REDACTED FOR PUBLIC RELEASE

University of Massachusetts Lowell

SAFETY ANALYSIS REPORT

(CHAPTERS 8-15)

University of Massachusetts Lowell

Research Reactor (UMLRR)

License R-125

Docket 50-223

(2015 REV. 0)

REDACTED FOR PUBLIC RELEASE

TABLE OF CONTENTS

CHAPTERS

Table of Contents

Table of Figures

8 Electrical Power Systems

8.1 Normal Electrical Power Systems

Electricity is supplied at 13,800 V from a pole on Riverside Street, down to underground conduits leading to switch and metering gear near the Power Plant (refer to Figure 5.1), from which point it is distributed to the area buildings. [redacted] Hall is fed by a 4160 V line, which runs in underground conduit from the Power Plant.

The incoming 4160 V supply is fed through two transformers in [redacted] Hall to two main distribution switchboards located in the building's basement level. The first transformer is rated at 750 kVA and supplies 277/480 V, 3 phase output to the first distribution switchboard; the second transformer is rated at 300 kVA and supplies 120/208 V, 3 phase output to the second distribution switchboard.

REDACTED FOR PUBLIC RELEASE

The 120/208 V main distribution switchboard has only one breaker to reactor equipment which supplies power to panel PPL-R1 inside the containment as shown in Figure 5.2. Other breakers on the 120/208 V main distribution switchboard feed other parts of [redacted] Hall.

The 277/480 V main switchboard supplies a number of components associated with the reactor including the Motor Control Center #1 and Motor Control Center #2, both of which are located in the basement of the containment building. The 277/480 V switchboard, in addition to feeding other parts of [redacted] Hall, also supplies normal power to the Emergency Distribution Switchboard (see Figure 5.2).

Under normal conditions, power for the reactor facility is distributed from:

1) Motor Control Center #l;
2) Motor Control Center #2;
3) PPL-R1
4) ELPL-R1

These four points are the distribution hubs that supply electrical power to the various process functions and lighting panels required for operation. The branch lines from these distribution centers and panels, to the various lighting and receptacle distribution sub-panels (designated LPL-R#) and terminal points, are shown in Figure 5.3.

REDACTED FOR PUBLIC RELEASE

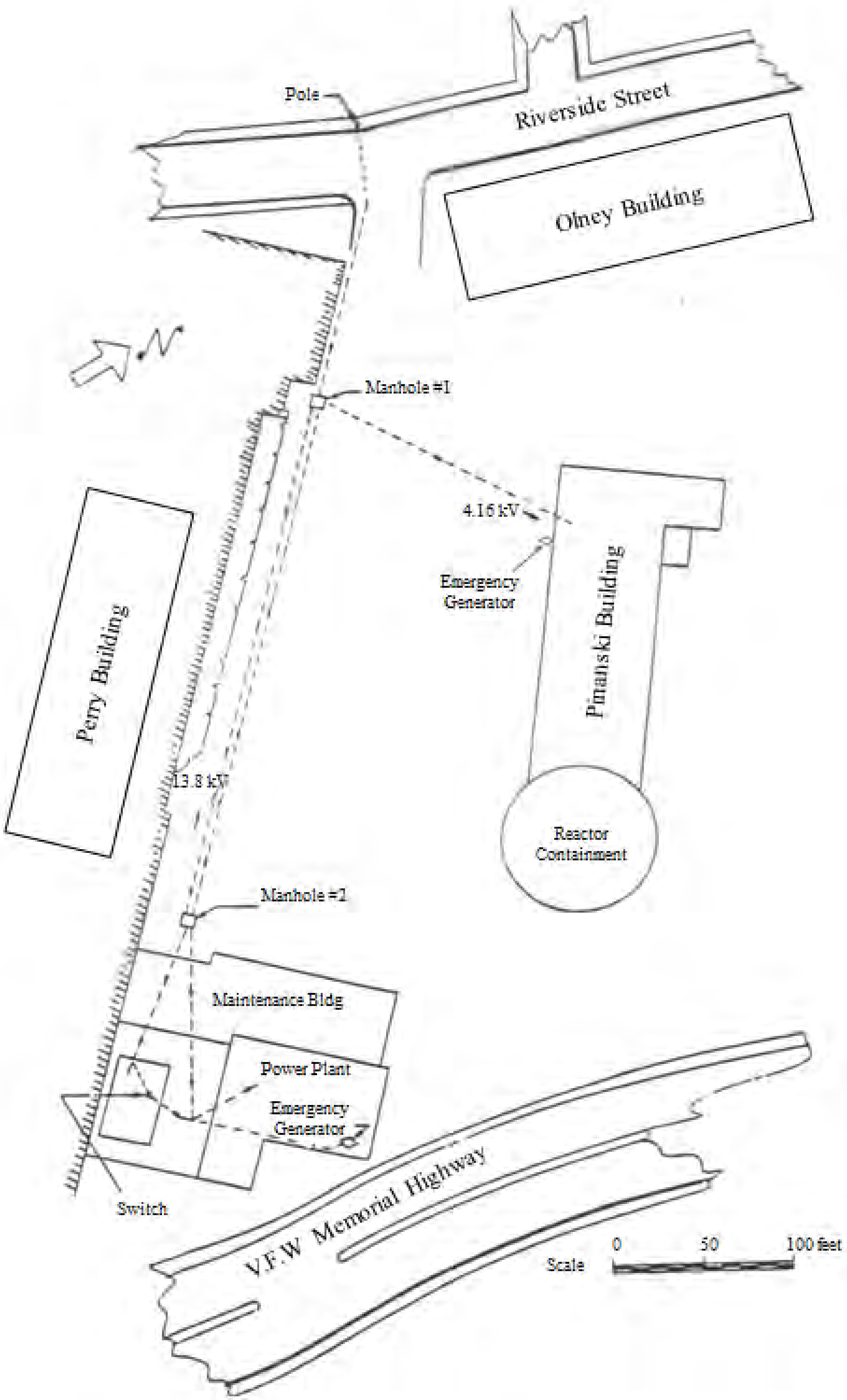


Figure 8-1: [redacted] Hall Electrical Power Supply

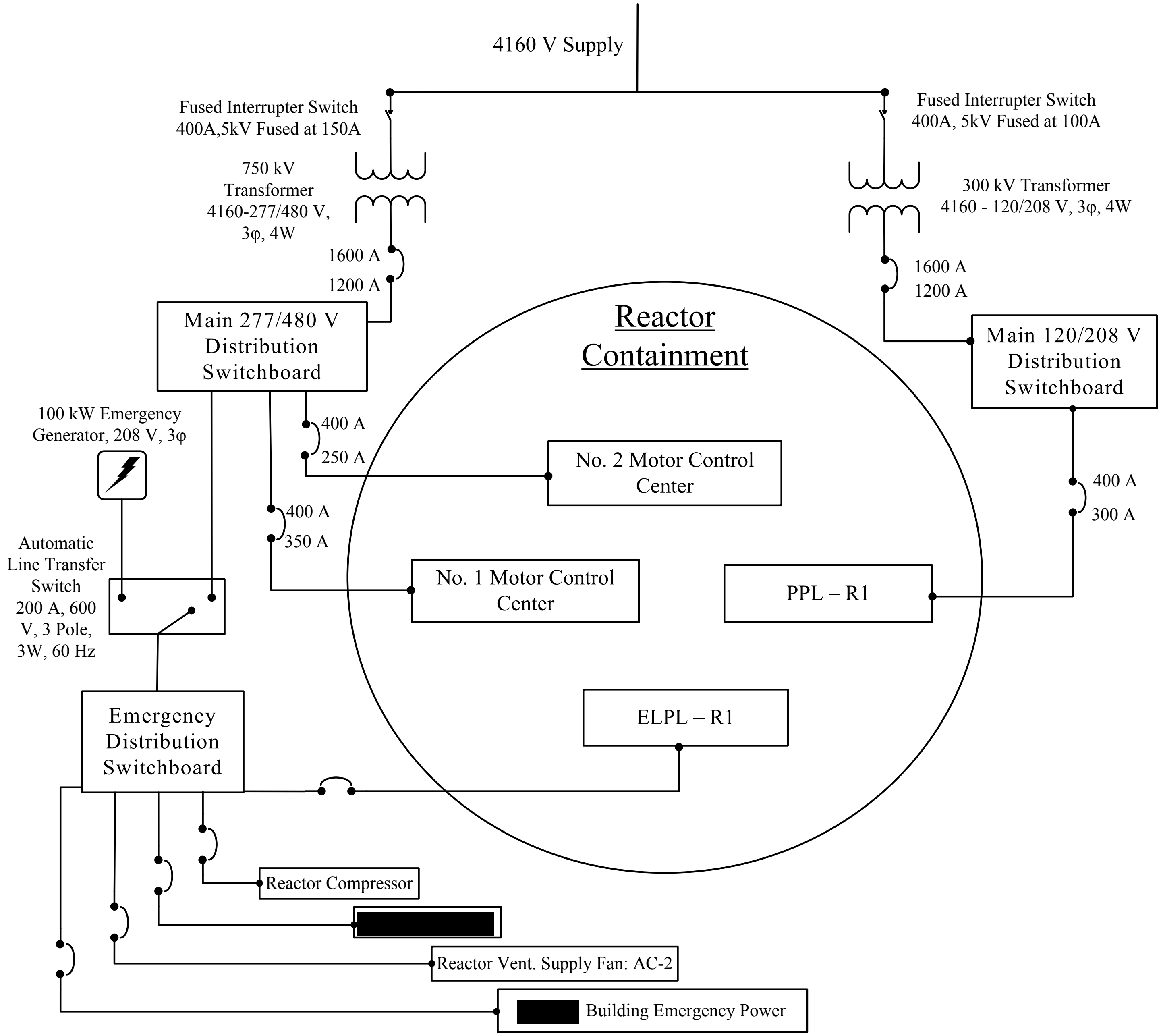


Figure 8-2: [redacted] Hall Electrical Distribution

The loss of normal electrical power to the reactor facility, any reactor safety system, or any reactor safety system component, will initiate protective action by opening the scram bus. Failure of any component of any safety channel cannot lead to failure of the reactor protection system. A malfunction in the trip amplifier cannot prohibit the functioning of the scram bus and scram bus relays which furnish power to the trip amplifier which in turn powers the blade electromagnets. The reactor protection system and scram bus are described in Chapter 7.

As shown in Chapter 13, a reactor shutdown from full power does not create enough decay heat to require forced cooling. Prolonged electrical outages will not have any adverse effects on reactor safety.

8.2 Emergency Electrical Power Systems

Emergency power is supplied from the emergency generator to the equipment specified in Figure 5.2, and distributed inside the containment building from ELPL-R1 as depicted in Figure 5.3. The Emergency Generator is a Kohler 100 kW, 208V, 3-phase powered by natural gas. During loss of normal house power an automatic line transfer switch will activate the emergency generator. The loss of normal electrical power will initiate an automatic reactor scram. An uninterrupted power supply (UPS) will continue powering console and nuclear instrumentation cabinets during the switch to emergency power. If the emergency generator fails to start, the UPS can supply power for approximately 30 minutes, which is sufficient time to monitor the neutron level indicators to ensure the reactor has shut down. If the UPS does not function, administrative procedures require the reactor operator to visually verify the control blades are in the core using a battery operated lights.

A loss of power will not affect the safety of any experimental facilities. Doors leading into experimental facilities are locked and alarmed to prevent inadvertent entry. Emergency lights with backup batteries are located throughout the containment building and will turn on after loss of normal power. These lights will continue to operate if emergency power is also lost, allowing personnel to exit the building safely.

Emergency coolant systems and emergency electrical supply to coolant pumps are not required as the reactor does not produce enough decay heat following a shutdown from full power (see Chapter 13). Prolonged periods without electrical power will not affect the integrity of the reactor or its components.

The area radiation monitors, containment building radiation alarms, and containment building public address system are fed by emergency power from the emergency generator.

Containment closure is achieved by de-energizing solenoids in the various building valve air supplies. This releases the air holding the valves open and allows containment closure. The operation of the emergency exhaust system requires operation of its own unique valve. Power is fed to this system's solenoid while containment is in effect. The power feed line to the emergency exhaust valve solenoid is isolated in a separate conduit from the power feed lines to other containment valves to ensure that a single failure cannot result in an inadvertent opening of containment valves.

A reactor compressors supplies compressed air for all of the air-lock doors throughout containment. The emergency generator will provide power to the compressor ensuring containment isolation during periods without normal power. In the instance where the emergency generator also fails, line pressure and back up compressed air tanks within the two personnel airlocks will provide sufficient air to ensure complete evacuation of containment while maintaining containment isolation.

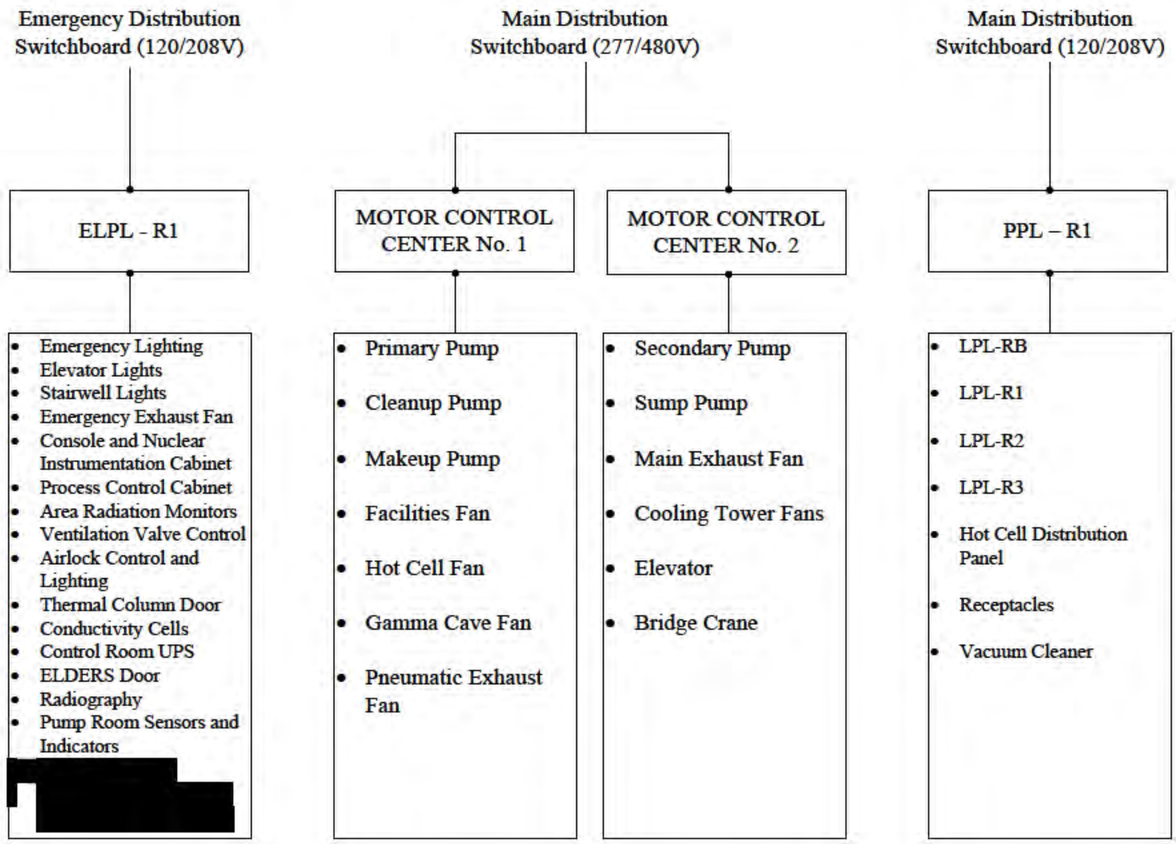


Figure 8-3: Reactor Building and Emergency Electrical Distribution

REDACTED FOR PUBLIC RELEASE

Table of Contents

Table of Figures

Table of Tables

9 Auxiliary Systems

9.1 Heating, Ventilation, and Air Conditioning

The internal volume of the containment building is about 375,000 cu ft, of which about 40,000 cu ft is occupied by the reactor pool, floors, walls, and columns, and other solid materials, leaving about 335,000 cu ft to be filled with air. Of this air, about 85,000 cu ft fills space below the beam level floor, leaving 250,000 cu ft in the relatively open space from beam level to ceiling. Certainly some mixing of airborne activity can be expected between these areas but because of the intervening floors and doors it is an order or two of magnitude slower than mixing throughout the freely open upper volume.

Air flows through the ventilation system at the nominal rate of 14,500 cfm. Even if the below beam-level air volume is included, this results in a removal rate constant of 0.0442 which is seven times as great as the radioactive decay constant of ^{41}Ar (0.0063 min^{-1}), the expected principal airborne activity in the reactor room air during normal operation. If just the above beam-level air is considered, the factor of seven increases to nearly ten.

9.1.1 Building Air Supply and Exhaust

The air supply blower (AC-2) is located immediately outside of containment on the third floor of the [redacted] building in a secure room. Air is drawn in from the side of the [redacted] building at this level where it is filtered, and either heated, cooled, or dehumidified before passing into containment through valve A. The blower, AC-2, supplies containment with 14,500 cfm, which is distributed internally from ducts around the periphery of the containment building at several levels, including a duct into the control room.

The exhaust blower (EF-12) is located on the second floor in containment and exhausts air nominally at 15,000 cfm, which is slightly more than the supply blower, so that a slight negative pressure is maintained. Air is removed through a large plenum located near the end of the bulk irradiation pool on the third floor, a small duct in the pump room, and the fume hood in the basement hot lab. The exhaust air is discharged to the atmosphere from a 100' high facility stack. The exhaust blower is interlocked so that if the supply blower stops, the exhaust fan cannot operate. The system schematic for the system can be found in Figure 9-1.

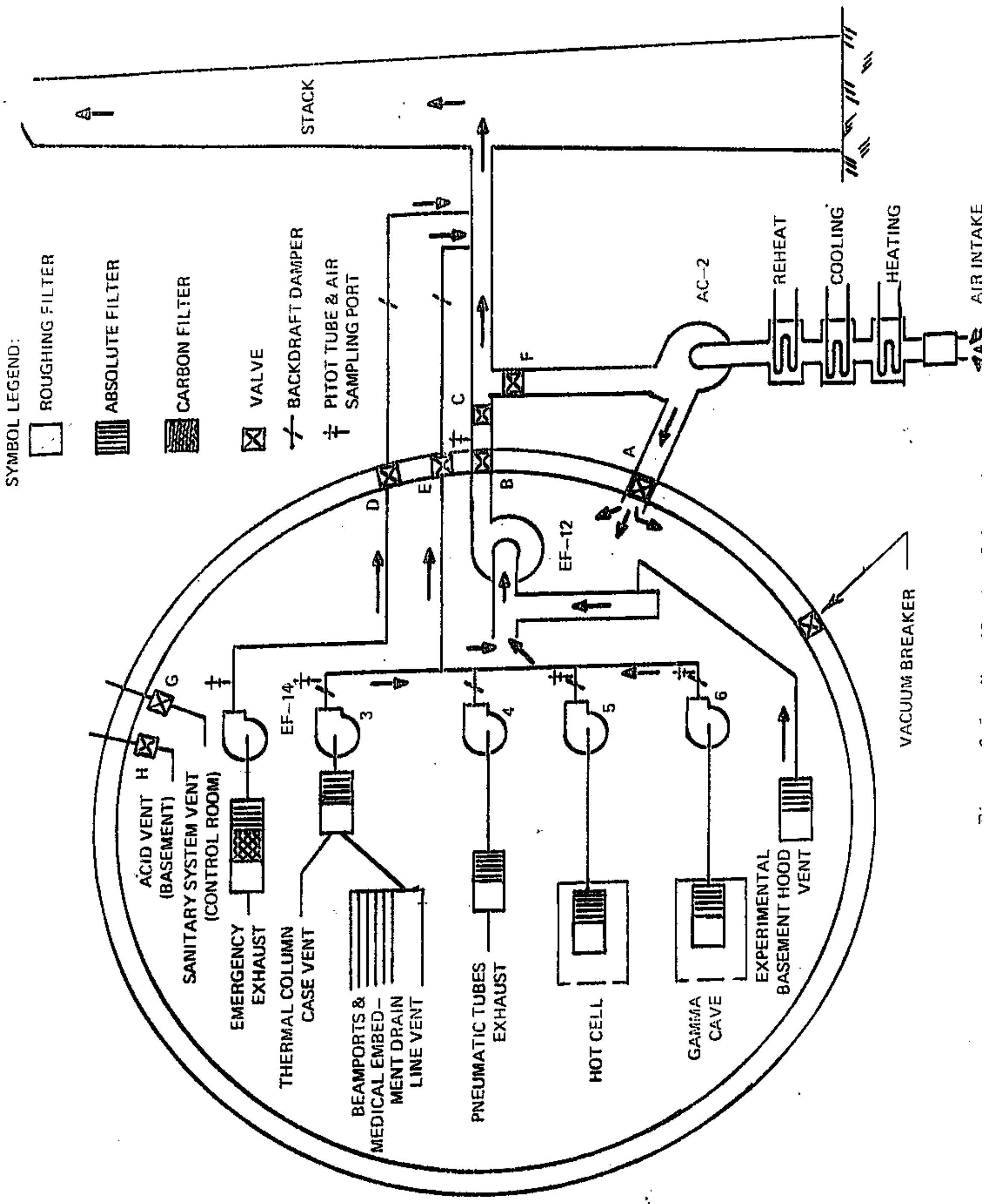


Figure 9-1: UMLRR Containment Ventilation System Overview

9.1.2 Experimental Facilities Exhaust

Four additional exhaust blowers are provided for the experimental facilities. The gamma cave, hot cell, and pneumatic tubes each have their own dedicated exhaust blower. The facilities exhaust blower services the beam ports and thermal column. The gamma cave, hot cell, and

REDACTED FOR PUBLIC RELEASE

facilities blowers are all located immediately outside of the gamma cave and are rated to exhaust air at 600 cfm. The pneumatic tubes blower is located on the second floor above the thermal column and is rated to exhaust air at 230 cfm. All of the experimental facilities blowers are equipped with HEPA filters.

9.2 Handling and Storage of Reactor Fuel

The movement and handling of fuel elements is governed by written procedures. A facility procedure for the receipt and storage of new fuel elements details individual responsibilities, inspections, radiation safety, and reporting requirements. A procedure is available for the safe handling of irradiated fuel that does not apply to shipment. Other procedures for the unloading and loading of a core to both a new configuration and to one whose properties have not been determined experimentally describe fuel movement from an operations perspective. Storage of both new and irradiated fuel elements is provided by fuel storage racks kept within the reactor pool. Examples of a device used to move reactor fuel can be seen below in Figure 9-1. These sections are joined to provide sufficient length to allow the operator at the pool surface manipulate fuel elements at a distance.

[redacted]

Figure 9-2: Fuel Element Handling Tool.

REDACTED FOR PUBLIC RELEASE

9.2.1 Fuel Storage

Eight storage racks are provided for storing a total of 72 elements as shown in Figure 10-2. Each rack holds nine elements in a planar array so that there is no possibility of inadvertent criticality. Each rack hangs from hooks extending from the pool liner at two different heights.

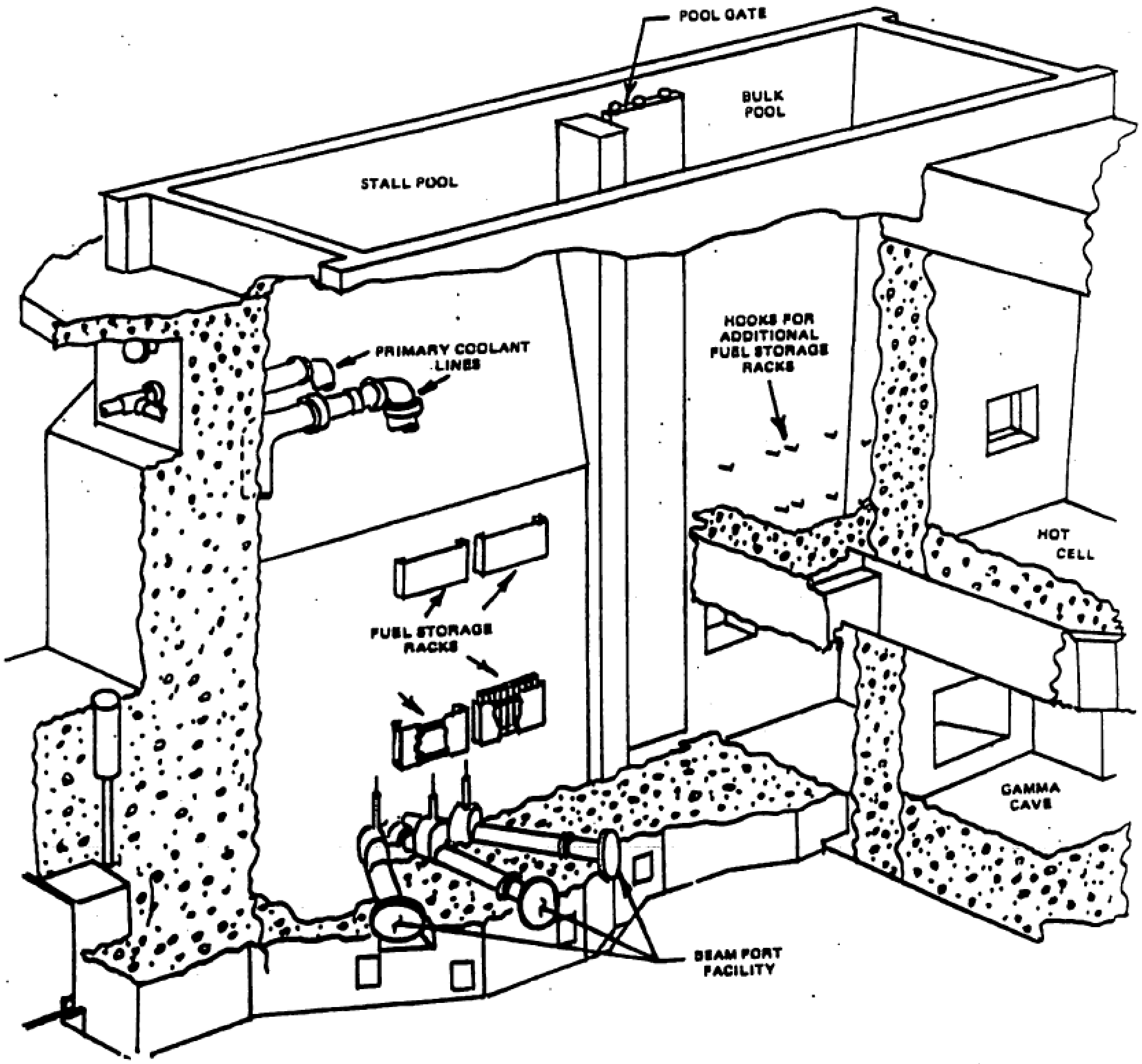


Figure 9-3: Location of Fittings for Fuel Storage Racks

Two vertically positioned aluminum channels, roughly 26” long, are separated by two horizontally positioned aluminum channels, roughly 35” long, creating a frame. The two horizontal channels provide nine equally spaced chamfered slots to accommodate fuel. The top channel slots are 3.25” square and the bottom channel slots are 2.875” square and hold the elements in place. This frame is attached to a plate consisting of a 0.25” thick sheet of aluminum and a 0.125” thick Boral sheet clad in 0.030” of aluminum. An aluminum plate located on the front of this rack acts as a bumper or guard.

Overall storage rack dimensions include a 36” width, 22.25” height, and a 6” depth. When an element is placed in the rack, only a small length of the top portion is visible. The lower section of an element will not protrude any lower than the side aluminum channels. This provides some protection if the rack comes off the hooks during movements. It should be emphasized that the bottom of the fuel storage rack is not completely isolated from the reactor pool water, but is, instead, open to allow for natural convection cooling of the elements being stored. An illustration of the UMLRR fuel storage rack is shown in Figure 9-2.

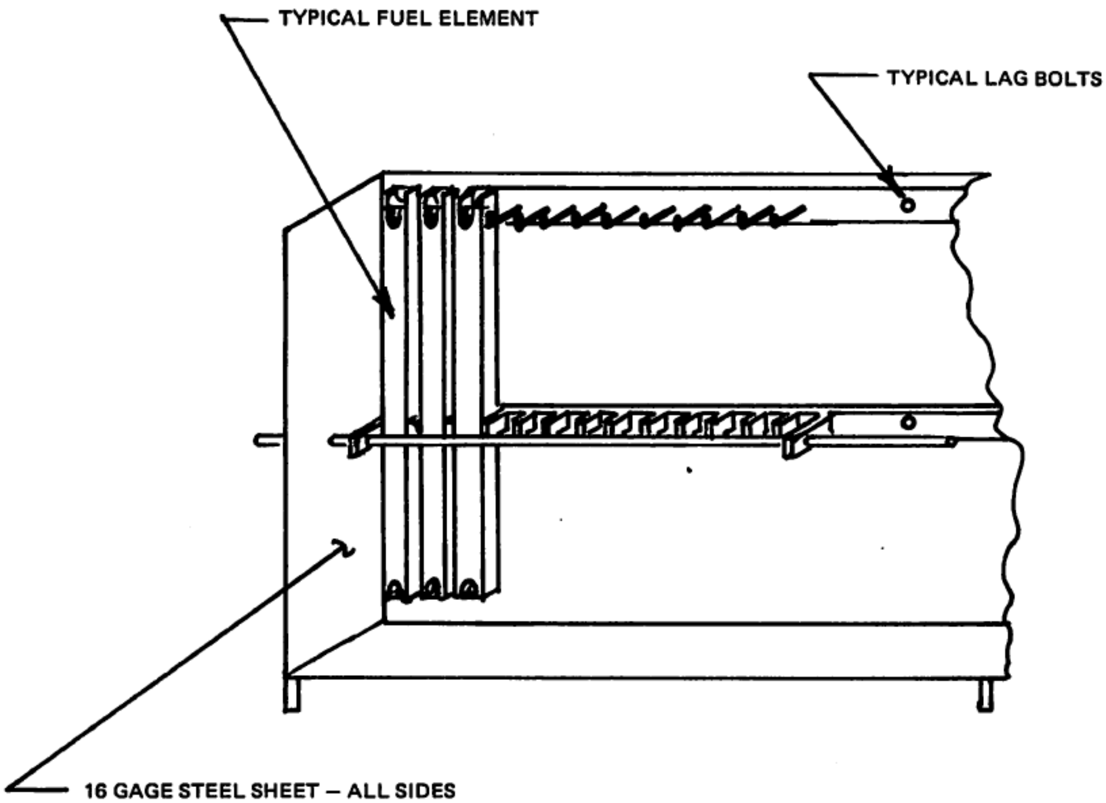


Figure 9-4: Fuel Storage Rack

9.2.2 Core Element Handling Tools

A set of handling tools allow for the movement of core elements, which includes fuel elements. One handling tool accommodates two different heads using the same set of extensions. One head, a bayonet-type fitting used primarily on fuel elements, provides a more reliable way to locate, grasp, and securely move a fuel element. This head is part of a 6' long aluminum extension. The second head, a general purpose aluminum hook used for the manipulation of other core elements, is part of a 12' long fiberglass extension. The extensions are assembled by fitting together a male-female bayonet connection in a socket over which a coupling is then threaded. The bayonets and coupling are aluminum. Several extensions of different lengths are available in order to reach the core box.

A second tool, used primarily on fuel elements, has the same style end bayonet fitting as described above, but is part of a shorter extension containing a universal joint. The universal joint allows the bayonet to hang directly over the fuel element regardless of the angle of the remaining extensions on the tool. This tool is of aluminum construction, consisting of 6' long extensions coupled together by glide snap buttons. Illustrations of the element handling tools can be found in Figure 9-5.

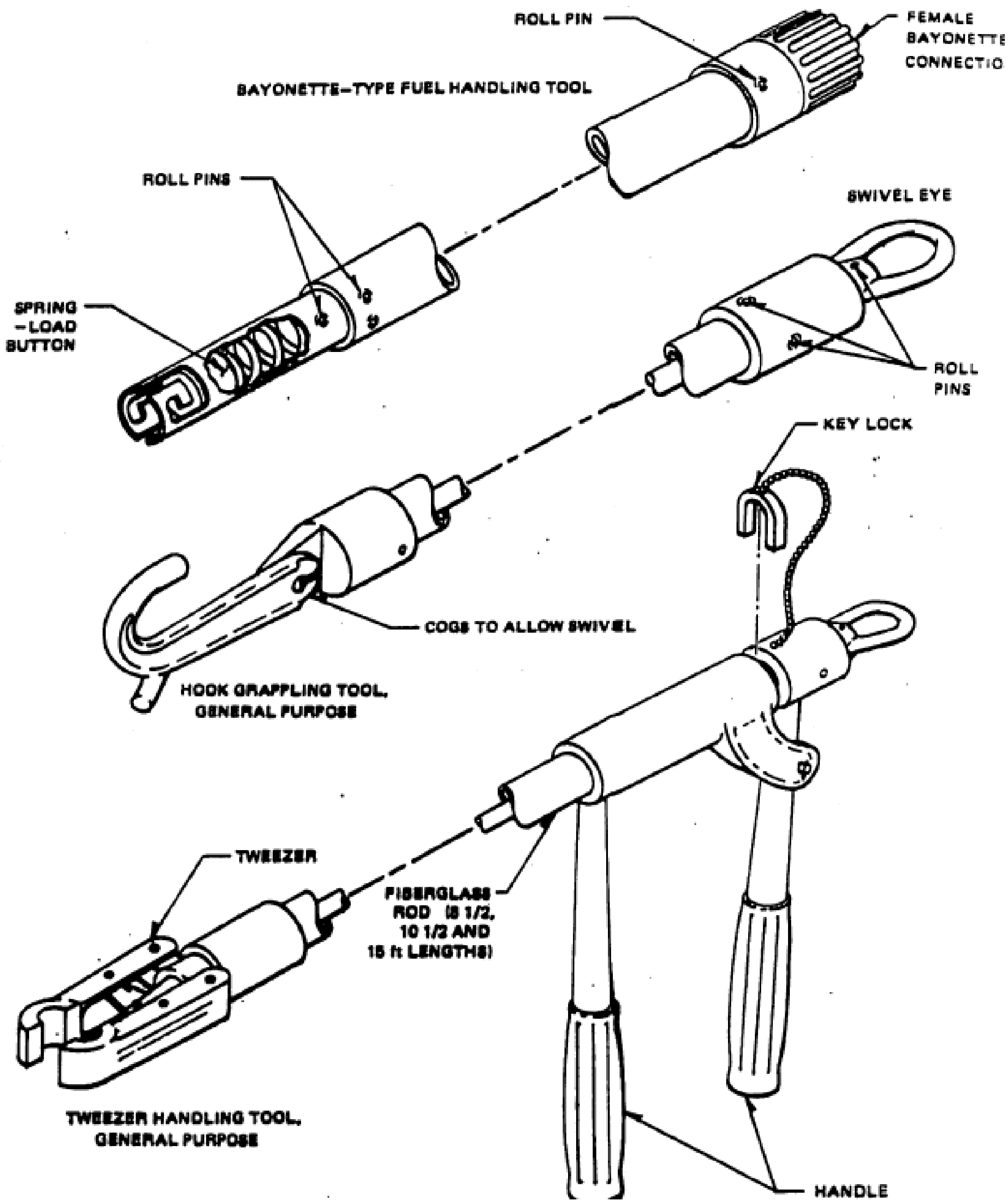


Figure 9-5. UMLRR Handling Tools

9.2.3 Polar Crane

A polar crane situated above the pool level can serve the containment building from the pool level down to the basement. It provides one 15 ton hook and an auxiliary 2 ton hook, both equipped with safety latches. There is a facilities procedure that specifies the proper operation of the crane and training programs for reactor staff.

