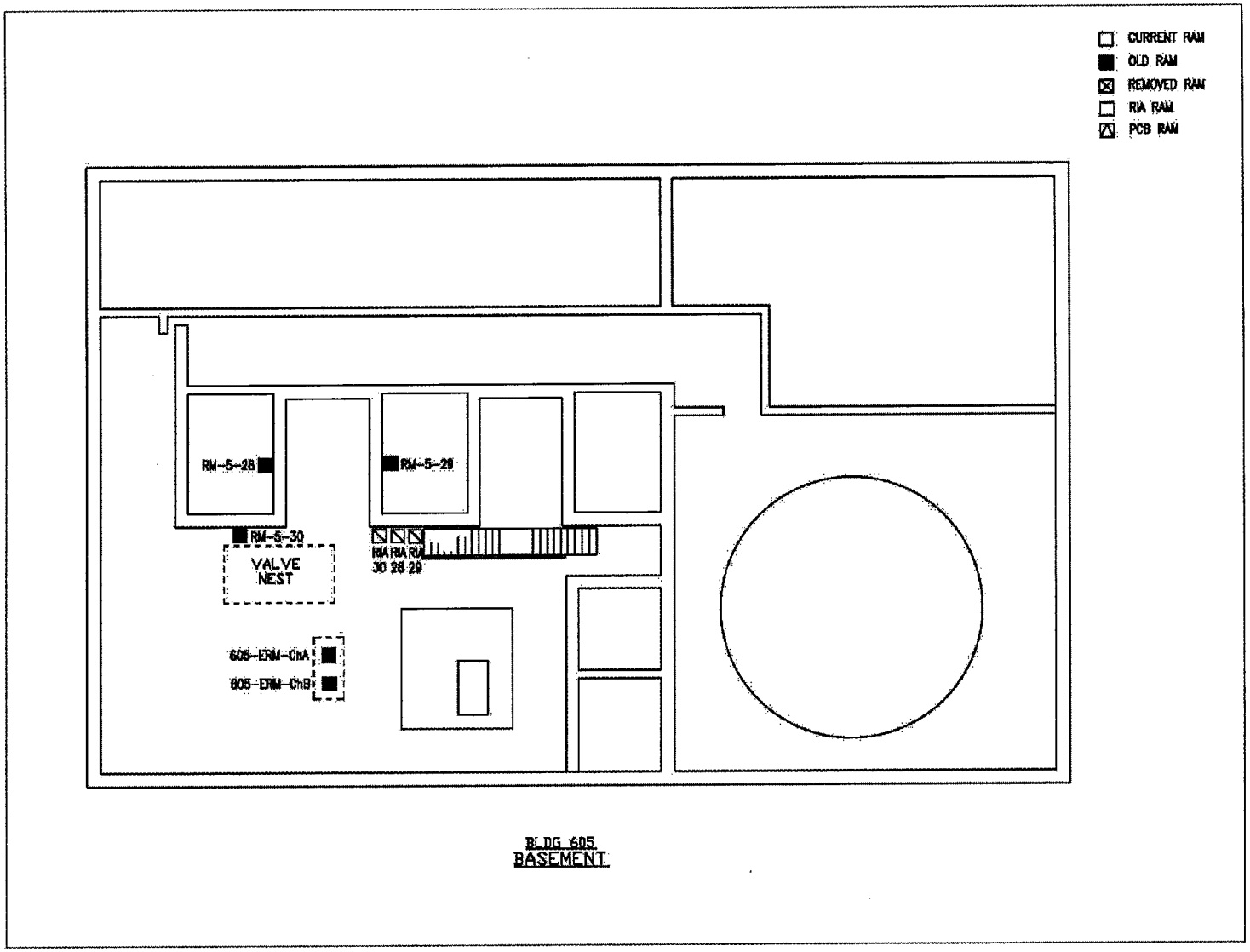


Figure 2-5. Layout of RTC-605.

that presently exist, including monitors that may be obsolete, inoperable or abandoned in place. Three monitors, RM-5-28, -29, and -30, have been abandoned in place. A portable RAM monitors radiation at the sample sink in 605.

There is currently an Operational Safety Requirement (OSR) checklist that must be completed before processing waste or performing work within radiological areas of TRA 605. Detailed Operating Procedure (DOP) 8.3.9 is the OSR checklist that specifies that one CAM and one RAM must be verified operational and monitoring the basement area during these activities. The portable CAM and RAM currently in place function as the monitors for this requirement, in lieu of the obsolete equipment abandoned in place or removed from the facility.

The Effluent Radiation Monitor (ERM) in RTC-605 is described in SDD 8.9.7 and monitors effluent from the facility before it is discharged to the evaporation ponds, in support of discharge permit monitoring requirements. It controls two pumps to divert water to holding tanks when pre-set levels are reached. The usefulness of these monitors to the RTC facilities and the future programs will be considered in the development of recommendations for overall RMS upgrade.

This summary of the existing radiation monitoring systems at the RTC is based on descriptions collected from historical documentation and staff interviews. The ATR Design Reconstitution Project is currently confirming the design requirements and technical bases for the facility, including the radiation monitors. The results of the Project may yield radiation monitoring requirements that differ from those identified in this Study. Any changes or conflicts will require resolution prior to final implementation of the recommendations presented here.

Most of the systems at the RTC are old or aging; most appear to be candidates for replacement. Upgrades in replacement monitors are being considered to maximize the benefit to the RTC and its future programs. The adequacy of existing radiation monitoring systems throughout the RTC and the potential need for changes and upgrades to these systems is evaluated in Section 4 and recommendations are presented in Section 5.

2.3 RMS Performance and Compliance to Requirements

Essentially all of the radiation monitors at the RTC are old and exhibit varying degrees of performance. Corrective maintenance is increasing on many of the units, and preventative maintenance and calibration is becoming increasingly difficult. As the monitors fail to perform to specifications or loose calibration they fail to meet the requirements of the RCP, the UFSAR and the TSR Administrative Control for radiological control.

The existing Bertold CAMs have experienced a failure rate of 8 to 16% over a 72 week period documented prior to 2001. Over the same 72 week period, RAM failure rate was 31% for weekly response checks; only 69% of the RAMs responded successfully to all response checks. The failures were due primarily to inaccurate response to the check source when background levels were above 3 mrem/hr. Since 2001 the performance of the instruments has remained problematic.

The CAMs are designed to monitor radiation associated with three different components of the air sampled: particulate, halogens (iodine) and noble gas. The requirements for iodine and noble gas monitoring have been undefined until recently. EDF-3077 (2001) has provided the first quantitative assessment of the air monitoring requirements by species to establish the technical basis for the monitoring requirements and alarm set points. Using the Radiological Hazard Index, the need and benefit of monitoring particulate, iodine and noble gas has been analyzed. For certain accidents, the postulated

source term includes greater fractions of iodine or noble gas, presenting a different monitoring challenge to properly detect and warn personnel of the presence of the hazard. The analysis allows the specification of appropriate monitoring and alarm set points for different CAMs. As discussed in Section 2.2.2.1 above, primary and auxiliary CAMs and their monitoring points have been specified based on this analysis.

Since the analysis is based on certain assumed accident scenarios, and the specification of monitoring requirements was based on the bounding or worst case source terms, changes in the ATR operations and experiments that change the bounding source term will effect the monitoring requirements. As such changes occur, experiment supporting analysis and USQ results should be used to revise these monitoring requirements. The locations of CAMs and their specified monitoring requirements and alarm set points may need to be changed accordingly.

Similarly, the requirements for RAM placement and alarm set points was determined as described in EDF-1977 by evaluation of postulated source terms from the bounding accidents described in the UFSAR Chapter 15. Certain events are expected to initiate RAM alarm prior to CAM alarm, providing early warning to personnel and supporting the ALARA goal of the RCP. As is the case for CAMs, changes in the ATR operations and experiments that change the bounding source term will effect the RAM monitoring requirements. As such changes occur, experiment supporting analysis and USQ results should be used to revise these monitoring requirements. The locations of RAMs and their specified alarm set points may need to be changed accordingly.

The new requirements identified for radiation monitoring in support of the HSIS and Pressurized Water Loop 2A have not been fully analyzed. Although these requirements will be defined during the design and safety analysis process, tentative requirements are suggested here to support the recommendations for future changes and upgrade of the DRMS.

For the HSIS, RAM coverage is needed along the transfer piping pathway wherever there is a potential for personnel exposure to the capsule radiation. Based on the pre-conceptual design (ref. ANNA design report), RAM coverage is needed on the main reactor floor from the point where the transfer piping emerges from the nozzle trench (or piping annulus), along the transfer piping route to the south side of the canal, and at the send-receive work station. RAM-10 as described in Section 2.2.2.2 DRMS appears to be located appropriately to provide the required radiation monitoring for the HSIS. RAM-4 is located near the point where the transfer piping enters the main reactor building floor, and RAM-10 is located near the HSIS work station at the canal parapet. CAM-coverage should be provided where there is a reasonable risk of airborne radioactivity. For the HSIS there is a credible risk of material release from the irradiated capsule when the receive station is opened for capsule removal. CAM coverage may need to be adjusted for optimized performance, e.g. to monitor the work station area by sampling air near the breathing zone of the HSIS Send-Receive Station operator(s). Primary CAM-3, as described in Section 2.2.2.1, should provide this coverage. Primary CAM-3 is located at the southwest corner of the canal, near the HSIS Send-Receive work station. The sample probe may need to be adjusted for optimal performance.

For the Pressurized Loop 2A, there is a potential for personnel exposure during experiment removal, similar to that for all other post-irradiation experiment removal operations. RAM-3 and RAM-4 are located to provide the necessary monitoring for over-reactor work such as experiment insertion and removal from the ATR loops and core irradiation cells. CAM-1, backed up by CAM-1A, provides the required air monitoring. These CAMs serve Pressurized Loop 2A as well as the other over-reactor work operations.

Potential plans for use of the Gas Cooled Loop Transfer Facility (GCL cubicle) to dry-cut gas loop experiment test trains for shipment to the post irradiation examination facility could increase requirements for monitoring of radiation and airborne radioactivity near this facility in the southeast section of the first basement. Auxiliary CAMs (DRMS-CAM-4 and -16) are well placed to function as a primary CAM for this location if analyses indicate the need for a primary instrument. A new primary RAM may need to be considered for this area as transient radiation fields will be present when raising and lowering experiments into and out of the GCL cubicle.

No additional monitors appear to be necessary to provide proper radiation monitoring for the new planned operations. CAM sample probe locations may require some adjustments and alarm set points may need to be revised; analysis in support of the new programs should confirm the adequacy of the monitoring and define any necessary changes or adjustments.

3. MODERN RADIATION MONITORING TECHNOLOGY

3.1 Discussion of New Commercial Plant RMS

The ANNA Team contacted several commercial nuclear power plant operators, as part of the trade study for this statement of work. Commercial nuclear power plants (NPPs) were contacted to determine what types of Radiation Monitoring Systems (RMS) are in use in the industry. Many plants have the originally installed equipment, now more than 30 years old. Original manufactured equipment was provided by several vendors including Westinghouse, General Electric, Kaman, Victoreen, Nuclear Measurements Corporation (NMC), Nuclear Research Corporation (NRC) and GA. Post Three Mile Island many plants installed Eberline PING (particulate, iodine, noble gas) airborne effluent monitors. One overall theme in the commercial industry is that plant wide system upgrades of the RMS would be beneficial. The systems are old and replacement parts are getting difficult to procure. Plant specific upgrades and new NRC requirements have made many of the commercial NPP RMSs unique, which adds to the difficulty in maintaining the systems.

Some of the original vendors have changed or ceased operation leaving some RMS equipment unsupported. Discussions with commercial NPP indicate that several of the RMS vendors have essentially gotten out of the business, or sold their shares to new companies. It appears that NMC no longer supports their systems. Westinghouse and Kaman have essentially gotten out of the RMS business, but still have limited support for installed systems. General Electric has started a Numac product line, and still fully supports their old systems. Victoreen has been purchased by Fluke Biomedical and also still fully supports their old systems. It appears that Eberline is phasing out their PING line of monitors, and now recommends the AMS-4.

The commercial NPPs contacted have contracted with following three main vendors, within the past 10 years or so, for Radiation Monitoring Systems upgrades:

Vendor	Contact
General Atomics (Sorrento)	Victor Kamachu (858) 735-7692
MGP	Mike Edelman (770) 432-2744 (ext. 132)
Apantec	Tom O'Malley (267) 436-3992
Berthold	
Thermo Scientific	Jeff Anspauth (317) 421-1513

More information on these companies and their radiation monitors is provided in Section 3.2 below.

A list of commercial NPPs contacted, and radiation monitoring systems in use, is included in Attachment A.

3.1.1 Commercial NPP RMS Upgrades Lessons Learned

1. Metal bellows pump are preferred over carbon vane pumps in Process Radiation Monitors (PRMs).

2. Have good design criteria before attempting to buy a new system. Specifically state required minimum detectable activity (MDA), range, source term (isotopes of interest, energies), and the maximum and minimum readings required on each channel, etc. Specify size requirements and check equipment prior to acceptance. Signoff drawings before fabrication, and carefully perform factory acceptance tests to verify your design specifications.