9.3 Fire Protection Systems and Programs

The majority of structures within the containment building consist of non-flammable material such as concrete, steel, and aluminum. Due to its position in the pool below a [redacted] head of water, the nuclear core is protected from any direct fire damage.

The development of smaller fires within the containment building, rather than to the building itself, is a possibility. These include the possibility of electrical fires and trashcan fires where combustible or flammable material would be disposed. In the event of an electrical fire in a Reactor Safety System (RSS) component, failure of that component would lead to a reactor scram.

[redacted] Active fire protection components include numerous fire extinguishers available throughout containment, smoke detectors, and fire pull-stations.

9.3.1 Active Components

Two smoke detectors are available in the containment building. One is located on the ceiling [redacted]. The second detector is located [redacted].

Fire alarm [redacted]. One is located on each of the top three levels and two are available in the basement; one near the stairwell in the Hot Lab and the other in the pump room.

Hand extinguishers are located throughout the containment building. Their type and location are listed in Table 9-1. The type and classification of the various extinguishers has been made to address any local area concerns / hazards that may be present in the area of the extinguisher, for example, the Halotron extinguisher located in the control room is specifically designed for use with sensitive electronics. The chemistry of the extinguisher is such that it does not result in additional damage to the electronics that it is designed to protect.

Table 9-1 Fire Extinguisher Locations

Extinguishers			
Level	Location	Type	Class
Third Floor	[redacted] Room	Halotron	A,B,C
	[redacted] [redacted] Room	CO2	B,C
	[redacted] Restroom	Dry Chemical	A,B,C
	[redacted]	[redacted]	[redacted]
	[redacted].	Dry Chemical	A,B,C
Second Floor	[redacted]	Clean Agent	A,B,C
	[redacted]	CO2	B,C
First Floor	[redacted]	CO2	B,C
	[redacted]/Sink	CO2	B,C
	[redacted]/Sink	Clean Agent	A,B,C
Basement	[redacted]/[redacted] Lab	CO2	B,C
	[redacted]	Dry Chemical	A,B,C
	[redacted] Exit	CO2	B,C
	[redacted]-[redacted] Entrance	Dry Chemical	A,B,C

9.4 Communication Systems

9.4.1 Intercom System

[redacted] The first is designated for communications [redacted] The second system is designated for communications inside [redacted] The system works by selecting a specific channel switch on the main receiver, and depressing the "speak" switch while talking into the receiver. Singular or multiple channel communications can be done from the main receiver. [redacted].

[redacted]:

[redacted]

9.4.2 Public Address System

A [redacted]. A university phone extension also exists for the public address system, which allows for telephones both inside and outside of the containment building to give announcements over the system.

9.4.3 Telecommunications System

A series of telephones located throughout the containment building are connected to the university's phone system, and can call one another by extension. All telephones can call outside and inside the containment building. Specific locations of these phones within the containment building include two in the control room ([redacted]), one next to the first [redacted] and one in [redacted] located in the basement.

9.4.4 [redacted]m

[redacted].

9.4.5 [redacted]

[redacted]

[redacted]

[redacted]

[redacted].

9.5 Possession and Use of Byproduct, Source, and Special Nuclear Material

9.5.1 Byproduct Material

The University of Massachusetts Lowell (UML) maintains a separate Type-A broad scope agreement state license for the possession and use of byproduct material. That license is administered by the UML Radiation Safety Office and is not a responsibility of the UML Research Reactor (UMLRR). Most uses of byproduct material at UML are performed under this license. The UMLRR operating license also allows the receipt, possession, use and transfer of byproduct material in the form of Cobalt-60, in quantities not to exceed [redacted] at any time. As this material is stored and used in the same pool as the reactor, it is placed under the Part 50 reactor license. Written procedures govern the receipt, storage, use, and inventory of this material. The physical protection plan describes the access authorization and physical protection requirements to minimize the risk of theft, sabotage, or unauthorized use of the sources as required by 10 CFR Part 37.

For this relicensing application, a reduction in the allowable cobalt-60 quantity is being requested. In addition, a provision for up to [redacted] per radionuclide and [redacted] total, atomic numbers 3 through 83 in any form, is being requested for the purpose of checks, calibrations, and characterizations of radiation monitoring instruments. Currently, the sources used for the radiation monitoring instruments are under the byproduct material license for the university. Table 9-2 lists the materials and quantities requested under relicensing.

Byproduct material for use with the radiation monitoring instruments is normally stored inside a locked cabinet within the reactor containment building. However, other approved storage locations may be used depending on the amount of activity involved. Written procedures govern the receipt, storage, and inventory of this type of material are maintained under the Type-A broad scope license for the university.

9.5.2 Special Nuclear Material

The UMLRR also maintains a separate NRC special nuclear material (SNM) license. That license is administered also by the UML Radiation Safety Office and is not a responsibility of the UML Research Reactor (UMLRR). The UMLRR Operating License authorizes the possession of certain SNM and quantities. This is limited to the [redacted] utilized in conjunction with operation [redacted] and the [redacted] and [redacted] sources. The latter sources are used for [redacted]. The [redacted] source is located in [redacted] The [redacted] is kept in storage [redacted]. It serves as a spare [redacted] and historically has been [redacted]. The fuel is stored as described in Section 9.2 of this chapter.

For this relicensing application, provisions for [redacted] sources and [redacted] [redacted] [redacted] ([redacted] in the form of [redacted] being requested. The former is for the purpose of [redacted]. The latter is for the purpose of [redacted]. The [redacted] sources and detectors [redacted] are currently under the [redacted] license for the university. Table 9-2 lists the materials and quantities requested under relicensing. The [redacted] sources are stored in locked shielded containers within the reactor containment building. The detectors are kept in a locked [redacted] until eventually placed in the [redacted]. The physical protection for the SNM described above is under the same 10 CFR Part 37 plan as for the cobalt-60 sources.

Table 9-2: SNM and By-Product Materials License Limits

Material	Current License Quantity	Re-license Request Quantity	Notes
[redacted]	[redacted]	[redacted]	[redacted]
Am-Be	[redacted]	[redacted]	[redacted]
Sb-Be	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted] calibrations
HEU	n/a	[redacted]	For use in fission chamber detectors
Atomic No. 3 through 83	n/a	[redacted]	For detector checks and calibrations

REDACTED FOR PUBLIC RELEASE

Table of Contents

Table of Figures

10 Experimental Facilities and Utilization

10.1 Summary Description

The UMLRR uses the nuclear reactor and gamma sources for research, education, and testing purposes. Current activities consist of neutron radiography, atomic displacement using fast neutrons, neutron activation analysis, high-dose rate gamma irradiation, and enhanced low dose rate gamma irradiation sensitivity. UMLRR is designed to provide these services through the use of the following experiment facilities:

- Three beam ports for neutron beam irradiation;
- A Fast Neutron Irradiator (FNI) for irradiating materials with fast neutron without excess gamma and thermal neutron fields being present;
- A dry irradiation room, located in the bulk storage end of the pool, that can be used for gamma irradiations;
- Hot Cell for the irradiation of materials and the remote handling of samples;
- A Medical Embedment that can be utilized for medical and or materials irradiations;
- A pneumatic system provide direct irradiation of small samples for neutron activation;
- N-16 Irradiation facility to calibrate and characterize dosimetry from high energy photons;
- Radiation baskets on the perimeter of the core and a flux trap with an aluminum reflector element, located in the center of the core for high flux irradiations;
- A thermal column, composed of graphite, is available for various types of neutron radiography and other types-of irradiations;
- A wet storage cobalt-60 irradiator used for gamma irradiations; samples can be lowered in a canister that provide high-integrated gamma rays exposures to the samples.

10.2 Experimental Facilities

10.2.1 Beam Ports

One eight inch beam port and two six inch beam ports are included in the reactor experimental facilities, located opposite the fast neutron irradiator within the stall pool. The beam ports provide leakage neutrons with energies throughout the fission energy spectrum for experimental application. Each beam port is, essentially, an air-filled tube that passes through the biological shield, into the pool, and is accessible from the experimental level.

Each beam port consists of a tube that extends from the inner pool wall, where it is flange bolted to the shutter housing, toward the reactor core face. This section is [redacted] in length, has a wall thickness [redacted] is referred to as the inner tube. The end nearest the reactor core has a cap that is welded over the exterior of the inner tube. The opposite end of the tube is welded inside of a one-inch thick aluminum plate, which measures [redacted] for the eight inch diameter port and [redacted] for the six-inch diameter ports. These plates are bolted to the flange of the shutter housing, which are located in the pool wall, but partially extend beyond the pool liner, into the pool. The shutter housing accommodates a large, cylindrical lead shield cast in aluminum that can be adjusted vertically from locations on the third floor. The lead shutters are roughly the length of the shutter housing [redacted] and vary only in diameter and weight with the 6" shutter at [redacted] pounds and the [redacted] shutter at [redacted] pounds. Opposite the inner tube side of the shutter housing is the shutter housing assembly. A common drain line is provided for port drainage and ventilation in this section to allow for adequate removal of seepage and radioactive gas. The shutter housing assembly is flange bolted to the stainless steel outer tube. All outer tubes terminate at a flange at the pool wall for experimental access. A stainless steel cover is provided for each flange on the outer tube. The six-inch beam port nearest the thermal column terminates at a [redacted] spacing in the wall referred to as the beam port box. This beam port box is stainless steel and part of the outer tube. Each outer tube provides four one-inch diameter conduit lines in this section to accommodate instrumentation. Illustrations of the beam port configurations can be found in Figure 10-1 and Figure 10-2.

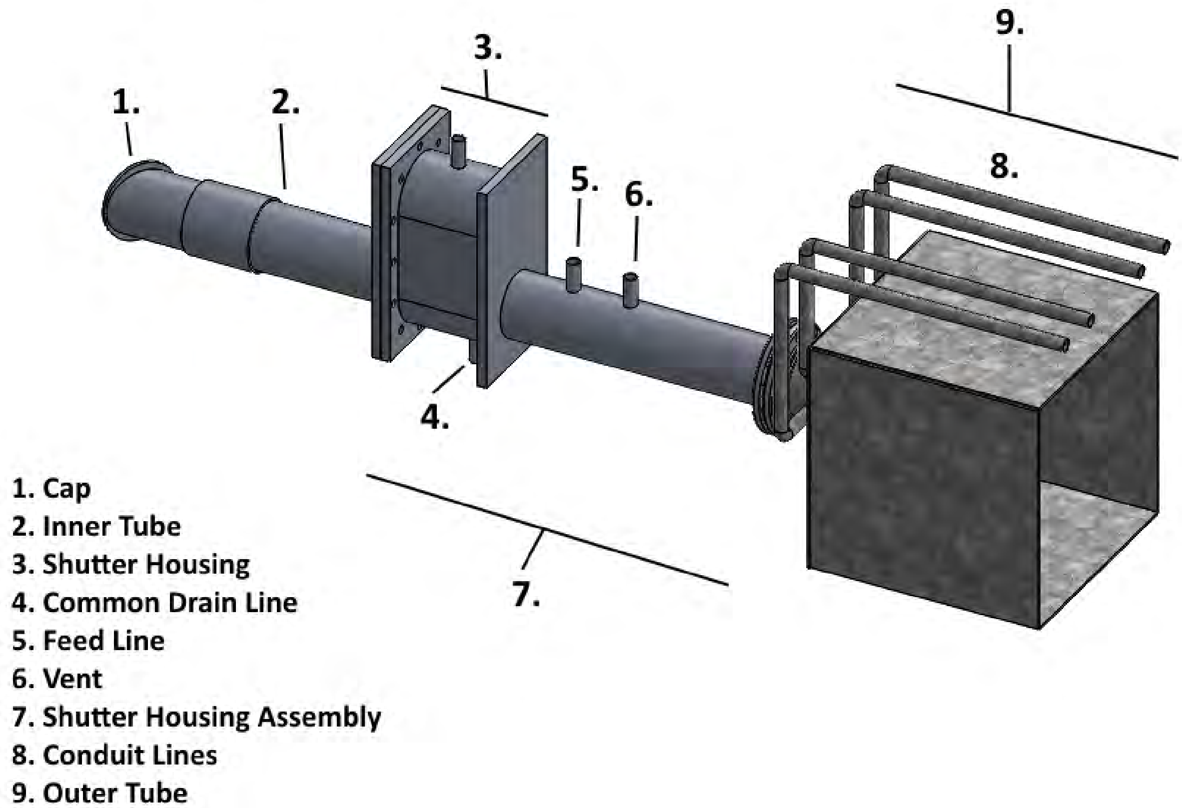


Figure 10-1: Six Inch Beam port with end box

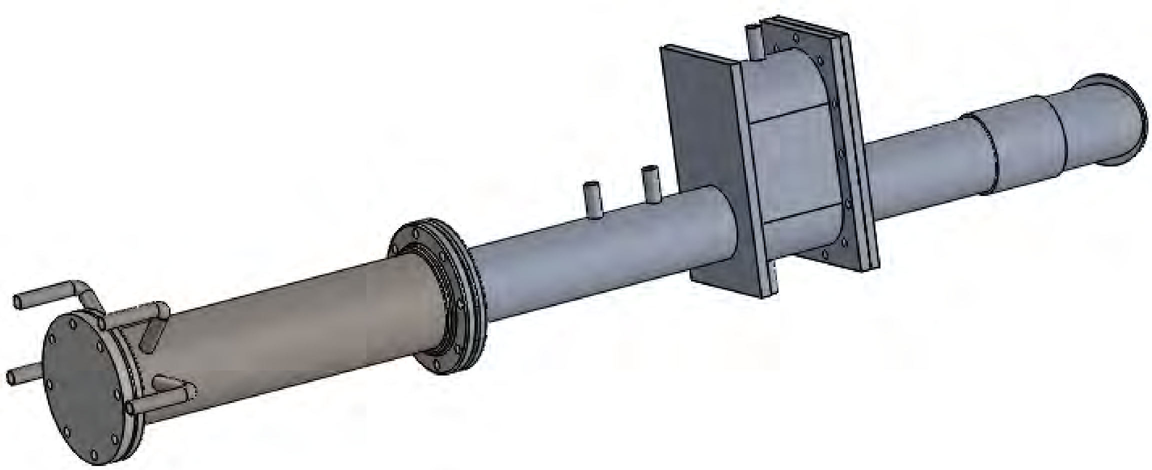


Figure 10-2: Six Inch Beam Port without End Box

In 2001, the [redacted] located on the east side of the pool were removed from operation in order to make room for a fast neutron irradiation facility in the pool. Only the inner tube section of the beam port was removed. To isolate the beam ports from the pool, the inner tube mounting bracket was replaced with an aluminum plate, attached at the shutter housing.

The three remaining beam ports are located on the west side of the reactor core. One six-inch beam port, located nearest to the thermal column in the stall pool, has permanent installed biological shielding, designed for safe, daily access and operation.

Several measures are taken to assure that radiation is kept within a controlled environment, minimizing dose to experimenters and personnel, and isolating it from non-radiation workers. The first physical barrier is a concrete shield, which surrounds the open end of the port. The barrier creates a room with three exterior walls, a fourth interior wall to shield the entrance, and a partial concrete ceiling of twenty-four inch depth to prevent scatter toward the third floor catwalk. All concrete walls for this enclosure are [redacted]. The second floor acts as the remainder of the ceiling in place of concrete blocks. The ceiling is supported by steel I-beams, which are welded to the inside of the two walls that create the entrance. The entrance is designed to mimic a simple labyrinth with walls on either side to prevent scatter of radiation through the shallow door[redacted] of borated plastic is attached to each side of the walls of the concrete enclosure and each side of the door. One inch of borated plastic is attached to the outside of the ceiling. Further shielding is accomplished through use of a lead shutter and a shield plug.

Each beam port is provided with a dense, removable plug. The plugs are unique to the diameter of the ports. They differ by length, diameter, and weight, but they contain the same essential material. The plugs are aluminum castings filled with ferro-phosphorus concrete except in the end facing the reactor, where this tip is filled with, roughly, [redacted] pounds of lead in the six-inch beam port plug and [redacted] pounds in the eight-inch beam port plug. Each plug is fitted with two conduit lines, each having a diameter of one inch to allow access for instrumentation. These conduit lines spiral around the inside of the plug from end to end in order to prevent direct streaming of radiation.

The beam port shutters have two different sizes as well. Their purpose is to reduce the gamma dose at the experimental side of the port. The [redacted] beam port shutter consists of a cylindrical aluminum shell [redacted] thick, which is [redacted] in diameter and [redacted] in length. This shutter is filled with roughly[redacted] of lead. It's orientation in the shutter housing positions it horizontally so that its[redacted] length is parallel with the port. A [redacted]diameter stainless steel anchor rod and [redacted] anchor pin is driven 4" into the top of the cylinder to connect a steel cable in order to operate the shutter. The shutter for the 8" beam port is nearly identical to the [redacted] beam port shutter with the exception of a few dimensions. It still retains the 9.75" length, but the diameter has increased to [redacted]" and the aluminum cylinder accommodates roughly 244 pounds of lead. The anchor rod has also increased to a depth [redacted]. All the steel cables run through aluminum conduit and terminate at the third floor with a closed spelter socket for lifting.

One of the main radiological considerations with the use of the beam ports is the generation of Argon-41. A vent is shared with the drain line for each beam port. The facilities fan exhausts gases through this line and it is capable of exhausting air at [redacted] cpm. The exhaust fan draws air directly from the ports, and since the shielding structure is not air tight, some air activated in the bunker will diffuse out of the facility. A series of detectors on the experimental level, located both within and in proximity to the beam port facility, measure radiation levels in the area.

10.2.1.1 Beam Port Evaluation

The beam ports, by the use of the shutter and plug assembly in their design, provide the necessary shielding for personnel working on the main reactor floor in and around the beam port. The thimble end of the beam port is seal-welded to the outer tube and no leaks have occurred during the operation history of the reactor. Gas removal and liquid removal capability control the generation of any activated effluents created in the port. The beam port shutter provides the main attenuation of the neutron and gamma radiation beam. Operations procedures detail how these facilities are accessed include: how the shutters can be raised and lowered using a manual crane. In summary, reactor operator procedures are in place and are used to control the opening of each beam port shutter. The radiological safety program is used to set up and test new experiments and associated shielding configurations prior to initial shutter openings during reactor operation. New beam port experimental shield configurations are typically and routinely meter-surveyed at low power levels. Survey results are mapped and documented. Dose assessments are then projected to higher working-power levels and additional shielding is added, if necessary, and controlled areas are defined, marked and mapped before going to the targeted higher working power level(s). A final health physics survey of floor areas in and around the beam port area of the experiment is conducted to assess the previous projections. Periodic health physics re-surveys are conducted and documented to assure that on-file radiation levels remain the same. In addition, all experimental users of beam facilities are required to receive formal radiological training prior to working in these facilities.

10.2.2 Fast Neutron Irradiator

The FNI provides neutrons in the fast energy range for experimental applications. It is an ex-core irradiator that replaced three existing beam ports and pneumatic piping on one side of the reactor core. Major components include an eleven-by-nine grid, shield blocks, a flux-shaping filter, a sample canister, and a guide column. The ex-core facility can be considered as being two assemblies: the support structure and the major elements it supports.

The major elements are arranged in a grid constructed from [redacted] thick aluminum sheet stock configured in a self-supporting manner occupying a [redacted]. The grid forms an [redacted] e [redacted] which holds four components: lead shielding elements, solid aluminum elements, a flux-shaping filter, and the dry sample holder. The dry sample holder sits in the center of the [redacted] occupies a [redacted] The sample holder is surrounded on all sides by lead shielding elements. Each lead shielding element is an aluminum can filled with [redacted] wrapped in a thin sheet of borated aluminum. Three rows of lead shielding elements are established between the nuclear core and the sample holder. The outermost row, located between the nuclear core and the sample holder, is filled with aluminum blocks. The three center grid positions in this row are occupied by a flux shaping filter. The filter is similar in design to the lead shielding elements, except that a single water-filled indentation exists on the front face of the element. The indentation is horizontally offset to accommodate the offset flux profile of the nuclear core.

The support structure starts with the [redacted]” grid, which sits in an aluminum frame that has four aluminum lifting plates welded to the outside. The frame sits upon five 43” long aluminum support columns that have a 4” outer diameter and a [redacted] thick wall. The support columns sit in short couplings at both ends and the bottom end is welded to the base plate. The base plate is a [redacted] thick aluminum plate measuring [redacted] The base plate promotes stability and distributes the weight of the facility uniformly over a greater area.

The sample holder is a large dry canister that occupies a five-by-three region within the FNI grid. The bottom of the canister contains about [redacted] of lead to offset the buoyancy force of the displaced water. A holding rack, placed just above the lead within the canister, is designed to position the samples to the centerline of the core. Thin borated aluminum sheets line the inside walls of the canister to reduce the thermal flux seen by the sample. The cover plate for the sample canister is a [redacted] thick aluminum plate secured with [redacted] titanium bolts and is kept watertight by a gasket. A second plate is furnished with watertight instrumentation ports to allow power to an experiment during the irradiation. Two side lifting plates are utilized for the movement of the canister to the pool surface for insertion and removal of samples and for 180^{o} rotation of the canister at mid irradiation. To provide for easy insertion of the sample canister, an inward-slanting aluminum guide collar is positioned over the shield blocks directly surrounding the sample region.

Some changes, both to the nuclear core and surrounding facilities, were made to provide room for the FNI facility. The inner tube sections of the three beam ports, located in the east side of the pool, were removed from their respective shutter housings. A 1" aluminum plate is bolted to the housing to cap the end. A section of the pneumatic tube that ran from a flange, located below the surface of the water, to the side of the nuclear core was removed and replaced with an aluminum end cap. In-core changes include the removal of graphite reflectors, the addition of lead void elements, and a rearrangement of fuel elements.

The five center graphite reflectors positioned in row A of the core were removed and replaced with five lead/void boxes. The lead void boxes consist of a [redacted] of lead with a center air space all sealed within [redacted] aluminum channel. Hollow rectangular aluminum stock maintains the airspace within the lead walls. The partial fuel elements located in core positions C5 and E5 were switched with full fuel elements located in core positions C3 and E3. This move was necessary to offset the decrease in core reactivity due to the lead void boxes.

10.2.2.1 FNI Evaluation

The FNI has successfully been used for many experiments over the years. Prior to the use of the FNI, appropriate analysis and an experiment review must be performed to satisfy the requirements of the Technical Specifications, operating procedures, 10 CFR 50.59 and other applicable regulations. The experiment review process defines the insertion, removal and radioactive handling procedures, including radiation monitoring, for the specific in-core experiment (See Chapter 11). The analysis demonstrated that the location of the facility, approximately [redacted] the reactor core, and its shielding composition have neutronically decoupled the facility from the reactor core.

Aside from this, only three other issues could be identified that might possibly affect reactivity levels or flux distribution with in the core. 1) Power/flux peaking due to lead void elements: The peak power density in the core increased slightly due to the flux tilting caused by the asymmetric placement of the five void elements and the movement of the partial fuel assemblies. This change was quite small and did not have any impact on the safety analyses performed for the UMLRR with LEU fuel. 2) Reactivity effects due to flooding of a single lead void element: The design of the lead void elements includes an air gap between layers of lead canned in aluminum. If the most reactive element was instantaneously flooded with water, the resulting reactivity worth was computed to be only about 0.20 %Δk/k. This is well below the 0.50 %Δk/k step change included as part of the original safety analysis. Thus, a sudden leak in one of these new elements poses no serious safety concern. 3) Reactivity effects due to movable experiments in the new FNI: Calculations for cases with and without the sample canister present in the facility showed a negligible effect on reactivity, which was below 0.01 %Δk/k. Thus, we cannot envision any situation where normal use of the new experimental facility during power operation will have any significant effect on the core reactivity.

Radiation exposure resulting from use of the FNI facility is limited to canister removal and sample removal from the canister post-irradiation. The design of the sample canister, as well as basic ALARA practices, helps limit dose to sample operators. The approximate outer dimensions of the sample canister are 15” wide by 9” deep by 60” in length. The active sample area is 12” by 12” and is located near the bottom of the canister. When the sample canister is removed from the FNI facility at the bottom of the pool at the end of its exposure, it is pulled close enough to the surface of the pool to reduce exposure to both the core and to the N-16 gammas emitted from the hot leg of the primary piping, but kept far enough below the surface to maintain adequate shielding. It remains suspended in water to allow the aluminum canister to decay. To retrieve the sample, the canister is brought to the surface of the pool, but is never removed entirely from the pool. The canister sits just above the water’s surface upon two support arms secured to the inner pool wall and the vast majority of the canister remains shielded by water. This allows for access to the canister while minimizing dose to the sample operator.

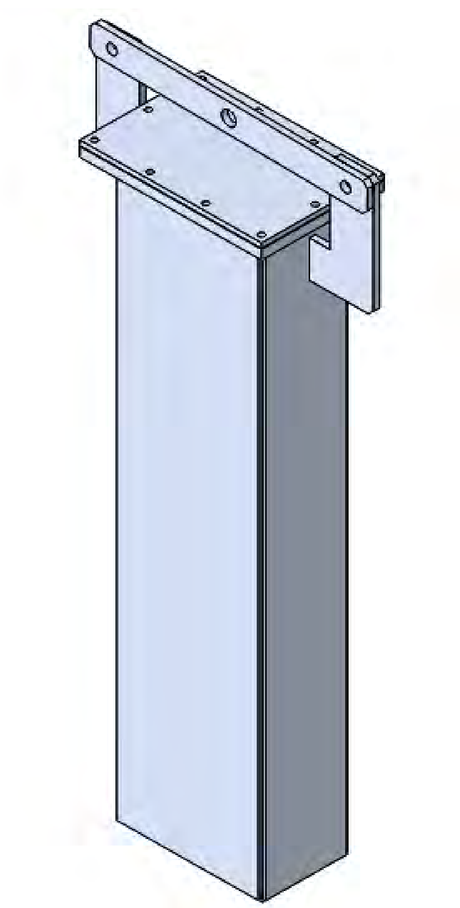


Figure 10-3: FNI Assembly

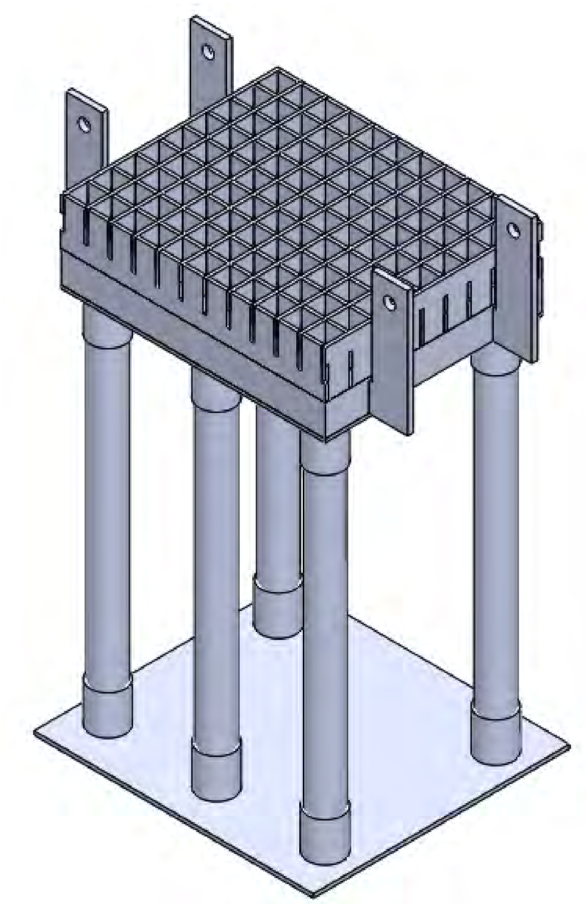
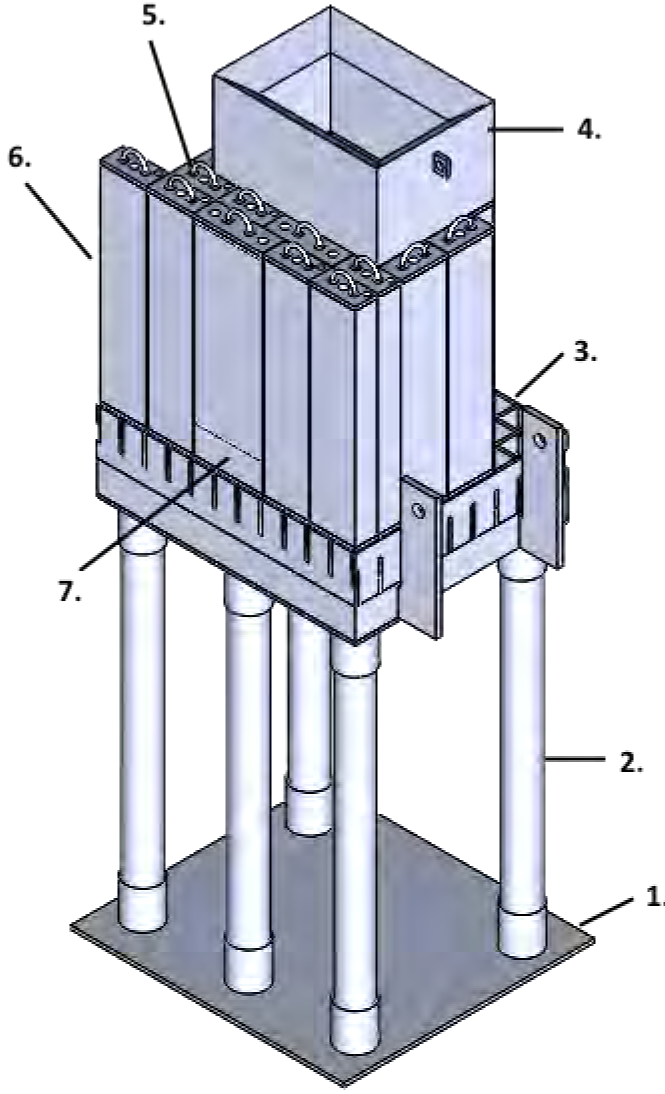


Figure 10-4: FNI Base Assembly



1. Base Plate
2. Support Column
3. Grid
4. Guide Collar
5. Lead Shielding Elements
6. Solid Aluminum Elements
7. Flux-Shaping Filter

Figure 10-5: FNI Base

10.2.3 Gamma Cave

A gamma radiation facility, adjacent to the lower section of the bulk pool, is a "dry room" providing opportunity for bulk irradiation of experiments in air. An appropriate [redacted] by [redacted] foot opening is provided in the pool wall with the center line of the opening directly opposite the center line of the core when in the operating position in the bulk pool. The pool liner is continuous in this area, thus keeping pool water from this facility. In addition, a strengthened aluminum plate is used to reinforce the pool liner at the opening in the concrete. Excluding the 2 by [redacted] foot opening in the wall, the gamma cave area is [redacted]. On the wall opposite the door is a HEPA filter supported by two I-beams. The face of the filter is approximately [redacted] by [redacted] feet and protrudes approximately [redacted] feet from the wall. Air is drawn through the filter by the gamma cave fan located just outside of the cave entrance. The gamma cave fan is capable of exhausting air at [redacted] cfm. Exhaust from this fan is discharged through the Facilities exhaust valve into the main exhaust stack pathway.

[redacted] The [redacted] pounds per cubic foot.

An interlock system, shared with the [redacted] embedment, [redacted] when in use and also acts as a local indicator as to the status of the facility. Immediate access to the gamma is via a [redacted] door. [redacted]. The [redacted]. [redacted]

[redacted]

[redacted] ports are located in the gamma cave walls to accommodate instrumentation; [redacted] All ports are a minimum [redacted] diameter and are stepped to [redacted] inches in the outer walls of the cave to accommodate a large shielding plug and to prevent direct streaming of radiation through the port. Both the port and the plug [redacted] on the port [redacted]. [redacted] eter. To prevent streaming, the conduit lines extend down [redacted] the concrete floor.

One G-M detector inside the gamma cave and one outside the gamma cave, located opposite the door on the containment wall, monitor radiation levels in the area and are part of the safety interlock system. Both detectors are read from the control room and an analog meter, located on the gamma cave gate, indicates if a field is present in the area immediately outside the gamma cave door. A third detector is located on the ceiling outside of the gamma cave door. This detector, primarily, monitors three of the experimental facilities fans, but, due to its proximity to the cave, can be used to monitor the area.

A [redacted] (See LTIR Print 104B1900 Window Plate) with a 3 [redacted] opening in the gamma cave. Welded into the face of this plate, on the pool side, are two hooks. In addition to using the reactor to irradiate samples in this facility, fuel storage racks can be hung from these hooks in order to irradiate via spent fuel elements. In addition to using the reactor to irradiate samples in this facility, the hooks provide a means of securing/supporting frames to seat sources in a repeatable geometry.

10.2.3.1 Cobalt 60 sources

The Cobalt-60 sources utilized in the operation of the UMLRR gamma facilities are primarily Nordion [redacted]. These sources meet or exceed all industry standards and regulatory requirements for sealed radioactive sources, such as: US Nuclear Regulatory Commission 10 CFR Part 36, ISO 2919-1999(E) and the equivalent American National Standard ANSI/HPS N43.6-2007, under performance classification E65646. The sources have dimensions of [redacted]) in length [redacted]) in diameter. These cobalt slugs are double-encapsulated in stainless steel to prevent contamination. Each source has a weight [redacted] and is licensed to have Standard Source Range Activity of Up to [redacted] The illustration below Figure 1-1 depicts the potential geometry that sources can be utilized in.

Figure 10-6: Cobalt-60 Sources and Geometry

10.2.3.2 Gamma Cave Evaluation

The Gamma Cave has successfully been used for many experiments over the years. Prior to the use of the Gamma Cave, appropriate analysis and an experiment review must be performed to satisfy the requirements of the Technical Specifications, operating procedures, 10

CFR 50.59 and other applicable regulations. The experiment review process defines the radioactive handling procedures, including radiation monitoring, for the specific irradiation experiments performed in this facility. Layered safety systems and operational procedures ensure the safe and effective operation of the facility within the applicable regulatory framework.

10.2.4 Hot Cell

The hot cell is located directly above the gamma cave facility. The hot cell is connected to the pool by means of [redacted] port (cavity) in the pool wall. There is a watertight door at each end of the cavity which may be raised or lowered by an operator at the pool surface level. The doors are interlocked in such a manner that only one door can be opened at a time. A [redacted]

Located above the gamma cave, the hot cell has the same [redacted] by [redacted] floor plan, but includes a 13ft high ceiling. The inner surface of the hot cell is lined with [redacted] carbon steel. [redacted] down from the ceiling, a [redacted] recess in each wall, perpendicular to the pool wall, allows an area on which two rails can be secured for the crane. The crane is motorized in all three directions: bridge travel, trolley travel, and hoist travel. An I-beam acts as the bridge for the crane and sits perpendicularly across both rails, riding on four wheels, capable of bridge travel. The crane hoist is suspended from the bridge and is capable of trolley travel along the bridge. The crane hoist uses a stainless steel wire rope with a [redacted]-[redacted] single reeving and has a 1-ton capacity. The crane is controlled by a wall mounted panel located to the right of the viewing window, outside of the hot cell.

Access to the hot cell is provided by a large door. [redacted] having a density of [redacted] pounds per cubic foot. A single steel-lined test port is located through the center of the door with an inner diameter of [redacted] on the inside, stepped to [redacted] starting in the center. The port accommodates a large concrete filled steel plug that provides shielding equivalent to the door. A locking lug on the plug allows it to be padlocked to prevent unwanted removal. Four identical port and plug assemblies are located on the wall under the window. Eight galvanized steel conduit lines, with a [redacted] from the outside of the hot cell to locations on the interior perimeter of the room. To prevent streaming of radiation out of the room, the conduit lines run from the room's exterior to the interior [redacted]

The viewing window allows operators to use the manipulators and crane safely from outside the hot cell. The window is a steel lining stepped down in dimension three times from the interior to the exterior of the room. The interior viewing area is [redacted] and the exterior viewing area is [redacted] The shell is fitted at both ends with leaded glass and oil fills the remaining volume in between. The window is complete with an oil expansion tank located above the window and a drain at the bottom. The window has the radiation attenuation equivalent [redacted] (See LTIR print107C3854 WINDOW).

Located above the hot cell window are two penetrations for the manipulators. The penetrations are [redacted], lined with carbon steel, and are centered to a height of [redacted] of the hot cell floor. Shielding having an equivalent of [redacted] is provided in the penetrations. The penetrations support a pair of standard duty extended reach master slave manipulators capable of performing such tasks as removing objects from the transfer drawer and pneumatic tube receptacle, reaching at least 10" into the transfer port, covering the entire area of the hot cell [redacted] and opening the transfer drawer. The electrical power supply for the manipulators is a 110V single phase 60 cycle source.

A transfer port located in the pool wall allows hot material to be safely transported from the pool to the hot cell. The transfer port is a [redacted] lined with [redacted] steel from the hot cell room through the long inner section of the port, ending at a flange [redacted] the pool. This shell is then flange-bolted to an aluminum section in the pool. The cavity is reinforced from the outside by stainless steel angle. The cavity is sealed on both sides by two watertight gates. One gate is located in the pool, centered above the gamma cave window. The inside of the gate perimeter is lined with a neoprene rubber p-shaped or bulb seal. The pressure of the water acting against the gate maintains watertight seal. The gate is held in place by and moves along the gate guide, which is a frame composed of aluminum angle, attached stall pool's interior walls. A handle located above the surface of the water allows access to the gate. The second gate is located between the hot cell room and the

10.2.4.1 Hot Cell Evaluation

The Hot Cell has successfully been used for many experiments over the years. Prior to the use, appropriate analysis and an experiment review must be performed to satisfy the requirements of the Technical Specifications, operating procedures, 10 CFR 50.59 and other applicable regulations. Appropriate radiation monitors, barriers and visual alarms are present to alert experimenters and operators of the presence of open beams that may be in use. Physical access is limited to this area to ensure personnel safety. A health physics survey of floor areas in and around the area is conducted to assess the facility radiation fields. Periodic health physics re-surveys are conducted and documented to assure that on-file radiation levels remain the same. In addition, all experimental users of facility are required to receive formal radiological training prior to working in the facility.

10.2.5 Medical Embedment

The medical embedment consists of a [redacted] chamber that extends through the wall in the bulk [redacted] It is centered to the reactor when the core is positioned in this section of the pool. The total length of the chamber is [redacted] at a flange on each end. The flange that exists on the interior of the pool terminates 3” beyond the pool wall. The interior surfaces of the medical embedment are made [redacted] the concrete, provide reinforcement. The brackets are welded on all four sides in two locations along the length of the chamber. Shielding is provided by a concrete wall on a moveable pallet positioned in front of the flange in the [redacted]. Steel tracks attached to the floor provide a strong, smooth surface for the pallet to transit along as well as a lip on the inner edge of each track in order to maintain proper alignment of the shield relative to the face of the medical embedment.

A wall extending from exterior pool wall to the inner containment wall creates a barrier in order to reduce access to the facility. Access is maintained by a set of [redacted], which are both [redacted] [redacted] The [redacted] is part of the [redacted] interlock system.

REDACTED FOR PUBLIC RELEASE

10.2.5.1 Medical Embedment Evaluation

The Medical Embedment has successfully been used for many experiments over the years. Prior to the use, appropriate analysis and an experiment review must be performed to satisfy the requirements of the Technical Specifications, operating procedures, 10 CFR 50.59 and other applicable regulations. Appropriate radiation monitors, barriers and visual alarms are present to alert experimenters and operators of the presence of open beams that may be in use. Physical access is limited to this area to ensure personnel safety. A health physics survey of floor areas in and around the medical embedment area is conducted to assess the facility radiation fields. Periodic health physics re-surveys are conducted and documented to assure that on-file radiation levels remain the same. In addition, all experimental users of facility are required to receive formal radiological training prior to working in the facility.

10.2.6 N-16 Irradiator

The N-16 Irradiator provides high energy gamma radiation for experimental purposes. The irradiator is an ex-core facility which uses radioactive N-16 in [redacted] The facility is located outside of the pool at the end of the stall pool on the third floor of the containment building.

When the reactor is operating in forced cooling mode, primary coolant that exits the core is pumped from the chemical addition lines through PVC pipe to an inlet located on the bottom section of a large diameter aluminum cylinder. The water then exits the cylinder from an outlet at the top, returning to PVC piping as it is discharged into the pool at a depth of one foot below the water's surface.

The cylinder, when filled with activated primary water, acts as the source in this facility. The cylinder creates a planar array measuring 18" in diameter and [redacted]pth. It is aligned and shielded such that [redacted] diameter surface creates a horizontal beam facing the Rat Hole. The cylinder is made of a thin gauge aluminum stock welded at the seams.

When the primary pump is on, the water level in the chemical addition line decreases by about [redacted] feet. The PVC pipe that draws activated primary coolant into the experimental facility extends down [redacted]" from the cap on the top of the chemical addition line. At this depth, it is well below the water level when the primary coolant pump is on, but it is not so low that it

REDACTED FOR PUBLIC RELEASE

obstructs the flow of water at the junction in the coolant lines as the primary is pumped through the nuclear core. A check valve on the upper end of this feed line just above the primary siphon breaker/vent eliminates the need to prime the facility pump.

Since the facility is located just outside of the pool, the pool wall is utilized for shielding on one side. The remaining sides are enclosed in concrete block draped with lead blankets providing a layer of lead on each side of the concrete. The top of this small enclosure is shielded with lead blankets supported by aluminum stock. The rear face of the cylinder with the input and output penetrations is shielded by a 0.5" thick sheet of lead.

10.2.6.1 N-16 Evaluation

The only controls for the facility are a switch to activate the pump and a throttle valve to adjust flow rate. The switch is located just outside of the shielding enclosure. To reduce time spent in this area when activating the pump, a check valve on the feed line eliminates the need to prime the system, thereby reducing exposure to personnel.

Radiation detectors in proximity to this facility include an ion chamber located under the bridge near the discharge line and a GM located on the wall opposite the cylinder. The ion chamber signal is read from the control room and is part of the radiation monitoring system (RMS). The GM is read locally only. Use of the N-16 system is controlled by operating procedures and the facility radiation safety program.

10.2.7 Pneumatic Tube System

The pneumatic tube system quickly moves small experimental samples, packaged in plastic carrier capsules, from a remote station in the basement of the facility to a terminal located in the flux region adjacent to the nuclear core. This experimental facility allows irradiation of samples for short, controllable periods, after which, they are conveyed to a receiving station. An auto timer is available to recall the sample after a set amount of time. The core is required to be in the stall pool position for use of this facility.

Two pneumatic tube systems were included in the original facility design. Station 1 was removed from operation in 2001 to accommodate a fast neutron irradiation facility. The receiving station for this non-operational unit is located next to the elevation on the first floor. The service tubes are all still in place for this unit with the exception of one section, which was previously located in the pool. This section of tube, at one end, held the terminal located in the flux region adjacent to the nuclear core. The opposite end of this tube was flange-coupled to a tube that penetrated the stall pool wall below the surface of the water. A plate is currently bolted to this flange to prevent pool water from draining. The current pneumatic tube system includes the following:

1) Control System – The control system consists of touch screen interface with redundant manual controls. The touch screen indicates the status of the pneumatic tube exhauster and location of the sample when in use. The exhauster must be energized by an operator in the control room. The controller options on the touch screen include a MANUAL DISPATCH selector, MANUAL RETURN selector, the AUTO TIMED mode, and… Additionally, a digital wall-mounted area radiation monitor with internal scintillator detector has been mounted alongside the cabinet, above the receiver station. In addition to a read-out on the monitor, the touch screen provides a trend of the monitor reading. The manual controls are as follows:

   VACUUM – energizes the windgate control valves for air flow direction

   DIRECTION – controls air flow either to the nuclear core or to the receiving station

   CONTROL -

2) CENTRIFUGAL EXHAUSTER – A centrifugal exhauster provides the means of creating system vacuum. The speed of the exhauster is variable, allowing the vacuum to be adjusted, thus providing a means of controlling the carrier capsule speed. The exhauster is rated at approximately 230 cfm at 5 in. Hg. The exhauster is connected directly to a drip-proof induction motor rated at 5 hp, 3600 rpm, and operating from a 220/440, 3-phase, 60 hz source.
3) WIND GATE CABINET– A solenoid-operated wind gate cabinet provides the means of changing the direction of air flow, and thus the means of determining direction. The wind gate cabinet operates from a 115-volt, single phase, 60 hz source.
4) SLIDE-GATE VALVES – Four manual slide gate valves (siphon breakers) are located in all lines immediately exiting the reactor pool.
5) TRANSIT TUBING – The transit or carrier guide tubes are formed of 2.5 inch outer diameter, No. 20 BWG (0.035) galvanized steel for all length outside the pool wall.

6) RECEIVERS – Two lead-lined sealed receivers are provided at two receiving stations. An additional receiver (short-chute) is provided in the hot cell. The receivers are utilized to perform the carrier recovery function.
7) DEFLECTOR – One horizontal deflector is provided in the transit tubing of one side of the dual system. The deflector functions to direct the rabbit to the hot cell of to one of the receiving stations as desired.

Lead-lined receivers minimize dose to sample operators. Receivers are lined with approximately [redacted] [redacted] of lead. In addition to the scintillator detector located above the receiver, two other detectors are associated with this facility. One Geiger-muller detector is located near the receiver station and another is located in close proximity to the HEPA filter, centrifugal exhauster, and windgate cabinet. Both detectors are read from the control room. The main radiological concern here is the activation of argon in the air. The centrifugal exhauster, in addition to providing the means of creating a system vacuum, removes air from this facility, passing it through a HEPA filter before exhausting it through valve D (Facilities valve) of the ventilation system.

The transit tubing consists of galvanized steel for all sections excluding those penetrating the pool wall and those submerged in water. Outside of the pool, just before penetrating the pool wall, the galvanized steel section is flange coupled to the aluminum section. The aluminum section penetrates the pool wall at a depth which lies, roughly, [redacted] [redacted] below the water's surface. At [redacted] feet below the water's surface, this section of tubing is flange-coupled to the final section, which ends with the terminal located in the flux region near the nuclear core.

10.2.7.1 Pneumatic Tube Evaluation

The system has operated successfully from the initial license. The reactor facility has added a "sample" hood in the reactor room for experimenters to transfer and open samples from the receiver to allow transport of samples to the facility laboratories. The hood is vented through a HEPA filter exhausting in the facilities exhaust system, in case of sample spillage or gaseous release. The pneumatic tube system is the most used experimental device for neutron activation. The receiver shielding limit the personnel radiation levels. Use of the pneumatic system and the type of materials irradiated are controlled by operating procedures and the facility radiation safety program.

10.2.8 Radiation Basket

Radiation baskets provide chambers for in core radiation experiments. The bottom section of the basket, referred to as the end box, is designed to fit into the core grid, allowing it to be placed in any core location.

The radiation basket is an aluminum element with an overall length of [redacted] The upper section is a [redacted] square channel referred to as the shell. The shell is roughly [redacted] in length with walls [redacted] thick and a plate welded over both ends. A tube of the same length extends down the shell and is held in place by the end plates to which it is attached. The end plates are open to the inner diameter of the tube. The inner and outer diameters of the tube measure 1.875" and 2" respectively. It is this tube in which samples are inserted for test purposes. The space between the tube wall and the square channel is typically filled with water when submerged in order to offset buoyant forces. Below the shell is the end box. In addition to allowing the radiation basket to be positioned in any core grid location, the end box contains a lifting rod to facilitate handling and lifting. Located 31" down from the element's top plate, the lifting rod is welded across the diameter of the end box. End box construction is uniform for all radiation basket elements.

In total there are three different kinds of Radiation Baskets they are as follows:

Water Radiation Basket (WRB): These elements are primarily used in the core periphery. This basket is not readily suitable for use as in the D5 core position, since it increases the local power peaking in the nearby fuel elements and it has a relatively large reactivity effect on the core. In addition, there is significant concern with the large positive worth associated with insertion of an experimental bayonet into D5 for the WRB design, which is roughly 3-4 times that seen in the reference design. It should be noted that, because D5 represents a high worth location, no movable experiments are allowed in this position.

Graphite Radiation Basket (GRB): The graphite design was originally selected since it minimized power peaking in the nearby fuel relative to a regular water-filled radiation basket. This graphite radiation basket is nearly identical to the water-filled one. This type of radiation basket is filled with graphite in the volume between the tube and the shell. The shell wall in the graphite radiation basket is thinner at 0.040".

Aluminum Radiation Basket (ARB): The third type of Radiation Basket uses aluminum in place of graphite it has a slight negative reactivity effect relative to graphite; however, aluminum tends to reduce the flux peaking seen in the neighboring fuel elements similar to graphite and it also has bayonet worth effects similar to graphite. This type of basket is illustrated in Figure 10-7.

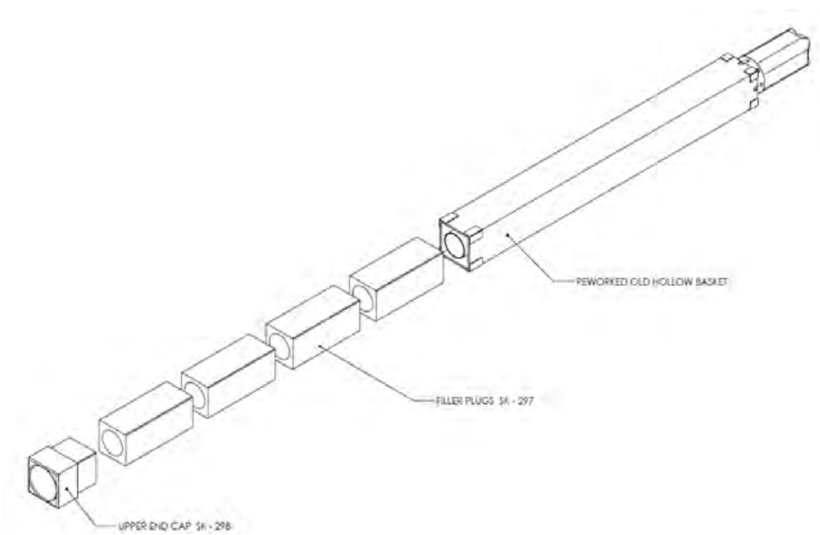


Figure 10-7: Aluminum Filled Radiation Basket

10.2.8.1 Radiation Basket Evaluation

The radiation baskets have successfully been used for many experiments over the years. Prior to the use of any of the baskets, appropriate analysis and an experiment review must be performed to satisfy the requirements of the Technical Specifications, operating procedures, 10 CFR 50.59 and other applicable regulations. The experiment review process defines the insertion, removal and radioactive handling procedures, including radiation monitoring, for the specific in-core experiment (See Chapter 11).

10.2.9 Thermal Column

The thermal column provides neutrons in the thermal energy range for experimental application. The thermal column is comprised of two separate assemblies. One assembly, a 4 by 4 foot square column is embedded within the reactor pool biological shield. The other assembly, the thermal column extension, is located between the pool liner and the nuclear core, and is supported by a structural aluminum member which is firmly attached to the pool structure.

The pool liner is continuous in front of the thermal column penetration of the pool wall, and the pool liner is reinforced at the opening by a [redacted] inch thick aluminum plate. The center line of the thermal column is aligned with the center line of the core when the core is located in the stall pool. A lead gamma shield, [redacted]", thick is located on the front end of the thermal column extension, facing the nuclear core. It is cooled by natural convection to the pool water and consists of a [redacted] inch thick lead slab clad in aluminum. The remainder of the thermal column extension consists of closely packed graphite blocks encased in aluminum. The blocks are of three different dimensions and resemble square posts aligned vertically in the aluminum casing. The graphite is nuclear grade.

The thermal column case, a [redacted] embedded column, is filled with graphite. This section exists in the biological shield and extends to the pool liner. The graphite stringers are removable to provide for experimental samples. A [redacted] foot deep experimental air chamber between the face of the graphite and the thermal column door provides location for air, water, and electrical service connections to the biological shield face. Two 3 inch aluminum ports are located in the upper walls in this air chamber. They bend at [redacted] degrees and end at the face of the biological shield. A third aluminum port with a 4 inch diameter is located in the ceiling of air chamber. It extends straight up, ending in the floor of the biological shield extension. A line common with other facility vent lines is located in the floor at front center of the graphite, and serves as a drain and ventilation line to remove condensation and radioactive gases. A scram interlock prevents reactor operation when the thermal column door is opened.

The section embedded in concrete is encased in a double shell through which cooling water passes by natural convection. Heat removal from the thermal column must be satisfactory to hold the graphite below that which would have any deleterious effects on the graphite of its container.

A heavy, steel thermal column door, roughly [redacted] feet wide and [redacted] feet tall, is provided as a shield to protect operating personnel against gamma radiation. The door is [redacted] and its rear face is plated with a [redacted] Boral sheet. The thermal column door moves on rails, set into the concrete floor perpendicular to the shield face, by means of a 110 volt, single-phase, 60 hz, 0.5 hp ratiomotor, which drives two of the four door wheels. The drive motor is operated with a door-mounted starter switch. The drive motor will move the [redacted] ton door at a rate of [redacted] in

REDACTED FOR PUBLIC RELEASE

either the open or closed direction. Four access ports are provided in the face of the door, horizontally centered to the nuclear core. Each port is fitted with four separate steel plugs. Each plug is drilled and tapped to accommodate a plug removal tool, which is used to insert and remove plugs. The [redacted] are [redacted] in diameter through the front face and most of the way through the door, then narrows to 6” in diameter near the rear.

One of the four ports located in the thermal column door has been fitted with a pneumatically actuated thermal neutron shield. The shield is a borated aluminum plate capable only of minimizing dose in the area of the thermal neutron beam for quick and immediate access to samples. A large movable shield has been built for this facility. It consists of concrete block and borated polyethylene bound to an aluminum base with wheels so it can move along the same rails on which the thermal column door moves. The main radiation detector associated with the thermal column is a GM detector located opposite the thermal column door on the wall of the containment building. In close proximity are two constant air monitors, one of which reads in the control room.

10.2.9.1 Thermal Column Evaluation

The Thermal Column (TC) has successfully been used for many experiments over the years. Prior to the use of any of the TC, appropriate analysis and an experiment review must be performed to satisfy the requirements of the Technical Specifications, operating procedures, 10 CFR 50.59 and other applicable regulations. Appropriate radiation monitors, barriers and visual alarms are present to alert experimenters and operators of the presence of open beams that may be in use. Physical access is limited to this area to ensure personnel safety, in addition, a reactor manual scram is located adjacent to this facility should circumstances warrant an immediate reactor shutdown. A health physics survey of floor areas in and around the thermal column area is conducted to assess the facility radiation fields. Periodic health physics re-surveys are conducted and documented to assure that on-file radiation levels remain the same. In addition, all experimental users of thermal column facility are required to receive formal radiological training prior to working in the facility.

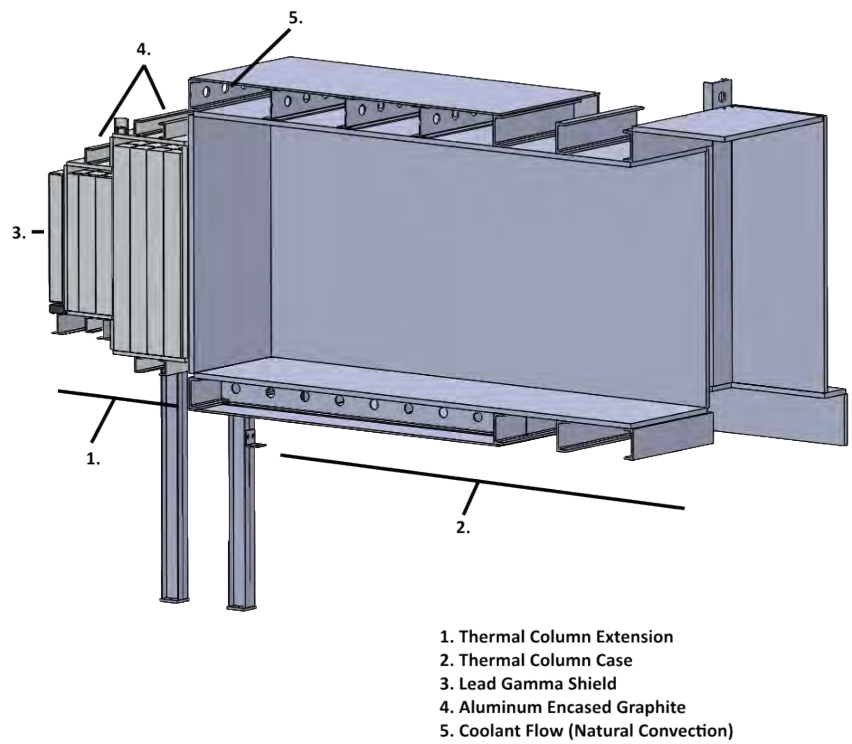


Figure 10-8: Thermal Column Details

10.3 Experiment Review

The Reactor Safety Subcommittee (RSSC) is responsible for the review and approval of all proposed tests and experiments using the reactor facilities. All proposed experiments are initially evaluated by the experimenter and a staff member approved by the RSSC. The evaluation includes the following considerations:

1) The reactivity worth of the experiment, which must be no greater than 0.5% k/k
2) The integrity of the experiment, including effects of changes in temperature, pressure, or chemical composition
3) Any physical or chemical reaction or interaction that could occur with reactor components
4) Any radiation hazard that may result from activation of the materials from external beams

The initial evaluation is reviewed by the Reactor Supervisor and the Radiation Safety Officer. If the experiment meets their approval and complies with the provision of the utilization license, the Technical Specifications, and 10CFR20, it is

a. Submitted by the Reactor Supervisor to the RSSC for approval if it is a new experiment or involves a safety question not yet reviewed by the subcommittee, or,
b. Scheduled with the Reactor Supervisor's approval if it is a routine experiment.

If the experiment is submitted to the RSSC for evaluation, the following aspects are considered:

a. The purpose of the experiment.
b. The effect of the experiment on reactor operation and the possibility and consequences of failure of some aspect of the experiment, including, where indicated of significant, chemical reactions, physical integrity, design life, proper cooling interaction with core components, radiation and reactivity effects.
c. Whether or not the experiment, by virtue of its nature and/or design constitutes a significant threat to the integrity of the core, the integrity of the reactor, or to the safety of personnel.
d. A procedure for the performance of the experiment.

A favorable RSSC evaluation must conclude that failure of the experiments will not lead to direct failure of any reactor component or of other experiments. No experiment may be conducted until a favorable evaluation indicated in writing is rendered by the RSSC.

If an experiment has had prior RSSC approval, it becomes a routine experiment. A routine experiment or a minor variation to a routine experiment with no significantly different safety questions may be done for the RSSC by agreement of the Reactor Supervisor and the Radiation Safety Officer.

Limitations governing the use of materials installed in the reactor and associated experimental facilities are necessary in order to avoid damage to the reactor or an excessive or undesirable release of radioactive materials in the event of failure of that experiment. To prevent direct interference with reactor operations, experiments are limited to exclude materials and apparatuses that cause rod shadowing and prevent the safe operation and shutdown of the reactor. Explosive material is not prohibited, but it is limited in quantity so that failure of the experiment does not result in damage done to the reactor, any reactor component, or to the Co-60 source. Corrosive materials are required to be doubly encapsulated in order to prevent interaction with reactor components and reactor pool water. Chapter 14, Technical Specifications, lists specific exclusions for experiments using the reactor and Co-60 source.

Table of Contents

Table of Figures

Table of Tables

REDACTED FOR PUBLIC RELEASE

11 Radiation Protection Program and Waste Management

11.1 Radiation Protection

Radiation sources at the University of Massachusetts Lowell (UML) are regulated by the U.S Nuclear Regulatory Commission (NRC) and the Commonwealth of Massachusetts Department of Public Health. Radiation protection oversight of the UML Research Reactor (UMLRR) license activities is provided by the Radiation Safety Program (RSP) which is a section of Environmental and Emergency Management (EEM). The RSP is made up of a Director of Radiation Safety (DRS) who is the acting Radiation Safety Officer (RSO) and a Radiation Safety Specialist (RSS). The director reports to the Director of EHS, who reports up through to the Vice Chancellor for Finance and Operation. The reporting chain varies for the Reactor Supervisor who reports up through to the Vice Provost for Research.

The Chancellor of UMass Lowell appoints the members of the Radiation Safety Committee (RSC). The RSC is responsible for assuring that an adequate safety program is developed and implemented within the university and publicizes campus radiation safety policy, regulations, and procedures. The RSC is responsible for annual review and audit of the UML RSP. Under the RSC a Reactor Safety Subcommittee is appointed and has the responsibility to review the safety aspects of the UMLRR.

11.1.1 Radiation Sources

The RSP here at the UMLRR oversees all radioactive sources. The radioactive sources include airborne, liquid, and solid which are described in more detail in the following sections. As is common with research reactors, the main airborne source concern is Ar-41 closely followed by N-16. The production of Ar-41 is mainly due to neutron activation in the beamport

REDACTED FOR PUBLIC RELEASE

facility and dissolved air in the primary coolant. N-16 is produced by a neutron activation of the oxygen in the primary coolant water. Solid sources present at the UMass Lowell Research reactor include irradiated and unirradiated fuel elements, start–up sources, sealed check sources, fission chambers, Co-60 irradiators, and solid radioactive waste. Table 11-1 and Table 11-2 below summarize the solid radioactive material present.

Table 11-1: All Standard, Check and Startup Sources at UMLRR

Source Description	Radionuclide	Principal Radiation	Activity	Physical Form	Seal or Unsealed
HP-4	Cs-137	γ	7.17 mCi on 3/18/1981	Solid encapsulated in stainless steel	Sealed
HP-3	Co-60	γ	0.532 mCi on 11/1/1988	Solid encapsulated in stainless steel	Sealed
NuMec 442	Pu-239	α,n	2 Ci on 10/25/2002	Solid encapsulated in stainless steel	Sealed
NuMec 372	Pu-239	α,n	1 Ci on 12/27/1978	Solid encapsulated in stainless steel	Sealed
MRC-AmBe-1737	Am-241	α,n	4.93 Ci on 10/1/1973**	Dually encapsulated in stainless steel	Sealed
SbBe Startup	Sb-124	γ,n	10 Ci FSAR	Encapsulated in aluminum jacket	Sealed
Cobalt-60 Pencils	Co-60	γ	66,730 Ci on 3/18/2014	Pencils encapsulated in stainless steel	Sealed

Table 11-2: Fissile and Fertile Material at UMass Lowell Research Reactor

Source Description	Type	Amount	U-235 (g)	Total U (g)
Unirradiated Fuel Elements	U_3Si_2Standard	8	1,600	8,080
	UAlx Standard	4	668	3,384
	UAlx Removable Plate	1	167	846
Elements in Core	U_3Si_2Standard	19	3,800	19,190
	U_3Si_2Partial	2	224	1,138
Usable Irradiated Elements in Storage	UAlx Standard	21	3,507	17,766
	UAlx Removable Plate	1	167	846
Spent Fuel Elements	None	N/A	N/A	N/A
Fission Chamber	Description	1or more		

REDACTED FOR PUBLIC RELEASE

11.1.1.1 Airborne Radiation Sources

The production of Ar-41 is mainly due to neutron activation in the beamport facility, pneumatic rabbit facility, and dissolved air in the primary coolant. N-16 is produced by the neutron activation of oxygen in the primary coolant water. The airborne waste handling systems are designed to prevent production and/or release of airborne radioactive wastes in amounts, as indicated in 10 CFR part 20, which would result in doses to individuals in the reactor containment building and in the external environs in excess of applicable limits. The continuous active venting of certain reactor facilities prevents the unwanted accumulation of possibly high concentrations of radioactive gaseous waste. The ducts, blowers, filters, and vents which direct and filter gaseous flow throughout and out of the Containment Building are described in Chapter 9. Chapter 10 provides further information for all of the experimental facilities.

11.1.1.1.1 Release Points

The thermal column case vent, the beamport and unused medical embedment drain line vents, and the pneumatic tubes will be exhausted continuously under typical operating conditions. The air mover providing common exhaust for the thermal column, beam tubes, and medical embedment is rated at 600 cfm; the pneumatic tube exhaust fan is rated at 230 cfm. The gamma cave and hot cell exhausts, provided by independent 600 cfm blowers, operate when these facilities are in use or as otherwise considered appropriate. All the above facilities exhausts are vented through a common duct to the main building exhaust line outside the reactor building. In order to reduce Ar-41 production, the core end of the beam ports are plugged with hollow, closed end plugs filled with nitrogen.

The emergency exhaust system will operate automatically under conditions specified in Chapter 6. It is also subject to manual operation, for instance, in a situation where it might be considered desirable to reduce airborne radioactivity levels by exhaustion, although the containment buildings internal pressure status does not demand automatic initiation of the system. The emergency exhaust blower is rated at 320 cfm and delivers exhaust via a duct to the main building exhaust line outside the building.

Appropriate filters, as indicated in Chapter 9, are in place when any of the exhaust systems described are in operation. The only design vents, which open to the atmosphere by routes other than the reactor stack, are the acid vent from the basement area and the sanitary

REDACTED FOR PUBLIC RELEASE

system vent from the control room. Both of these valves operate automatically in the ventilation containment system, and neither of these vents delivers any significant radioactive gaseous waste to the environment. The double airlock doors, which allow normal entrance and egress to and from the containment, provide additional pathways to the external atmosphere via the [redacted] Building, but the extent of containment air venting to the atmosphere by this route is negligibly small.

11.1.1.1.2 Performance Tests

Airflow rates in the facilities exhaust systems and in the emergency exhaust system, as well as stack flow rates, are measured at regular intervals as required by Technical Specifications. Filters in facilities exhausts and the emergency exhaust system are subjected to appropriate particulate penetration tests or replacement at regular intervals as specified in the Technical Specifications (Chapter 14, TS 4.5.2).

Two continuous air monitors in the reactor building and the stack air monitor continuously respond to the airborne radioactivity levels in the reactor building and in the stack effluent, thus providing a mechanism for noting possible failure or fault in the performance of certain gas waste removal systems.

11.1.1.1.3 Ar-41 Release

The Ar-41 release rate has been measured inside the stack with the reactor operating at 1 MW and the pneumatic and facilities fans discharging air from the pneumatic tube and the beam ports. The Ar-41 release rate was determined to be 15.7 μCi/s with both fans operating and 11.9 μCi/s without the fans running, representing the steady state concentration inside the reactor building. During reactor operations the containment building pressure must be maintained below ambient atmospheric pressure using the normal ventilation system in accordance with Technical Specification (TS) 4.4.

In order to estimate bounding dose levels from the normal operation of the facility, different scenarios are considered for the facility personnel and members of the public. In deriving dose estimates for facility personnel, it is assumed that the reactor is operating at 1 MW for a period of 2,000 hours that is consistent with 10 CFR Part 20 Appendix B. Dose estimates for members of the public are derived using a yearly, continuous exposure with the reactor operating at 1 MW full power.

Scenario A – Reactor Building Interior

The measured Ar-41 production rate in the building is 11.9 μCi/s and the main ventilation exhaust discharge rate is 7.1 m^3/s. Using the containment volume of 9,486 m^3 and considering the decay of Ar-41 (half-life 109 minutes), the steady state Ar-41 concentration level inside the reactor building is calculated as 1.4×10^{-6} $\mu Ci/cm^3$. The maximum air concentration limit for occupational workers is established in Table-1 of Appendix B, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage," to 10 CFR Part 20 at 3.0×10^{-6} $\mu Ci/cm^3$. The DAC concentration limit corresponds to a 5 rem occupational dose for an individual worker assumed to be exposed to the limiting DAC continuously for 2,000 hours with the reactor at full power.

Facility personnel are exposed inside the reactor building from the finite, hemispherical cloud of uniformly distributed Ar-41 in the air. The bounding analysis for the maximum facility worker exposure shows that the total radioactivity concentration of 1.4×10^{-6} $\mu Ci/cm^3$ is below the DAC limit of 3.0×10^{-6} $\mu Ci/cm^3$ and, therefore the occupational radioactivity dose levels are below the 10 CFR Part 20 limit of 5 rem (0.05 Sv).

Scenario B – Personnel Access Doors and Truck Door

The containment has two airlocks at the first and third floor connecting it to interior floor areas inside the adjacent [redacted] building. There is also a 12'x10', 3/8" thick truck access metal door facing the adjacent parking lot. The outside of the roll-up door is not considered a controlled area and potentially accessible to members of the public (see Section 13.2.1 on MHA for additional details).

The access points inside the [redacted] building [redacted] doors and the outside of the [redacted] are considered radiological unrestricted area and the public dose must remain below the regulatory limits in 10 CFR Part 20.1301 "Occupational dose limits for individual members of the public," that specifies a TEDE limit of 100 mrem (1 mSv). The radiation exposure is due to gamma radiation of the decaying Ar-41 isotope through the containment walls and access points (i.e., airlocks and truck access door).