3. Go with fixed filter paper CAMs if possible, as they are easier to maintain and have fewer moving parts subject to breakage.

4. Specify 3 point source calibration on radiation detectors.

5. Keep it simple. Ask vendor to remove options that you do not need.

6. Commercial NPPs have been eliminating strip charts and going with digital downloads.

7. Users groups are a valuable asset. General Atomics, MGP, and Thermo Scientific have active user groups that meet regularly.

8. Best to keep communication loops autonomous so one bad detector does not take down entire system.

9. Use of wireless personnel dosimeters as health physics Area Radiation Monitors has been an identified good practice.

10. Extended range channels signal wire needs to be in dedicated ridged conduit. These channels run off pico-amp signals and are subject to electrical interference.

11. Find a system that can use existing wiring, if possible. Running new signal and power wiring is expensive if seismic and cable isolation requirements are needed.

12. Pay attention to isokinetics on air monitors used to quantify releases or release rates.

13. Commercial NPPs have had air moisture problems in some CAMs, and had to install mechanical moisture separators in intakes.

14. Recommend having the RMS on a battery back-up (*e.g.,* Elgar) in case of loss of power.

3.2 Vendor Options and Equipment Features

3.2.1 Apantec

Apantec has supplied recent commercial NPP RMS upgrades. The company initially operated as the NRC, then formed NRC/Aptec. NRC/Aptec was bought out by Canberra. Canberra had a strong foot hold in the commercial NPP health physics gamma spectroscopy counting systems. Canberra installed RMS channels at several commercial NPPs, and then decided to get out of the RMS business. Several of the engineers from NRC/Aptec and Canberra bought the business and formed the company Apantec. Apantec fully supports the old NRC/Aptec and Canberra systems. The commercial NPPs using Apantec equipment report that the systems are reliable have good engineering support, and that the company is knowledgeable of U.S. nuclear regulations. While the company does not have a long track record, they seem to be an up and coming vendor.

Apantec offers a wide range of RMS detectors to upgrade existing systems. Their systems feature a variety of detectors such as GM Tube, Ion Chamber and Scintillation detectors, which attach to a Pre-Amp that can line drive up to 2 miles, or serial interface up to 1000 m or provide Ethernet up to 100 m. The standard outputs are chart PLC, Serial RS-485/RS-232 and Ethernet TCPIP. They have a variety of CAM units, in the particulate, iodine and noble gas configurations. All monitors have the normal outputs plus offer an optional wireless output.

Apantec has considerable experience with wireless systems having installed Wireless Area Radiation Networks for Brookhaven, Jefferson Lab, the Royal Navy, States of South Carolina and Delaware and in China. Many of these are mobile and or vehicle mounted.

Apantec offers software systems to log data and monitor the systems.

3.2.2 Berthold Technologies

Berthold Technologies is located in Bad Wildbad in the German Black Forest. There is a U.S. branch of the company located in Oak Ridge Tennessee. It has developed sensors, detection systems and instruments dating back to 1949, and offer high performance standard products, optimal solutions for specific customer applications and OEM instruments for Biosciences, Medicine, Industrial Process Control and Radiation Protection. The original Berthold product line consisted mostly of sensors and detection systems for nuclear radiation and X-rays. They serve and support customers with a worldwide distribution organization with emphasis on applications assistance and product maintenance.

Berthold supports existing Berthold systems as well as provides replacements RAM and CAM monitors. Berthold offers software systems to log data and monitor the systems.

3.2.3 General Atomics Electronics Systems Inc.

The vendor that has apparently been in the RMS business from the start is General Atomics Electronics Systems Inc. (GA-ESI), also known as Sorrento and GA. This company is well established in the commercial NPP industry, and several NPPs have the originally installed Sorrento equipment still in operation. Others have upgraded their old systems with new Sorrento systems. Many commercial NPPs RMS engineers belong to the Sorrento Users Group (UG). The UG meets twice a year and drives issues, resolution, and improvements. Many end users report that the UG is a valuable asset. The second General Atomics Electronic Systems, RMS Users' Group meeting of 2007 will be held August 6-10, in Seattle, WA. Approximately 60 people are expected to attend. A general consensus is that Sorrento equipment is rugged, dependable and well supported; although, the equipment is somewhat more expensive then their competitors. The company is knowledgeable of USNRC regulations, and has a long track record in the U.S.

The RAM units from GA are Geiger Mueller tube detectors with a built in microprocessor that performs data acquisition and control functions, and provides alarm relays, analog outputs, and digital communications.

The CAM units from GA could be the fixed filter particulate detectors with the built in microprocessor that performs data acquisition and control functions, and provides alarm relays, analog outputs, and digital communications. Iodine and noble gas models are also available.

General Atomics offers software systems to log data and monitor the systems.

3.2.4 MGP

A new vendor to the U.S. RMS market is MGP. MGP is a subsidiary of the synOdys Group. MGP is well established in Europe starting in the 1960s, and has made some inroads in the US. A general consensus is that MGP equipment is sophisticated, technically advanced and well supported. Several commercial NPPs have purchased MGP Process Radiation Monitors (PRMs), including plant vent monitors and N-16 monitors. Although the PRM equipment is somewhat less expensive, users report the equipment is delicate and less rugged then their competitors. Some end users of MGP equipment reported difficulty in communicating with MGP due to language barriers (MGP is French) and MGPs unfamiliarity with U.S. regulations. MGPs electronic personnel dosimeters are however widely used throughout the U.S. commercial NPP industry. Many plants are using the wireless electronic personnel dosimeters as health physics Area Radiation Monitors (ARMs).

Two years ago MGP was contacted to upgrade the RMS at the ATR and recommended the following monitors.

1. Typical RAM replacements would be based upon GIM204 a low range gamma monitor using a silicon detector with a MTBF of 20,000 hours. It has an RS232 serial link for parameter configuration of the monitor through a computer and two 0/4 - 20mA analog outputs, one 0/4 - 20mA analog input, three programmable relays, and two RS485 isolated serial links.

2. Typical CAM replacements would be based on ABPM203m but packed differently. It is called ABPM203P (wall mount as opposed to movable). This is an alpha beta particulate monitor with a movable filter that allows up to 6 months autonomous operation (approximately 200 filter advances). It has a RS 232 Serial link for parameter configuration of the monitor through PC and two 0/4 - 20 mA analog outputs, one 0/4 - 20 mA analog input, three programmable relays, and two RS 485 isolated serial link. Other models of this monitor can also detect iodine and noble gases.

They further specified the Stack monitor replacements would be based on GIM202 another low range gamma monitor with a stainless steel ionization chamber. It has an RS232 serial link for parameter configuration of the monitor through a computer and two 0/4 - 20mA analog outputs, one 0/4 - 20mA analog input, three programmable relays, and two RS485 isolated serial links.

MGP offers software systems to log data and monitor the systems.

3.2.5 Thermo Scientific

Established in 1956 as Thermo Electron Corporation, Thermo Fisher Scientific has long been a leader in the instruments industry. With the acquisition of Eberline the company now offers a complete line of Radiation Measurement and Protection equipment. They supply the nuclear industry, DOE National Laboratories, national and international safeguards organizations, defense and law enforcement agencies with instrumentation and systems. They also offer a complete line of modern wireless dosimetry systems and integrated software packages.

The Thermo Scientific 17th Annual User Group Meeting for Dosimetry and Health Physics instrument users will meet on Sept 24-27, 2007 at the Hilton Savannah DeSoto, in Savannah, Georgia, USA.

Table 3-1 presents an evaluation of five major companies that offer RMS products. The higher the number, the better the company meets the criteria evaluated. Table 3-2 presents equipment comparisons between the five major companies.

Table 3-1. Vendor comparison.

Criteria	Apantec	Thermo Scientific	Berthold	General Atomics	MGP
Experience of Company	3	3	4	4	4
U.S. Company	4	4	2	4	3
Users Group	1	3	0	3	2
Number of installations in the U.S.	2	0	0	4	3
Ability in achieving a 40-year life expectancy	2	2	3	3	2
Spare parts over 40-year life	2	3	3	3	3
7-8 decade range of measurement	3	3	3	3	3
Output variety	4	4	0	3	3
Control/Data loggers, Software packages	3	4	0	2	3
Wireless systems	3	3	0	2	3
Totals	27	29	15	29	29

Explanation of Criteria used:

Experience of Company: 1 – Less than 5 years, 2 – 5 to 10 years, 3 -10 to 20 years, 4 – greater than 20 years

US Company: 1- No, 2 - No, but extensive installations in US, 3 – No, but facilities in US for repair and support, 4 – Yes

User Groups: 0 – unknown, 1 - None, 2 Limited, 3 – Yes

Number of US installations: 0 – unknown, 1 – Less than 5, 2 – 5 to 10, 3 – 10 to 20, 4 – more than 20

Able to achieve 40 year life time: 1 – unknown, 2 – long track record but less than 40 years, 3 – existing installations of 40 years

Spare Parts: 1 – unknown, 2 – commitment to support equipment, 3 – proven ability to support equipment

Range of Measurement (7 – 8 decade ranges of equipment): 1 –unknown, 2 – 7 decades or less, 3 – 8 decades or more

Outputs: 0 – unknown, 1 - Analog only, 2 – analog and strip chart, 3 - analog, strip chart, serial digital, 4 - analog, strip chart, serial digital, IP and others

Software Packages: 0 – unknown, 1 - none, 2 –proprietary custom systems, 3 – standard formats and open systems, 4 - standard format, open system, and integrated with dosimetry

Wireless systems: 0 – unknown, 1 – none, 2 – can be custom added, 3 – standard product line

Four of the five RMS vendors evaluated scored very close in this Study, indicating there is no clear preferred vendor. Only Berthold scored low, primarily because the requested information was not provided. Since Berthold is not a U.S. company, they scored low in that category and would likely score lower than the other vendors in a total of all category scores. This preliminary evaluation suggests that Bids or Quotes should be requested from at least the four leading vendors.

Table 3-2. Vendor equipment comparison.

Criteria	Aparatec	Thermo Scientific	General Atomics	MGP
General RAM	RAM 616	FHT 6020	RD-10, RD11, or RD12	GIM204
Type	Geiger Mueller Tube	Various probes	Geiger Mueller Tube	Gamma detector
Outputs	Chart PLC, Serial RS-485/RS-232 and Ethernet TCPIP	RS-232, RS-485, analog and digital	Relays - 13 maximum; relay drivers - 21 minus number of relays; analog - 2 (0–100_A); 6 (0 to 10 mV), 1 (4–20 mA); communication (digital) - 3 half-duplex serial (2at 4800 baud, 1 at 1200 baud)	RS232 serial link for parameter configuration of the monitor through a computer and two 0/4 - 20mA analog outputs, one 0/4 - 20mA analog input, three programmable relays, and two RS-485 isolated serial links
Seismic (shock) and thermal resistant	No	No	No	No
Cost Range	$30,000 to $50,000	$12,000	$30,000 to $50,000	$15,000
General CAM	iCAM-110	AMS-4	CAM-01 and CAM-03	ABPM203P, ABPM203L, or ABPM203S
Type	Alpha beta particulate monitor or added Iodine and Nobel gas	Alpha beta particulate monitor or added Iodine and Nobel gas	Alpha beta particulate monitor or added Iodine and Nobel gas	Alpha beta particulate monitor or added Iodine and Nobel gas
Outputs	Chart PLC, Serial RS-485/RS-232 and Ethernet TCPIP	Analog and Ethernet	Relays - 13 maximum; relay drivers - 21 minus number of relays; analog - 2 (0 to 100_A), 6 (0 to 10 mV), 1 (4 to 20 mA); communication (digital) - 3 half-duplex serial (2 at 4800 baud, 1 at 1200 baud)	RS232 serial link for parameter configuration of the monitor through a computer and two 0/4 - 20mA analog outputs, one 0/4 - 20mA analog input, three programmable relays, and two RS485 isolated serial links

Table 3. (continued).

Criteria	Aparatec	Thermo Scientific	General Atomics	MGP
Seismic (shock) and thermal resistant	No	No	No	No
Cost Range	$30,000 to $50,000	$20,000	$30,000 to $50,000	$20,000 up to $80,000 for Iodine or Nobel Gas
Stack RAMs	RAM 616	RMS 3	RD-10, RD11, or RD12	GIM202
Type	Geiger Mueller Tube	Geiger Mueller Tube	Geiger Mueller Tube	Gamma monitor with a stainless steel ionization chamber
Outputs	Chart PLC, Serial RS-485/RS-232 and Ethernet TCPIP	RS-232 or RS-485 serial port RMS3 OPT3 4 to 20 mA or 0 to 20 V Logarithmic Analog Output RMS3 OPT2 TTL Logic level input (Required for use with DA series detectors) Serial to Ethernet converters	Relays - 13 maximum; relay drivers - 21 minus number of relays; analog - 2 (0 to 100_A), 6 (0 to 10 mV), 1 (4 to 20 mA); communication (digital) - 3 half-duplex serial (2 at 4800 baud, 1 at 1200 baud)	RS232 serial link for parameter configuration of the monitor through a computer and two 0/4 - 20mA analog outputs, one 0/4 - 20mA analog input, three programmable relays, and two RS-485 isolated serial links
Seismic (shock) and thermal resistant	Yes	No but could be certified	Yes	Yes
Cost Range	$100,000	$10,000 to $50,000	$100,000 to $250,000	$100,000

Table 3. (continued).

Criteria	Apantec	Thermo Scientific	General Atomics	MGP
Stack CAM	AM300PIGM	FHT-3511	RS-58D (Part and Iodine), RS-60D (Part , Iodine, Nobel Gas)	PING206S
Type	Alpha beta particulate monitor or added Iodine and Nobel gas	(Not exactly a CAM but not a RAM either) Measures 511 keV annihilation photons to determine the concentration of positrons in the duct or stack	Alpha beta particulate monitor or added Iodine and Nobel gas	Particulate Iodine and Noble Gas Monitors
Outputs	Chart PLC, Serial RS-485/RS-232 and Ethernet TCPIP	RS-485/RS-232 and Ethernet TCPIP	Relays - 13 maximum; relay drivers - 21 minus number of relays; analog - 2 (0 to 100_A), 6 (0 to 10 mV), 1 (4 to 20 mA); Communication (digital) - 3 half-duplex serial (2 at 4800 baud, 1 at 1200 baud)	RS 232 Serial link for parameter configuration of the monitor through PC and MASS application software four 0/4 - 20 mA analog inputs, four 0/4 - 20 mA analog outputs, six programmable relays SPDT, five programmable DPDT relays, five RS 485 isolated serial links
Seismic (shock) and thermal resistant	Yes	Yes	Yes	Yes
Cost Range	>$100,000	$50,000	$100,000 to $250,000	$100,000 to $250,000

3.3 Recommended New Technology for the RTC

3.3.1 Intelligent Monitors

In the past the output signals from most monitors were analog outputs intended to feed either data recorders or data acquisition modules which then fed control computers. In recent years many vendors have moved the intelligence out from the control computers to the monitors and have changed the way data is transferred. Rather than an analog signal many new monitors have digital outputs that either travel down serial cables or more recently Ethernet cables. Many monitors now have IP addresses and this allows a great deal of flexibility in communications.

The intelligence in the monitor also allows for continuous system checking and polling of the systems so that the control computer gets a constant status report from the units. This helps prevent situations where a monitor fails in a state that is not immediately detected.

An important consideration of these more intelligent devices is the requirement for digital signal cables. Replacement of existing monitors with the newer intelligent units may require the replacement of the communication cabling between the remote locations to the control centers, adding additional cost to the upgrade project.

3.3.2 Wireless Technology

In recent years wireless telemetry systems have become more commonly used at commercial nuclear power plants. One major early use of wireless was to monitor personnel dosimeters remotely. Each person wears a dosimeter that is connected wirelessly to a base station that logs dose rates and totals. Often these systems are fully integrated into work package control and access control. The system can be set up to limit access into certain areas to only those personnel that have valid current work packages and sufficient training.

The same wireless technology can be used for area monitors and continuous air monitors. Early application of this technology was for perimeter monitoring and in mobile units. Wireless systems allow flexibility in locating the monitors, including portable units. The health physics department and plant engineering can set up mobile monitors as job requirements change. Also in areas where changing or adding instrumentation cabling can be difficult, wireless systems offer an alternative.

Drawbacks of wireless systems include potential interference and security issues. Some facilities do not allow wireless devices; the security plans at these facilities would need to be examined. The advantages and disadvantages of the wireless system would have to be evaluated, and potential revision of the security plan would have to be considered. Interference either by structures that block or limit the range of the signals can be overcome by the addition of repeaters that boost the signals.

Nearly all major vendors offer some form of wireless systems. Some have fully developed product lines and others can add them to monitors in a custom configuration.

Some commercial plants have used the wireless dosimeters for at least temporary area monitoring by hanging the dosimeters on the walls of areas that they need to monitor. Most modern dosimeters have a battery life of several months, so wireless monitors offer a more flexible and probably less expensive option when the need arises to monitor an area for special conditions.

4. COMPARISON OF REQUIREMENTS AND EXISTING MONITORS

4.1 Compliance to Current and Future Requirements

The existing radiation monitors in the RMSS (RE-530A, 530B, and 530C) are adequate to meet the requirements specified for this safety class system. However, as is the case for most of the radiation monitors at the ATR, they are aging, becoming increasingly difficult to maintain, and could be replaced with better, modern equipment that would provide improved performance.

The SPING that monitors the ATR exhaust at the stack plenum is no longer produced by the vendor (Eberline). The Eberline company has been acquired by Thermo Systems (now Thermo Fisher Scientific) and is now offering a new and improved version of the instrument. Since the SPING is needed to provide data to support compliance to the environment release regulations at 40CFR61, it is adequate for that task as currently configured. However, new guidance in the regulation (40CFR61.93) requires that the effluent stream be sampled using the technique of ANSI N13.1 that employs a special design shrouded probe. Upgrade of the SPING monitor should also address the new sampling requirement. The potential impact to the environment as a result of liquid effluents is also monitored by the detection system on the WWTF in the ATR and the monitors at RTC-605. Continued demonstration of compliance to the regulations requires that these monitors remain operational and be considered for upgrade.

The numerous monitors that are included in the DRMS, when operating properly, are more than adequate to meet the requirements of the radiological control program. However, these (Bertold) monitors are aging, becoming increasingly difficult to maintain, and could be replaced with better, modern equipment that would provide improved performance. Although the existing system includes 43 RAMs and 26 CAMs, the requirements of the RCP can be met with less than half this number. Eight Primary CAMs and 20 Primary RAMs, properly configured, located and supported by a few readily available portable backup units, would be sufficient to meet the radiation monitoring requirements of the ATR RCP.

There are also several Process RAMs in place in the existing DRMS. Process RAMs warn operations personnel of abnormal radiation conditions within plant piping systems or adjacent to plant process equipment. They can be used for data prior to entering a cubicle or a measurement parameter to key operator action during a process. These instruments are not required for protection of personnel in the context of EDF-1977. No Process RAMs were identified as Primary or necessary to meet regulatory, TSR or RCP requirements. However, the ATR Operations has used the information provided by these monitors to assist with certain system operations and process control. Some of the process RAMs may be identified as higher priority by Operations than by Health Physics or Radiological Control. Decisions to repair, replace or upgrade should seek input from the ATR Operations.

The approximately 37 old Tracer Lab RAMs, 26 Tracer Lab CAMs and 9 GNC CAMs, although many are still operational, are not required to meet requirements. They could serve to provide backup information, special work area monitoring, or substitute for some auxiliary units; they are not required to meet any radiation monitoring requirements at the ATR or other RTC facilities.

The three monitors originally installed for monitoring high-level radiation fields that are postulated to exist after a serious accident are not required. These units, GM-21-41, -41, and -43, were retired in 2005 per the evaluation in USQ-2005-097. Although replacement parts may still be available to support reassignment of these units, there is little benefit identified for them.

Other RMSs at the RTC were found to be adequate to support the requirements of the RCP. Although these systems are also aging and suffer from increased difficulties with maintenance and vendor support, they are not expected to be required to serve much longer. The systems at RTC-632, -604 and -661 will be deactivated in the near future as the facilities undergo D&D, or they will be replaced as necessary to support future programs that may eventuate.

The minimal system of monitors deemed necessary to meet current requirements is illustrated in Figure 4-1 (A-E). With some potential adjustments, this minimal system will also support the requirements of future program additions as noted in Section 2.3. The options evaluated and the recommendations for replacement and upgrade of the RTC RMS are based on this minimum set of (Primary) monitors, existing (Auxiliary and Process) monitors and variations on additional supplemental improvements that should be considered.

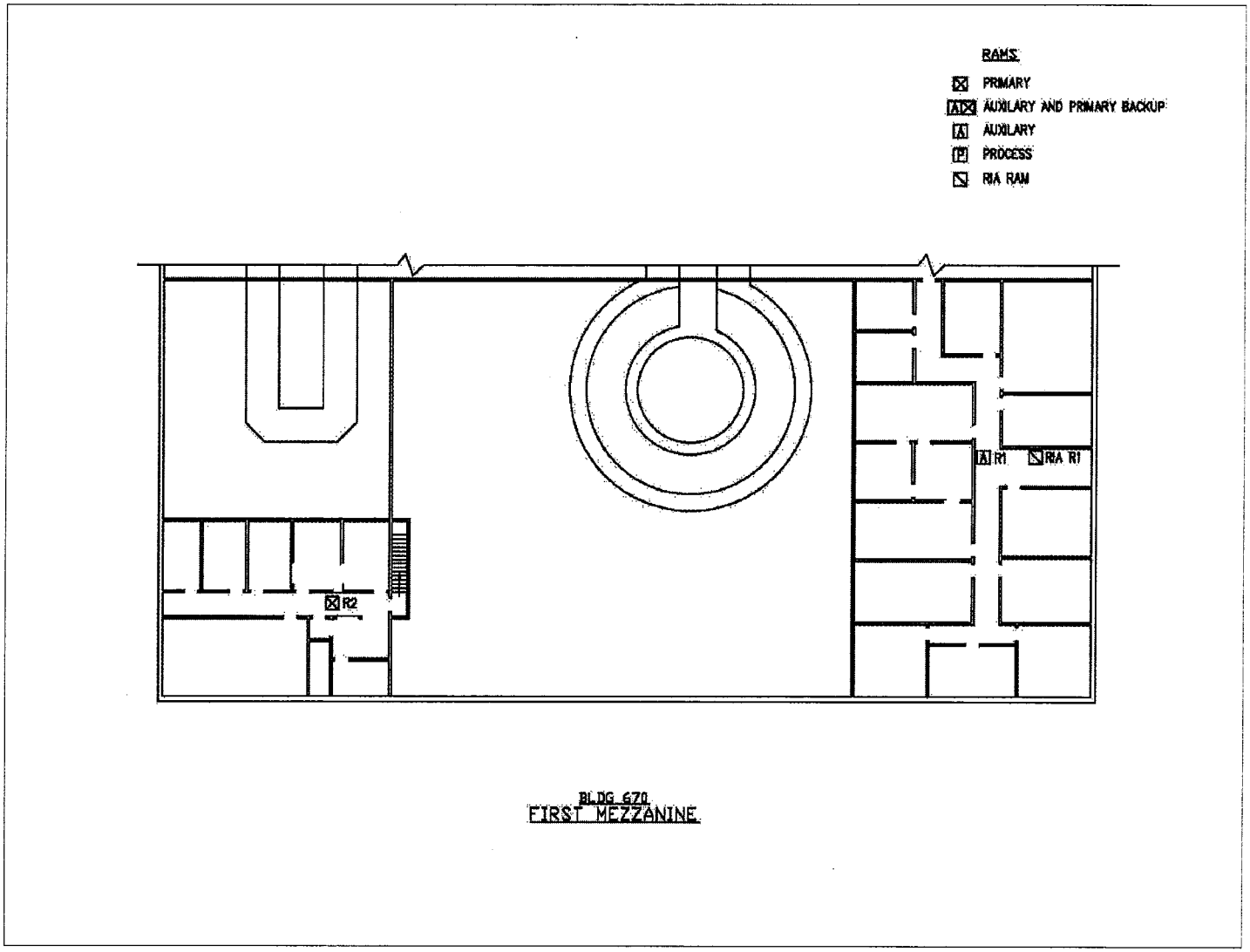


Figure 4-1A. Minimal Mezzanine.