The potential direct exposure from Ar-41 in the reactor bay to a person located at the above locations was developed using an MCNP model (see Section 13.2.1 on MHA). The entire reactor building is assumed to be filled with Ar-41 at a concentration of $1.4x10^{-6}$ µCi/cm^3. The calculated doses are shown in Table 11-3 assuming that an individual is located at the specific location for one full year with the reactor operating at full power. The highest dose of 1.4 mrem (.014 mSv) is at the truck access door well below the regulatory limit of 100 mrem (1 mSv).

Scenario C – Public Areas outside Containment

The operating ventilation system facilitates the removal of Ar-41 through the building exhaust system limiting Ar-41 dose to facility workers. The reactor building interior, beam ports and pneumatic facility exhaust air are combined and vented to the atmosphere through the 30.5m(100 ft) high building stack. The Ar-41 release rate was measured at 15.7 µCi/s with the pneumatic and facilities fans operating with the reactor at 1 MW power. With the continuous use of the pneumatic fans and facilities fans the gaseous release of Ar-41 is 15.7 µCi/s. With this rate and a flow rate of 15,000 ft^3/min (7.1 m3/s) from the 100 ft reactor stack results in a concentration of 2.28×10^{-6} µCi/mL exiting the stack. The annual release of Ar-41 is calculated assuming continuous year round operation, which is unrealistic, but useful for estimating a bounding dose limit resulting from a hypothetical annual release of 494.6 Ci per year.

The dose to a member of the public, due to this level of Ar-41 airborne concentration, was conservatively calculated assuming that the person stands at the point of maximum exposure continuously for the year and immersed in the Ar-41 cloud. The stack release is analyzed by HotSpot, an atmospheric dispersion code that provides a first-order approximation of the radiation effects associated with the atmospheric release of radioactive materials. Even though the code is primarily used for short-range (less than 10 km), and short-term (less than a few hours) predictions, an approximation method is available to estimate long-term effects (see Section 13.2.1 on MHA for more details).

The dose estimate is obtained by using a weather pattern that is reflective of historical meteorological data calculating percentile doses up to 16 wind direction sectors. The computer model assumed Pasquill stability class F (moderately stable) with the historical wind speed data. Wind rose data shown on Figure 11-1 was taken at Hanscom Air Force Base in Bedford, MA for the year 2013.

Additional confirmatory analyses were performed using the EPA COMPLY computer code verifying the HotSpot calculated dose values. The COMPLY analysis assumed a typical Gaussian atmospheric plume dispersion with site specific average meteorological data to derive downwind concentration and dose values due to the measured Ar-41 effluent release rates. All parameters including stack height, terrain, wind speed, and directions were consistent between the two models.

The Total Effective Dose Equivalent (TEDE) for the HotSpot and COMPLY calculations are shown in Table 11-4. Figure 11-1 depicts historical wind rose data while Figure 11-2 depicts the HotSpot isopleths using the historical wind rose data. The maximum public TEDE (HotSpot) of 7.2 mrem (.072 mSV) is ~1800 m (~1 mile) away from the containment for a full year exposure.

The EPA COMPLY program calculated the maximally exposed receptor location at 500m (~0.3 mile) with a dose of 0.6 mrem. The difference between the two dose estimates and maximum dose rate locations are due to different modeling methodologies and are not substantially different for these types of analyses.

The above bounding analysis demonstrates that the dose to the member of the public due to routine airborne Ar-41 effluent releases from the UMLRR during normal operations do not present a significant exposure hazard and the TEDE levels for all locations are well below the 10 CFR Part 20.1301 limit of 100 mrem.

Table 11-3: Access Door TEDE

Location	Ar-41 TEDE (mrem)
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

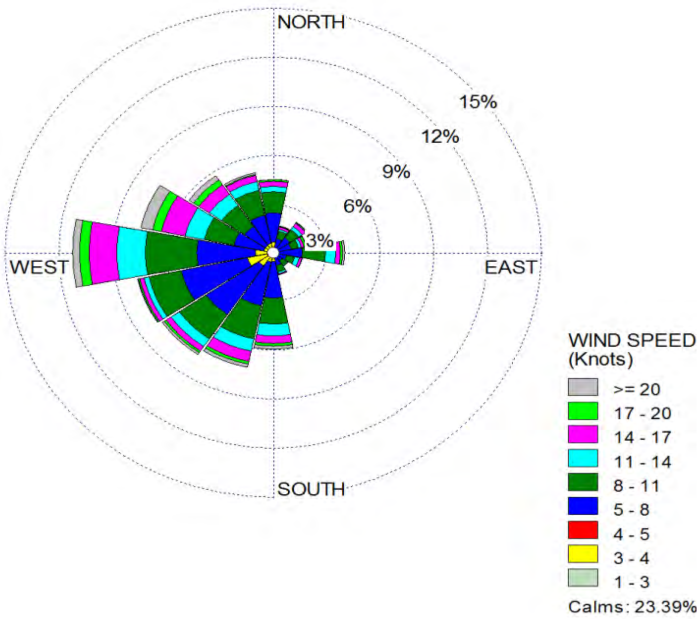


Figure 11-1: 2013 Wind Direction Distribution for Hanscom Air Force Base

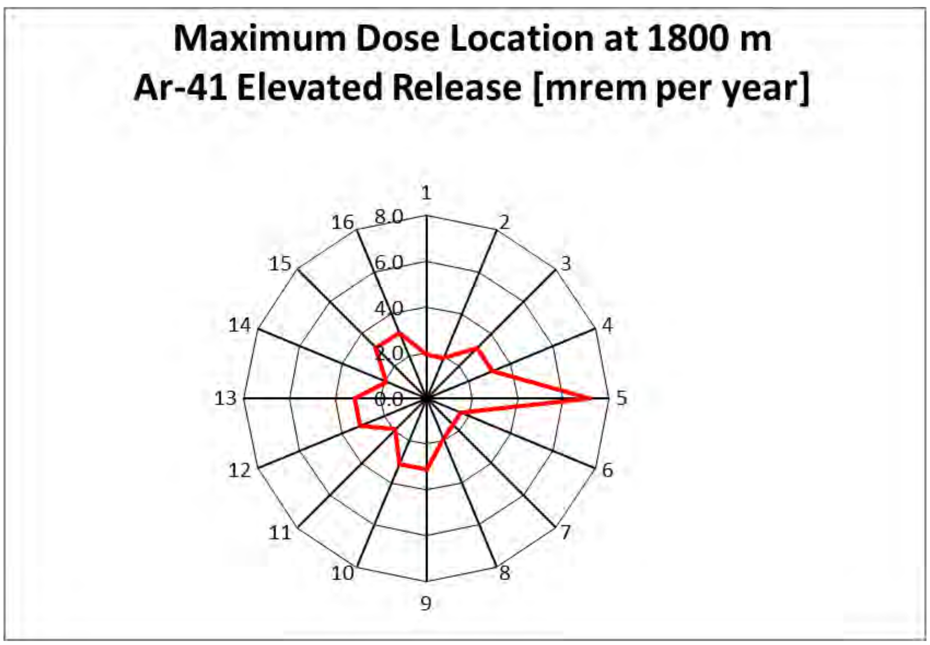


Figure 11-2: Ar-41 Elevated release, TEDE isopleths – HotSpot results

Table 11-4: Stack Release TEDE

Location	Ar-41 TEDE [mrem]
[redacted]	

11.1.1.2 Liquid Radioactive Sources

The release of liquid radioactive waste to the environment is via the sanitary sewer system and therefore is limited to the conditions set forth in 10CFR-20.2003. The annual average gross beta release quantity is [redacted]/yr. This is based on actual releases over the past 5 years (5 year totals = [redacted]Ci in [redacted] cm^3 liquid).

11.1.1.2.1 Release Point

The outlet to the sanitary sewer system is located in the liquid radioactive waste storage room. This sewer ties into the Lowell City Sewer main which, after being treated at the Lowell wastewater treatment facility, ultimately empties into the Merrimack River seen in Figure 1.

11.1.1.2.2 Dilution Factors

Data obtained from the City of Lowell Water Department shows that the reactor liquid effluents, which drain into the sanitary sewer from the [redacted] building, get diluted with 3[redacted] cm^3 per year. This flow would reduce the reactor effluent concentration by a factor of [redacted]

Further dilution is obtained in the Merrimack River. Data from the Corps of Engineers[2] show the minimum recorded flow rate as [redacted] cubic feet per second [redacted] This flow would reduce the treatment plant effluent concentration by a factor of [redacted] The total dilution factor from UMass Lowell to the Merrimack is [redacted]

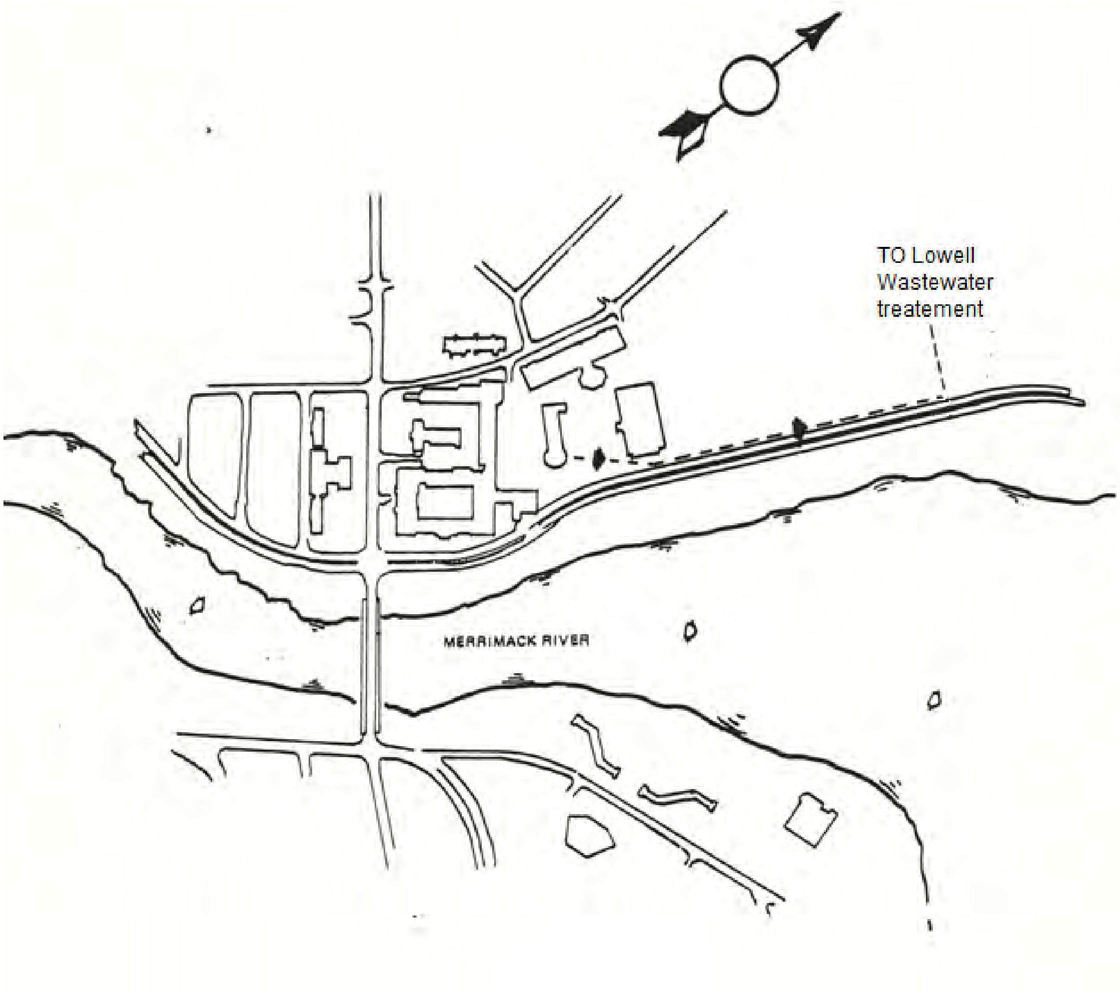


Figure 11-3: University of Massachusetts Lowell and Lowell City Sewer Line

11.1.1.2.3 Estimated Doses

The closest point of human consumption of water from the Merrimack River is through the water treatment plant in Lawrence, Massachusetts. At an average release of 0.8734 µCi and concentration of 4.03×10^{-8} µCi/cm^3 per year, over the past 5 years applying the dilution factor of 8.33×10^{6}, results in a downstream concentration of less than 4.84×10^{-15} µCi/cm^3. Assuming that a concentration of 10^{-7} µCi/cm^3 is equivalent to a whole body dose of 500 mrem/ yr, a concentration of 3.95×10^{-12} µCi/cm^3 is equivalent to 2.4×10^{-5} mrem/yr. Extrapolating this dose to a population of 75,000 (population served by Lawrence water system) results in an annual population dose of 1.8×10^{-3} man-rem.

11.1.1.3 Solid Radioactive Sources

Solid radioactive sources are generated here at the UMLRR from normal operation. As discussed in Section 11.1.1 all solid sources and reactor fuel are tabulated in Table 11-1 and

Table 11-2. Any solid radioactive waste is segregated by material and half-life and disposed of per 10 CFR 20.2001. Solid waste with a half-life greater than [redacted] days will be transferred to an authorized user and a half-life of less than [redacted] days will be allowed to decay-in-storage until statistically indistinguishable from background radiation. Long lived solid waste is stored on site until sufficient volume is generated to warrant removal from a certified radioactive waste broker.

Solid radioactive waste is stored in plastic lined waste baskets and documented into the waste inventory. Storage drums are inspected quarterly for container integrity, radiation exposure measurements, and contamination. Historically the UMLRR has generated roughly [redacted] cubic [redacted] per year or roughly [redacted] drums of solid radioactive waste. The last radioactive waste shipment sent out [redacted] and [redacted] gallons of waste on June 6th 2013.

11.1.2 Radiation Safety Program

The organization, authority, and responsibility for the UMass Lowell Radiation Safety Program is presented in Figure 2. The main components of this program are:

A. Executive Management

B. Radiation Safety Committee,

C. Radiation Safety Office,

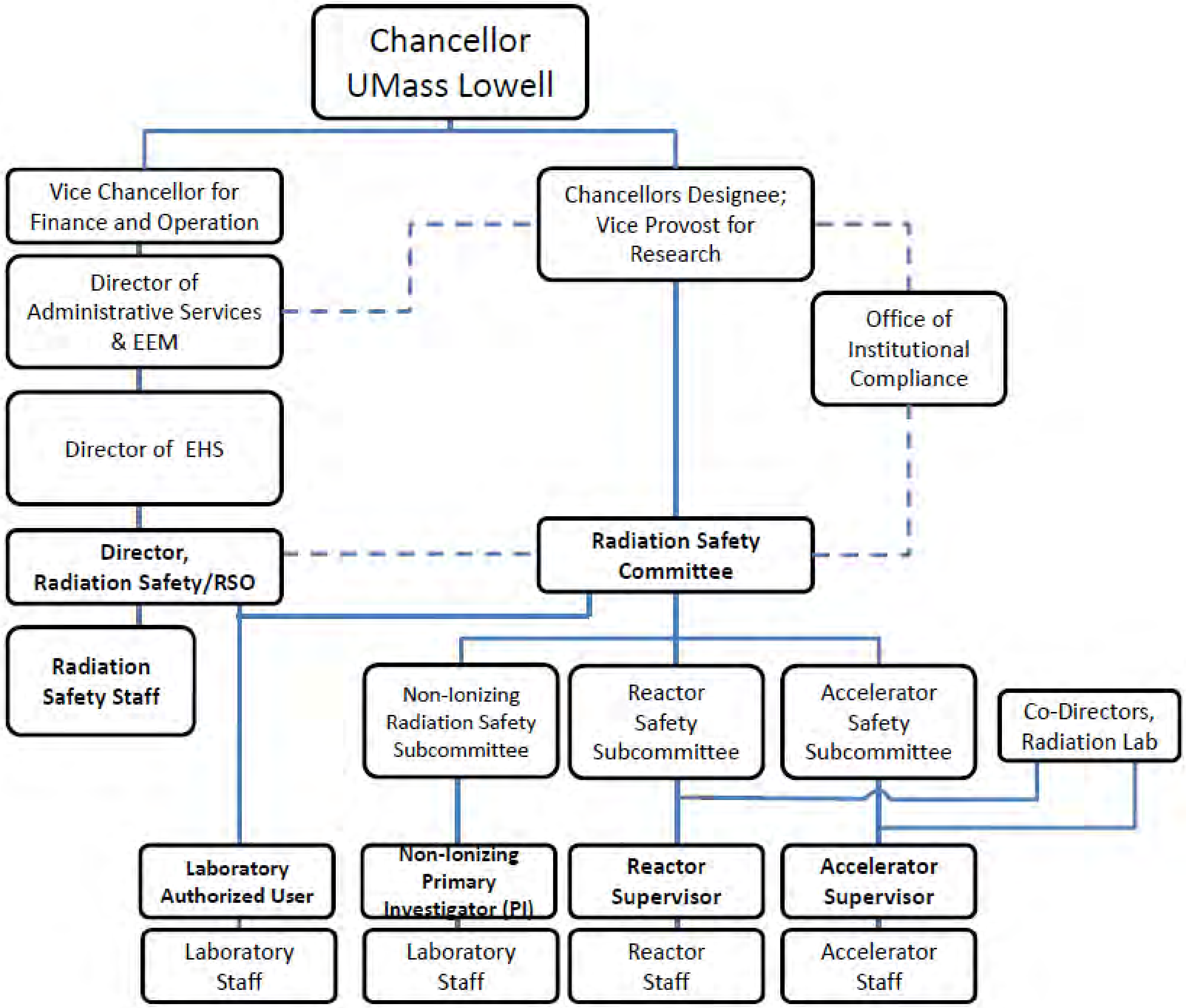


Figure 11-4: Organizational Chart of the UMass Lowell Radiation Safety Program

11.1.2.1 Executive Management

The executive management maintains responsibility for the University of Massachusetts Lowell radiation safety program including the radioactive materials license and all activities associated with the license. As the head of the University of Massachusetts Lowell, the Chancellor is ultimately responsible for the radiation safety program and the activities associated with its licenses. As such, the chancellor:

- Is knowledgeable of the radiation safety program and resulting audits
- Grants the authority to the Director of Radiation Safety to manage the day to day oversight of the program.

REDACTED FOR PUBLIC RELEASE

- Appoints the chairperson and members of the Radiation Safety Committee and defines their roles, duties, and responsibilities.
- Grants the authority to the Radiation Safety Office and Radiation Safety Committee to immediately stop all radiation related work in a laboratory determined to be out of compliance with accepted radiation safety standards and practices.

To provide enhanced oversight to the radiation safety program at UMass Lowell, the chancellor has delegated authority over the program to the Director of Radiation Safety.

11.1.2.2 Radiation Safety Committee

Members of the Radiation Safety Committee are appointed by and responsible to the Chancellor of the University of Massachusetts Lowell. The Committee includes members who represent broad areas or divisions of UMass Lowell and is a mechanism for publicizing information concerning the UMass Lowell radiation safety program to the various radiation workers, authorized users, and members of management.

The committee is headed by a Chairperson who is appointed by the Chancellor of the University of Massachusetts Lowell. The Chairperson of the RSC should not be the Director of Radiation Safety. In his absence, the Chairperson may appoint a member of the RSC to temporarily assume the role and duties of the RSC Chairperson. The chairperson should meet the following criteria.

- Knowledgeable of radiation safety issues
- Good leadership abilities
- Authority within the organization
- Desire to serve as the chairperson and time to dedicate to the committee

The members of the Radiation Safety Committee, at a minimum, will be comprised of the following individuals:

- The UMass Lowell Director of Radiation Safety, who serves as the radiation safety officer for this license.
- A minimum of 2 members of university upper management (deans, directors, RSC chair, etc…)

- A minimum of 2 university staff/faculty radiation researchers/Authorized Users.
- A minimum of 2 university staff/faculty members including:
    - A representative of the UMass Lowell Research Reactor, who must also be a member of the UMass Lowell Reactor Safety Subcommittee.
    - A representative of the UMass Lowell Van der Graff Accelerator, who must also be a member of the UMass Lowell Accelerator Safety Subcommittee.

The Radiation Safety Committee meets on a quarterly basis and minutes will be generated. A quorum will be met for committee meetings when at least 50% of the membership is present. The Director of Radiation Safety must be present at a RSC meeting to constitute a quorum.

At least one member of upper management will be present during a formal Radiation Safety Committee meeting. Formal meetings are defined as those meetings in which votes are taken and decisions made concerning the university safety program. Because this is a university with a complex management structure, upper management will be defined as any individual who, as part of their job description, reports to the Chancellor, a Vice Chancellor, or the Provost. This includes, but is not limited to, university deans, directors, and the Chairman of the Radiation Safety Committee.

The Radiation Safety Committee (RSC) is responsible for reviewing the UMass Lowell ALARA program, including personnel exposure and survey results in addition to discussing any significant incidents such as spills, contamination, etc... The RSC shares the responsibility with the DRS and upper management for conducting periodic program audits and is responsible for acting on the findings of the program audit.

The RSC evaluates new Authorized Users, new uses of byproduct material, and new radiation laboratory work spaces. The RSC annually reviews the status of UMass Lowell authorized users and reauthorizes those users who are in compliance with the UMass Lowell safety program.

11.1.2.3 Process for Program/Procedure Review and Approval

Any member of the Radiation Safety Committee may propose a change to an approved program or procedure. The RSC will meet and discuss the implications of the proposed change during a meeting of the RSC and vote to implement the issue. Prior to the RSC meeting, all RSC members will be informed of the proposed change. Members will be provided with the information necessary to assess the implications of the proposed change. A quorum must be present at the RSC meeting to vote on the issue. The proposed change is approved if a majority of the present members vote to implement the change. The RSC meeting minutes will reflect the reason for the change and summarize the radiation safety matters considered prior to approval of the change.

The Radiation Safety Office and the Radiation Safety Committee is respectful towards and mindful of all radiation related regulations. Both entities would not knowingly revise or change UMass Lowell policy such that it is in conflict with a current radiation protection regulation. In addition, all major changes or revisions to the UMass Lowell radioactive material program will be documented for review during a license inspection.

All changes and revisions to the UMass Lowell radiation safety policy will be implemented such that these changes will not significantly increase the chance or likelihood of exceeding a state or federal regulatory limit.

If the RSC votes to implement a change to an approved procedure or program, a member (typically the DRS) will be assigned the responsibility for implementing the change. This person will be responsible for assuring that the new program or procedure is properly implemented and that those individuals affected by the change are properly trained in the new program/procedure. Program implementation will be documented in the RSC meeting minutes.

When items of non-compliance are identified, the RSC will review the incident to determine the root cause of the non-compliance. The committee will assign corrective actions to prevent recurrence. The non-compliance will be documented in the minutes of the meeting that the corrective actions will be implemented.

11.1.2.4 Radiation Safety Office

The Radiation Safety Office is headed by the Director of Radiation Safety (DRS) who oversees the daily affairs of the campus radiation safety program and serves as the Radiation

Safety Officer. As the Radiation Safety Officer, the DRS is responsible for developing and managing the radiation safety program within the limits set forth by federal and state regulations. This program contains the policies and procedures relating to the safe use of radiation sources in the University. Applications for the generation, purchase, use, or disposal of radioactive sources or devices shall be reviewed by the DRS who may also approve the purchase of radioactive materials for previously reviewed experimental protocols. With agreement from Reactor Supervisor, or their designees, the DRS may also approve applications for routine reactor use provided that such use has been previously reviewed by the appropriate Safety Subcommittee.

New, and therefore un-reviewed, experiments using radiation emitting materials or devices must submit an application to the DRS for a radiological safety review. The DRS shall review the protocol for content and, when complete, submit it to the Radiation Safety Committee for approval or to the Reactor Safety Subcommittee. The Reactor Safety Subcommittee decision is binding subject to approval by the Committee. As a requirement of the UMass Lowell radiation safety program, the Director of Radiation Safety shall serve as a permanent member of the Radiation Safety Committee and all its subcommittees.

In his absence, the DRS may designate an individual to act on his behalf for all management, safety, and approval issues related to the campus radiation safety program.

11.1.2.4.1 Radiation Safety Specialist

The Radiation Safety Specialist reports directly to the Director of Radiation Safety. Specific duties and responsibilities of the Radiation Safety Specialist include:

1. Performing radiation safety surveys,
2. Performs radioactive sample analysis using appropriate radiation detection equipment,
3. Calibrating radiation survey meters,
4. Leak testing sealed radioactive sources,
5. Performing routine quality control and maintenance on analytical equipment,
6. Maintaining the radioactive source inventory,
7. Maintaining the radioactive waste storage and disposal program,
8. Maintaining the radiation dosimetry program,
9. Analyzing and, if appropriate, packaging radioactive materials being shipped to and from the university,

REDACTED FOR PUBLIC RELEASE

10. Assisting the DRS in providing radiation safety training to radiation workers and members of the general public,
11. Collecting and analyzing environmental samples as required

11.1.2.4.2 Radiation Safety Interns

The Radiation Safety Office has a close working relationship with the UMass Lowell Health Physics/Radiological Sciences department which frequently assigns student interns to the Radiation Safety Office. These interns assist the DRS and Radiation Safety Specialist and may be assigned specific projects or duties related to the UMass Lowell radiation safety program.

11.1.2.5 Training for Radiation Workers and Ancillary Personnel

As per 10 CFR19.12(a), individuals likely to receive an occupational dose of 100 mrem in a year are required to receive radiation safety training commensurate with their assigned duties. Training will be performed by qualified individuals such as the DRS, Radiation Safety Specialist or individuals affiliated with the radiation safety program who have, as a minimum, an associate's degree in health physics (or its equivalence) and one year of work experience in the radiation safety field. The DRS (or another individual qualified to provide radiation safety training) is responsible to train new safety workers in the radiation safety training program.

Radiation Worker Training will include basic radiation science, radiation protection principles and ALARA, handling of radioactive materials, introduction to relevant Federal, State, and UMass Lowell regulatory provisions, and radiation emergency or accident response procedures. The Radiation Safety Office presently performs online and in person radiation safety training. Radiation training is tailored to each individual and will include laboratory or site specific safety training in addition to the topics detailed above. Radiation workers are required to complete radiation refresher training every two years. Maintenance and ancillary personnel meeting the requirements of 10 CFR19.12(a) are required to receive job specific safety training prior to being allowed unescorted access into a radiation lab. Such individuals are required to undergo refresher training every two years. Records of initial training and refresher training are maintained by the Radiation Safety Office (RSO).

11.1.2.6 Audit Program

The RSC will meet at least quarterly to review the status of the radiation safety program. RSC meetings will include a review of all audit findings, incidents, and emergency response actions, as applicable.

The radiation safety committee is responsible for implementing an audit of the UMass Lowell radiation safety program. At a minimum, an audit of the UMass Lowell program must be performed annually. The radiation safety committee will use the results of the audit to identify areas in need of review, assess findings and identify corrective actions. The audit will be performed by an individual qualified to do such a radiation safety audit. After the conclusion of the audit, a final report will be made available to RSC members and UMass Lowell management. The UMass Lowell management shall verify that corrective actions cited in the audit are implemented.

11.1.2.7 Records

It is a legal requirement of our radioactive material licenses that certain records be maintained and made available to the licensing agency. In accordance with 10 CFR 20.2101 and as part of good radiation safety program, the Radiation Safety Committee requires that the following information be recorded by the Radiation Safety Office:

1. up-to-date inventories of all radiation sources,
2. radiation surveys and monitoring records of a general and special nature,
3. records of all incidents (spills, releases, contamination problems) involving radiation sources,
4. leak test data on all radiation sources,
5. personnel monitoring records,
6. instrument calibration records,
7. waste disposal records,
8. licensing data,
9. emergency equipment lists,
10. minutes of Radiation Safety Committee and subcommittee meetings,
11. applications for authorization to use radiation sources,
12. copies of authorizations and a list of all Authorized Users.

13. Decommissioning files in accordance with state and NRC regulations

11.1.3 ALARA Program

The University of Massachusetts Lowell is committed to maintaining exposures As Low As Reasonably Achievable (ALARA). Although current occupational radiation exposure limits provide a very low risk of injury, it is prudent to practice radiation safety techniques and protocols to minimize unnecessary exposures to radiation. The object of an ALARA program is to “reduce occupational exposures as far below the specified limits as is reasonably achievable by means of good radiation protection planning and practice, as well as a management commitment to policies that foster vigilance against departures from good practice." (USNRC Reg. Guide 8.l0)

The ALARA program at UMass Lowell consists of the following elements:

A. Training: A radiation safety training program is provided by the Radiation Safety Office. The goal of this program is to allow those individuals who may come in contact with radioactive materials or radiation generating equipment to recognize and protect themselves from sources of radiation.

B. Dosimetry: A comprehensive program of dosimetry services including badge monitoring and bioassays is provided by the university. The Radiation Safety Office will investigate any radiation exposures greater than 10% of the regulatory limits listed in Table 11-5 and will ensure future exposures are maintained ALARA.

C. Radiation Surveys: A radiation survey program is used to check each area where radiation sources are used. Laboratories are checked to ensure proper techniques are used during procedures involving radiation sources.

D. Safety Reviews: The RSO and the UMass Lowell Radiation Safety Committee (or specific subcommittee) reviews and must approve of all experiments in which radioactive material is used. In addition, the RSO and RSC annually audit the radiation safety program of each Authorized User or radioactive sources to verify compliance with federal, state, and university regulations. The RSO may require Authorized Users to show how well their project meets the ALARA principles.

REDACTED FOR PUBLIC RELEASE

Table 11-5: Occupational Effective Dose Equivalents (rem/year)

Total Dose Equivalent (body)	5
Dose to Lens of the Eye	15
Dose to Extremities or Organs	50
Dose to Embryo (declared pregnancy)	0.5/term

11.1.4 Radiation Monitoring and Surveying

11.1.4.1 Radiation and Contamination Surveys

The purpose of these surveys is to identify and limit the spread of radioactive contamination and to ensure that radiation levels in the laboratory are kept As Low As Reasonably Achievable (ALARA). Work areas and equipment used in conjunction with radioactive material use/storage shall be surveyed with a meter appropriate to detect the type of radiation used (radiation field measurements) and for removable contamination (e.g. wipe testing).

Dose-rate surveys, at a minimum, should be performed in locations where workers are exposed to radiation levels that might result in radiation doses in excess of 10% of the occupational dose limits or where an individual is working in a dose rate of 0.025 mSv (2.5 mrem/hr) or more.

Contamination surveys should be sufficient to identify areas of contamination that might result in doses to workers or to the public. Removable contamination shall be surveyed using a wipe test of the surface, which is counted in an appropriate counting instrument. The counting instrument shall have a minimum detectable activity equal to or better than the contamination control limits specified in this section.

Contamination Zones will be posted for areas where controlled access is maintained for the purpose of contamination control. Persons should not enter such a zone without authorization and proper personnel protection.

11.1.4.2 Radiation Monitoring Equipment

The Radiation Safety Office and the Radiation Safety Committee approve radiation detection instrumentation used for personnel safety and contamination monitoring. Each radioactive materials laboratory is required to have a portable survey meter available during experimentation.

Portable hand-held Geiger Counters, such as those manufactured by Ludlum, Eberline, or Civil Defense, will be used to detect the presence of beta-emitting radioactive materials such as P-32, Sr-90/Y-90, or equivalent. These meters may be calibrated to read out in count rate, exposure rate, or both. Low energy sodium iodide probes, such as those manufactured by Ludlum or Eberline, will be employed in the detection of low energy X-ray or gamma-emitting isotopes such as I-125, Cr-51, Mn-54, and Zn-65. Ion chambers, such as those manufactured by Ludlum, Eberline, or Bicron, or Civil Defense will be used to conduct exposure rate determinations by the Radiation Safety Office during regular or emergency situations. Neutron meters, such as those manufactured by Ludlum, shall be used to monitor neutron radiation fields and/or emission rates.

The Director of Radiation Safety is responsible to assure that survey instruments are properly and timely calibrated. To this end, the DRS, or his designee, will maintain calibration and inventory records for all campus hand-held radiation survey meters. The status of campus radiation survey meters will be reviewed each month. Those meters requiring calibration will be taken out of service by the DRS or his designee and returned to their respective laboratory after calibration. If a survey meter is misplaced or non-operative, it will be so noted in the inventory list and taken off the calibration schedule until the device is found / repaired. The reactor staff is responsible for assuring that hand held survey meters needing repair are given to the radiation safety office prior to being placed back in service.

To assist the Radiation Safety Office (RSO) and members of the radiation laboratory in identifying calibrated instruments, the RSO may, at its discretion, place calibration stickers on hand-held survey instruments. The use of calibration stickers is not to be considered part of the UMass Lowell regulatory and is not required. As such, an individual may, upon request, be provided with a copy of a hand-held survey instrument's calibration record(s) if proof of calibration is requested.

Survey meters are calibrated by exposure to a radiation source of known output and are performed under conditions of minimum scatter. If the calibration is performed in a small room, scatter corrections shall be made either experimentally or computationally. Primary photon exposure rates at a given distance are evaluated using the inverse-square law based on the radiation output at the reference position. Air attenuation is neglected. Gamma survey equipment is exposed to an appropriate gamma source, such as Cs-137 or Co-60. Neutron survey equipment is exposed to a neutron source, such as a Pu-Be source, Californium source, or characterized reactor beam-line. Appropriate equipment, such as Geiger Counters, may be calibrated using a pulser system rather than exposure to a radiation source. After pulser calibration, the detector should be exposed to a known source of radiation to obtain a count rate to radiation output conversion constant. Those detectors calibrated by a pulser but not exposed to a reference radiation source shall not be used as a regulatory device to monitor radiation fields.

Analytical instruments used for measuring contamination or used in the UMass Lowell bio-assay program will be calibrated using sources and sample preparation characteristic of the materials to be analyzed. Gas counters will be calibrated annually using beta and/or alpha sources of known activities. The liquid scintillation system will be calibrated annually using H-3 and C-14 of known activity in the solutions and geometries of interest. Gamma multi-channel analyzing systems will be calibrated for efficiency and energy once every 5 years using gamma standards covering the energy range of interest and will be calibrated annually to a single calibrated button source, such as Co-60 or Cs-137, to detect energy shifts or efficiency changes. An energy shift or an efficiency change of ±20% will necessitate a full energy and efficiency recalibration of the system. Single channel gamma analysis systems or multi-channel systems used to detect a specific isotope (such as a thyroid scanner) are calibrated to the isotope of need or its equivalent either annually or prior to use as a regulatory device. Any system taken off-line or out of service will be recalibrated prior to use as a regulatory device.

In addition to handheld radiation monitoring devices, fixed area radiation monitors are present throughout the reactor containment building. During reactor operations particulate and gaseous sampling is monitored. All radiation monitors have readouts in the control room. Table 11-6 is a summary of all radiation monitoring equipment used by the UMLRR, some which are required by Technical Specifications.

REDACTED FOR PUBLIC RELEASE

Table 11-6: Radiation Monitoring Equipment used in the UMLRR

Type of Radiation Monitor	Radiation Detected	Use
Continuous Air Monitors (iCAMs)	Beta-Alpha	Monitor air levels at pool level and on experimental level
Gamma Detector (GP100)	Gamma	Area dose rate monitoring throughout containment
Neutron Detector (NP100B)	Neutron	Fission product monitor
Ion Chamber Detector (IP100)	Gamma	Area dose monitoring suitable for burst radiation
Stack Effluent Monitor (CAM200PGFF)	Beta-Gamma	Monitor gaseous and particulate effluents released through the stack
EcoGamma	Gamma	Monitor environmental levels around UMLRR

Radiation monitoring equipment is calibrated as required by Technical Specifications. Gamma sensitive area radiation monitors are calibrated annually using a low range 100 mR/hr (1 mSv/hr) and high range gamma emitting source 100 R/hr (1 Sv/hr) at fixed distances.

The GP100 detectors have an energy range of 80 keV to 3.0 MeV with a low range sensitivity of 1800 cpm/mR/hr and a high range sensitivity of 4.2 cpm/mR/hr. the IP100 detectors have an energy range of 50keV to 3.0 MeV with a sensitivity of 0.4 μR/pulse. The fission product monitor is calibrated using a neutron source with the strength of 100mR/hr at a fixed distance. The NP100 detectors have an energy range of 0.025 eV to 15 MeV and a sensitivity of 0 mR/hr to 10 R/hr. The CAMs are calibrated annually using a fixed alpha Am-241 and beta Cl-36 source, as well as monthly background checks. The stack effluent monitor is calibrated annually, using three beta Cs-137 sources, a Tc-99 source and a Cl-36 source all placed in the reference geometry. The stack effluent monitor consists of one extended range beta detector, for gaseous monitoring, that has a range of 1×10^{-6} μCi/cc to 1×10^{5} μCi/cc of Xe-133 with a sensitivity of approximately 2.3×10^{7} cpm/μCi/cc. The stack effluent monitor consists of an extended range scintillation detector for particulate monitoring that has a range of 50 keV to 1 MeV beta and 70 keV to 3 Mev gamma. The sensitivity for beta detection is 3.7×10^{5} cpm/μCi/cc for Cs-137 and for gamma detection is 6.0×10^{3} cpm/mR/hr for Cs-137.

REDACTED FOR PUBLIC RELEASE

11.1.5 Radiation Exposure Control and Dosimetry

The UMass Lowell Research Reactor ensures that doses are maintained ALARA and there will be no uncontrolled effluent radioactive releases to the environment through measurements discussed in the following sections. The past 5 years of historical data show that the average badged worker receives no detectable exposure, seen in 11-7 below.

Table 11-7: Badged Personnel Exposure per Year

Year	MWHs	Badged Personnel	Average Whole Deep Dose	Average Extremity Extremity Dose
2009	186	19	M	M
2010	114	16	M	M
2011	99	20	M	M
2012	151	20	M	M
2013	107	19	M	M

Note: 'M' indicated no detectable exposure

11.1.5.1 Radiation Shielding

The design of the swimming pool reactor and its containment building are such as to provide more than sufficient shielding to abide by the requirements of 10 CFR Part 20. Bulk shielding against the core radiations is provided by the pool water and the normal and high density concrete shield around the pool; the structural details of the pool and biological shield are presented in section 4.3 and 4.4. Additional shielding between the building and the external environs is provided by the two-foot thick concrete shadow shield which lines the containment building walls.

Actual radiation levels above the pool depend largely on the purity of the water. Radiation surveys conducted at 1 MW indicate a normal level less than 10mR/hr to be expected above the pool under the reactor bridge.

Normal external dose rates in the containment building in most non-experimental areas of the first floor, second floor, and third floor are less than 1 mrem/hr. Dose rates in certain locations near ongoing experiments (e.g., certain beam tube experiments) may be greater than this at times; however, in such cases, local shields (e.g. cement blocks, lead bricks, etc.) are utilized as required to reduce dose rates to acceptable levels. Gamma radiation levels in the holdup tank area of the pump room in the containment building basement are normally high (several R/hr) during forced flow at 1MW, see section 11.1.5.1.1 below. Access to the pump room is restricted and appropriate supervision is required for all personnel operations in this area.

While dose rates may vary considerably at specific locations, depending on the types of experiments being conducted, individual workers, in accordance with UMLRR policies and 10 CFR 20 regulations, are not allowed to accumulate more than currently established values.

Radiation doses to visitors and other non-staff personnel who are not directly involved with the operation and/or use of the reactor are carefully controlled. Access to high radiation areas (as defined in 10 CFR 20) is not normally allowed, and personnel monitoring is provided as a required in 10 CFR 20. For the majority of people in the above category integrated exposures for a normal visit average much less than 10 mrem; in all cases normal policy is to limit integrated doses in accordance with values in 10 CFR 20. All restricted areas are posted and controlled in accordance with 10 CFR 20.

The liquid and gaseous waste handling systems are presented in section 11.1. In these systems, the primary coolant loop and its included components are the only potential sources of external radiations. Local shielding is utilized as required for personnel operations involving the primary coolant system.

11.1.5.1.1 Nitrogen-16

N-16 is produced via the threshold reaction O-16 (n, p) N-16, by the interactions of neutrons with energy in excess of 9.6 MeV with O-16 in the core coolant water.

The holdup tank is approximately a cylindrical volume with dimensions of 260 cm diameter and 180 cm height. Surveys performed in the pump room during steady 1MW operation have concluded that the unshielded exposure rates in the holdup tank area at the highest are 1.2 R/hr, an exposure rate of 700 mR/hr is located in the vicinity just past the concrete shielding.

N-16 is the greatest source of external gamma radiation in the primary coolant system. For sustained operations N-16 levels in the area of the holdup tanks have been discusses in section 5.6. Local concrete block shielding is provided to lower pump room radiation levels in the holdup tank area, to acceptable levels for the personnel entry and operations. The cleanup demineralizer, as discussed in section 5.4, collects activities from the primary coolant; however, the external radiation levels from these activities while the reactor is in operation are small compared to levels from theN-16. After shutdown and allowance for decay ofNa-24, the resin held activity has been found not to be an external radiation hazard of significance. Spent cleanup system resins during resin changes have been found to have exposure rates less than 1 mrem/h on contact.

11.1.5.2 Ventilation

The design and description of the UMass Lowell Research Reactor containment ventilation system is given in section 9.1. Inhalation doses resulting from airborne radioactivity in the containment building are insignificant. The only airborne constituent of any note which is likely to be present in the building is Ar-41 produced in experimental facilities discussed in section 11.1. Ar-41, an inert gas, does not represent an inhalation dose problem. Containment building Ar-41 concentrations are not great enough to result in an external dose problem of any consequence.

11.1.5.3 Containment

The design and description of the UMass Lowell Research Reactor containment is given in Chapter 1 and Chapter 6. For normal operations, dose rates outside the containment building were originally expected to be very close to normal external background levels. Environmental radiation surveys conducted around the perimeter of the containment building during 1MW operation of the UMLRR have confirmed this expectation. Normal levels at 1MW are less than 0.05 mrem/hr.

11.1.5.4 Entry Control Devices

Unescorted access to the UMass Lowell Research Reactor is only given to personnel who have received Radiation Worker Training and have an approved Limited Access Application. Basic Facility training ensures personnel are familiar with all radiation areas as well as all safety controls surrounding each area. Access to the containment doors is granted by the Reactor Supervisor, who programs the personnel’s hand geometry as well as access card.

Areas inside the containment building are posted and controlled per 10 CFR Part 20 Subpart G to ensure personnel safety. The use of locked and controlled doors, flashing lights, bells, etc are utilized where needed to alert worked to any potential radiation field.

11.1.5.5 Protective Equipment and Materials

Disposable and non-disposable laboratory coats and overalls, of paper and plastic impregnated fibers, are available. Footwear of disposable plastic and non-disposable synthetic rubber is available as booties, rubbers, and boots. Gloves of plastic, cloth, and rubber are also on hand. Soft and hard protective headwear is available. Such clothing will be provided as required for all work in contaminated or contaminating environments and will be readily available as necessary for routine operation. Six full face gas masks equipped with canisters designed for efficient collection of radioactive particulates and iodine are maintained for use in areas of airborne contamination. Two 45min self-contained compressed air units are available for emergency use in situations of high airborne radioactivity levels.

11.1.5.6 External Dosimetry

Based on dosimetry data collected over the past 20 years for similar protocols, isotopes, and quantities used at UMass Lowell, it is unlikely that occupational radiation exposures will exceed 10% of the allowable annual dose limits specified in 10 CFR 20.1502, therefore dosimetry is not required. However, UMass Lowell, at the discretion of the RSO, RSC, or Authorized User, badges individuals entering the reactor of handling gamma/beta sources. Dosimetry services are provided by a NVLAP accredited vendor.

11.1.5.7 Internal Dosimetry

Routine bioassay will be performed on individuals using isotopes because that individual could receive an intake in excess of 10% of the annual limit on intake (ALI). However, the need for routine bioassay for new protocols will be evaluated as part of the process for applying for new uses of radioactive material. Also, routine bioassay will be evaluated if existing protocols require a significant increase in the isotope used.

Not withstanding the above discussion, bioassay may be performed on request or in the case of an abnormal event such as an accidental injection or a known or suspected ingestion of radioactive material. The DRS, RSC, or a qualified representative designated by the RSC, will determine when a bioassay is necessary, provide the necessary support to perform the bioassay, and interpret the results of any analysis. As an alternative, the DRS and/or RSC may use a qualified bioassay specialist to take and analyze bioassay samples.

In general, urine bioassay will be used to determine the intake of all isotopes (other than thyroid scans for I-125) in the event of a suspected intake. However, other types of bioassay such as whole body scans may be used; depending on the time elapsed since the incident and the required sensitivity. A professional health physicist experienced in internal dosimetry may be consulted to identify the most appropriate bioassay method.

11.1.6 Contamination Control

The Radiation Safety Office (RSO) is responsible for performing all regulatory radiation surveys. These surveys will be subject to regulatory review and auditing process:

1. The RSO will perform appropriate (field, contamination) *weekly* surveys on laboratories working weekly with unsealed forms of radioactive material in an amount greater than or equal to 10% of the smallest annual limit on intake (ALI) (i.e. stochastic or non-stochastic) listed for that radionuclide (or combined ALI for multiple radionuclides) in 10 CFR Part 20
2. The RSO will perform appropriate *monthly* surveys on laboratories who do not meet the criteria in item (1) above but who works monthly with unsealed forms of radioactive material in an amount greater than or equal to 10% of the smallest annual limit on intake (ALI) (i.e. stochastic or non-stochastic) listed for that Radionuclide (or combined ALI) in 10 CFR Part 20.
3. The RSO will perform appropriate quarterly surveys on laboratories who do not meet the criteria in item (2) or item (1) above but who *annually* work with unsealed forms of radioactive material in an amount greater than or equal to 25% of the smallest annual limit on intake (ALI) (i.e. stochastic or non-stochastic) listed for that Radionuclides in 10 CFR Part 20.
4. The RSO will perform appropriate quarterly surveys on laboratories storing unsealed forms of radioactive material in a quantity greater than or equal to 100% of the smallest annual limit on intake (ALI) (i.e. stochastic or non-stochastic) listed for that Radionuclides in 10 CFR Part 20
5. The RSO is responsible for having an appropriate radiation survey performed after a major radioactive material release to document the final status of the spill.

Contamination Zones will be posted for areas where controlled access is maintained for the purpose of contamination control. Persons should not enter such a zone without authorization and proper personnel protection. Table 11-8 defines a contaminated zone in restricted areas:

Table 11-8: Contaminated Zone Definition

Type of Radiation	Removable Contamination Limits (dpm/100 cm^2)
Beta/photon emitter (except tritium)	500
Tritium	1,000
Alpha emitter	50

11.1.7 Environmental Monitoring

Environmental monitors are used throughout the [redacted] Building attached to the UMass Lowell Research Reactor. Area dosimeters are located in the 1st and 3rd floor airlocks as well as in [redacted] 301 and [redacted] 101, the furthest location from the reactor but still within the building. The historical data from the four locations mentioned above represent the dose to the building occupants. Table 11-9 below provides the historical data, but in summary, occupants in the [redacted] building received no more than 10 mrem per year from the reactor facility.

Table 11-9: Environmental Monitoring - Yearly Averages (mrem/year)

Year	MWHs	1st Floor Airlock	3rd Floor Airlock	[redacted] 101	[redacted] 301
2009	186	<10	<10	<10	<10
2010	114	<10	<10	<10	<10
2011	99	<10	<10	<10	<10
2012	151	<10	<10	<10	<10
2013	107	<10	<10	<10	<10

11.2 Radioactive Waste Management

11.2.1 Radioactive Waste Management Program

Radioactive waste is segregated by material type and half-life. Radioactive waste will be disposed of in one of three ways as per 10 CFR 20.2001: 1) transfer to a person properly licensed to receive such waste via a licensed waste vendor or broker, 2) release into a sanitary sewer in conformance with regulations, and 3) decay-in-storage.

All solid waste with a half-life greater than 120 days will be transferred to an authorized recipient for disposal. Such waste shall be stored on site until a sufficient quantity of long-lived material is generated to warrant a transfer. All liquid scintillation waste will be similarly transferred to an authorized recipient for disposal. Liquid scintillation waste containing less than 0.05 µCi/gram are handled and disposed of as deregulated waste with respect to the radioactive waste regulations.

Solid waste with a half-life less than or equal to 120 days will be held in storage for decay until the material is statistically indistinguishable from background radiation as measured on an appropriate survey meter maintained in a low background area with the meter maintained at its most sensitive setting.

UMass Lowell maintains a program to track the quantity of radioactive liquids disposed via the sanitary sewer. Disposal is allowed only in approved radioactive areas and through sinks specifically designated for that purpose. The acceptable disposal limits are determined by the RSO based on the waste discharge to the sanitary sewer and the allowable monthly effluent limits. Logs are maintained to track the isotope and quantity of material disposed via the sink. Completed logs are maintained on file by the RSO.

Radioactive Waste Collection Procedures

1. Short-lived (<120d) radioactive waste may be stored by the laboratory for decay. Those sources not meeting this criteria or laboratories which do not wish to store short lived waste shall have the waste collected by a member of the Radiation Safety Office.
2. Radioactive waste is required to be separated into individual storage bags by isotope, although H-3 and C-14 may be combined into a single container/storage bag and materials with a < 120 day half-life may also be combined.
3. The reactor staff is responsible to assure that the waste container has a “Caution Radioactive Material” (or equivalent) label and the following information is contained on the package or label:
    a. The laboratory which generated the waste
    b. The isotope (or isotopes, if appropriate)
    c. And, an estimate of the total activity of each isotope contained within the package
4. The reactor staff shall be responsible to assure that the waste is contained in a proper waste storage container
    a. Solid wastes typically shall be stored in a plastic lined waste basket (including cardboard) or metal drums.

REDACTED FOR PUBLIC RELEASE

b. Liquid wastes shall be contained in compatible sealable containers (plastic or glass sealable jugs).
c. Sharps waste shall be contained in an appropriate sharps container
d. Animal carcasses shall be placed in a plastic bag and sealed in a brown paper biohazard bag (e.g. Kraft bag).

5. When a radioactive waste container is filled at a radiation laboratory, the reactor staff shall contact the Radiation Safety Office to arrange a pickup.

Radioactive Waste Storage Procedures

1. Radioactive waste brought to the reactor storage area and the package integrity checked to assure source control.
2. The waste shall be documented / logged into the waste inventory.
3. The waste shall then be stored in an appropriate waste container such as a 55 gallon Type-A shipping drum.
4. Storage drums containing radioactive waste shall be inspected for container integrity, radiation exposure measurements, and contamination. Radiation posting of the area, if necessary, shall be performed as per the requirements of 10 CFR 20.1902
5. If the integrity of a waste container is found to be breached, the materials stored within shall be transferred into an intact container. Proper Health Physics procedures, as documented above in the "Collection" section, shall be performed by the individual transferring the waste.

Radioactive Waste Disposal Procedures

1. Appropriate liquid radioactive waste may be disposed of via a sewer system as described above.
2. Long-lived radioactive waste may be stored in the reactor storage site until a sufficient volume of waste is stored to necessitate removal from a certified radioactive waste broker.
3. Decay-in-storage waste shall be held in either the reactor storage site until the waste is statistically indistinguishable from background as specified above.

REDACTED FOR PUBLIC RELEASE

11.2.2 Waste Minimization Statement

To minimize the generation of radioactive waste, the following guidelines will be incorporated in the radioactive materials program:

1. The decay-in-storage of shorter-lived radioactive isotopes.
2. The substitution of short-lived for long-lived radionuclides where possible to achieve minimization through decay-in-storage.
3. The substitution of non-radioactive procedures for radioactive procedures where practicable.
4. Limiting the use of consumables when using long-lived radionuclides.
5. Maintaining segregation of contaminated versus non-contaminated laboratory waste.
6. The use of appropriate decontamination techniques when necessary.

11.2.3 Radioactive Waste Control

11.2.3.1 Solid Waste

The amounts of solid wastes generated as a result of rector operations are relatively small. Operation of the cleanup demineralizer system results in the eventual need to replenish the ion exchange resins. A single charge from the ion exchange demineralizer represents about [redacted] cubic [redacted] of resin which will nearly [redacted]llon waste shipping drums. Activities are less than [redacted] per drum of spent resin.

Normal operation of the gaseous waste handling system results in the generation of some solid waste in the form of filters (absolute and/or charcoal). On a routine basis, activities on the filters do not [redacted]. Activity contaminated filters will be bagged and, after decay of any significant short-lived components, transferred to appropriate metal drums for waste pickup by an authorized contractor. On an annual basis approximately no more than six filters require replacement.

Additional solid wastes will be produced as a result of experimental and maintenance operations. Such items as disposable clothing, sample transfer rabbits, contaminated paper and laboratory items, miscellaneous hardware, and certain cleanup and “housekeeping” items are disposed of routinely by a disposal contractor. .

11.2.3.2 Liquid Waste

The primary coolant loop is essentially a closed system with no continuous liquid effluent release to the environment. Any liquid effluent produced in the reactor (i.e., pump gland leaks, washings from demineralizers, laboratory sink effluent, etc.) is transferred to the appropriate liquid waste hold-up tanks. The liquid radioactive waste in the waste tank is then analyzed for its radioactive content and the liquid dispersed in accordance with applicable regulations.

11.2.3.3 Airborne Waste

The radioactive gaseous release of concern in Ar-41, a more in depth description can be found in section 11.1.1. The radiological monitoring system includes several elements intended to give an indication of airborne radioactivity levels in the containment building and in the stack gas effluent. The gas effluents are calculated each year to ensure the Ar-41 is less than that specified in 10 CFR 20 Appendix B, Table 2, Column 1.

Table of Contents

Table of Figures

12.0 CONDUCT OF OPERATIONS

This chapter describes and discusses the Conduct of Operations at the University of Massachusetts Lowell Research Reactor (UMLRR). The Conduct of [redacted], the quality assurance plan, the reactor operator selection and re-qualification plan, the startup plan, and environmental reports. This chapter of the Safety Analysis Report (SAR) forms the basis of Section 6 of the Technical Specifications (See Chapter 14).

12.1 Organization

The UMLRR falls within the organizational structure of the University of Massachusetts Lowell and is administratively controlled and operated as shown in Figure 12-1. The reactor and laboratory facilities of the UMLRR are available to faculty members or graduate and undergraduate students interested in pursuing research involving radiation, radioisotopes, or the reactor. The research programs are coordinated, supervised, and monitored by the permanent staff employed by the facility. Under all normal operational and design basis conditions there is an adequate management organization:

- that are knowledgeable regarding the TS to operate a safe facility,
- are responsible for complying with regulations and license conditions,
- that implement a meaningful radiation protection program that will protect the health and safety of the public

12.1.1 Organizational Structure

University of Massachusetts Lowell is an educational institution organized by the Commonwealth of Massachusetts and administered through a Board of Trustees appointed by the Governor of the Commonwealth. The university structure is shown in Figure 12-1.

12.1.1.1 Contractors

The UMLRR was designed, manufactured, and installed by the General Electric Company. The building which houses the reactor was designed by the architectural firm of W. Chester Brown Associates and built by the Harvey Construction Company, Inc. The welded steel containment shell was furnished and erected by the Chicago Bridge & Iron Company.

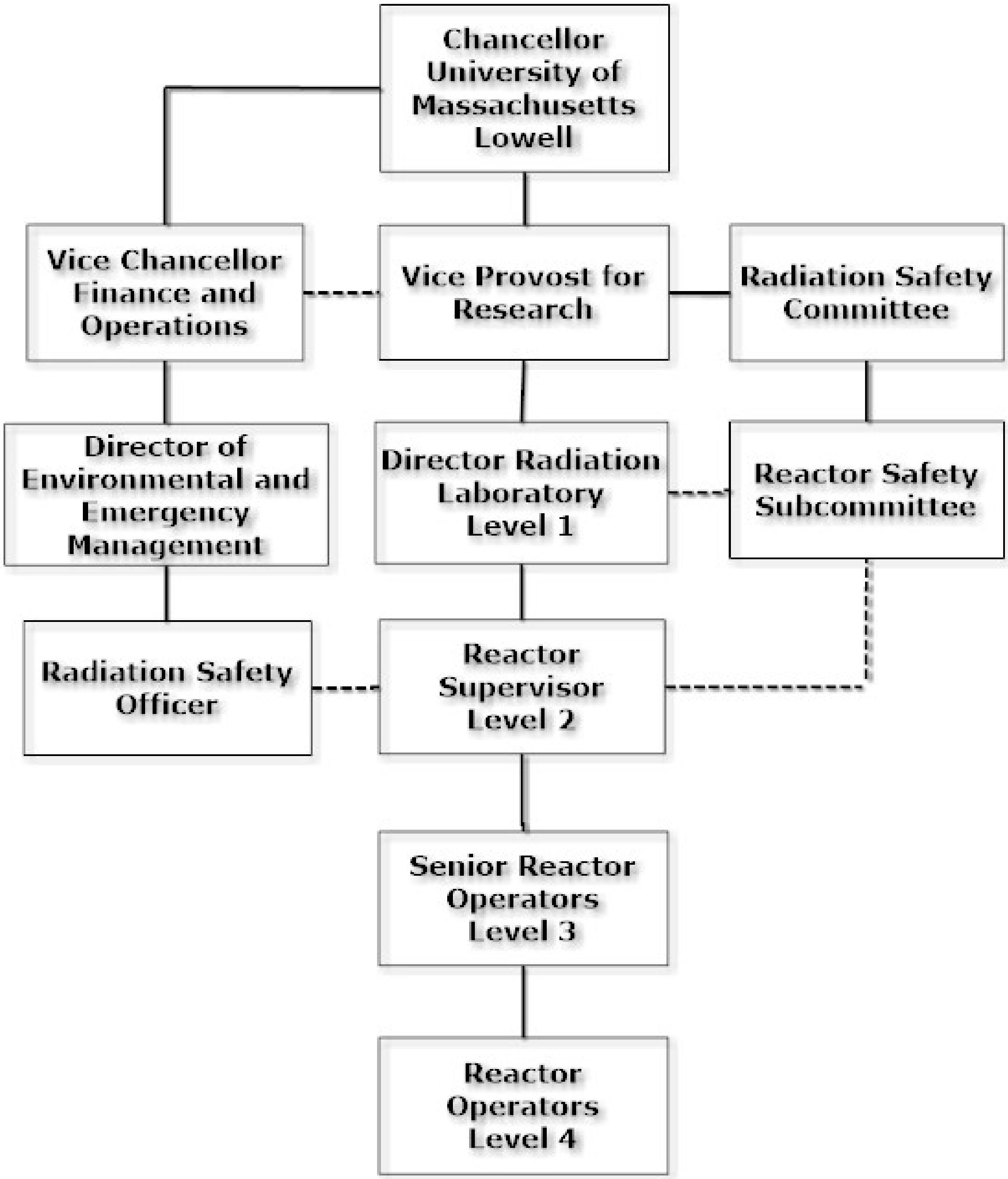


Figure 12-1: UML Organizational Structure

12.1.2 Operating Organization

The reactor is operated under a U.S. Nuclear Regulatory Commission (USNRC) license and is controlled administratively by the Radiation Laboratory which, under the Director, is organized as shown in Figure12-2.

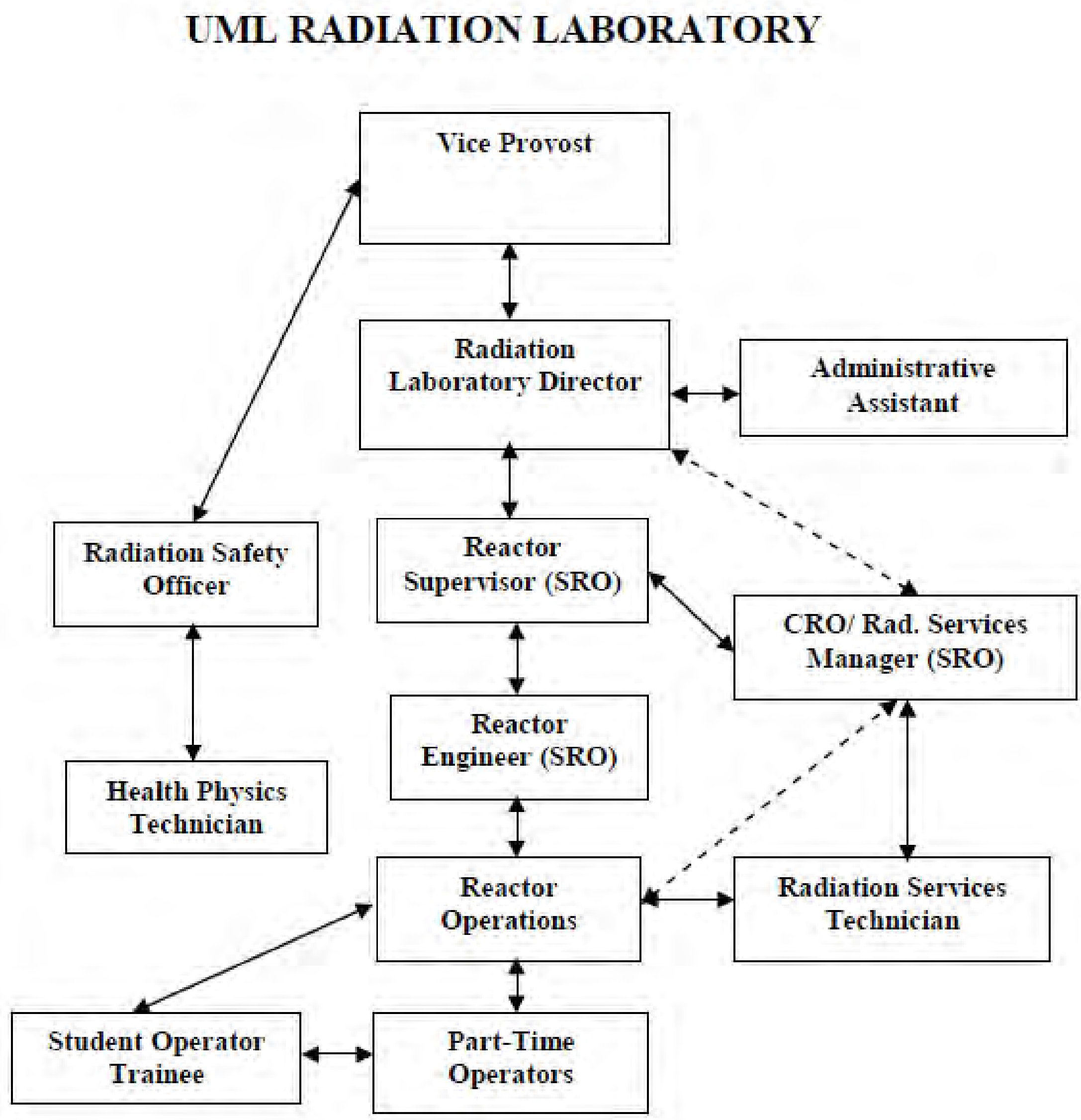


Figure12-2: Radiation Laboratory Operational Organization

12.1.2.1 Reactor Supervisor

The Reactor Supervisor (RS) is responsible to the Director of the Radiation Laboratory for the operation of the reactor. The RS has direct responsibility for all activities in or about the reactor facility which may affect reactor operations, or, in conjunction with the Radiation Safety Officer, involve radiation hazards. Supervising, through subordinate managers and their staff:

- The operation and utilization of the reactor facility
- Preparing and administering the facility budget
- Negotiating with and employing the necessary staff for operation of the facility and
- Being available to faculty members for consultation on research proposals for the utilization of the reactor or associated laboratory facilities.

These responsibilities also include, but are not limited to, the control of reactor fuel, maintenance of the reactor and equipment, refueling the reactor, compliance with USNRC or other applicable regulations, the status of auxiliary support and safety equipment, the training and retraining of operations personnel, and the safe conduct of all phases of reactor operations. The Reactor Supervisor is assisted in the performance of these duties by the Chief Operating Officer, the Reactor Engineer and the reactor facility staff.

12.1.2.2 Chief Reactor Operator (Radiation Services Manager)

The Reactor Supervisor is in charge of the Reactor Operations, which consists of a Chief Reactor Operator (CRO), a Reactor Engineer, and all other licensed personnel. The CRO assists the Reactor Supervisor particularly in the scheduling and supervision of experiments utilizing the reactor or any supporting facilities and equipment. The CRO shall be a licensed Senior Reactor Operator with the experience and skills necessary for the safe conduct of reactor operations.

12.1.2.3 Reactor Engineer

The Reactor Engineer (RE) assists the Reactor Supervisor particularly in the responsible for coordination of repair, upgrade and maintenance of logs and records, the maintenance of the physical conditions of the reactor and supporting equipment, and the training and retraining of personnel. The RE shall be a licensed Senior Reactor Operator with the experience and skills necessary for the safe conduct of reactor operations.

12.1.2.4 Senior Reactor Operator

The Senior Reactor Operator (SRO), under the direction of the CRO, is responsible for the safe operation of the reactor. The SRO will supervise all experiment, maintenance, and any other activities capable of affecting the operation of the reactor. A licensed senior reactor operator pursuant to 1O CFR 55 shall be assigned each shift and be responsible for all activities during his shift which may affect reactor operation or involve radiation hazards. The Reactor Operators on duty shall be responsible directly to the Senior Reactor Operator.

12.1.2.5 Reactor Operators

The Reactor Operators under the direction of a Senior Reactor Operator are responsible for the safe operation of the reactor and all its appurtenances including the reactor control system, reactor cooling system, reactor bridge, reactor pool, all experimental systems associated with the reactor, overhead crane, reactor building ventilation system, makeup and cleanup demineralizer systems, retention tanks, and all other equipment capable of affecting the operation of the reactor. Any licensed reactor operator shall be authorized at any time to reduce the power of the reactor or to scram the reactor without reference to higher authority, when in his judgment such action appears advisable or necessary for the safety of the reactor; related equipment, or personnel. Any person working on the reactor bridge shall be similarly authorized to scram the reactor by pressing a scram button located on the bridge.

12.1.3 Staffing / Shift Crew Composition

For a given shift, the minimum crew will consist of two licensed operators designated by the CRO. The CRO will insure that license requirements as specified in appropriate University of Lowell procedures are met. In all cases, a Senior Reactor Operator may perform the duties and assume the responsibilities of a Reactor Operator.

Of the two shift Operators, one must be in the control room at all times during which the control system is unlocked. The operator at the reactor console has the primary responsibility under the Senior Reactor Operator for the operation of the reactor and all associated control and safety devices. The other Reactor Operator is responsible for required tasks in or about the reactor such as logging remote meter readings, inspection of equipment remote from the control room, supervising experiments, contacting meteorology, etc.

12.1.3.1 Support Groups

Much routine maintenance is performed by the reactor operations staff. When necessary, work of a nature that requires help from other than the operating staff is ordered and supervised by the operations staff, normally through the Reactor Supervisor or one of his designees.

The [redacted] e University maintenance [redacted]

12.1.4 Selection and Training for Required Personnel

12.1.4.1 Reactor Supervisor

The Reactor Supervisor is expected to have a thorough knowledge of nuclear engineering, particularly in the field of core physics and nuclear kinetics, as well as a thorough knowledge of all rules, regulations, practices, and procedures required by the USNRC, the Massachusetts Department of Public Health, and the UML Radiation Safety Committee. They must have the ability to deal effectively with others and to train and direct personnel. They must hold a USNRC Senior Reactor Operator License, and should have had considerable supervisory experience at a similar facility. The Reactor Supervisor is expected to hold an advanced academic degree in one of the physical sciences or engineering disciplines.

12.1.4.2 Chief Reactor Operator

The Chief Reactor Operator is expected to be familiar with the physics as well as the engineering aspects of reactors similar to the UMLRR. They will normally be cognizant of other systems but to a lesser degree. They must have a thorough knowledge of all rules, regulations, practices and procedures required by the USNRC, the Massachusetts Department of Public Health, and the UML Radiation Safety Committee. They must be able to deal effectively with others and to instruct reactor personnel. They must hold a USNRC Senior Reactor Operator License and should have had supervisory experience. The Chief Reactor Operator is expected to hold an advanced academic degree in one of the physical sciences or engineering disciplines.

12.1.4.3 Reactor Engineer

The Reactor Engineer is expected to be familiar with the physics as well as the engineering aspects of reactors similar to the UMLRR. They will normally be cognizant of other systems but to a lesser degree. They must have a thorough knowledge of all rules, regulations, practices and procedures required by the USNRC, the Massachusetts Department of Public Health, and the UML Radiation Safety Committee. They must be able to deal effectively with others and to instruct reactor personnel. They must hold a USNRC Senior Reactor Operator

License and should have had supervisory experience. The Reactor Engineer is expected to hold an advanced academic degree in one of the physical sciences or engineering disciplines.

12.1.4.4 Senior Reactor Operator

A Senior Reactor Operator is expected to have knowledge of the engineering aspects and reactor physics of the UMLRR, as well as of the rules, regulations, practices and procedures required by the USNRC, the Massachusetts Department of Public Health, and the UML Radiation Safety Committee. They must have considerable knowledge of the safety precautions peculiar to nuclear operations and the ability to supervise, instruct and train employees in reactor operations as well as to operate reactor equipment themselves. They must possess a USNRC Senior Reactor Operator License and are expected to hold a Baccalaureate degree in one of the physical sciences or engineering disciplines or be enrolled in such program.