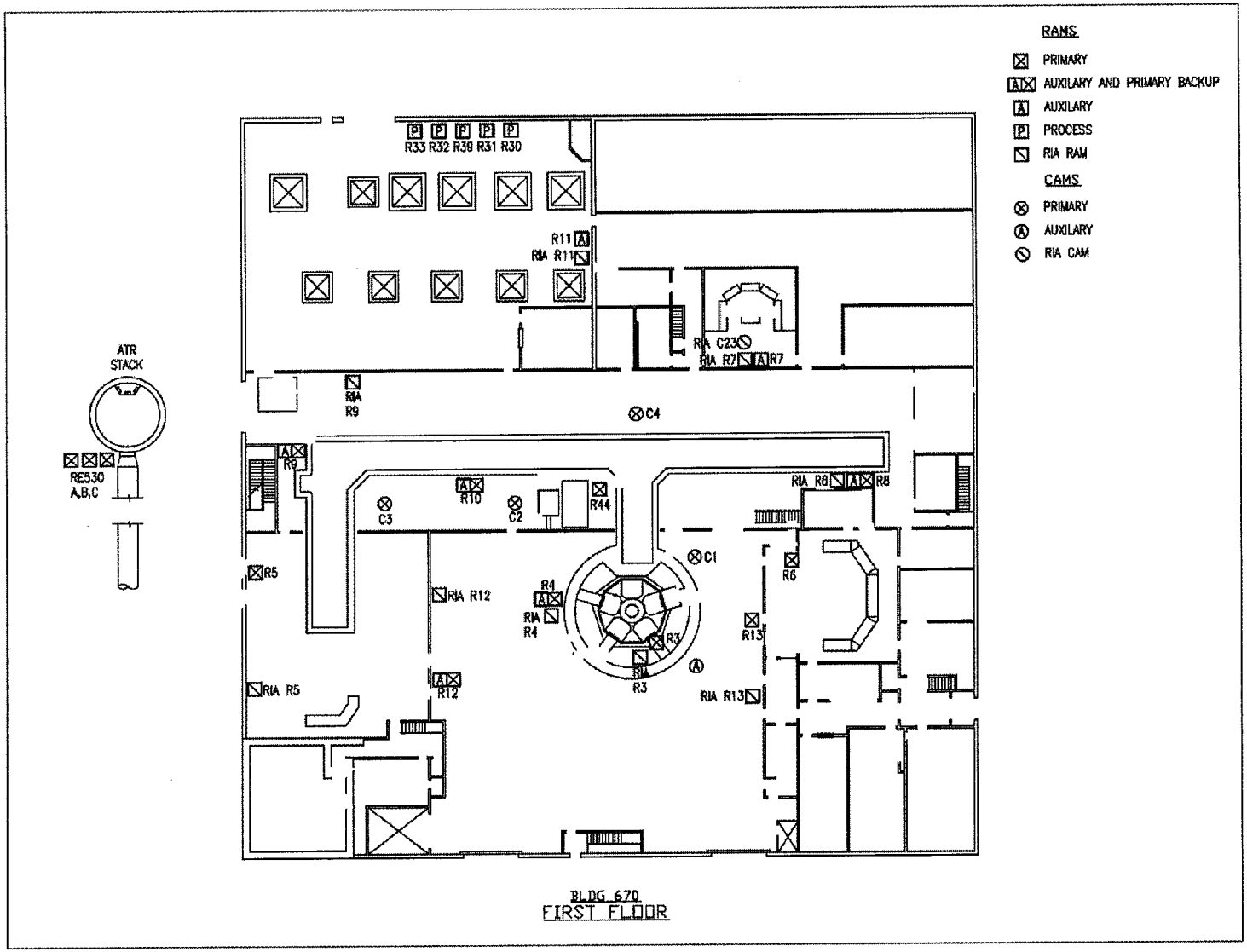


Figure 4-1B. Minimal first floor.

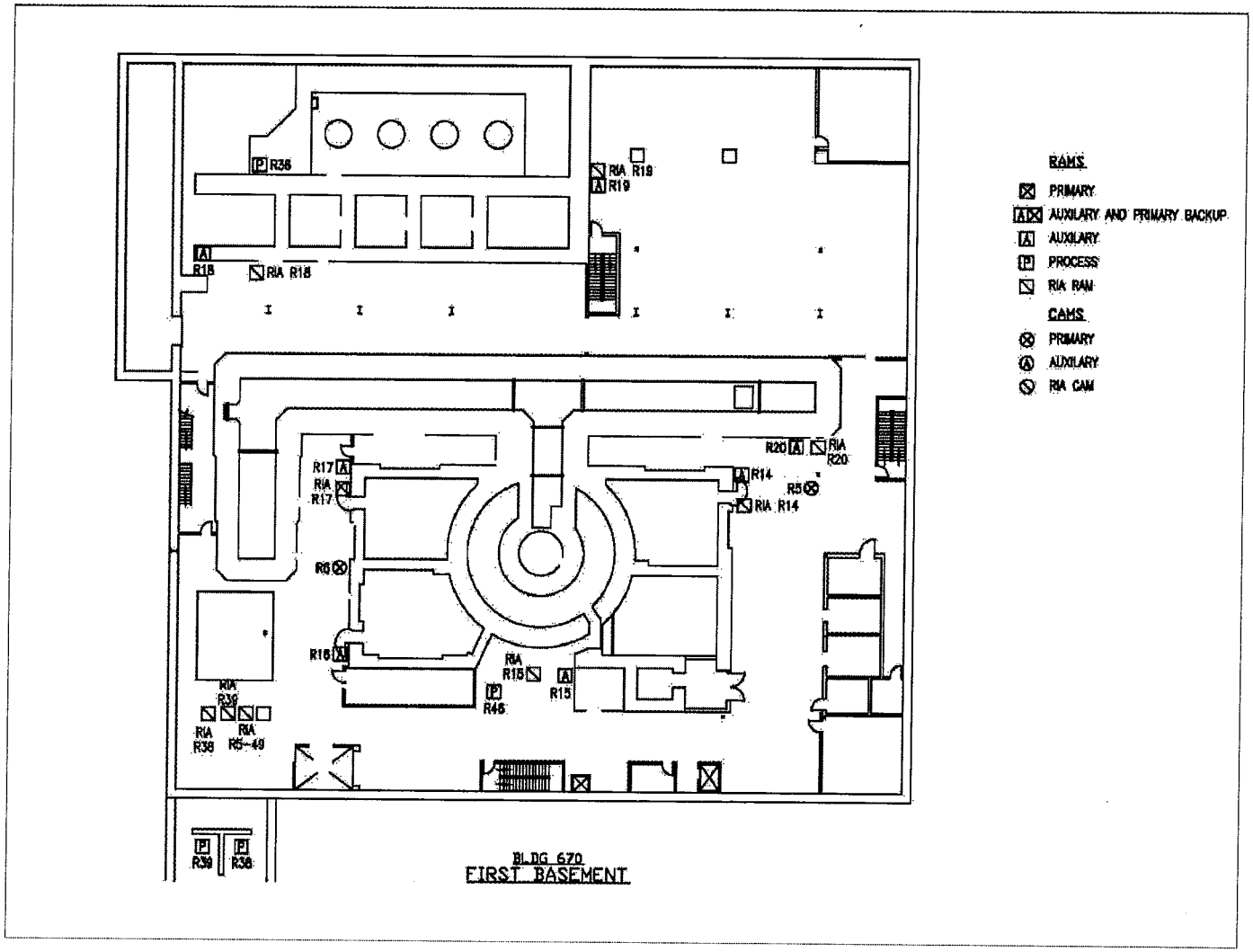


Figure 4-1C. Minimal first basement.

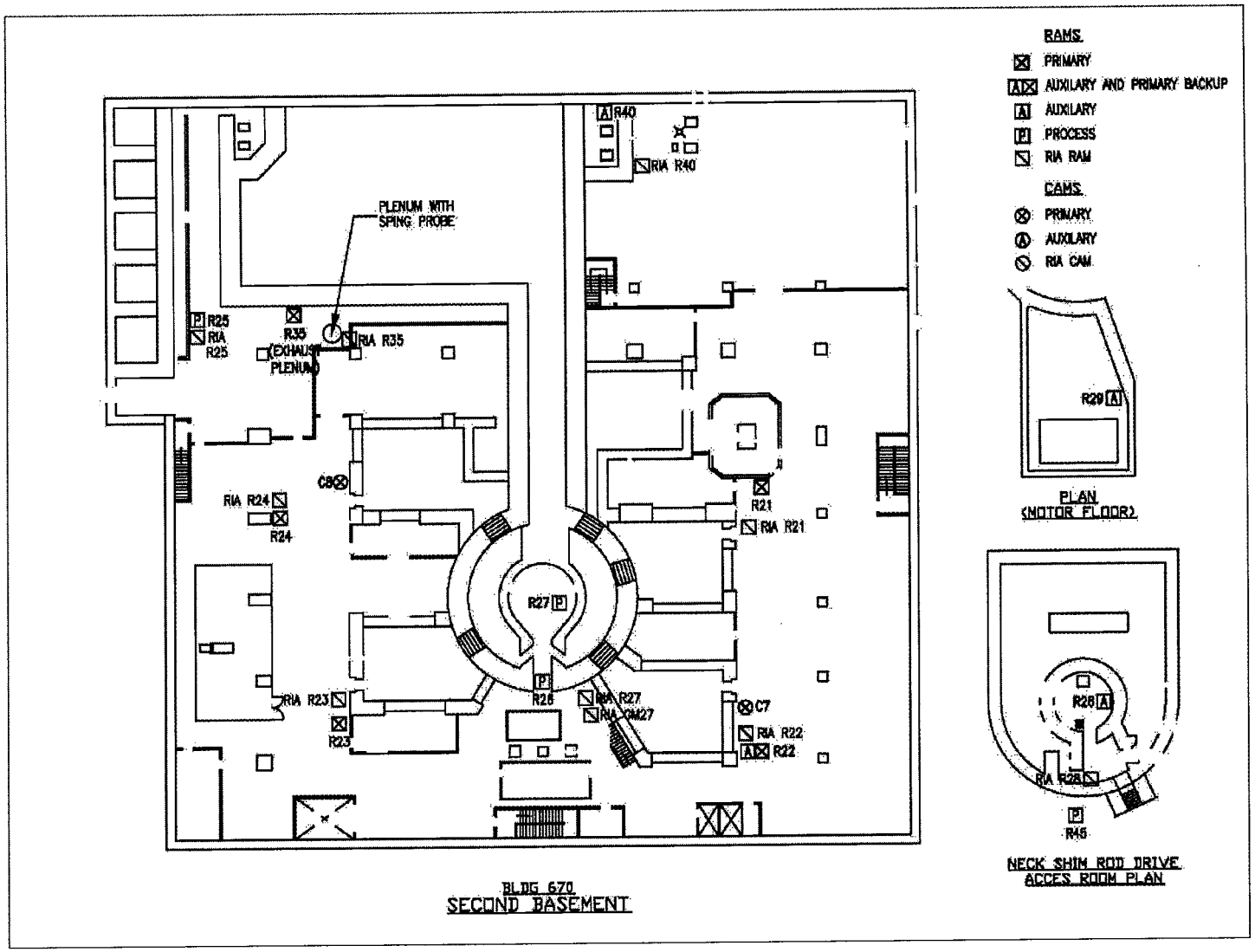


Figure 4-1D. Minimal second basement.

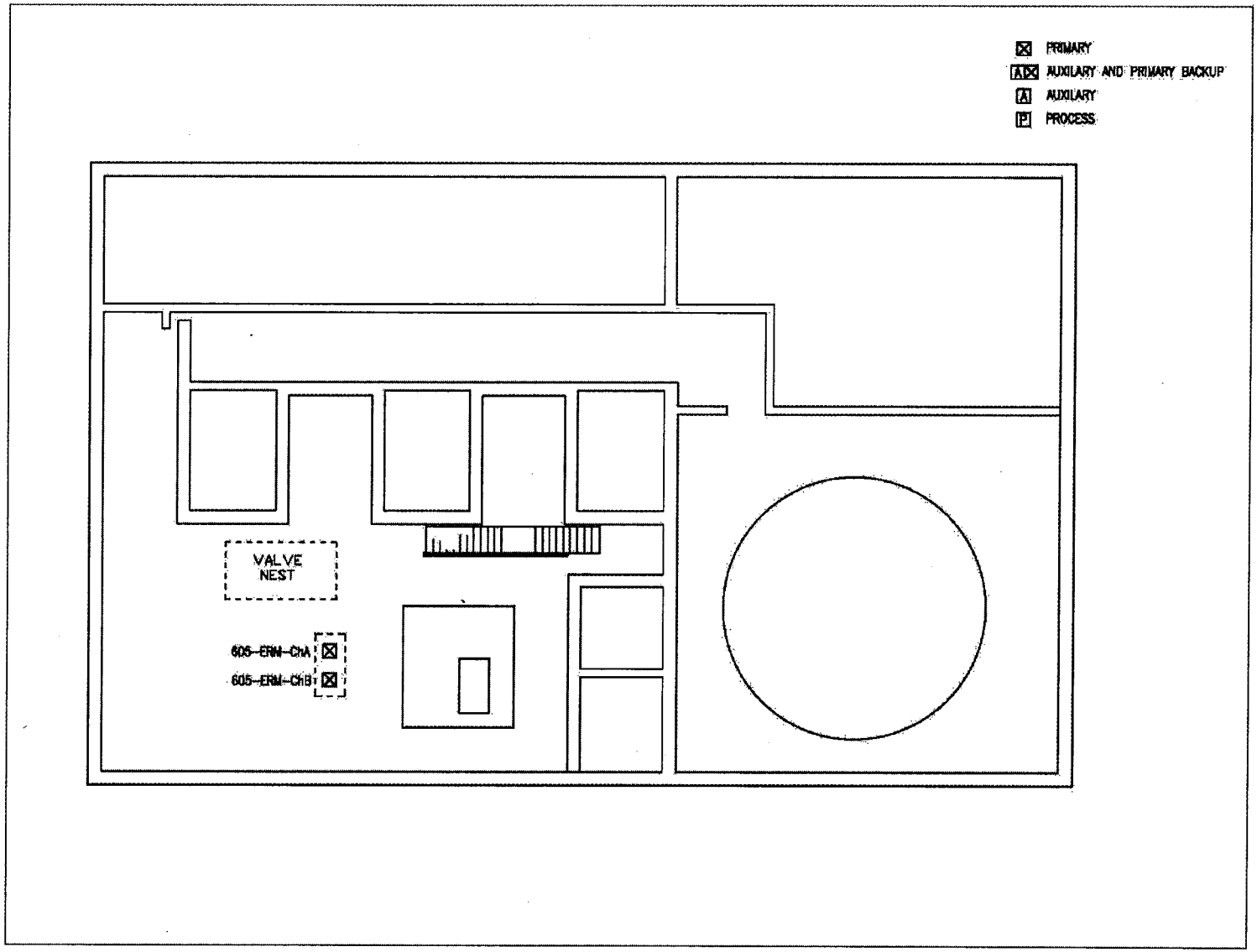


Figure 4-1E. Minimal RTC-605.