12.1.4.5 Reactor Operator

A Reactor Operator is expected to have working knowledge of the basic science and engineering underlying the UMLRR as well as of the rules, regulations, practices, and procedures required by the USNRC, the Massachusetts Department of Public Health and the UML Radiation Safety Committee. They must understand the safety precautions peculiar to nuclear operations and be able to perform the various manipulations and exercise the various judgments required in the regular operation of the reactor. They must possess a USNRC Reactor Operator License are expected to hold a High School Diploma and be enrolled in a program that would result in a Baccalaureate degree in one of the physical sciences or engineering disciplines.

12.1.4.6 Selection and Training of Personnel

The UMLRR Selection and Training Program contains the detailed information concerning the selection, training, licensing and re-qualification of reactor personnel. This plan addresses the qualifications, initial training, licensee responsibilities, and re-qualification of UMLRR reactor operations personnel.

In order to develop and maintain an organization qualified for operation and maintenance of the UMLRR, personnel will be selected and trained as operators using the guidelines described in ANSI/ANS 15.4, Selection and Training of Personnel for Research Reactors. Personnel who have been selected and trained to operate a research reactor shall have that combination of academic training, job-related experience, health, and skills commensurate with their level of responsibility in order to provide reasonable assurance that decisions and actions during all normal and abnormal conditions will be such that the reactor is operated in a safe manner. To ensure that the above qualifications are satisfied, all personnel selected to be certified at the RO level and SRO level pursuant to 10 CFR 55 will participate in an initial training program and then a subsequent requalification program after their certification is received from the NRC. The physical condition and the general health of UMLRR reactor operations personnel shall be such that they are capable of properly operating under normal, abnormal and emergency conditions. The primary responsibility for assuring that medically qualified personnel are on duty rests with the UMLRR Reactor Engineer.

12.1.4.7 Initial Training and Certification

Initial training of personnel (trainees) to be certified as ROs and SROs will consist of documented stages of self-study and on-the-job training. The content of the training shall cover the physical facility, applicable theory and design, procedures, and applicable rules and regulations. The anticipated result of this training is a confident, well versed, decisive individual capable of performing the duties of a licensed operator during normal and abnormal situations. Certification of a candidate is achieved after extensive training followed by the successful completion of an examination administered by the NRC.

In addition to the selection and training of reactor operations personnel, the UMLRR provides formal training for all facility personnel in radiation protection topics, in items required by 1O CFR 19, in the As Low as Reasonably Achievable (ALARA) concept and in other related areas.

12.1.5 Radiation Safety

The Radiation Protection Program has been established to protect the health and safety of UMLRR staff, research associates, students, and the general public. A primary component of this program is dedicated to the fundamental principle of maintaining individual exposures and radioactive effluents to the ALARA principle. Responsibilities for maintaining the UMLRR ALARA Program extend to all individuals who are granted unescorted access to the reactor facility.

All personnel using radioactive materials or radiation sources shall become familiar with the requirements of the Radiation Protection Program and conduct their operations in accordance with them. However, the Health Physics Staff has the authority to interdict or terminate the use of radioactive materials or radiation sources if adequate health physics support is not available or if significant deviations from established procedures have occurred or are likely to occur. Requirements and procedures set forth in this program are designed to meet the following fundamental principles of radiation protection:

- Justification - No practice shall be adopted unless its introduction produces a net positive benefit;
- Optimization - All exposures shall be kept as low as reasonably achievable economic and social factors being taken into account, and
- Limitation - the dose equivalent to individuals shall not exceed limits established by appropriate state and federal agencies. These limits shall include, but not be limited to, those set forth in the Code of Federal Regulations (CFR).

All personnel using radiation sources shall become familiar with the requirements of the Radiation Safety Program and conduct their operations in accordance with them. The Radiation Safety Program uses ANSI/ANS 15.1 1, Radiation Protection at Research Reactors, as a guide. The details of the Radiation Safety Program can be found in Chapter 11.

12.2 Review and Audit Activities

12.2.1 UMLRR Radiation Safety Committee

12.2.1.1 Membership

The Radiation Safety Committee is appointed by the Chancellor of UML and approved by the Board of Trustees. The committee includes, in addition to certain persons required by Federal Regulations, members who represent broad area or divisions of UML which are likely to use radiation sources and is thus a mechanism for dissemination of information to the various possible users.

12.2.1.2 Committee Responsibilities, Delegation of Authority, and Subcommittees

The Radiation Safety Committee promulgates policy, regulations, and procedures relative to radiation safety. The Committee has the ultimate responsibility for all aspects of safety in the use of any device or source capable of emitting hazardous radiation. The Committee promotes the safe use of radiation sources and insures the health and safety of personnel and property both within the University and the public at large.

The Committee is responsible for assuring that an adequate safety program is developed and implemented. This is accomplished through delegation of authority to various person, ad hoc subcommittees and standing subcommittees with specific expertise in areas under their purview. In order to ensure good communication and to ensure that all activities are carried out according to established policies and procedures, the Radiation Safety Officer is a permanent member of the Radiation Safety Committee and all subcommittees. The various delegated authorities are outlines below.

a. The (Standing) Accelerator Safety Subcommittee reviews all aspects of safety in and around the accelerator facility. Subcommittee members are appointed by the Radiation Safety Officer and the Accelerator Supervisor, persons with training experience relative to accelerator operations. Decisions of the Subcommittee are binding subject to the ultimate approval by the Committee.

b. The (Standing) Reactor Safety Subcommittee considers all safety aspects of the reactor. Subcommittee members are appointed by the Radiation Safety Committee and include, in addition to the Radiation Safety Officer and Reactor Supervisor, persons with training and experience relative to reactor operations and persons with specific expertise in various scientific and engineering disciplines. Decisions of the Subcommittee are binding subject to the ultimate approval by the Committee.

c. The Radiation Safety Officer, in addition to administering the Radiation Safety Program, reviews all applications to use radiation sources. The Radiation Safety Officer in agreement with the appropriate Supervisor approves applications for the use of the accelerator or reactor of a routine nature already considered by the appropriate Subcommittee and ultimately the Radiation Safety Committee.

Additional requests of a routine nature relating to the use of other radiation sources are approved by the Radiation Safety Officer. This approval is considered to be in effect subject to ultimate review by the Committee. Requests to use such radiation sources, which, in the judgment of the Radiation Safety Officer involve a safety question not yet considered by the

Committee, are placed before the Committee. The Committee resolves the question either by direct action, or, where indicated, by appointment of an Ad Hoc Subcommittee composed of persons with expertise in the area under question whose decision is binding subject to approval by the Committee.

The Radiation Safety Office under the direction of the Radiation Safety Officer, with the ultimate approval of the Committee, formulates the safety program, which must be consistent with applicable Federal and State regulations governing the use of radioactive material and radiation producing devices. The approved program containing the overall policies and procedures relating to the safe use of radiation sources in the University is distributed to actual or potential users in the form of the Radiation Safety Guide for the University.

12.2.1.3 Committee Meetings

The Committee and all Subcommittees meet as frequently as required in order to fulfill their responsibilities. The Committee or any of the Subcommittees shall also meet when a respective member formally requests a meeting. Binding committee decisions require a majority of the members to be present including the Radiation Safety Officer or his designee. Minutes of the meetings will be recorded and kept on file for review.

12.2.2 UML Reactor Safety Subcommittee

The Reactor Safety Subcommittee (RSS) is composed of at least five members, one of whom is the Radiation Safety Officer and another of whom is the Reactor Supervisor. The other members are appointed (by the Radiation Safety Committee) with the aim of achieving a proficiency in all areas of reactor operation and reactor safety. Normally the members are senior scientific or engineering staff members or faculty. The Chairman is normally chosen from the senior members and normally does not have line responsibility for operation of the reactor.

The authority of the Subcommittee is the authority of the Radiation Safety Committee. The responsibilities of the Subcommittee include:

a. Review and approval of normal, abnormal, and emergency operating and maintenance procedures and records. The Facility Technical Specifications lists specific procedural categories covered.

b. Review and approval of proposed changes to the facility systems or equipment, procedures, and operations.

c. Review and approval of proposed tests and experiments utilizing the reactor facilities.
d. Determination of whether a proposed change, test, or experiment would constitute and un-reviewed safety question requiring a change of the Technical Specifications or facility license.
e. Review of all violations of the Technical Specifications and USNRC Regulations, and significant violations of internal rules or procedures, with recommendations for corrective action to prevent recurrence.
f. Review of the qualifications and competency or the operating organization to assure retention of staff quality.

The Subcommittee meets at the request of any member, and at least quarterly. Minutes of all meetings are kept. A Quorum of the Subcommittee is an absolute majority of the full Subcommittee and must include the Radiation Safety Officer or his designee and the Chairman or his designee.

12.2.3 Experimental Approval Mechanism

All proposed experiments using the reactor are evaluated by the experimenter and a staff member approved by the Reactor Safety Subcommittee. The evaluation includes consideration of 1) the reactivity worth of the experiment which must be no more than 0.5% $\Delta k/k$, 2) the integrity of the experiment, including effects on temperature, pressure, or chemical composition, 3) any physical or chemical reaction or interaction that could occur with reactor components, and 4) any radiation hazard that may result from the activation of materials from external beams.

The initial evaluation is reviewed by the Reactor Supervisor and the Radiation Safety Officer; if the experiment meets their approval and complies with the provision of the utilization license, the Technical Specifications, and 10 CFR 20, it is

a. Submitted by the Reactor Supervisor to the Reactor Safety Subcommittee for approval if it is a new experiment or involves a safety question not yet reviewed by the subcommittee, or,
b. Scheduled with the Reactor Supervisor's approval if it is a routine experiment.

If the experiment is submitted to the Subcommittee for evaluation, the following aspects are considered.

a. The purpose of the experiment.

b. The effect of the experiment on reactor operation and the possibility and consequences of failure of some aspect of the experiment, including, where indicated or significant, chemical reactions, physical integrity, design life, proper cooling interaction with core components, radiation and reactivity effects.
c. Whether or not the experiment, by virtue of its nature and/or design constitutes a significant threat to the integrity of the core, the integrity of the reactor, or to the safety of personnel.
d. A procedure for the performance of the experiment.

A favorable Subcommittee evaluation must conclude that failure of the experiments will not lead to direct failure of any reactor component or of other experiments. No experiment may be conducted until a favorable evaluation indicated in writing is rendered by the Reactor Safety Subcommittee. If an experiment has had prior Subcommittee approval, it then becomes a routine experiment and approval of a routine experiment or a minor variation with no significantly different safety questions may be done for the subcommittee by agreement of the Reactor Supervisor and the Radiation Safety Officer.

12.3 Procedures

Written procedures are established for the Reactor and its associated facilities. These procedures provide detailed guidance in the operation, utilization of the reactor and the laboratory facilities. These procedures shall be adequate to assure the safe operation of the reactor, the protection of the health and safety of the general public and the staff at the facility, and the protection of the environment.

12.3.1 Reactor Procedures

Reactor procedures provide methods and guidelines for operation of the reactor and associated systems to ensure safety and performance within the limits of the Technical Specifications. Changes to these procedures or to any other special operating or maintenance procedures which have safety significance, must be reviewed by the Reactor Safety Subcommittee (RSS) prior to the approval by the Reactor Supervisor. Procedural changes that would affect the basis of a Technical Specification or otherwise involve an un-reviewed safety question require approval of the U.S. Nuclear Regulatory Commission prior to issuance.

Changes which are editorial or have no safety significance may be made by the Reactor Supervisor, or his authorized delegate, but must be documented and subsequently reviewed by the RSS. The following is a list of evolutions or programs which typically require written procedures for the reactor operations staff. This list in no way limits the scope of procedures which may be covered under this section, i.e. radiation monitoring calibration procedures related specifically to the reactor may be covered under Reactor Procedures.

a. Start-up, steady-state operation, and shutdown of the reactor;
b. Fuel loading, unloading, and movement in the reactor core and/or pool;
c. Removal and installation of a control blade offset mechanism;
d. Pre-start-up operational checks of the reactor control and process instrumentation systems;
e. Start-up and shutdown of the primary and pool coolant systems and the associated auxiliary systems;
f. Administrative control of all facilities which could affect reactor safety, core reactivity and or ancillary systems;
g. Emergencies requiring immediate actions by reactor operations staff to place the reactor in a safe condition;
h. [redacted] fuel or sources licensed under the reactor;

12.3.2 Radiation Safety

UML Radiation Safety Guide provides methods and guidelines for the implementation and the maintenance of the UML Radiation Protection Program. This program has been established to protect the health and safety of UML, with specific portions dedicated to the UMLRR staff, research associates, students, and the general public. Changes to these procedures are made by the Radiation Safety Officer or their authorized delegate, and are subsequently reviewed by the RSC. The following is a list of evolutions or programs which typically require written procedures for the health physics and or reactor operations staff:

a. Reactor facility radiation monitoring program which may include surveys, personnel monitoring, radioactive waste management, and sampling and analysis of solid, liquid, and gaseous wastes released from the facility;

b. Calibration of area radiation monitors, facility air monitors, laboratory radiation detection systems, personal radiation monitoring devices, and portable radiation monitoring instruments;
c. Administrative guidelines for the facility personnel indoctrination training program;
d. Receiving and opening packages of radioactive materials and their subsequent transfer within the facility;
e. Monitoring of radioactivity in the environment surrounding the facility;
f. Leak-testing of sealed sources containing radioactive materials;
g. Shipment of radioactive materials;
h. Radioactive analysis of the primary and pool coolant; and
i. Preparation for shipping and the shipping of byproduct material.

12.4 Required Actions and Reportable Events

The following incidents and conditions relating to the operation of the reactor require that the NRC be informed per ANSI/ANS 15.1, "The Development of Technical Specifications for Research Reactors". Occurrences which are considered reportable events also require certain actions prior to returning the reactor to its normal condition. In all cases, within 24 hours of the occurrence of a reportable event, as described, a report shall be made by telephone through the NRC Operations Center, Washington, DC, NRC Region 1. Detailed actions are outlined below.

12.4.1 Safety Limit Violation

If a Safety Limit (SL), as defined by the Technical Specifications, is violated, cessation of reactor operations is required until resumption is authorized by the NRC. A prompt report of the safety limit violation to the NRC with a subsequent detailed follow-up report (Licensee Event Report) is required. The Licensee Event Report (LER) shall include: the circumstances leading to the violation including, when known, the causes and contributing factors; date and approximate time of the occurrence; effect of the violation upon the reactor and associated systems; effect of the violation on the health and safety of the facility staff and general public; and the corrective actions to prevent recurrence. Prompt reporting of the violation shall be made to the NRC Project Manager for UMLRR no later than the following working day. The LER will be submitted to the NRC Document Control Desk, with a copy to the NRC Project Manager, within fourteen days.

12.4.2 Release of Radioactivity

Should a release of radioactivity of greater than allowable limits occur from the reactor facility boundary, reactor conditions shall be returned to normal operation or the reactor shall be shut down. If it is necessary to shut down the reactor to correct the occurrence, operations shall not be resumed until authorized by the Reactor Manager. The NRC Project Manager for UMLRR shall be notified no later than the following working day. The LER will be submitted to the NRC Document Control Desk, with a copy to the NRC Project Manager, within fourteen days.

12.4.3 Other Reportable Occurrences

Other occurrences that are considered reportable events are listed below. The NRC Project Manager for UMLRR shall be notified no later than the following working day. The LER will be submitted to the NRC Document Control Desk, with a copy to the NRC Project Manager, within fourteen days. A return to normal reactor operations will not be allowed until authorized by the Reactor Supervisor. (Note: Where components or systems are provided in addition to those required by the Technical Specifications, the failure of the extra component or system is not considered reportable provided that the minimum number of components or systems, specified or required, still remain to perform their intended reactor safety function.) Those "other reportable occurrences" are:

a. Operation with actual safety system settings for required systems less conservative than the Limiting Safety System Settings (LSSSs) specified in the Technical Specifications;
b. Operation in violation of limiting conditions for operation established in the Technical Specifications;
c. A reactor safety system component malfunction which renders or could render the reactor safety system incapable of performing its intended safety function unless the malfunction or condition is discovered during maintenance tests or periods of reactor shutdown;
d. An unanticipated or uncontrolled change in reactivity greater than 0.5 % $\Delta k/k$. Reactor trips resulting from a known cause are excluded;
e. Abnormal and significant degradation in reactor fuel or cladding, or both; coolant boundary, or containment boundary (excluding minor leaks), which could result in exceeding prescribed radiation exposure limits of personnel or environment, or both;

f. An observed inadequacy in the implementation of administrative or procedural controls such that this inadequacy causes or could have caused the existence or the development of an unsafe condition involving the operation of the reactor.
g. Conditions arising from natural or offsite manmade events that affects or threaten to affect the safe operation of the facility.

12.5 Reports

12.5.1 Annual Report

Annual reports detailing the activities of the reactor facility in connection with the operation of the reactor will be submitted to the NRC Document Control Desk within 60 days following each state fiscal calendar year. Each annual report shall include the following information:

a. A brief narrative summary including:
   (1) Operating experience (including operations designed to measure reactor characteristics);
   (2) Changes in the reactor facility design, performance characteristics, and operating procedures related to reactor safety during the reporting period; and
   (3) Results of surveillance tests and inspections;
b. A tabulation showing the energy generated by the reactor (in megawatt-days);
c. The number of emergency shutdowns and inadvertent scrams (unscheduled shutdowns);
d. Discussion of the major maintenance operations performed during the reporting period, including the effects, if any, on the safe operation of the reactor;
e. A summary of each change to the reactor facility, operating procedures, tests, and experiments carried out under the conditions of 10 CFR *50.59;*
f. A summary of the nature and amount of radioactive effluents released or discharged to the environs beyond the effective control of the licensee at or prior to the point of such release or discharge;
g. A description of any environmental surveys performed outside the reactor facility; and
h. A summary of radiation exposures received by facility personnel and visitors, including the dates and times of significant exposure and a brief summary of the results of radiation and contamination surveys performed within the facility.

12.5.2 Licensee Event Report (LER)

Section 12.4 includes the reporting requirements for the relevant events. Each specific case is identified and the explicit reporting requirements for the event are listed.

12.5.3 Unusual Events

A written report shall be forwarded within 30 days in the event of:

a) Discovery of any substantial errors in the transient or accident analyses or in the methods used for such analyses, as described in the safety analysis or in the bases for the technical specifications;
b) Discovery of any substantial variance from performance specifications contained in the technical specifications and safety analysis.
c) Discovery of any condition involving a possible single failure which, for a system designed against assumed failures, could result in a loss of the capability of the system to perform its safety function.

12.6 Records

In addition to the requirements of applicable regulations and in no way substituting therefore, records and logs of the following items, as minimum, shall be kept in a manner convenient for review and shall be retained as indicated.

12.6.1 Five Year Records

Records to be retained for a period of at least five years:

a. Reactor operations:
b. Principal maintenance activities;
c. Experiments performed including aspects of the experiments that could affect the safety of reactor operation or have 'radiological safety implications;
d. Reportable occurrences;
e. Equipment and component surveillance activities;
f. Facility radiation' monitoring surveys;
g. Fuel inventories and transfers; and
h. Changes to procedures systems, components, and equipment.

12.6.2 Lifetime Records

Records to be retained for the life of the facility:

a. Gaseous and liquid radioactive effluents released to the environs;
b. Off-site environmental monitoring surveys;
c. Personnel radiation exposures;
d. Updated, "as-built" drawings of the facility;
e. Minutes of the Radiation Safety Committee (RSC) and the Reactor Safety Subcommittee (RSS) ; and
f. Any reportable Safety Limit violation

12.7 Emergency Plan

The UMLRR Emergency Plan contains detailed information concerning the UMLRR's response to emergency situations. The UMLRR Emergency Plan is written to be in accordance with ANSI/ANS 15.16, "Emergency Planning for Research Reactors". The information below provides a general overview of the emergency plan.

The UMLRR Emergency Plan is designed to provide response capabilities to emergency situations involving the UMLRR. The plan deals with the UMLRR facility, the spectrum of emergency situations and accident conditions that could arise within the facility, and the associated emergency responses that are required due to the unique nature of the reactor facility. Detailed emergency procedures are referenced in this plan. This approach provides the UMLRR facility emergency response staff the flexibility to cope with a wide range of emergency situations without requiring frequent revisions to the plan.

The responsibility for the plan rests with the UMLRR Reactor Supervisor who is also responsible for response to and recovery from emergencies. Implementation of the UMLRR Emergency Plan on a day-to-day basis is the responsibility of the Senior Reactor Operator on duty. Provisions for reviewing, modifying and approving emergency implementation procedures are defined in the UMLRR Emergency Plan to ensure that adequate measures to protect the staff and the general public are in effect at all times.

12.8 Physical Security Plan

The UMLRR Physical Security Plan describes the physical protection system and the security organization which will detect the attempted theft or theft of Special Nuclear Material (SNM) at the UMLRR. It outlines the objectives and describes the security requirements and security measures for the reactor facility.

The Reactor Supervisor or his designated representative has overall responsibility for the initiation and implementation of the Physical Security Plan. The Physical Security Plan should be annually reviewed and revised as necessary.

12.9 Quality Assurance Program

The QA program is largely based on the surveillance requirements for important systems and sub-systems specified in the UMLRR Technical Specifications. The QA program is dynamic and is modified as indicated by operating experience to assure an adequate program. The areas included in the QA program are:

a) Reactor Control and Safety Systems
b) Radiation Monitoring Equipment
c) Containment Building and Filter Checks
d) Pool Water Level Channel
e) Emergency Power System
f) Maintenance

The QA program is intended to ensure that:

a) Proper authority for scheduling, carrying out, and approving surveillance tests or maintenance is documented,
b) Personnel involved in the various aspects of surveillance or maintenance are qualified in a prescribed manner. Training and qualifications will be documented.
c) The equipment and test components used to perform the various checks are calibrated, certified, and properly documented.
d) Performance verification in the various surveillance and maintenance tasks is documented. Repair and/or replacement of components will be controlled from inception through installation and performance tests.
e) Surveillance and maintenance schedules are maintained.

12.10 Operator Training and Requalification

The UMLRR Operator Training and Requalification Program is designed to provide assurance that all operators certified at the RO and SRO levels, pursuant to 10 CFR 55, maintain competence and proficiency in all aspects of licensed activities. The objectives of the program are to review/retrain in areas of infrequent operation, to review facility and procedural changes, to address subject matter not reinforced by direct use, and to improve in areas of performance by direct use and to improve in areas of performance weakness.

The UMLRR Operator Requalification Program uses ANSI 15.4 as a guide and is divided into the following four main components:

a. Written Examinations;
b. On-The-Job Training;
c. Operating Tests; and
d. Documented Review of Changes.

A biennial written examination is given to licensed operators to verify the individual's knowledge level in the categories mentioned below. The examinations will be of a scope and complexity equivalent to the licensing examinations administered by the NRC. The results of the examination shall provide the basis for a determination of those areas in which an operator needs retraining. Preplanned lectures shall be used to retrain those operators who demonstrate deficiencies in any part of the examination. The examination shall contain questions from each of the following categories:

a. Reactor Theory, Thermodynamics, and Facility Operating Characteristics;
b. Normal and Emergency Procedures, and Radiological Controls; and
c. Facility and Reactor Plant, and Radiation Monitoring Systems.

The minimum acceptance score in any one category and on the entire examination shall be established. Failure in one category will require retraining the operator until a satisfactory passing grade is attained in that category. Failure of the entire test will place the operator in an accelerated training program until retraining results in a satisfactory passing of the re-examination. Furthermore, the individual will be removed from licensed activities until the written re-examination is passed.

On-the-job training consists of performing evolutions which are typically accomplished only by licensed operators. These evolutions include plant control manipulations and plant evolutions (e. g., start-ups, shutdowns, significant reactivity changes, etc.) required by 10 CFR 55.59 (c) (3).

On-the-job training provides assurance that (1) the operator maintains his competence in manipulating the plant controls and in operating all apparatuses and mechanisms required by his license, and (2) that he has a thorough understanding of all emergency procedures.

Documented reviews ensure that all licensed individuals are cognizant of all design, procedural, Technical Specifications, and facility operating license changes. The operators sign an attached review sheet indicating that the documents describing these changes have been read and understood.

12.11 Startup plan

The UMLRR has been in operation since initial criticality was achieved in 1974. Conversion to an LEU core was accomplished in 2000. For any activities that might require a written startup plan, it will be supplied under a separate document.

12.12 Environmental Reports

The UMLRR falls under a categorical exclusion as described in 10 CFR 51.22, and therefore no environmental report is necessary. On January 23, 1974, the AEC staff concluded in a memorandum addressed to D. Skovholt and signed by D. R. Miller, "that there will be no significant environmental impact associated with the licensing of research reactors or critical facilities designed to operate at power levels of [redacted] MW(t) or lower and that no environmental impact statements are required to be written for the issuance of construction permits or operating licenses for such facilities."

Since this Safety Analysis Report is written in support of extending the license expiration date for an additional 20 years, no changes in land and water use are contemplated. Emissions of radioactive materials or other effluents will not change as a result of extending the license term.

12.12.1 National Environmental Policy Act (NEPA) Considerations

The following presents a summary of impacts associated with NEPA.

12.12.1.1 Endangered Species Act

The site occupied by the UMLRR does not contain any listed species, critical habitats, or national wildlife refuges.[i] The UMLRR effluents will not impact any endangered species.

12.12.1.2 Coastal Zone Management Act

The site occupied by the UMLRR is not located within any managed coastal zones, nor do the UMLRR effluents impact any managed coastal zones.

12.12.1.3 National Historic Preservation Act

The National Register of Historic Places (NRHP) lists two historical sites located on the UML campus – the Allen House (1982) and the Wannalancit Mills (1976 and 1978). The location of the Allen House is approximately 1.6 km (1 mile) southwest of the UMLRR. The location of Wannalancit Mills is approximately 1 km (0.6 mile) east of the UMLRR. Given the distances to the each site from the UMLRR, continued operation of the UMLRR will not impact any historical sites.

---

[i] U.S. Fish and Wildlife Service Trust Resources List, New England Ecological Services Field Office, http://www.fws.gov/newengland

REDACTED FOR PUBLIC RELEASE

Table of Contents

Table of Figures

Table of Tables

REDACTED FOR PUBLIC RELEASE

13 Accident Analysis

13.1 Accident-Initiating Events and Scenarios

The Accident Analysis demonstrates that various facility design features, the safety limit, limiting safety system settings, and limiting conditions for operation have been selected to ensure that no credible accident can lead to unacceptable radiological consequences to people or the environment. The following sections provide a summary of accident-initiating events postulated in NUREG 1537. The analysis of the events and determination of consequences is given in Section 13.2. One of the events listed below, the Maximum Hypothetical Accident, involves a non-credible scenario that assumes the release of fission products from one side of one fuel plate. The analyses for the non-hypothetical events show no possibility of fuel damage.

13.1.1 Maximum Hypothetical Accident

An accident resulting in a significant release of fission products is considered highly improbable. None of the postulated and analyzed accidents would lead to the gross failure of the fuel plate cladding and uncontrolled release of fission products.

The likelihood of the major failure of the fuel plate cladding is considered non-credible. The fuel elements must meet rigid quality control standards; pool water quality is carefully controlled; and fuel handling can only occur under strictly controlled procedures. Minor physical damage to the fuel plate cladding is possible due to manufacturing defects, corrosion, or handling damage and might result in the release of small amounts of fission products into the reactor pool. This type of damage is very infrequent as demonstrated by many years of operating experience with plate fuel, and would not result in a significant fission product release that could serve as the basis for a bounding fuel failure scenario. In 40 years of operation, the UMLRR has not experienced a fission product release. In addition, experiments containing fissile material (fueled experiments) are presently not allowed in the UMLRR core and would require a separate analysis and license amendment.

13.1.2 Insertion of Excess Reactivity

The scenarios considered are a step reactivity insertion and a ramp reactivity insertion. Rapid reactivity changes can occur due to the failure of a fixed experiment or other device, due to a rapid cold water insertion event, or possibly due to the rapid removal of an experimental bayonet from one of the in-core radiation baskets. Although never instantaneous in practice, to be conservative, these postulated rapid changes are often modeled as step (or near-step) reactivity changes in the system. The inadvertent withdrawal of a control blade is the most obvious initiating event that could be associated with a postulated ramp reactivity insertion. The analyses for both scenarios demonstrate that the Technical Specifications limiting conditions for reactivity ensure fuel damage will not occur for these events.

13.1.3 Loss of Coolant Flow

A loss of flow scenario could occur with a pump failure, a loss of electrical power, or an inadvertent shutdown of the pump. During the forced cooling mode of operation, the primary pump supports a nominal flow rate of about [redacted] GPM. If, for any reason, forced flow is lost, then the downward flow coasts down until it ceases. Upward flow then is initiated by the difference in fluid density in the heated channels and the surrounding pool. This establishes an equilibrium natural convection flow when the buoyancy forces balance the fluid friction forces in the coolant channels. Eventually the system temperatures and individual channel flow rates stabilize and then continue to decrease slowly as the internal heat source (i.e. decay heat) steadily decreases in time. The analyses demonstrate that the peak fuel temperature remains far below the level at which fuel damage will occur.

13.1.4 Loss of Coolant

An event or sequence of events leading to a total loss of water from the reactor pool is considered non-credible. The pool is specifically designed to preclude the probability of drainage. It is constructed of reinforced concrete with approximately six-foot thick walls and a heavy aluminum liner to resist the most severe earthquake that might reasonably be expected in the area. Penetrations of the reactor pool below the top of the core are welded or use water-tight seals. In view of the inherent integrity of the design features, a loss of pool water to the point of uncovering the core is highly improbable. Nevertheless, several referenced studies have shown a loss-of-coolant accident (LOCA) will not result in fuel damage for a reactor operating under 3MW since the relatively low decay heat in the fuel is incapable of causing fuel failure. In addition, an extensive analysis of direct and indirect radiation exposure from the unshielded sources at the bottom of the reactor pool is presented in Section 13.2.4. If such an unlikely scenario were to occur, the direct and indirect dose rates to personnel would not be realized since the reactor containment building would be evacuated before the water completely drained from the reactor pool. Geometry factors and the protective shielding of containment building walls limit the indirect doses outside of the reactor building.

13.1.5 Mishandling or Malfunction of Fuel

Mishandling of fuel is considered improbable due to the careful design of the fuel handling tools and because of strict administrative and procedural controls required for handling fuel. The malfunction of fuel also is considered improbable due strict quality assurance and control during manufacture. Water quality in the reactor pool is maintained to a high standard to minimize corrosion. Other analyses presented in this chapter show that overheating of the fuel to the point of causing damage is not possible for the credible operational events.

13.1.6 Experiment Malfunction

Damage to the core from this type of accident is considered improbable due to the careful design of all in-core experiment facilities. The review process for experiments is administered under restrictive specifications. Procedural controls impose strict performance standard on in-core and ex-core experiments.

13.1.7 Loss of Normal Electrical Power

There is no consequence to the reactor for a loss of normal electrical power. The reactor safety and building isolation systems are designed to be fail-safe. The reactor would automatically shut down and the building would isolate for a loss of electrical power.

13.1.8 External Events

Damage to the core from external events (lightning, floods, meteorological disturbances, and seismic events) is not considered credible since the core is contained within a thick reinforced concrete tank that is [redacted] gallons of water, and is located within a [redacted] building.

13.1.9 Mishandling or Malfunction of Equipment

Damage to the core from accidents of this type is not considered credible due to the passive safety features of the reactor. While the operator is integral to the operation of the reactor and provides a redundant factor for reactor safety, the redundancy in the reactor protection system prevents the possibility of a single-point human failure. An operational error by the operator or even the loss of the operator would not result in a situation creating an accident beyond those analyzed in this chapter. The reactor is designed so that instrument or equipment failures generally result in a reactor shutdown. Strict administrative and procedural controls supplement the engineering design to further increase the margins of safety.

13.2 Accident Analysis and Determination of Consequences

13.2.1 Maximum Hypothetical Accident

To derive a bounding radiation hazard to facility personnel and members of the public, a Maximum Hypothetical Accident (MHA) is postulated as an enveloping event involving the removal of the cladding from one side of one fuel plate while the fuel is in the reactor pool. The MHA is considered the worst-case fuel plate failure for the UMLRR leading to the maximum potential radiation hazard from fuel failure. In postulating the MHA no assumption is made about the cause of the failure or the likelihood of the event, and no mechanism is identified that would produce such failure and fission product release. The postulated removal of the cladding from one side of the fuel plate would result in a release of volatile fission products accumulated in the gap and from portions of the fuel meat.

The radiological hazard associated with the MHA is the postulated fission product release within the facility and to the surrounding environment. The consequences of the release of volatile fission products to the primary coolant and reactor pool, and then to the containment space are presented below. In addition, scenarios are analyzed, which result in the escape of fission products to the surrounding environment. The information presented in this chapter is based on many years of experience in operating Material Test Reactor (MTR) plate type fuel, and also on appropriate information developed for the U.S. NRC and documented in NUREG 1537[i] and NUREG/CR-2079[ii].

13.2.1.1 Source Term

The major parameter characterizing the radiological impact is the fission product inventory in the fuel due to burnup and power density. The radionuclide inventories determine the maximum concentration of fission products in the fuel plate and the amount that may be released following the fuel element cladding failure. Some of the fission products would diffuse into the reactor pool and the reactor bay area, and ultimately be released into the surrounding environment. The calculations are based on the assumption that operating the reactor at maximum power level for a sufficiently long period of time fission products concentrations reach equilibrium levels and therefore all halogens and noble gases are at their saturation activity. The resulting equilibrium nuclide concentration of fission products depends upon the total energy release in the reactor, the decay process for each nuclide, and the yield of the species from fission and can be expressed as[iii]

$$\lambda_i N_i = 3.1 \times 10^{11} \times PW_0 \times \gamma_i$$

where,

$$\lambda_i = radioactive\ decay\ constant\ for\ the\ i^{th}\ isotope$$
$$N_i = saturation\ number\ of\ atoms\ for\ the\ i^{th}\ isotope$$
$$PW_0 = reactor\ power\ (watts)$$
$$\gamma_i = fractional\ fission\ yield\ for\ the\ i^{th}\ isotope$$

The analysis assumed that the UMLRR reactor operated at full, 1 MW power at equilibrium conditions with the minimum number of fuel plates. The fission product inventories with significant contribution to the radiological hazard are listed in Table 13-1. The inventories were calculated at equilibrium conditions using the maximum power level (1 MW), the fission yield, and decay data of the individual isotopes. The analysis was supplemented with results from Woodruff[iv] for some of the isotopes. The Woodruff analysis was performed with ORIGEN with an EPRI-CELL corrected cross section data to incorporate neutron spectrum effects specific to test reactors.

REDACTED FOR PUBLIC RELEASE

The assumption of continuous operation and the consequent maximum saturation activity is highly conservative for the fission product release during the MHA. The UMLRR typically operates only for several hours at a time and radionuclides with longer half-lives will not reach equilibrium concentrations as assumed in the MHA analysis.

In Table 13-1 (column 3) the isotopic content is listed for the maximum power fuel plate with a peaking factor of two corresponding to a power of 6.94 kW with the minimum number of 18 fuel assemblies in the reactor core. It is assumed, conservatively, that the failed fuel plate is located at the peak neutron flux position in the reactor core and fails at the end of the operating period resulting in maximum fission product inventory.

Fission product release from the surface of the fuel is limited to fission fragment recoil due to the low temperature of the fuel limiting fission product diffusion processes. The amount of activity released primarily depends on the fuel temperature and the exposed fuel surface area. The fuel temperature, even operating at full 1 MW power would be low and diffusion of fission products inside the fuel would be essentially zero. Any release of fission products would only be from the surface of the fuel through kinetic energy imparted by the fission fragment recoil. For the MTR-type fuel NUREG/CR-2079 recommends the recoil distance of 1.37E-03 cm based on available measurement data (fission product release fractions based on U.S. NRC Regulatory Guides 1.183 and 1.195 are not applicable due to the much higher operating fuel temperatures of power reactors, different fuel type, and the postulated reactor core damage mechanism).

For the postulated MHA with the cladding removed from one side of the fuel plate, it is assumed that 100% of gaseous activity produced within the recoil range escapes from the fuel. The release of other semi-volatile fission products (Sr, Cs, etc.) is assumed to be negligible due to the low operating temperature. The amount of noble gases and iodine released from one side of the fuel plate within the recoil distance is listed in Table 13-2 (column 2).

The main conservative assumptions in the analysis are:

- Fission products are at their equilibrium, saturated level (infinite operating time).
- Failed fuel plate located at peak neutron flux location.
- Fuel plate fails at the end of operation.

The MHA scenario assumes the instantaneous release of the fission products into the reactor pool without radioactive decay after the postulated stripping of the fuel plate cladding. All noble gases escape into the reactor bay and only the radioiodines diffuse into the water solution. Further simplifying assumptions are:

Radionuclides released from the fuel plate instanteneously mix with the total reactor pool water without radioactive decay. The primary flow pathway through the pool utilizes the entire pool volume (stall and bulk sections), which together have conservatively 67,500 gallon of water (actual pool volume is 10% greater).

All iodine isotopes are released in elemental form and readily dissolved in the primary coolant.

The mole fraction of radioiodines may be calculated as,

$$X_W = \frac{N_I}{N_A} \times \frac{1}{VK\rho/M}$$

Where:

$N_I =$ *radioiodine atoms released*

$N_A =$ *Avogadro's number*

$V =$ *reactor pool volume* $(6.75 \times 10^4 \text{gal})$

$K =$ *conversion factor*

$\rho =$ *density of water* (g/cm^3)

$M =$ *molecular weight of water*

REDACTED FOR PUBLIC RELEASE

After substituting the appropriate values, the mole fraction for total iodine is X_w= 6.00E-14. The partial pressure of iodine in air, P_I may be estimated using the vapor pressure of pure iodine, P_o from the equation[v]

$$log_{10}P_0 = A - \frac{B}{T + C}$$

Where,

$T = temperature, 316.483K$ and, $A = 3.36429;\ B = 1039.159; C = -146.589$

and then,

$$P_I = P_0 \times X_w$$

For a pool temperature of 110F (316.5K) P_o=1.33 mmHg, and then the partial pressure of total iodine in air is calculated as P_I=7.96E-14 mmHg. The molar fraction of total iodine in air, assuming standard atmospheric pressure is given as $X_{air}=P_I$ / (760 mmHg)=1.05E-16.

By noting that the free volume of the reactor containment, V_R=9486 m^3 (3.35E+05 ft^3), the total moles of iodine, M_I inside the building is obtained as $M_I=P_I$ x V_R / 24.5=3.43E-11. The radioactive iodine isotopes released into the reactor containment area are obtained using the following equation:

$$A_i = 2N_A\lambda_i M_I \frac{N_i}{N_I}$$

The resulting iodine and noble gas activities are listed in Table 13-2 (column 3). It is also assumed that inside the containment the concentration of the iodine is in equilibrium between the pool water and the building air and the only reduction is due to radioactive decay in some of the scenarios discussed in following section.

13.2.1.2 Scenarios for the Maximum Hypothetical Accident

A number of locations and MHA scenarios were considered to provide bounding dose estimates for facility personnel and members of the public. During reactor operations the containment building pressure must be maintained below ambient atmospheric pressure using the normal ventilation system in accordance with Technical Specification (TS) 4.4. In addition, while the reactor is in operation TS 3.5 requires the containment integrity to be maintained, and the emergency exhaust as well as the containment isolation system to be operable.

Multiple combinations of fixed area radiation detectors would automatically trigger containment building ventilation isolation after radiation alarms indicate fission product release inside the containment building. Operation personnel would verify that the ventilation system is shut down before evacuating the building. After the normal ventilation system shuts down and isolation valves are closed, the emergency exhaust system is designed to relieve any overpressure. The emergency exhauster is equipped with carbon and HEPA filters and discharges air through the building stack maintaining negative building pressure.

In most scenarios below, it is assumed that operation personnel respond in accordance with procedures for the radiological event and ensure that the containment building is isolated. However, for some scenarios, it is more conservative either to leave the ventilation system in operation (fails to shut down) or have the emergency exhaust system fail to start resulting in bounding (higher) dose estimates to facility personnel or member of the public.

<u>Scenario A – Reactor Building Interior</u>

The reactor containment building is a radiological restricted area and all facility personnel are designated as radiation workers. The occupational dose must remain below the regulatory limit in 10 CFR Part 20.1201 "Occupational dose limits for adults," that specifies the facility workers will be exposed to airborne gaseous fission products with the following conservative assumptions:

- No credit for radioactive decay.
- No credit for iodine deposition on the building surfaces.

- Normal ventilation system shuts down, building is isolated and emergency exhauster fails to start. It ensures that all fission products are contained inside the building exposing facility personnel to the maximum radiation dose.
- Facility personnel evacuate the reactor building in 10 minutes. Evacuation drills have demonstrated that personnel within the reactor building can be evacuated within 5 minutes. For conservatism, it is assumed that the evacuation takes place in 10 minutes during which time there is no radioactive decay and building ventilation is off resulting in maximum exposure to personnel.
- Dose to personnel exposed inside the reactor building results from a finite, hemispherical cloud of uniformly distributed gaseous fission products. The hemisphere has a volume 9486 m3 (3.35E5 ft^3), equal to that of the reactor building.

Facility personnel will be exposed to radiation due to submersion and inhalation effects in a radioactive cloud inside the containment. 10 CFR Part 20.1201 establishes the annual radiation dose limit to facility personnel as the more limiting of either the whole-body total effective dose equivalent (TEDE) of 5 rem (0.05 Sv) or to any individual organ or tissue as 50 rems (0.5 Sv). The analysis below presents results for the thyroid and whole-body TEDE.

<u>Scenario B – Personnel Access Doors and Truck Door</u>

The containment has [redacted] interior floor areas [redacted]. The containment building [redacted] concrete wall, the double [redacted] doors are [redacted] and [redacted]) with a distance between [redacted] and [redacted], respectively. The airlock shells extend into the classroom building with a [redacted] thick metal shell surrounded by [redacted] along the walls, and with a [redacted] concrete above the first, [redacted] concrete below [redacted] hallways, each with a locked security door. Public access is outside of the security doors.

The containment also has a [redacted] thick truck access metal door facing the adjacent parking lot. On the outside there is a roll-up sheet metal garage door creating a [redacted] space between the doors. The outside of the roll-up door is not considered a controlled area

REDACTED FOR PUBLIC RELEASE

and potentially accessible to members of the public. Figures 13-4A and 13-4B show the containment elevation, 1st floor plan view [redacted] the [redacted] The access points inside the [redacted] building security doors and the outside of the roll-up truck garage doors are considered radiological unrestricted area and the public dose must remain below the regulatory limits in 10 CFR Part 20.1301 "Occupational dose limits for individual members of the public," that specifies a TEDE limit of 100 mrem (1 mSv).

The following assumptions are made in analyzing the scenario:

- The ventilation system including the emergency exhaust is off without any leakage to the outside environment.
- Radioactive decay for all isotopes.
- Radiation exposure is due to gamma shine or gamma radiation through the containment walls and access points i.e., airlocks and truck access door.

<u>Scenario C – Leakage around Containment Truck Access Door</u>

The containment building is designed such that the maximum allowable leakage rate [redacted] It is difficult to imagine any physical scenario that creates a pressure [redacted] with the combination of an MHA congruent with an extreme weather event. The leakage would preferentially be directed through the building stack due to the air pressure differential resulting in a stack level discharge. If the building is slightly over pressurized, it is conceivable that a small leakage could [redacted]. For completeness it is assumed that no more than [redacted]y of the building volume would [redacted]. The following assumptions are made in analyzing the scenario:

- The ventilation system is off and the emergency exhaust system fails to start.
- Containment building leaks at a conservative rate of 1[redacted]day resulting in a ground release (a one inch gap around the truck access door with a Δp ~7kPa (extreme weather condition) would result in a [redacted]
- Radioactive decay considered for the gamma shine component and the ground release.

REDACTED FOR PUBLIC RELEASE

- Historical wind pattern assumed for the slow ground release. Wind rose data shown on Figure 13-1 was taken at Hanscom Air Force Base in Bedford, MA for the year 2013. Figure 13-2 and 13-3 shows the wind speed frequency distribution at the same location by speed classes and directions. Hanscom Air Force base is [redacted]

Scenario D – Public Areas outside Containment

The outside area of the containment is considered radiological unrestricted area with potential public access near to the containment wall since the area is not fully fenced in. Two locations are considered, one near the containment and another at the location with the maximum dose due to dispersion of the radioactive plume. The following assumptions are made:

- Ventilation system fails shutting down and the entire MHA radioactive source is an elevated release exhausted to the outside through the [redacted] building stack with one complete room exchange in [redacted]
- No radioactive decay.
- Prevailing wind for the area is westerly based on data indicated on Figure 13-1.
- The wind is blowing from the west throughout the scenario with stability category F (Pasquill F moderately stable).
- Radiation exposure near the containment is due to gamma shine through the containment walls and truck access door as well as submersion and inhalation from the radioactive plume.
- At the maximum radiation exposure location, the occupant would be exposed to submersion and inhalation of the radioactive plume containing fission products dispersed by atmospheric transport.

Scenario E – Public Areas outside Containment

This scenario is not considered as bounding for either the gamma shine or plume dispersion component. However, it is included as the most likely evolution of a potential

MHA and therefore it provides the most representative exposure scenario. It is the same as Scenario D except for the following assumptions:

- Ventilation system is shut off and the emergency exhaust system operates discharging the radioactive fission products over an 18 hour period.
- No credit for the installed carbon and HEPA filters in the discharge path.
- Radioactive decay considered for the gamma shine component and the ground release.
- Wind directions reflect the historical weather pattern shown in Figure 13-1, 13-2, and 13-3.
- Dilution of emergency exhaust flow from the main air intake is neglected
- Radiation exposure near the containment is due to gamma shine through the [redacted]
- At the maximum radiation exposure location, the occupant would be exposed to submersion and inhalation of the radioactive plume containing fission products dispersed by atmospheric transport.

13.2.1.3 Dose Analysis

The dose analysis for each location was performed by incorporating the above listed assumptions for facility personnel and members of the public. The radiation exposure of an individual is converted to doses using Dose Conversion Factors (DCFs) for the inhalation and submersion external exposure pathways available in the Federal Guidance Reports (FGRs) No. 11 and 12.[vi, vii] The occupational and public TEDE doses were calculated for each locations described in Scenarios A through D above using both FGR-11 and FGR-12 with the calculated radioactive isotope inventory. Table 13-3 lists the applicable thyroid and whole-body DCFs for the radionuclide isotopes considered in the analysis.

Another parameter used in the analysis is the average breathing rate of an individual adult, which is assumed to be [redacted], consistent with the value given in Appendix B of 10 CFR Part 20.

REDACTED FOR PUBLIC RELEASE

Scenario A – Reactor Building Interior

After the radiation alarm indicates fission product release due to the MHA, personnel [redacted]. The radiation dose is due to inhalation and submersion in the semi-hemispherical gaseous cloud of the reactor building volume containing fission products.

The inhalation and submersion doses are given by

$$H(inhalation) = DCF(i) \times BR \times A_i \times t$$
$$H(submersion) = DCF(s) \times A_i \times t$$

where

$DCF(i) = \ Inhalation\ Dose\ Conversion\ Factors\ [Sv/Bq]$

$DCF(s) = \ Submersion\ Dose\ Conversion\ Factors\ [Sv \times m^3/Bq \times s]$

$BR \quad = Breathing\ rate,$ [redacted] $\frac{m^3}{\mathrm{hr}}$

$t \quad = \quad Time, 10\ minutes$

$A_i \quad = \quad i^{th}\ radionuclide\ concentration\ in \frac{Bq}{m^3}$

The thyroid committed effective dose equivalent (CEDE) and whole-body total effective dose equivalent for the 10 minutes residence time are shown in Table 13-4. The calculated occupational thyroid dose of [redacted] and whole-body TEDE of 464 mrem [redacted]) are below the regulatory limit for thyroid dose [redacted] mrem and occupational TEDE [redacted].

Scenario B – Personnel Access Doors and Truck Door

The closest public area where a member of the public may potentially be exposed to radiation dose is [redacted]s. The containment wall is [redacted] thick concrete that provides ample shielding to gamma ray radiation. However, less shielding is provided at the [redacted] The possible exposure to the general public would be due to direct and scattered gamma radiation from the decay of the fission products contained inside the containment air space. It is assumed that the ventilation system and emergency exhaust are shut off resulting in the maximum dose estimates to the member of the public.

In order to calculate the gamma ray dose rate after the postulated MHA a three dimensional MCNP model was developed for the containment building. MCNP is a general-purpose, continuous-energy, generalized-geometry, time-dependent, Monte Carlo radiation-transport code designed to track many particle types over broad ranges of energies[viii]. MCNP uses continuous-energy nuclear and data libraries generated from multiple sources. It is useful in analyzing radiation shielding of complex three-dimensional geometries.

The gamma ray energies and intensities input to the MCNP model were obtained from a nuclear data base[ix] that contains detailed decay radiation information for the isotopes. The fission product isotopic concentrations were consistent with the previous Scenario A. The MCNP analysis primarily tracks gamma fluxes at selected point and surfaces. The code uses a photon flux-to-dose rate conversion recommended by the ANSI/ANS providing surface dose rate values[x].

Figures 13-4A and 13-4B indicates the containment elevation and [redacted]. The corresponding MCNP model includes the containment as an equivalent volume semi-spherical building. The MCNP model schematically shown in Figure 13-5A and 13-5B included the two airlocks with the access hallways, reactor pool, and the containment building wall with the embedded truck access door. Most concrete structures inside the building were not modeled except the reactor pool, which is a conservative assumption, since the concrete floor and other structures provide extra shielding. The gamma fluxes and associated surface doses were calculated outside of the security doors leading to the airlocks (public access point), at positions outside the truck access door, and at a location adjacent to the outside containment wall using the photon flux-to-dose rate conversion factors from ANSI/ANS 6.1.1.

Time-integrated dose values were derived for a selected exposure time by considering the radioactive decay for each isotope and averaging the total dose rate over the time period.

The time integrated doses for the analyzed locations are shown in Table 13-5 and plotted in Figure 13-6. At every location except adjacent to the truck access door, the calculated dose values are well below the 10 CFR Part 20.1201 regulatory limit of 100 mrem (1 mSv) even for a stay-time of 30 days. The stay-time o[redacted], but is useful for estimating an upper bound for the gamma shine dose.

The containment truck access door provides a large surface gamma source where the dose for a 30-day stay-time would exceed the [redacted] limit at the [redacted] In a more realistic situation with a stay location at leas[redacted] away from the door, the dose is [redacted] a [redacted]-day stay-time that is below the limit of [redacted] mrem ([redacted] [redacted] Locations further away from the door as indicated in Table 13-5 and Figure 1[redacted] will reduce the radiation dose to even lower level ([redacted] mrem ([redacted] mSv) [redacted] 9.5 m, and [redacted]

The truck access is located inside the facility perimeter. The door faces a two-way access drive for vehicle parking located across from and behind the containment building. Subsequently, there is also pedestrian traffic through the parking lot and the access drive.

Scenario C – Leakage around Containment Truck Access Door

In this scenario the public is potentially exposed to gamma radiation from the containment near the containment truck access door and radiation exposure from the postulated [redacted] The exposure is due to submersion and inhalation effects of the ground release. The gamma radiation component is the same as for the previous scenario except that the total source inside the containment is slowly reduced by the leakage resulting in a lower total gamma source. It is again assumed that the ventilation system and emergency exhaust are shut off resulting in the maximum dose estimates to the member of the public.

The ground level release is analyzed by HotSpot[xi], an atmospheric dispersion code that provides a first-order approximation of the radiation effects associated with the atmospheric release of radioactive materials. The code is primarily used for short-range (less than 10 km), and short-term (less than a few hours) predictions. For long-term predictions (releases over days) an approximate method may be used utilizing a series of HotSpot

REDACTED FOR PUBLIC RELEASE

calculations with sequential atmospheric releases. The methodology utilized in the code conforms to NRC Regulatory Guide 1.145[xii]

The code uses the Gaussian-plume dispersion model and can consider historical relative wind frequencies (Figure 13-3) based on observation of speed and directions. The historical meteorological data are used to calculate percentile doses in up to 16 wind direction sectors. Since the leakage is slow, using the historical wind probability distribution is considered more reflective of the potential radiation exposure of the public. The total effective dose equivalents are calculated using FGR-11 and FGR-12 dose coefficients along the plume sector center lines.

Radioactive decay was considered for the volume source inside the containment affecting both the intensity of the gamma shine and also the source strength of the ground level release. The radioactive decay for the integrated dose due to the ground release was obtained by performing a series of HotSpot calculations with source terms incorporating the effect of radioactive isotope decay.

Near the [redacted] away from the release point with negligible contribution from gamma radiation as shown in Table 13-6. The maximum TEDE at [redacted]), [redacted] from the [redacted], while the maximum TEDE due to the ground release is [redacted]. These values are well below the regulatory limit of 100 mrem (1 mSv). Figure 13-7 shows the TEDE isopleth graph for the ground release assuming a historical wind distribution.

Scenario D – Public Areas outside Containment

In this scenario the ventilation system keeps running (fails shutting down) and all the fission products are discharged through the [redacted] high building stack in less than [redacted] minutes. The HotSpot model assumed that the wind is westerly, with Pasquill stability class [redacted] stable), and wind speed of [redacted] A more stable atmospheric condition together with lower wind speed results in a conservatively higher fission product concentration.

REDACTED FOR PUBLIC RELEASE

Near the containment location all exposure is due to gamma shine that is quickly reduced as the fission products are eliminated through the stack. For conservatism, the reduction of source term due to the air discharge was not considered (only [redacted] plume containing fission products dispersed by atmospheric transport.

The TEDE for the various locations are shown in Table 13-7. Two additional locations were also considered for completeness. Facility perimeter – there is partial fencing along the closest public road about [redacted] meters from the containment. The TEDE of [redacted] mrem [redacted] at the perimeter is primarily due to the scattered gamma radiation. Another location is the perimeter about 100 meters from the containment that includes most buildings at the site. The TEDE is negligible due to the relatively high elevation of the stack and essentially no gamma radiation from the containment. The maximum public TEDE is [redacted] km meters away from the containment and at [redacted] mrem [redacted]) is well below the regulatory limit of 100 mrem.

Figure 13-8 shows the TEDE contour isopleth map for the UMLRR location with the assumption of the wind blowing from the West all through the accident duration. Figure 13-9 shows the plume centerline TEDE behavior as a function of distance indicating that close to the discharge point the dose is negligible as the plume disperses through the atmosphere by the prevailing westerly wind.

<u>Scenario E – Public Areas outside Containment</u>

Scenario E is included only for completeness as the most likely evolution of a potential MHA. The emergency ventilation system will discharge the fission products through the building stack as an elevated release. The analysis was modeled with a weather pattern that is reflective of historical data, which may not be a conservative assumption for the relatively short duration of this scenario [redacted] bounding value due to the atmospheric dispersion of the radioactive plume with the wind constantly blowing from a preselected direction is provided by Scenario D, while Scenario B provides an upper bound for the gamma shine dose near the containment.

The results of the calculations are shown in Table 13-8, and Figure 13-10 indicates the TEDE isopleths for the duration of the scenario. Near the containment, the dose is

REDACTED FOR PUBLIC RELEASE

primarily due to gamma shine while farther away the radioactive plume submersion and inhalation dose is the dominant component. The TEDE levels for all locations are well below the 10 CFR Part 20.1301 [redacted]

13.2.1.4 Dose Analysis Summary

A hypothetical release of fission products from the failure of the cladding of one fuel plate under water in the reactor pool has been analyzed for several scenarios. The calculated TEDE due to radiation exposure both inside and outside the building to operating personnel and members of the public are shown in Tables 4-8. In most cases, the TEDE for the general public and occupational workers are well below the annual dose limits specified in 10 CFR Part 20. The only case where significant exposure occurs requires a member of the public standing right at the surface of the containment truck access door for more than [redacted] after a MHA. Even a reasonable distance ([redacted]) from [redacted] would result in a TEDE below the regulatory limit for a [redacted].

In conclusion, the dose calculations due to radiation exposure after a postulated MHA event demonstrate that the maximum TEDE doses are well below the occupational limit in 10 CFR 20.1201 and the public dose limit in 10 CFR 20.1301.

13.2.1.5 Tables and Figures

Table 13-1: Total Fission Product Activity (per Fuel Plate)

Isotope	Fission Yield γ_i	Decay Constant λ_i [1/s]	Fission Product Activity [Ci/plate]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

from Woodruff[iv] - adjusted for 1 MW total reactor power.

Table 13-2: Fission Product Releases

Isotope	Fission Product Activity Released into Fuel Pool [Ci]	Fission Product Activity Released into Reactor Bay [Ci]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

from Woodruff[iv] - adjusted for 1 MW total reactor power.

REDACTED FOR PUBLIC RELEASE

Table 13-3: Dose Coefficients (FGR-11 and FGR-12)

Isotope	Thyroid Inhalation $\left[\frac{Sv}{Bq}\right]$	Thyroid Submersion $\left[\frac{Sv \times m^3}{Bq \times s}\right]$	Whole-Body Inhalation $\left[\frac{Sv}{Bq}\right]$	Whole-Body Submersion $\left[\frac{Sv \times m^3}{Bq \times s}\right]$
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

from “External Dose-Rate Conversion Factors for Calculation of Dose to the Public,” DOE/EH-0070, Department of Energy, July 1988

Table 13-4: Occupational Total Effective Dose Equivalent Scenario A

Isotope	Thyroid Inhalation CEDE (mrem)	Thyroid Submersion CEDE (mrem)	Whole-body Inhalation TEDE (mrem)	Whole-body Submersion TEDE (mrem)
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]		[redacted]		[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]

REDACTED FOR PUBLIC RELEASE

Table 13-5:Total Effective Gamma Dose Equivalent Scenario B

Location	TEDE Dose [mrem]				
	1 hr	2 hr	24 hr	48 hr	720 hr
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 13-6: Total Effective Dose Equivalent Scenario C

Location	TEDE Dose [mrem]					
	1 hr			30 days		
	Gamma	Ground	Total	Gamma	Ground	Total
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 13-7: Total Effective Dose Equivalent Scenario D

Location	TEDE Dose [mrem]		
	Gamma	Elevated	Total
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

Table 13-8: Total Effective Dose Equivalent Scenario E

Location	TEDE Dose [mrem]		
	Gamma	Elevated	Total
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

REDACTED FOR PUBLIC RELEASE

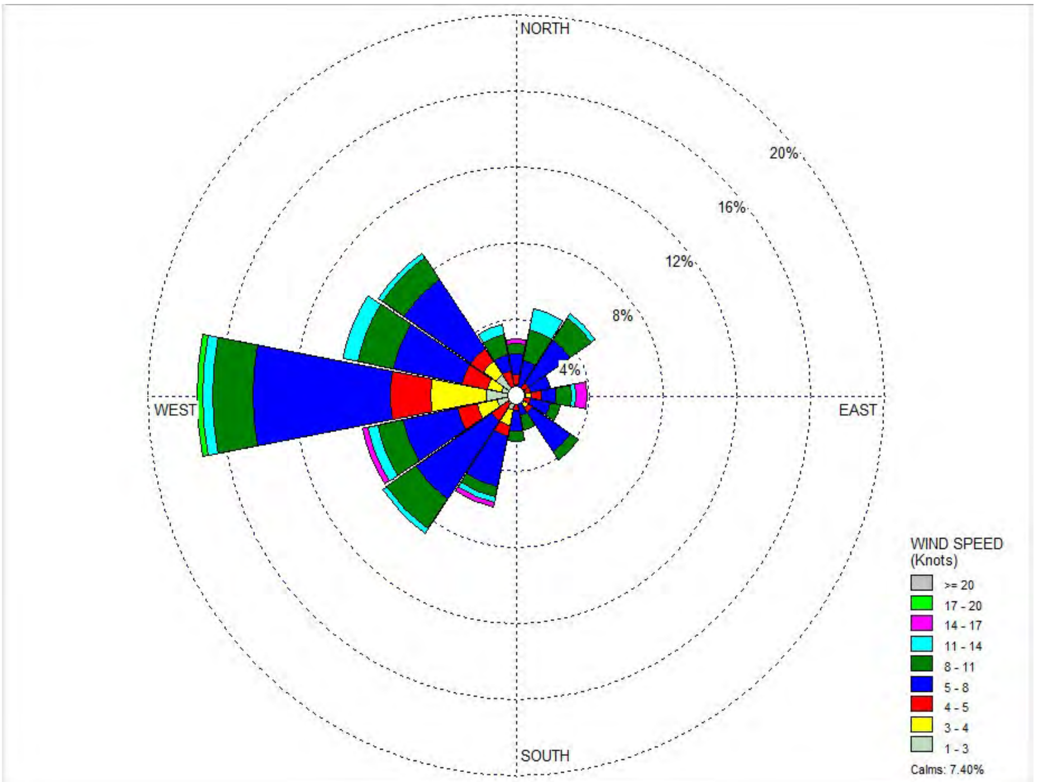


Figure 13-1: Wind Direction Distribution for Hanscom Air Force Base January 1st 2013 – December 31st 2013

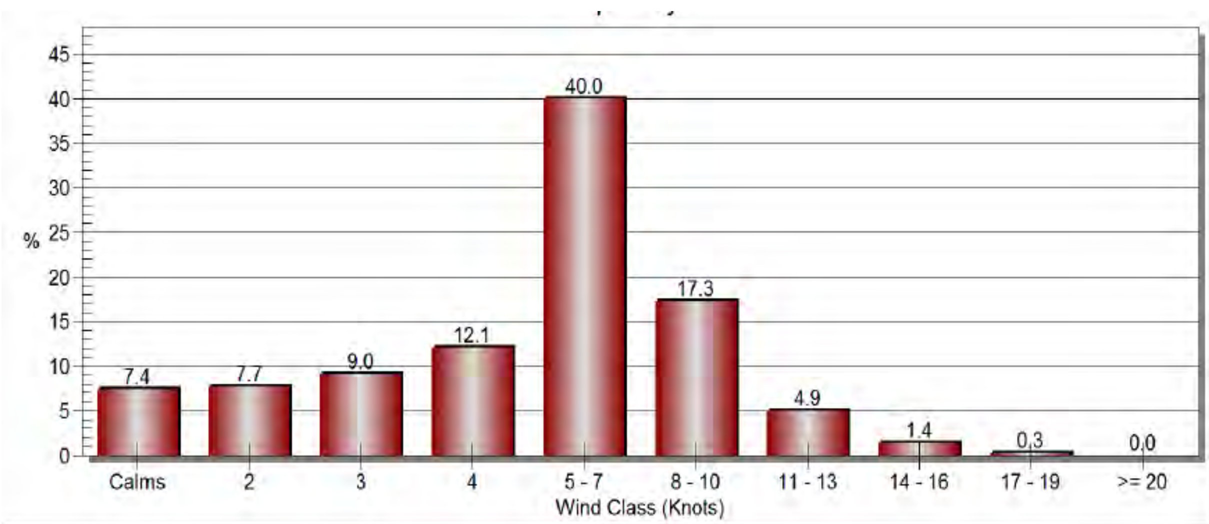


Figure 13-2: Wind Class Frequency Distribution for Hanscom Air Force Base January 1st 2013 – December 31st 2013

Wind Speed Frequency (knots)

Wind Direction (knots)	2	3	4	5-7	8-10	11-13	14-16	17- 19	>20	Total (%)
348.75-11.25	0.27397	0.27397	0.54795	1.09589	0.54795	0.00000	0.27397	0.00000	0.00000	3.01370
11.25-33.75	0.00000	0.00000	0.27397	1.64384	1.64384	1.09589	0.00000	0.00000	0.00000	4.65753
33.75-56.25	0.00000	0.27397	0.54795	2.73973	1.36986	0.27397	0.00000	0.00000	0.00000	5.20548
56.25-78.75	0.00000	0.54795	0.27397	1.09589	0.00000	0.00000	0.00000	0.00000	0.00000	1.91781
78.75-101.25	0.54795	0.27397	0.54795	0.82192	0.82192	0.27397	0.54795	0.00000	0.00000	3.83562
101.25-123.75	0.27397	0.00000	0.54795	1.09589	0.54795	0.00000	0.00000	0.00000	0.00000	2.46575
123.75-146.25	0.54795	0.27397	0.27397	2.46575	0.54795	0.00000	0.00000	0.00000	0.00000	4.10959
146.25-168.75	0.00000	0.00000	0.27397	0.82192	0.82192	0.00000	0.00000	0.00000	0.00000	1.91781
168.75-191.25	0.00000	0.27397	0.54795	1.09589	0.54795	0.00000	0.00000	0.00000	0.00000	2.46575
191.25-213.75	0.82192	0.82192	0.54795	2.73973	0.54795	0.27397	0.27397	0.00000	0.00000	6.02740
213.75-236.25	0.00000	0.54795	1.09589	4.93151	1.91781	0.27397	0.00000	0.00000	0.00000	8.76712
236.25-258.75	1.09589	1.09589	1.09589	3.01370	1.36986	0.54795	0.27397	0.00000	0.00000	8.49315
258.75-281.25	1.64384	3.01370	2.19178	7.39726	2.19178	0.54795	0.00000	0.27397	0.00000	17.26030
281.25-303.75	0.82192	0.82192	1.36986	3.83562	1.91781	0.82192	0.00000	0.00000	0.00000	9.58904
303.75-326.25	1.36986	0.82192	0.82192	4.38356	1.36986	0.27397	0.00000	0.00000	0.00000	9.04110
326.25-348.75	0.27397	0.00000	1.09589	0.82192	1.09589	0.54795	0.00000	0.00000	0.00000	3.83562
Sub-Total	7.67123	9.04110	12.05480	40.00000	17.26030	4.93151	1.36986	0.27397	0.00000	92.60270
Calms										7.39726
Total										100.00000

Figure 13-3: Wind Speed Relative Frequency Distribution by Speed and Direction for Hanscom Air Force Base (January 1st 2013 – December 31st 2013)