5. RECOMMENDATION

The recommendation for what and how to upgrade the RMS at the RTC was developed from engineering evaluation of several options. The options were developed based on the assumption that the RTC should consider the cost and benefit of a Minimal, Basic, Intermediate and Optimal system upgrade. Each option included consideration of the information gathered from INL staff on the existing system features and performance and the information obtained from consultations with commercial nuclear power plant operators and suppliers of modern radiation monitoring equipment.

5.1 Evaluation of Options

5.1.1 Minimal Upgrade

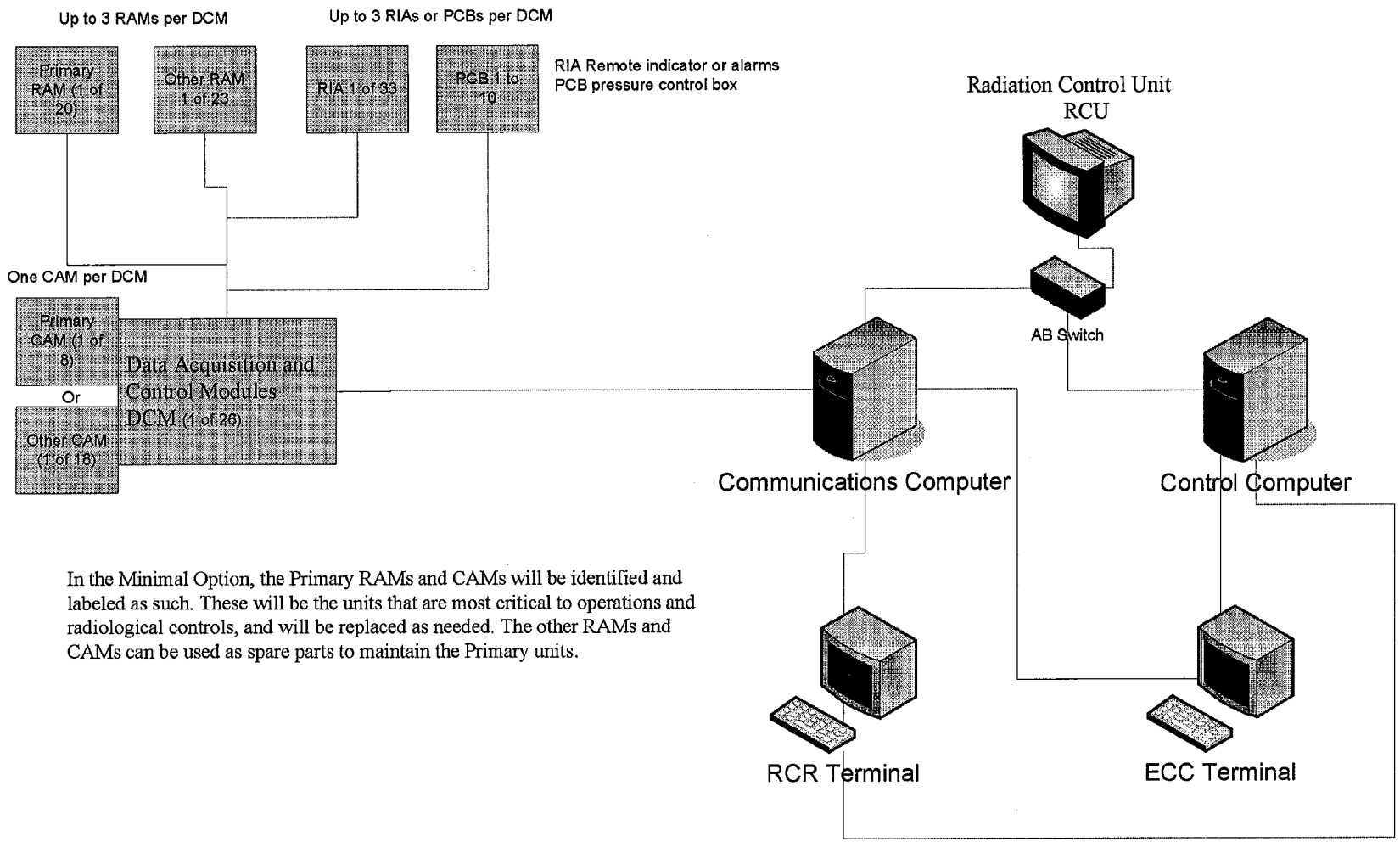
It was determined that at a minimum, a few changes are needed to assure that the radiation monitoring at the ATR can meet the current requirements. A few of the CAMs in the DRMS should be configured and relocated to provide the measurements prescribed in EDF-6174. As described in Section 2.2.2.1 above, eight of the existing CAMs should be designated as Primary CAMs and numbered one through eight. They should be configured to provide the particulate, iodine and noble gas measurements as specified in the EDF and relocated as specified to provide optimal monitoring of working areas. The remaining CAMs should be designated as Auxiliary and used as backup for Primary units or to provide supplementary data. The Auxiliary units are not required to meet any other requirements identified in this Study.

There are 20 RAMs in the existing system at the ATR that should be designated as Primary, since they are considered necessary to meet the requirements of the radiological control program. As prescribed in EDF-1977 and summarized in Section 2.2.2.2 above, the Primary RAMs are necessary and collectively are sufficient to meet all requirements identified in this Study. All other RAMs in the existing system at the ATR are considered Auxiliary or Process RAMs; they provide useful supplementary information to plant operators and radiological control staff. The continued use or upgrade of the Auxiliary or Process RAMs should be determined by a separate evaluation that included input from all users of these instruments. The recommended separate evaluation could be done prior to any changes or upgrade of the ATR RMS or at time of any monitor failure, maintenance or planned system change. Figure 5-1 illustrates the configuration of the DRMS in the Minimal Upgrade Option.

The RMSS is a safety class system that must be maintained per the ATR Technical Safety Requirements. The three RAMs that support the RMSS are sufficient to meet the requirements identified, however their condition, maintenance history and performance should be evaluated to determine the best plan for their continued operation. New replacement detectors should be considered, however a strong maintenance program with adequate spare parts inventory, vendor support and available backup monitors may prove sufficient to continue with the existing detectors at the present time.

For this Minimal Upgrade option, the other operational RMS at the ATR should remain as they exist. The RAMs on the gas delay tank, the SPING on the stack plenum, and the loop piping monitors should remain as is with continued maintenance. As units fail, become more difficult to maintain or are planned for change, they should be individually evaluated for removal or upgrade by the users of each monitor.

The existing Control and Communications computers and the existing software remain as is under this minimal option. The system is adequate to meet requirements.



In the Minimal Option, the Primary RAMs and CAMs will be identified and labeled as such. These will be the units that are most critical to operations and radiological controls, and will be replaced as needed. The other RAMs and CAMs can be used as spare parts to maintain the Primary units.

Figure 5-1. Minimal DRMS upgrade option.

Finally, it is deemed prudent that this minimal option include some basic improvements to the existing system documentation and the maintenance program to compensate for the difficulties that are expected from the lack of new upgraded equipment. The SDDs for all RMS equipment should be updated and the equipment maintenance plan should be improved, e.g. with increase spare parts inventory and spare backup monitors, to assist with system maintenance and to help ensure minimal service interruptions or schedule delays that could eventuate from problems with the old RMS equipment.

5.1.2 Basic Upgrade

An increase in the benefits of this RMS upgrade over those of the Minimal Option is the basis for the Basic Upgrade Option considered in this Study. Increased costs commensurate with the increased benefits are expected and assumed in the evaluation of this option. All of the required changes of the Minimal Upgrade option are also required and included in this Basic Upgrade option.

All Primary monitors of the DRMS (20 RAMs and 8 CAMs) would be replaced with new modern intelligent units. The new units would communicate over existing cabling, but include Ethernet or Wireless communication capability for ease of future upgrade of the RMS. The Auxiliary and Process monitors are retained to provide supplemental information and maintained operable per the current maintenance program. As these units fail or become difficult to maintain, they would be evaluated for removal from the RMS or replaced with new modern intelligent units. The existing Control and Communication computers and associated software would be retained. Figure 5-2 illustrates the configuration of the DRMS in the Basic Upgrade Option.

The three RAMs that support the RMSS should be replaced with modern intelligent monitors and detectors that meet the quality (seismic design) requirements, and include a strong maintenance program with adequate spare parts inventory, vendor support and available backup monitors. The new monitors could continue to use existing wiring.

The ATR airborne effluent monitor should be upgraded. This Basic Upgrade Option includes the replacement of the old SPING with a new monitor that includes a sampling probe compliant with the DOE guidance in ANSI N13.1.

The two monitors on the RTC-605 Effluent Monitoring System (EMS) should be replaced, 605-ERM-ChA and –ChB. These units are currently local read out and alarm monitors, not remote monitors. The upgraded units could be similar local, non-communicating units; however, the provision of Ethernet communication or other remote monitoring capability would greatly enhance the usefulness of these units. They also could be considered for addition to the DRMS.

5.1.3 Intermediate Upgrade

An increase in the benefits of this RMS upgrade over those of the Basic Upgrade option is the basis for this Intermediate Option. Increased costs commensurate with the increased benefits are expected and assumed in the evaluation of this option. All of the required changes of the Basic Upgrade option are also required and included in this Intermediate Upgrade option. However, in addition to replacement of all the Primary monitors with new modern intelligent units, this option includes removal of all the old Tracer Lab units, the replacement of the Control and Communication computers and associated software and the installation of new Ethernet cables to each monitor location. Figure 5-3A illustrates the configuration of the DRMS in the Intermediate Upgrade Option. A variation on this option, illustrated in Figure 5-3B is the provision of a wireless Ethernet to cover most monitor locations, eliminating most of the new Ethernet cable installation. Provision of the Wireless network at the ATR will need to be evaluated and confirmed feasible prior to any procurement action for this option.

Also included in this Intermediate option is the replacement of the RMSS detectors with new modern units with Ethernet communications, the upgrade of the SPING to a new modern system with a shrouded sample probe that meets the requirements of ANSI Standard N13.1, and replacement of the EMS monitors at RTC-605 WWTF. This Intermediate Upgrade would include revision of the SDDs for all equipment changed and concomitant changes in the maintenance program.

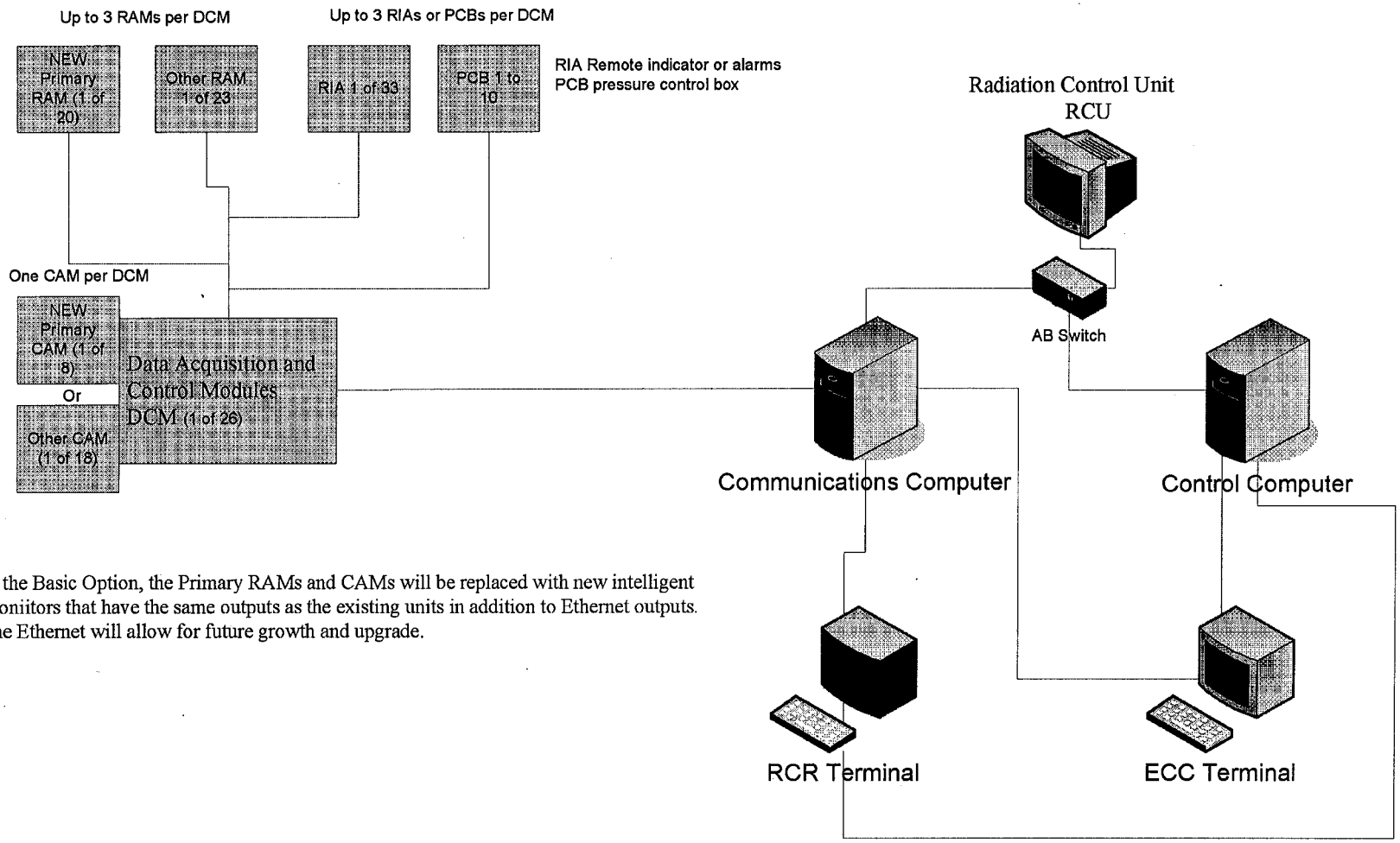
5.1.4 Optimal Upgrade

An increase in the benefits of this RMS upgrade over those of the Intermediate Upgrade option is the basis for this Optimal Upgrade Option. Increased costs commensurate with the increased benefits are expected and assumed in the evaluation of this option. All of the required changes of the Basic Upgrade option are also required and included in this Intermediate Upgrade option. However, in addition to replacement of all the Primary monitors with new modern intelligent units, this option includes the replacement of all or a portion of the Auxiliary and Process monitors with new modern intelligent units. Some additional Ethernet cabling may be required over that necessary for the Intermediate Upgrade to cover the locations of the additional new monitors. This Optimal Option also includes the variation to provide a wireless Ethernet in place of most new Ethernet cabling. As with the Intermediate Upgrade option, provision of the Wireless network at the ATR will need to be evaluated and confirmed feasible prior to any procurement action for this option. Figure 5-4A illustrates the configuration of the DRMS in the Optimal Upgrade Option. A variation on this option, illustrated in Figure 5-4B is the provision of a wireless Ethernet to cover most monitor locations, eliminating most of the new Ethernet cable installation. Provision of the Wireless network at the ATR will need to be evaluated and confirmed feasible prior to any procurement action for this option.

With the provision of the Wireless Ethernet feature, this Optimal Option also includes the integration of a personal dosimetry program. The benefits of this upgrade are explained in the description in Section 3.2. An optional feature of the integrated personal dosimetry program into the RMS is an Area Access Control function. The benefits of the Area Access Control feature are described in Section 3.2.

The Optimal Upgrade option provides an impressively simple looking system when the old DRMS equipment is removed, and looks even more simplified in the wireless communication configuration. Figure 5-5A illustrates the final system in the Optimal Upgrade Option; and if the wireless Ethernet variation is used, Figure 5-5B illustrates this system.

The cost and benefit of all the upgrade options should be evaluated by system users at the ATR and compared to budget constraints, schedule constraints and other Program needs prior to any procurement actions.



In the Basic Option, the Primary RAMs and CAMs will be replaced with new intelligent Moniitors that have the same outputs as the existing units in addition to Ethernet outputs. The Ethernet will allow for future growth and upgrade.

Figure 5-2. Basic DRMS upgrade option.

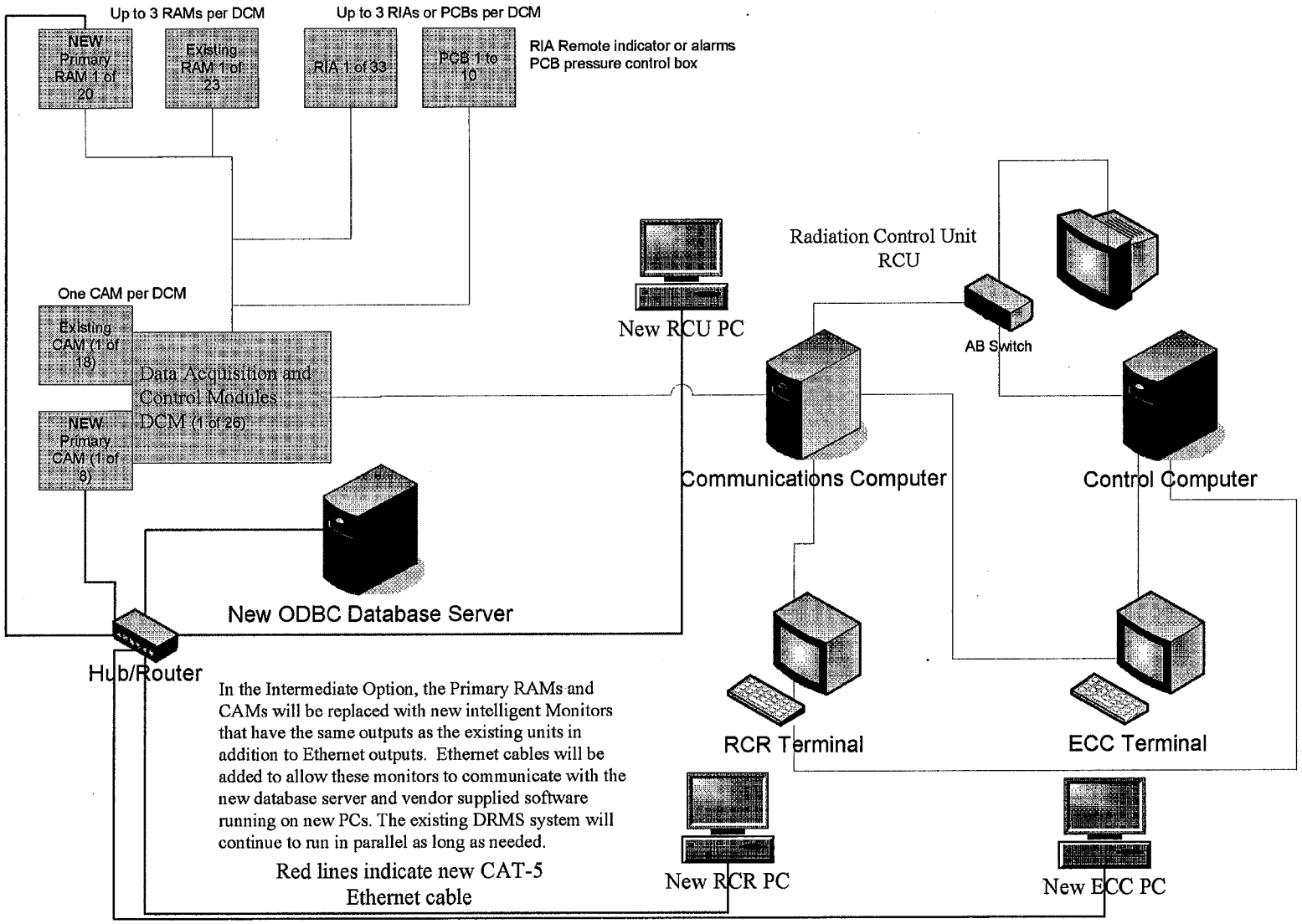


Figure 5-3A. Intermediate DRMS upgrade option.

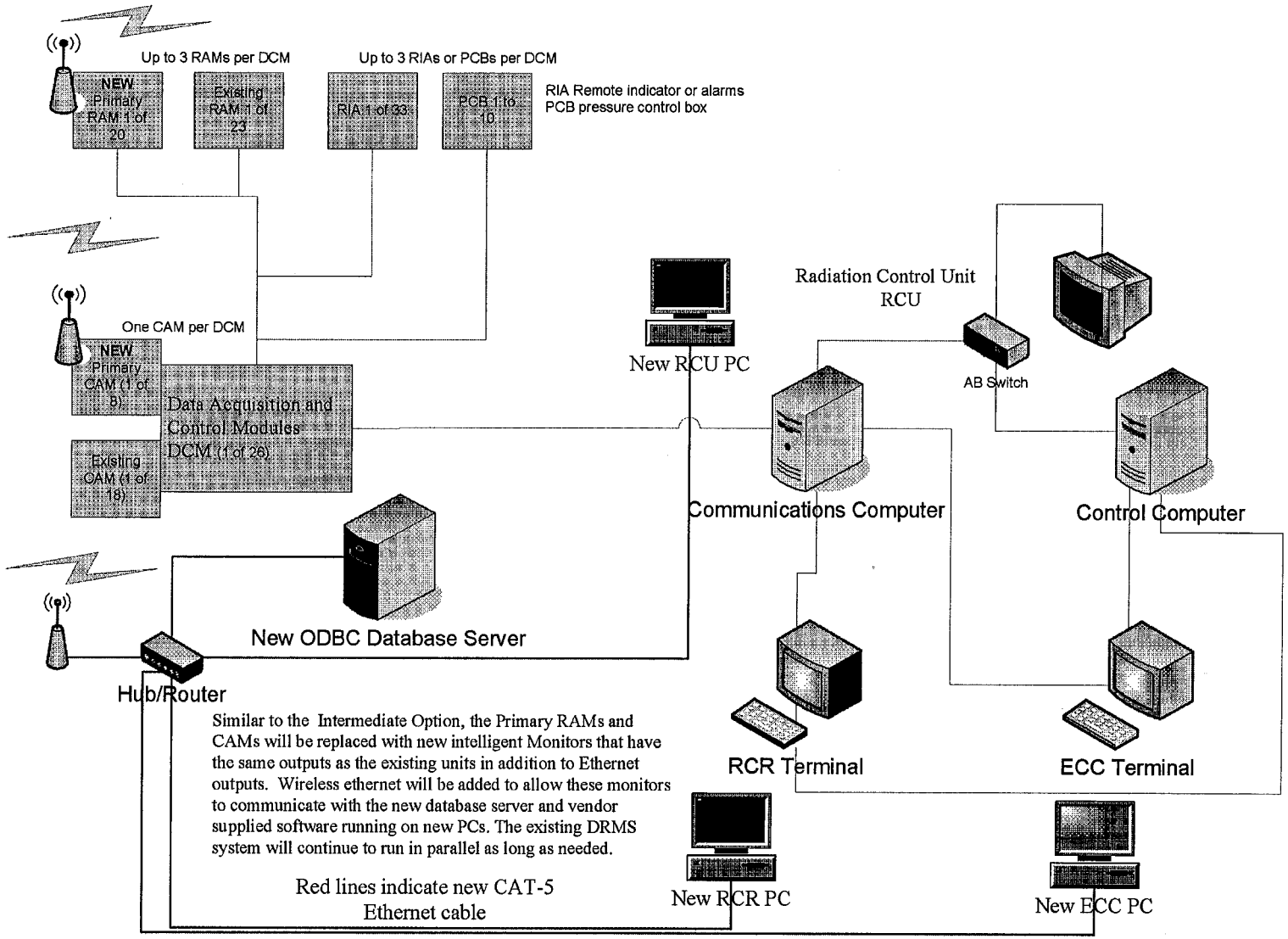


Figure 5-3B. Intermediate DRMS upgrade option with wireless variation.

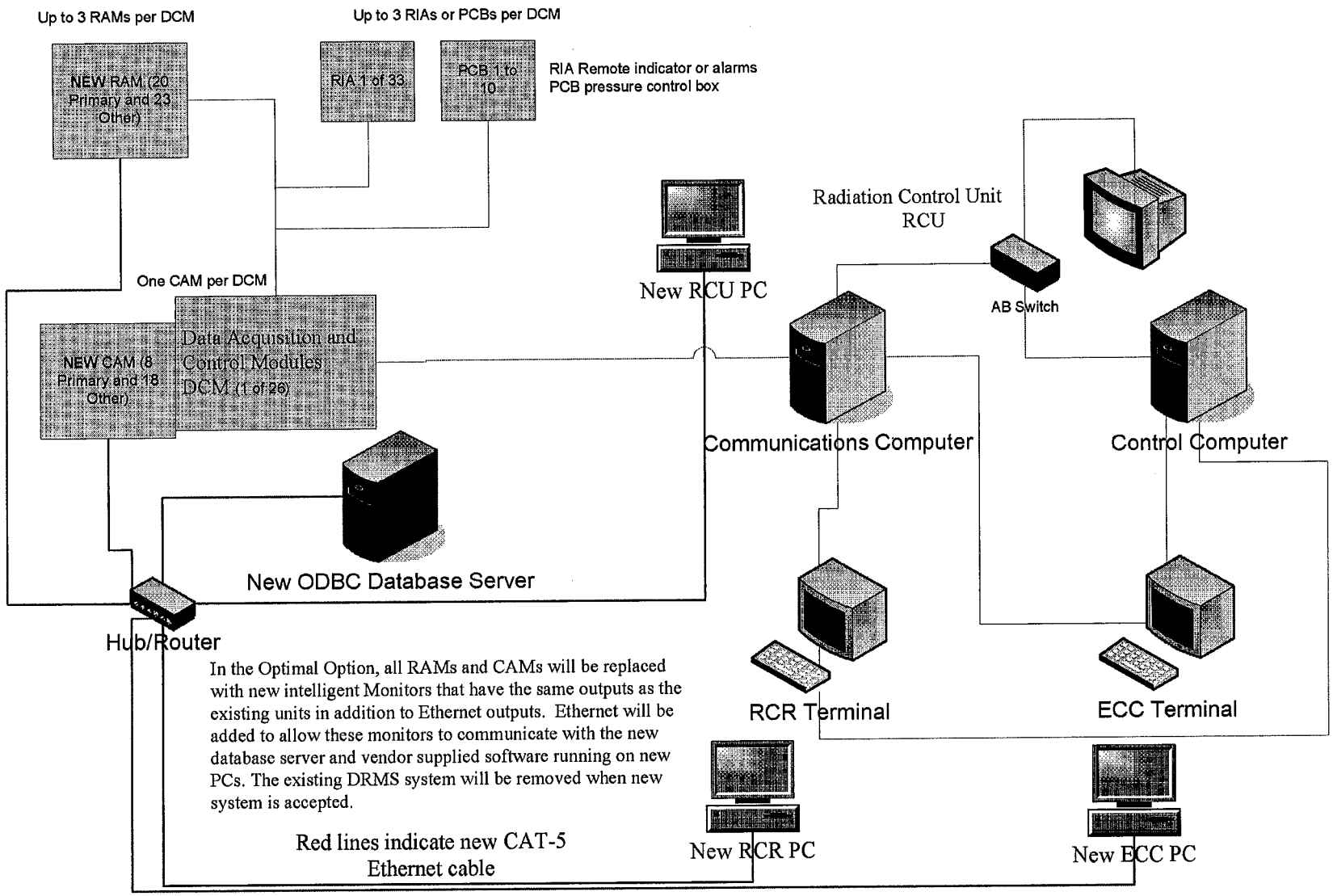


Figure 5-4A. Optimal DRMS upgrade option with Ethernet cabling.

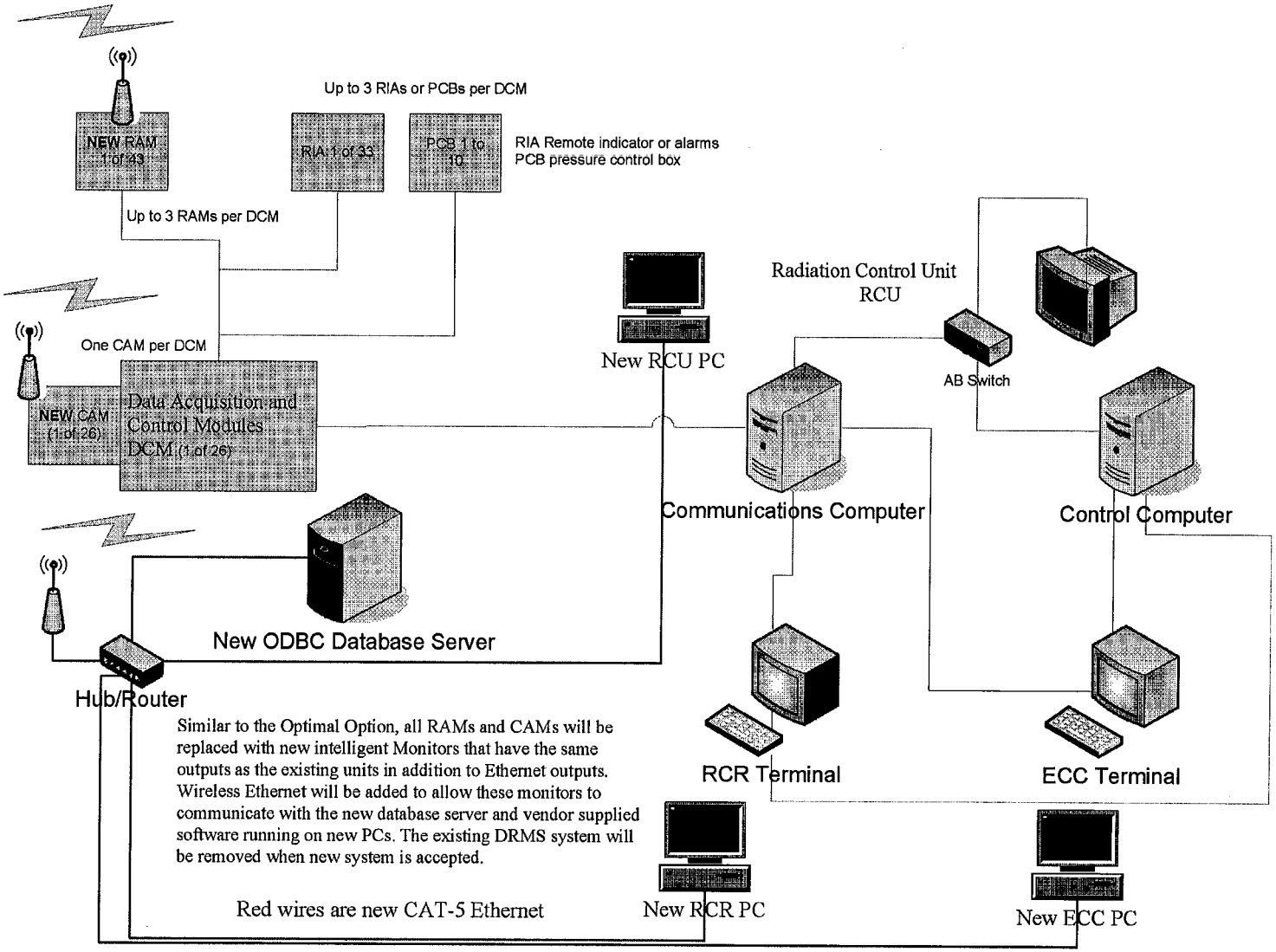


Figure 5-4B. Optimal DRMS option with wireless Ethernet.

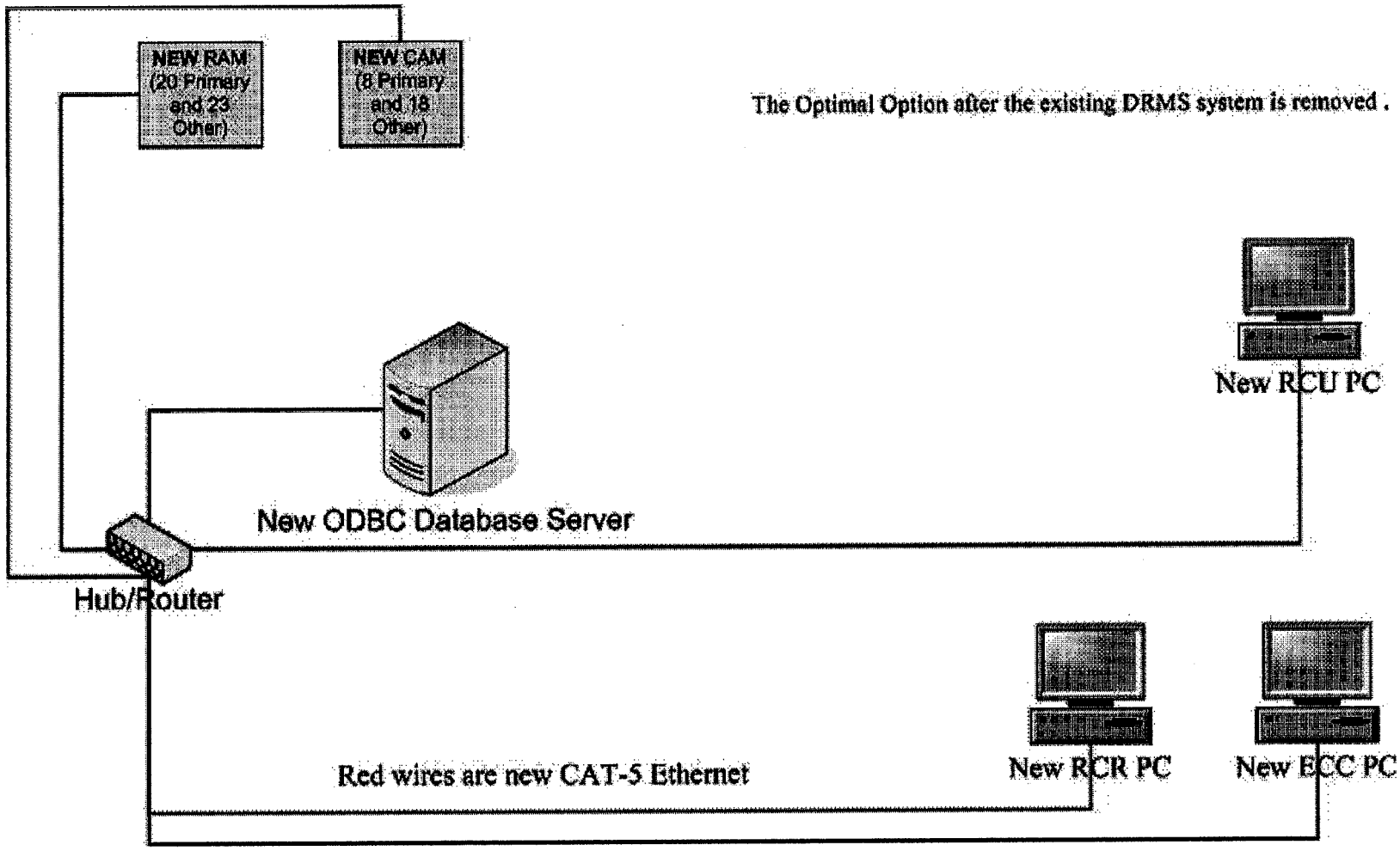


Figure 5-5A. Optimal system with DRMS removed.

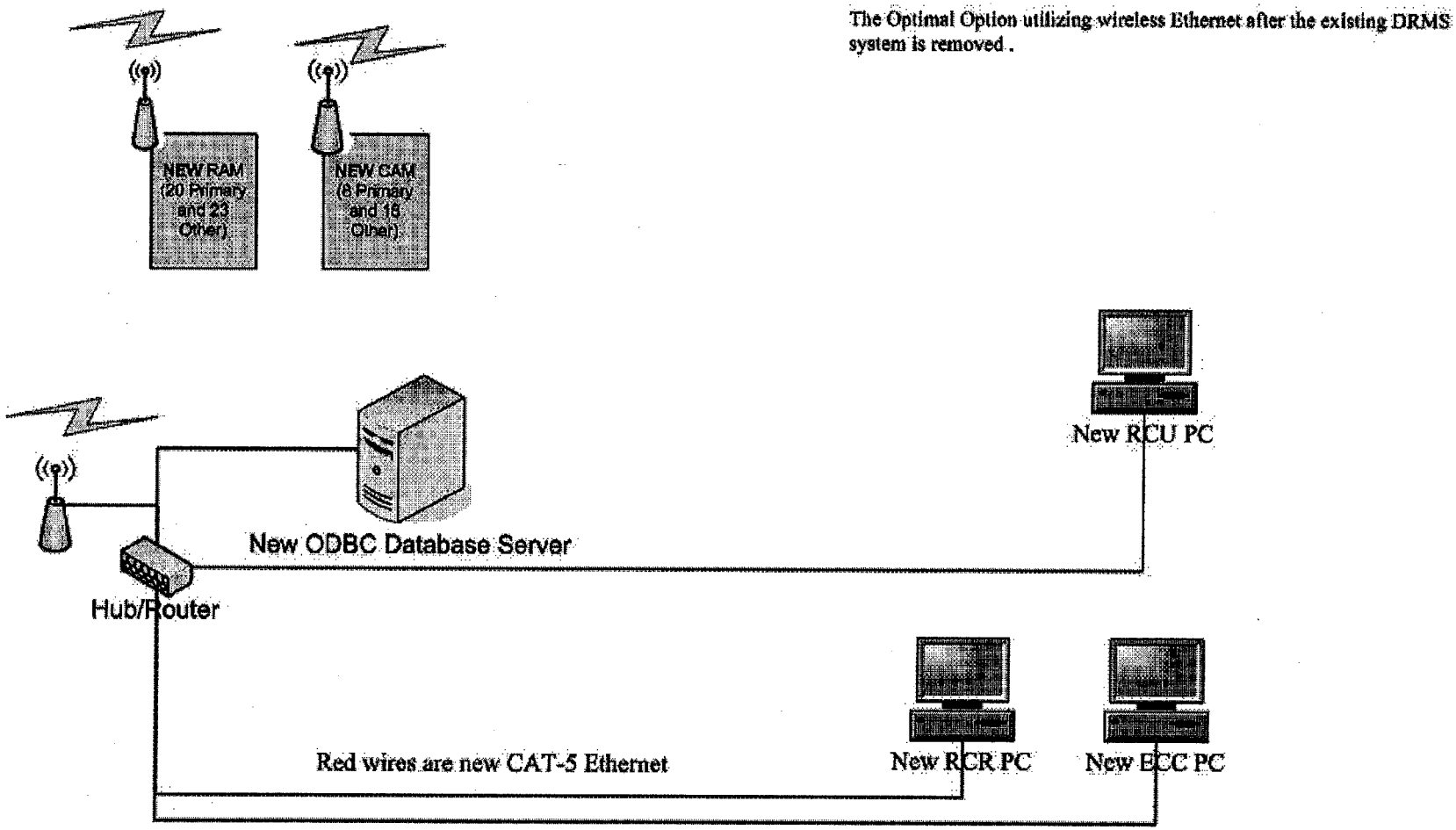


Figure 5-5B. Optimal system with wireless and DRMS removed.

5.2 ANNA Team Recommendation

To provide the best value to current and future operations at the RTC, the ANNA Team recommends the Intermediate Upgrade option. All primary radiation monitors should be replaced with new modern intelligent radiation monitors. The principal drivers for this recommendation are maintainability and improved performance. The old monitors are failing at an increasing rate, replacement parts are often unavailable, and continued safe operations at the RTC are at an increased risk of interruption, suspension or termination for lack of require radiation monitor support. New technology available at a reasonable cost can provide a superior radiation monitoring function at the RTC, and especially at the ATR. Additional upgrades are recommended as optional, but could be easily added to this modern system at a future time. The secondary and auxiliary monitors could also be replaced with new units to improve the overall performance of the DRMS as included in the Optimal Upgrade Option, however the additional cost should be weighed against the option of retaining the old units, run to failure and consider replacement in the future.

Also included in the ANNA Team recommendation is the replacement of the DRMS control and communications system (computers and software) with a new modern system that can provide high performance at a reasonable cost. The new system will allow Ethernet communication and control from multiple locations and the addition of automatic data backup and control at a remote location. By upgrading to intelligent monitors with both analog and Ethernet connection, the existing system can be kept in service until the new system is fully operational and qualified. The old system can then be removed or left in place to provide complete system backup.

It is further recommended that BEA conduct a high level cost/risk/benefit analysis that compares the recommendation and the other options to the priorities of other budget demands, needs and Program plans at the RTC to help choose the best path forward.

When the preferred upgrade is finally chosen, a procurement specification should be drafted and used to solicit bids and proposals from the leading vendors of radiation monitoring systems. The ANNA Team has identified and evaluated several vendors for this Study. Before completing the procurement specification for bids, BEA should evaluate the feasibility of using wireless technology at the ATR. The application of Wireless communication to the upgraded RMS at the ATR could have a significant impact on cost, performance, and flexibility of the RMS; however, the selection and procurement of new equipment will require potentially different efforts without the specification of such technology.

One additional recommendation is offered for consideration prior to finalizing the procurement specification. The need and benefit of separate iodine monitoring for the CAMs in the ATR RMS should be further evaluated. Since iodine is expected to be particulate (in most cases) or gaseous (in rare cases) it can be measured in the bulk samples of CAMs equipped to measure radiation in particulate filter samples and noble gas grab samples. The need and benefit of separate iodine measurement in CAMs could greatly effect the recommended monitoring system configuration and thus the cost of procurement, operation and maintenance of the ATR RMS. Alternate technologies may be available to provide the required iodine data. The requirement, and measurement technique, for obtaining iodine data should be reviewed and confirmed.

5.3 Technical Basis for Recommendation

The technical basis for the RMSS monitors is not well defined (SDD 7.7.4 is currently being updated). Further review is recommended to determine the need for changes or upgrade of this system to demonstrate compliance to the requirements that stem from 10CFR830. The RAMs used in this system

may not be sufficient by themselves to provide a proper (or at least the best) response. An effluent sample and measurement of radionuclide concentrations at the stack may be a necessary (or at least useful) addition to provide accurate data for actuating the require response.

The technical basis for the SPING that monitors the ATR effluent at the stack exhaust plenum appears to be to support reporting requirements and demonstration of compliance to 40CFR61. Lack of adequate vendor support for the existing unit and revisions to guidance on sample methodology contribute to the technical basis for recommending an upgrade to this monitor. The upgraded unit could be used to supplement the RMSS as well as the 40CFR61 monitoring.

The Recommendation (and each upgrade option) includes a basic change to the existing radiation monitoring system at the ATR and the updating of description documents to properly demonstrate compliance with the requirements identified (derived from 10CFR835). The DRMS must designate certain CAMs and RAMs as Primary and configure the monitors as specified in the EDFs that derived the technical bases. The system description documents should be updated to describe these changes and support the current technical basis. The configuration may also require periodic changes, e.g. to relocate sampling points or area coverage, as new operations or experiments are planned that change the technical bases.

Additional bases supporting the Upgrade Recommendation are provided by evaluation of existing system performance, cost of maintenance, future program plans and comparison to the modern RMS at commercial nuclear plants and features of new equipment offerings from the industry.

The new intelligent monitors offer improved performance through features such as automatic and frequent operational checks, automatic remote and manual calibration, and vendor support (trouble shooting over the internet). User groups consisting of several participants that employ the same or similar monitors, offering the ATR users information on performance issues and solutions to common problems that may arise.

After consultation with several commercial nuclear power plant operators and evaluation of radiation monitor vendors and their products, the most beneficial features of modern radiation monitoring systems were determined. Those features applicable to the ATR and most beneficial were included in the options for upgrade. Four options were considered, further evaluated and ranked. The ANNA recommendation is based on the top ranked option.

The ANNA Team recommendation is based on a review of the technical and regulatory requirements, features available in new modern equipment, and equipment cost and potential schedule challenges. If implemented, the recommended upgrade will provide the RTC with a cost-effective, reliable system that can be operated at a high level of performance and be maintained with a significantly lower level of effort.

6. COST AND SCHEDULE ESTIMATES

6.1 Cost Estimate

The approximate planning costs of the various upgrade options are detailed in Table 6-1 below. The entries are described as:

- **DRMS Detectors.** This entry is for the monitors and detectors that are part of the DRMS system. There are many variables such as specifications of the units and the varying costs from different vendors, so an average of the costs from high to low was selected and applied, which results in an approximate per unit cost of $50,000.00.

- **RMSS Monitors.** This entry is for the monitors and detectors that are part of the RMSS system. Since this is a safety class system, the most stringent requirements apply; an approximate cost of $100,000 per unit was determined to be appropriate.

- **Ethernet Cables.** This entry is for the hardware and miscellaneous costs to install each run of CAT5 Ethernet cable in the ATR.

- **Computers.** This entry is an estimate for the workstations to be installed to supplement or replace the existing DRMS systems.

- **Software.** This entry is for the new software packages support the new workstations for the DRMS.

- **Documentation.** This entry is a rough planning estimate of the level of effort needed to document the system correctly, including modifying drawings, SDDs and operating manuals.

Labor costs are broken into Technician and Engineering and are included to show a rough order-of-magnitude (ROM) of the work involved in upgrading the Radiation monitoring System. Detailed costs have not been prepared for this preliminary Study. Additional costs are anticipated for detailed engineering design, preparation of procurement specifications, revision of drawings and documents and development of supporting technical bases and feasibility studies. The inclusion of ROM costs and schedules allows a fair comparison of the evaluated Options.

Additional costs can be incurred if the requirements that the ATR imposes on the vendors include stringent seismic or Quality Level standards. Most vendors of radiation monitors have certifications from DOE, OSHA, NRC and other agencies for their standard products. Custom designed items may have to be qualified and the costs can escalate rapidly to two, three and four times as much.

Table 6-1. Comparison of ROM costs for the upgrade options.

		Minimal		Basic		Intermediate		Optimal	
		Qty		Qty		Qty		Qty	
DRMS Monitors	$50,000 each	0	$	28	$1,400,000	28	$1,400,000	69	$3,450,000
RMSS Monitors	$100,000 each	0	$	3	$300,000	3	$300,000	3	$300,000
605-ERM Monitors	$50,000 each	0	$	2	$100,000	3	$100,000	3	$100,000
Ethernet cables	$5,000 materials	0	$	0	$	31	$155,000	72	$360,000
Computers	$7,000 each	0	$	0	$	4	$28,000	4	$28,000
Software	$10,000 per package	0	$	0	$	4	$40,000	4	$40,000
Documentation			$200,000		$300,000		$400,000		$400,000
Technician	$75 per hour	100	$7,500	500	$37,50	1200	$90,000	2500	$187,500
Engineer	$135 per hour	100	$13,500	200	$27,000	300	$40,500	600	$81,000
			$221,000		$2,164,500		$2,553,500		$4,946,500

Note: See Appendix A for explanation of the cost estimates.

6.2 Schedule Estimate

Scheduling of the options depends on many factors. Most vendors can supply smaller numbers of monitors in 3 to 4 months, but this is dependent on the supplier's backlog for other projects. If there is a large order ahead of ATR, the schedule can be delayed by several months. When specifications for the procurement are prepared, the issue of timing of delivery should be addressed and a firm delivery commitment requested from the vendors. Detailed design, installation and system qualification are additional schedule considerations. The ATR is an operating research facility. Interruptions are not easily accommodated. Any installation work that requires access to areas restricted during reactor operation will have to be coordinated with the outage schedule. Total calendar time for any upgrade could be significantly longer than the estimated minimal time for typical instrument upgrades.

The installation of new and the removal of old hardware, especially wire and cabling, can be time consuming. Thus the consideration of using existing cabling or a wireless Ethernet becomes important to the evaluation of Options. Upgrade Options that require less installation time, less reactor downtime, and offer easier qualification and quicker implementation, may be considered preferable to those that would require longer installation schedules.

Table 6-2 provides a comparison of the rough estimate time schedules for equipment procurement and installation of the four Options. Although not an accurate schedule for the Upgrade Project, the estimates have been developed uniformly, allowing a fair comparison of the four options.

Table 6-2. Relative schedule estimates.

	Equipment Procurement Time	Installation Time
Minimal Upgrade	NA	2 weeks not critical path to update documents
Basic Upgrade	3-4 months	4-8 weeks
Intermediate Upgrade	3-4 months	6-10 weeks
Optimal Upgrade	4-8 months	8-12 weeks
Note: See Appendix A for explanation of the time estimates.		

7. SUMMARY

BEA should conduct a high level cost/risk/benefit analysis of the recommendation and options. At least a few changes must be made to be fully compliant with requirements (configure Primary monitors, ensure Maintenance Program alignment and update SDDs for all required monitoring systems). So even the Minimal Option has some cost. Prudence suggests spending more on new equipment to save on operation, maintenance and upgrade cost later. Preparation of a procurement specification to use for bid solicitation may require a few more evaluations before all required equipment is identified and included. Bids should be requested from several vendors, we identified 4 or 5 candidates.

A few additional evaluations are recommended to support the procurement specification and the technical basis for the upgrade.

- An evaluation is needed to support the technical basis for the radiation monitoring appropriate for the new HSIS and the reactivation of Loop 2A. The potential source terms derived from the safety analysis of the planned operations can be used to confirm the selection of appropriate RAMs and CAMs to monitor the HSIS and the Loop 2A, and to demonstrate compliance to the RMS requirements.

- An evaluation of the appropriate design specification to include in the request for quote (RFQ) from vendors should be developed from the recommendations in this Study. The evaluation should include a determination of the appropriate quality level and the associated Performance Category applicable to each monitor, e.g. seismic design criteria.

- Prior to issuing the RFQ, the feasibility of using wireless communication in the ATR should be investigated. There is anticipated cost savings associated with wireless communication over the installation of Ethernet cabling, however security and electronic interference issues at ATR need to be resolved.

- The integration of personnel dosimetry, particularly wireless dosimetry should also be considered prior to the RFQ. Some vendors offer this advanced technology as an integral part of their equipment. The integration of such advanced technology offers improved performance and cost savings to ATR operations in the future.

- Finally, it is recommended that the users of the RMS at RTC participate in the Users Groups that convene regularly for exchange of information on RMS equipment advances, problem solving and lessons learned. The User's Groups can assist with future upgrades to the RMS at RTC and potentially save cost and help INL realize optimal system benefits.

8. REFERENCES

1. SDD 7.7.4, Radiation Monitoring and Seal System, NISYS Report, Rev. 2, August, 2007
2. SDD 7.8.16, ATR Digital Radiation Monitoring System-System Design Description.
3. SDD 7.8.4, ATR Radiation Monitoring System.
4. SDD 8.9.7, Effluent Radiation Monitor (ERM for RTC-605).
5. SAR-153, Updated Final Safety Analysis Report for the ATR, Rev. 11, April 25, 2006.
6. TSR-186, Technical Safety Requirements for the ATR.
7. EDF-6174, Air Flow Study of the Advanced Test Reactor Building TRA-670, Rev. 11, January 30, 2003.
8. EDF-ATR-1977, Radiation Monitoring Requirements for the Advanced Test Reactor, Rev. 10, February 26, 2002.
9. EDF-TRA-ATR-3077, Minimum Requirements for Airborne Radioactivity Monitoring at the Advanced Test Reactor, Rev. 9, June 20, 2001.
10. EDF-TRA-ATR-1408, Fixed Continuous Air Monitor (CAM and Radiation Area Monitor (RAM) Requirements for the Advanced Test Reactor Critical Facility, Rev. 2, January 30, 2003.
11. ANNA-ISIS-RPT-008, Pre-conceptual Design Report for the ATR Isotope Shuttle Irradiation System (Rabbit), January 2007.
12. ANNA-HC-RPT-007, Pre-conceptual Design Report for ATR Hot Cell and Canal Extension, January 2007.
13. INEEL/INT-97-00088, Conceptual Design Report, Advanced Test Reactor Radiation Monitoring System Upgrade, December 1998.
14. Dwg. 412888, "ATR Stack Exhaust Radiation Monitoring System RMS."