REDACTED FOR PUBLIC RELEASE

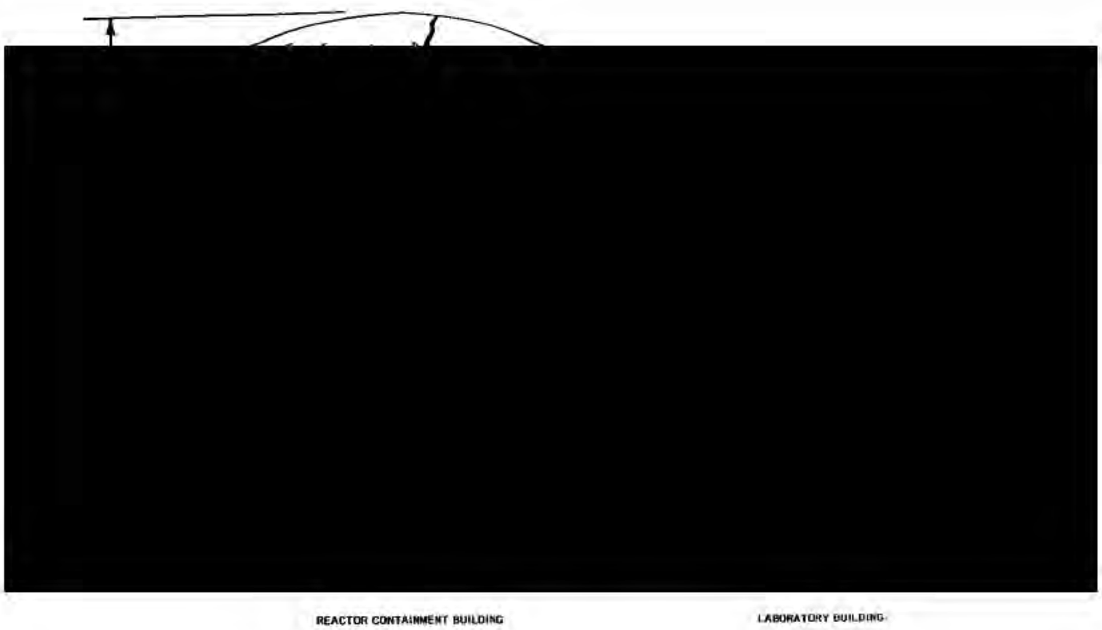


Figure 13-4: UMLRR Containment Elevation View

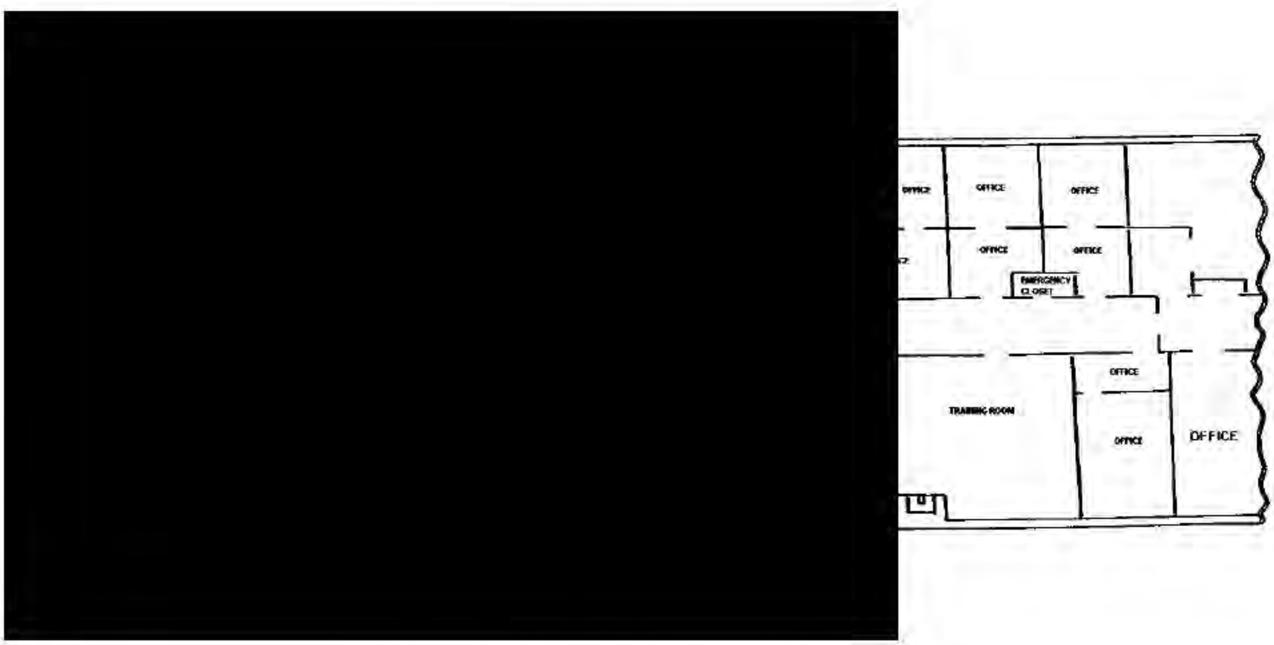


Figure 13-4:B UMLRR Containment 1st Flooor View

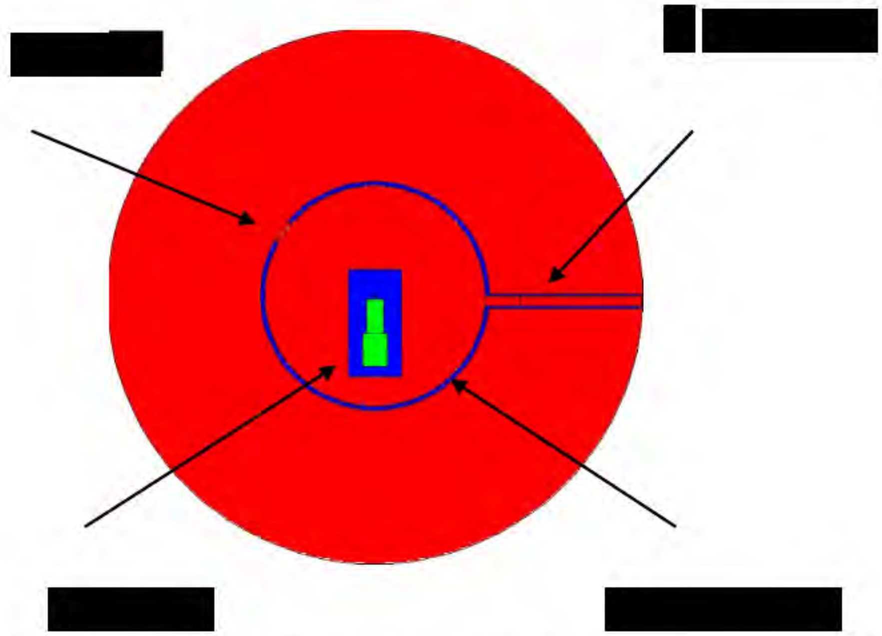
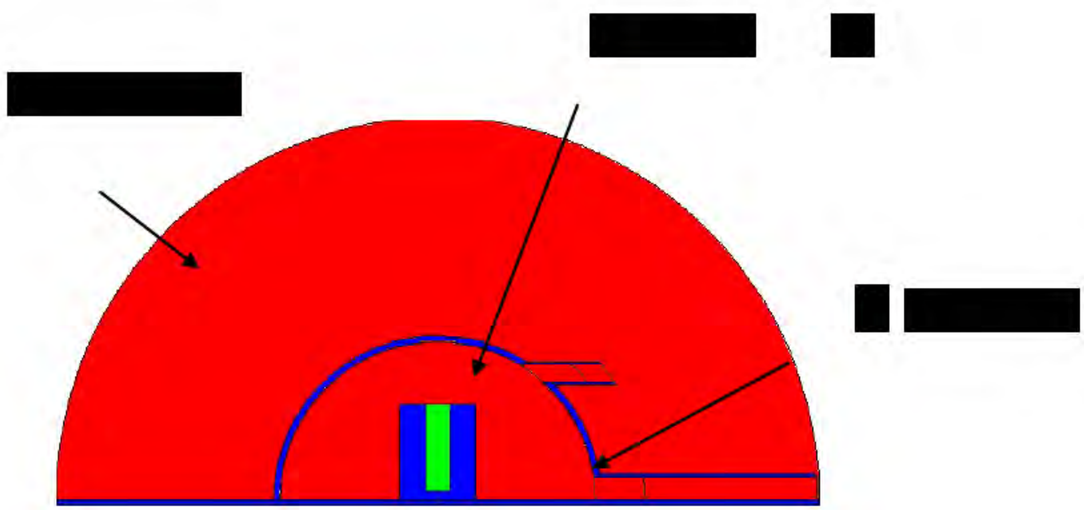


Figure 13-5: MCNP Containment model, x-y floor view



[redacted]

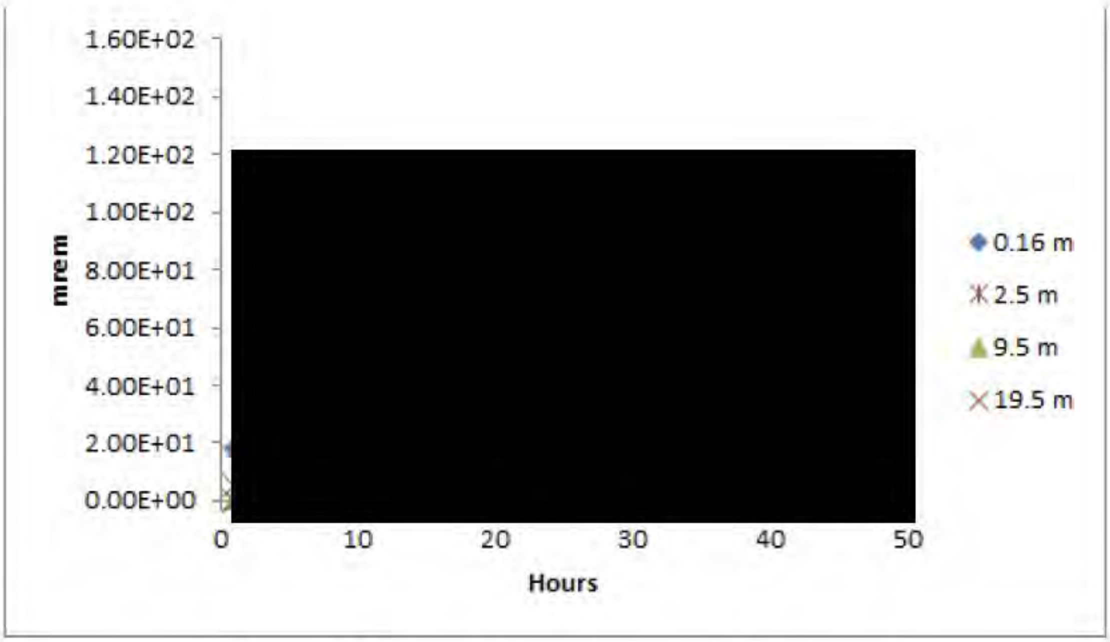


Figure 13-6: Total gamma dose at containment truck door – Scenario B

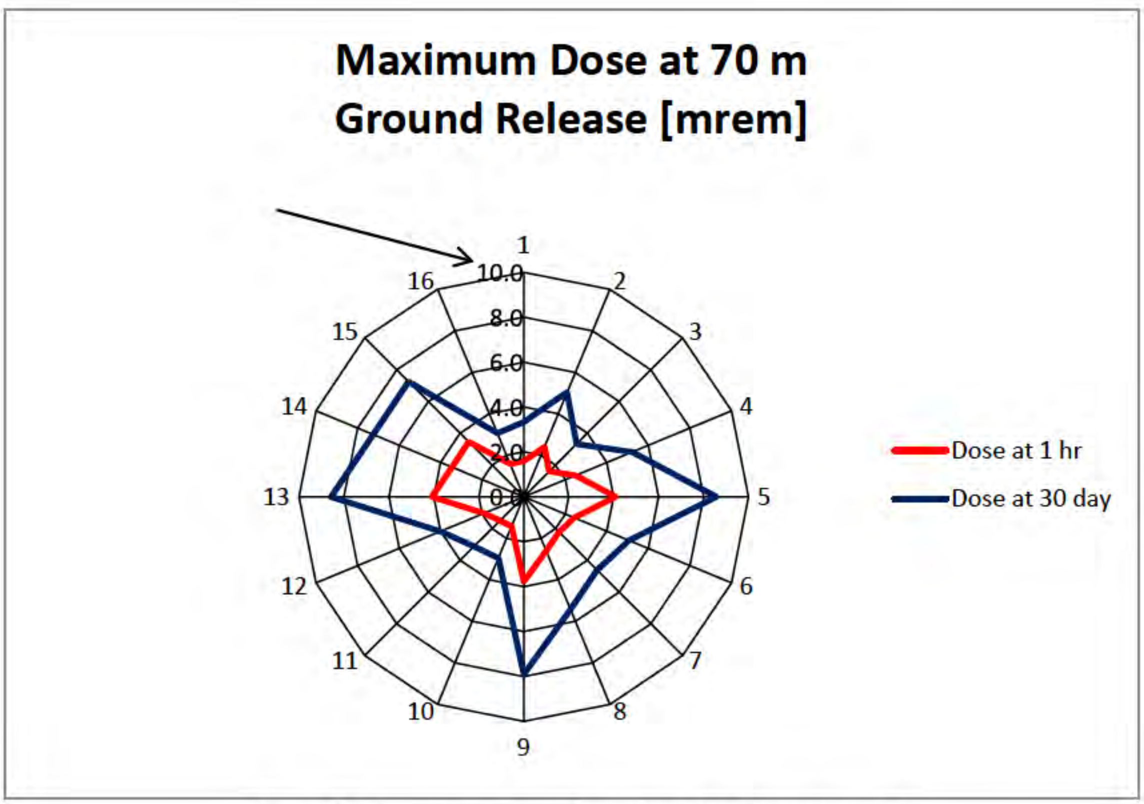
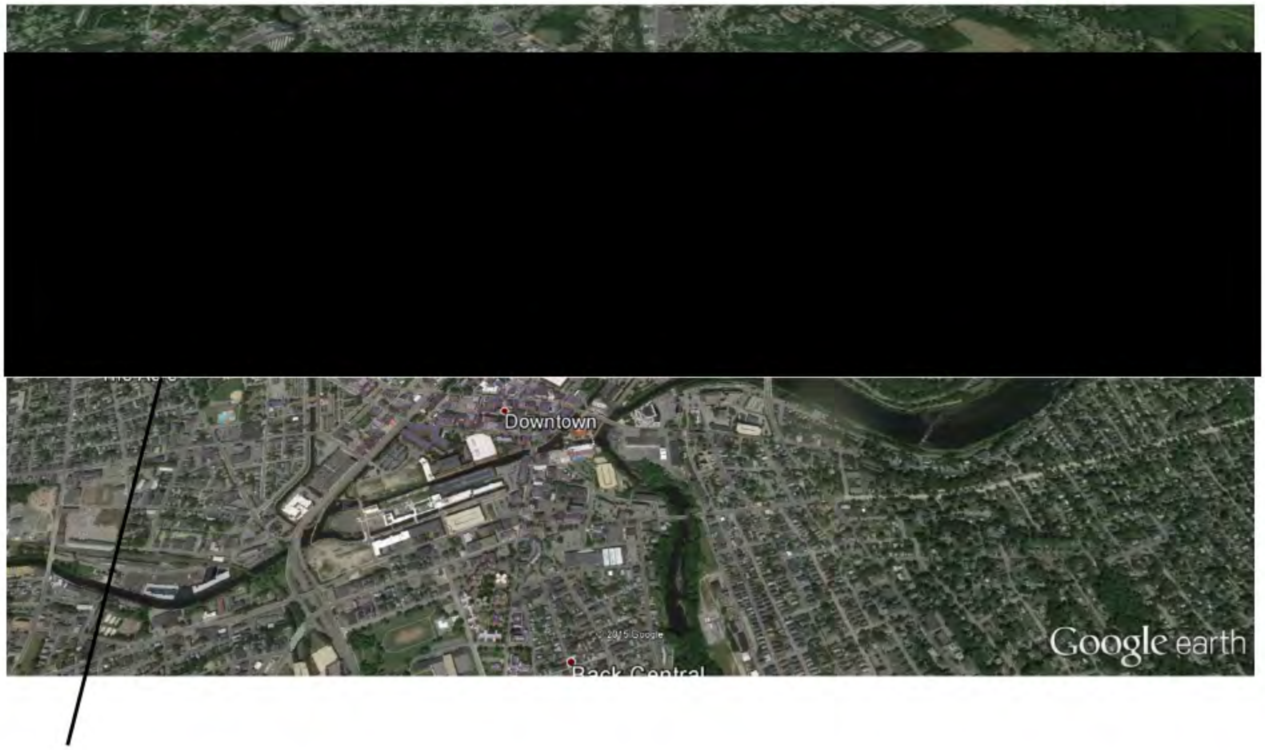


Figure 13-7: Scenario C - Ground level release, 1%/day, TEDE isopleths



UMLR

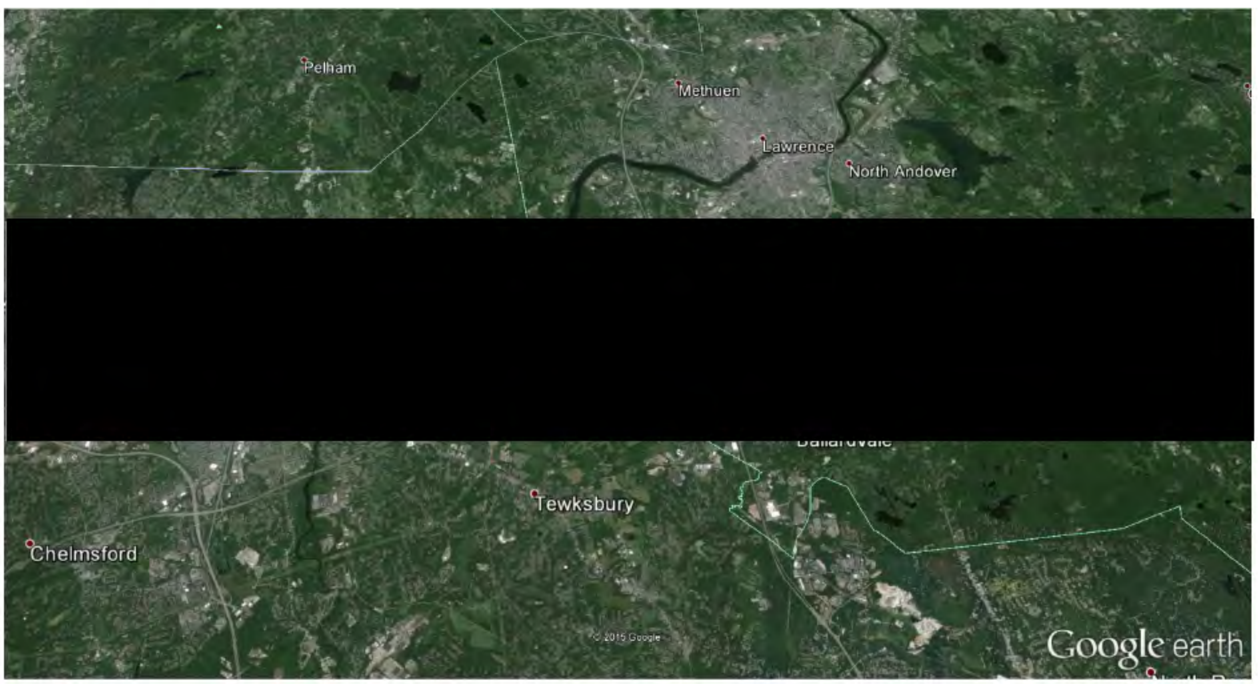


Figure 13-8: Scenario D - Elevated level release, dose contours in mrem (Red – [redacted])

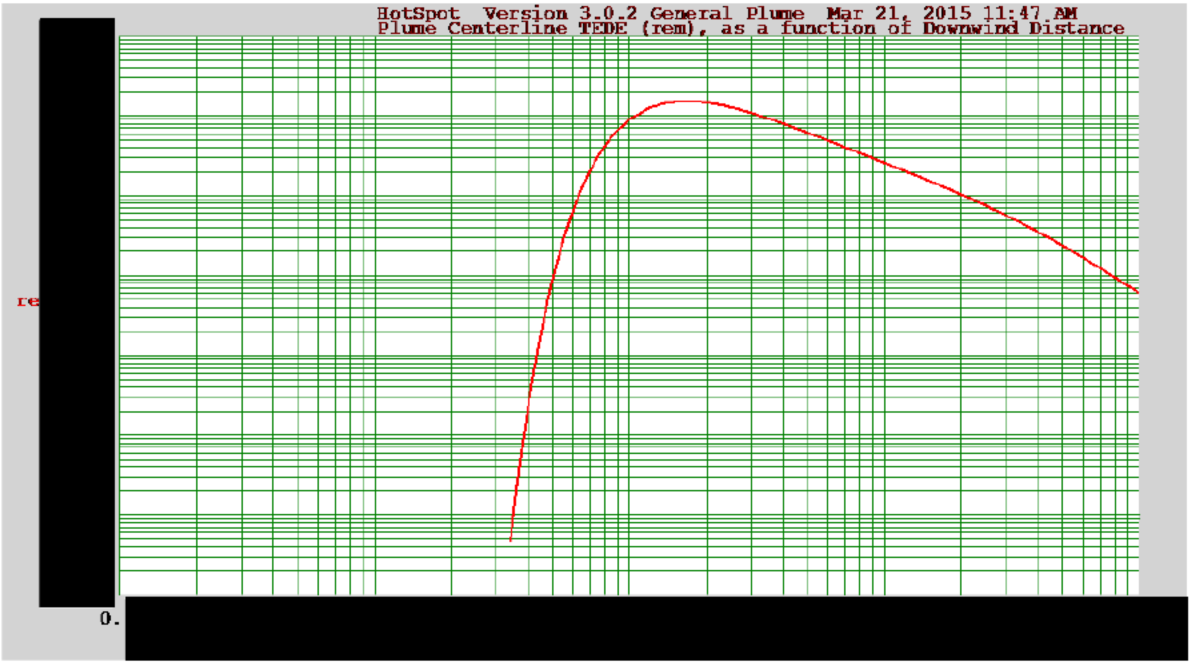


Figure 13-9: Scenario D - Elevated level release, TEDE along plume center line; Max. [redacted]

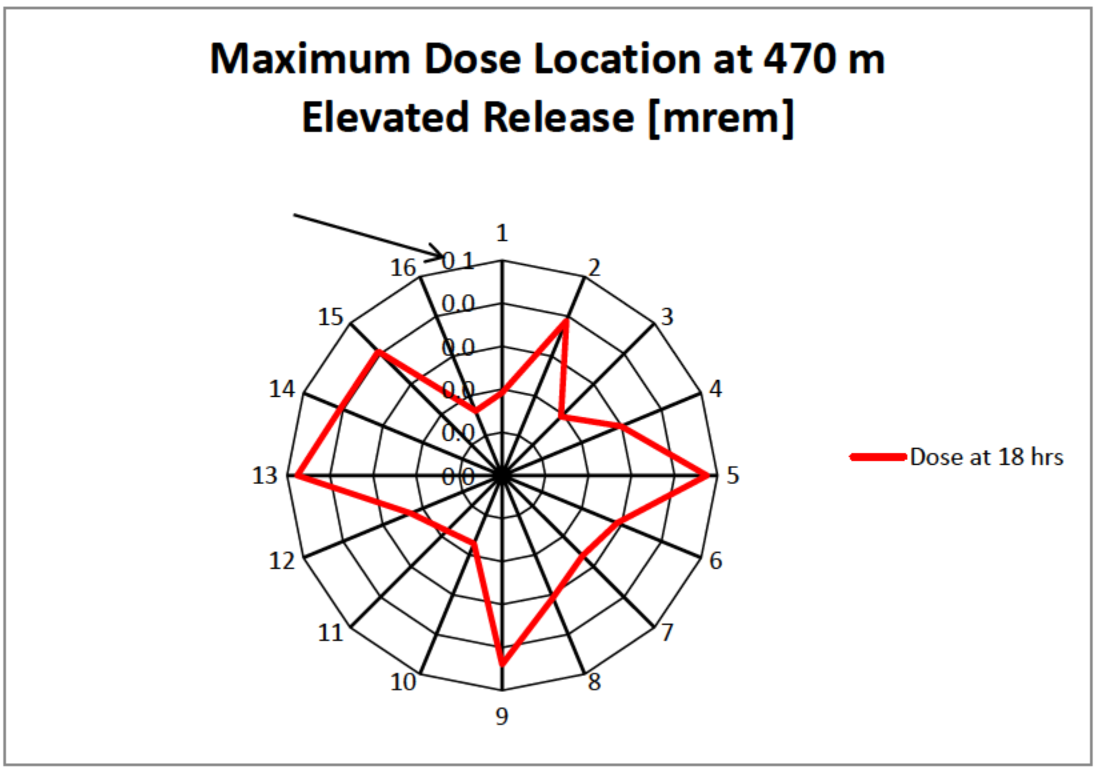


Figure 13-10: Scenario E – Elevated release, 18 hrs, TEDE isopleths

13.2.2 Insertion of Excess Reactivity

Two different accident scenarios for an insertion of excess positive reactivity are evaluated in this section. First, a step insertion of positive reactivity based upon the maximum step insertion that the UMLRR can withstand with no core damage, and second, a continuous ramp insertion of positive reactivity based on the continuous withdrawal of the UMLRR four control blades.

13.2.2.1 Rapid Step Insertion of Positive Reactivity

Rapid reactivity changes can occur due to the failure of a fixed experiment or other device, due to a rapid cold water insertion event, or possibly due to the rapid ejection of an experimental bayonet from one of the incore radiation baskets. Although never instantaneous in practice, to be conservative, these postulated rapid changes are often modeled as step (or near-step) reactivity changes in the system. In particular, of interest here is the maximum step change in reactivity that can be tolerated under both forced and natural convection flow such that ONB is not exceeded during the transient. Four cases have been selected to evaluate the consequences of this transient, as follows:

Case 1 nominal forced convection: P_o [redacted] MW, Q = [redacted] GPM, T_{in} = [redacted] C

Case 2 worst case forced convection: P_o = [redacted] MW, Q = [redacted] GPM, T_{in} = [redacted] C

Case 3 nominal free convection: P_o = [redacted]

Case 4 worst case free convection: P_o = [redacted] kW, T_{in} = [redacted] C

For the nominal cases, T_{in} = [redacted] C was selected arbitrarily in the middle of the range for normal operation (roughly [redacted] – [redacted] C). For the worst case runs, the inlet temperature is assumed to be at its LSSS value of [redacted] F). In addition, for the limiting cases, the initial power level and flow rate are taken at their LSSS values, which coincide with the nominal values as modified by the hot channel factors from Table 4-11, that is, $P = P_{nom} \times$ [redacted] and Q = Q_{n}[redacted]

In all the cases, the transient is essentially terminated by an overpower trip signal that is set at [redacted] MW for forced flow and [redacted] kW for free flow (the LSSS values), with an instrument delay time of [redacted] msec, an average blade insertion speed of [redacted] m/[redacted] and the assumption that Blade 4 does not drop with the other safety blades. From a height of [redacted]

REDACTED FOR PUBLIC RELEASE

[redacted] withdrawn, Blades 1 – 3 have a combined worth of about 7 dollars as discussed in Chapter 4 of this report. In addition, all the runs use a radial peaking factor of [redacted] and the axial profile shown in Figure 4-15 with $f_z = 1.50$. To find the maximum reactivity allowed in the PARET runs, the step reactivity addition was increased in units of 0.01 %Δk/k = 0.1 mk until ONB is reached at some point in the transient. The highest value of step reactivity used that did not result in hitting the ONB limit was then tabulated as the desired ρ_{max}.

Table 13-9 summarizes the results of these four step reactivity cases. As apparent, the range of step changes that can be tolerated varies from about [redacted] mk to [redacted] mk, depending on the specific assumptions that are made. Clearly, the forced flow case with LSSS values for P_o and Q gives the most restrictive situation, and the two natural convection simulations are least restrictive, indicating that an 8.4 mk step change ([redacted]) will not lead to ONB before the reactor protective system begins to shut down the transient. For the limiting case (i.e. Case 2), the PARET calculations indicate that a [redacted] reactivity addition does not lead to ONB during the transient, but that a 6.5 mk step change exceeds the ONB safety limit for a short time period.

Table 13-9: Max. step reactivity insertion allowed w/o hitting the ONB limit

Case #	Max reactivity insertion	P_{max} (MW)	Max T_{clad} (°C)
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

Since failure of an experiment is the most likely initiating event for a rapid reactivity insertion transient, a Technical Specification maximum single experiment worth a 5 mk (0.5% Δk/k) is well within the upper limit of [redacted] mk. To show this, a step change of 5 mk was made with the conditions as noted above for Case 2. The resultant power vs. time and the maximum coolant, clad, and fuel temperatures vs. time for the transient are shown for this case in Figure 13-11. As apparent, although the power reaches a peak of about 3.5 MW, the high power interval is very short with only a moderate amount of energy being deposited. The power starts to decrease immediately as the blades start to enter the core shortly after 0.21 seconds into the transient (note that this happens just after the 210 msec instrument delay time used as part of the PARET model). The clad and fuel temperatures peak shortly after the power peak, and then these also drop rather rapidly, with the transient being essentially over within [redacted] second of the initial step change. Since the initial flow rate is maintained, the decay heat is easily removed and all the temperatures eventually decrease until they approach equilibrium with the inlet temperature. Clearly, with a maximum clad temperature of about [redacted] C, there is a large margin to ONB throughout the transient. Thus, even the very conservative ONB safety limit is not exceeded in the event of a worst-case experiment failure with a reactivity worth of [redacted] mk.

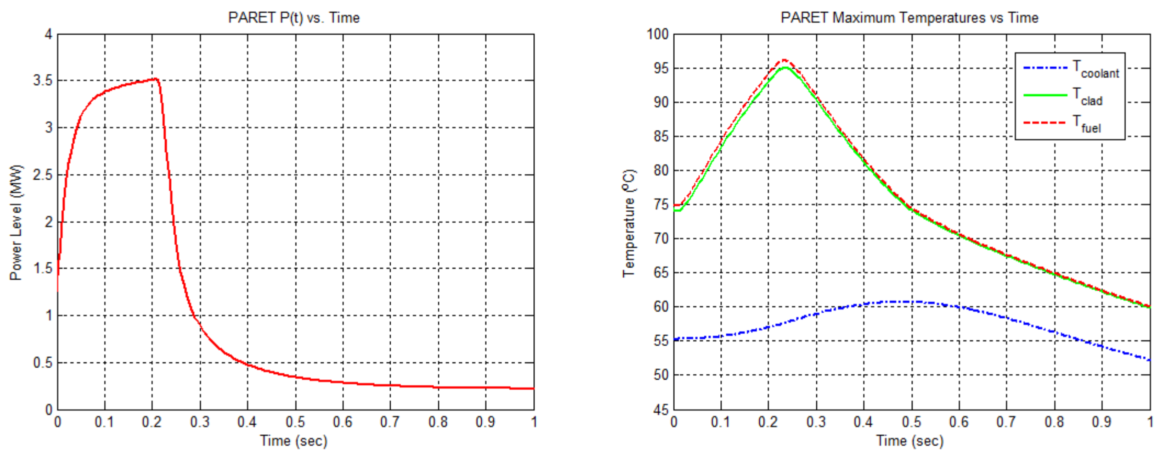


Figure 13-11: Response to 5 mk step change with LSSS values of P_o, Q, and T_{in} with UMLRR fuel.

As a final PARET run for the step reactivity cases, the same 5 mk step-change scenario as above was simulated using the WPI fuel specifications instead of the UMLRR fuel data. For the steady state cases, the UMLRR fuel has already been shown to be more limiting than the WPI fuel due to the reduced number of fuel plates per assembly. This same behavior is expected here, but the simulation was run for completeness and to quantify the additional margin to ONB that can be expected with use of the WPI UAl_x-Al fuel elements. The results of this simulation are shown in Figure 13-12, where we see the same basic dynamic behavior as apparent in Figure 13-11, but here the peak temperatures are lower than the simulation with UMLRR fuel. In particular, the peak clad temperature in the WPI fuel for a 5 mk step change in reactivity is only about 86 C, which is roughly 9 C less than the UMLRR fuel. Thus, as expected, the UMLRR fuel design clearly presents the more limiting situation. The result demonstrates that no further UMLRR vs. WPI fuel comparisons are needed or warranted.

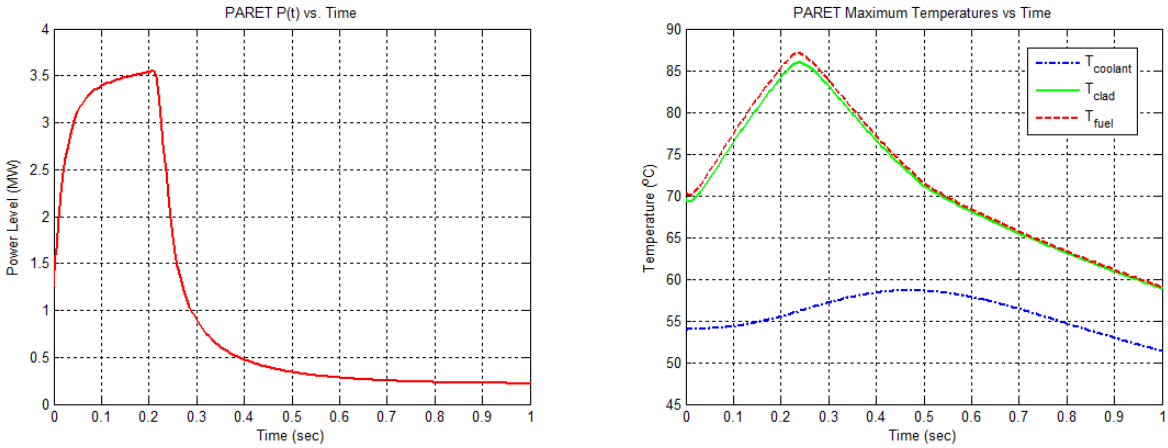


Figure 13-12: Response to 5 mk step change with LSSS values of P_o, Q, and T_{in} with WPI fuel.

13.2.2.2 Ramp Reactivity Insertion

The inadvertent withdrawal of a control blade, either as a malfunction or an operator error, is the most obvious initiating event that could be associated with a postulated ramp reactivity insertion. As a check on the actual blade movement rates, the blade speeds and maximum differential worths were measured as part of the annual UMLRR blade surveillances performed in January 2015. The safety blades' insertion rate was about 4 inches/min and the maximum differential worth of Blade 4 was a little under 0.3 %Δk/k per inch, which gives a maximum insertion rate of about 0.02 %Δk/k per second. For the Regulating Rod, the insertion rate was about 55 inches/min and the maximum differential worth was under 0.025 %Δk/k per inch. These values combine to give a reactivity insertion rate of 0.023 %Δk/k per second. This is less than half the Technical Specification (TS 3.2.2) limit of 0.05 %Δk/k per second.

As a conservative evaluation, the analysis here focuses on a ramp insertion speed of 0.07 %Δk/k per second = 0.7 mk/s, with simulations performed for both forced and natural convection operation. Other cases were run with lower ramp speeds. The results were very similar except for the timing of the over-power trip, and so are not presented here. Since the goal is to identify the worst-case consequences of an inadvertent blade withdrawal, the 0.7 mk/s ramp insertion simulations in PARET assumed a range of values for initial power, inlet temperature, and pump flow rate.

For specificity, the six cases presented for these analyses are identified as follows:

Case 1: Forced flow with a 0.7 mk/s reactivity insertion rate with P_o = 1.00 MW, T_{in} = 43.3 C, and Q = 1370 GPM

Case 2: Same as Case 1 with P = 1.25 MW

Case 3: Same as Case 1 with T_{in} = 30.0 C and Q = [redacted] GPM

Case 4: Natural convection flow with a 0.7 mk/s reactivity insertion rate with P_o = 100 kW and T_{in} = 43.3 C

Case 5: Same as Case 4 with P = 125 kW

Case 6: Same as Case 4 with T_{in} = 30.0 C

Note that the remaining simulation parameters (delay time, safety blade insertion rate upon scram, blade worth profile, etc.) were the same as used above in the step insertion cases. These parameters were held fixed for all the PARET runs. For the power trip point, 1.25 MW was used for forced flow cases and 125 kW was used for all natural convection runs.

The key results for the ramp reactivity insertion cases are summarized in Figures 13-13 and 13-14 for both the forced flow and natural convection cases, respectively. Clearly, Cases 1-3 focus on forced flow mode and Cases 4-6 highlight the natural convection mode. The 2nd case in each set simulates the reactor operating approximately at its LSSS point just before the ramp insertion occurs. However, as seen in the middle plots in Figures 13-13 and 13-14, the power setpoint is reached nearly instantaneous, and the blades start to drop shortly afterwards (after the instrument delay). The temperature change over this short an interval is negligible. To observe the power rise and temperature increase during the ramp reactivity insertion, the 1st case in each set has the initial power at its nominal maximum value for the given operational mode, which then increases due to the reactivity insertion until the overpower setpoint is reached and the blades start to drop. For these cases, a small rise in the maximum system temperatures is seen over the interval for the power rise.

The 3rd set of forced and natural convection runs, as seen in the bottom set of plots in Figures 13-13 and 13-14, represent nominal expected behavior during routine operation of the reactor, with the use of nominal P_o, T_{in}, and pump flow rates for the two operating modes.

The behavior of these cases looks very similar to the top plots, except that the base temperatures are lower because of the lower inlet temperature and the larger coolant flow rate for the forced flow case.

Notably, the time interval for each of the transients is only 3 seconds. However, for the natural convection cases shown in Figure 13-14, the time scale goes from 57 to 60 seconds. For these cases, the first 57 seconds of simulation time were used to get the natural convection flows in both the average and hot channels to converge, and then the ramp reactivity insertion was initiated from equilibrium at t = 57 seconds.

In summarizing the ramp reactivity insertion cases, it is apparent that the analyzed accident scenarios represent relatively mild transients to the overall system. In all cases, the reactor protection system is assumed to work and, with an instrument delay time of only 0.21 seconds, there is little time for the reactor power and system temperatures to increase significantly. Accordingly, there is no real possibility of reaching the UMLRR onset of nucleate boiling (ONB) safety limit for this class of transients. Thus, a scram-protected ramp reactivity insertion is not a limiting transient scenario for the UMLRR.

13.2.2.3 Cold Water Insertion Event

Positive reactivity can be inserted into the reactor core by the sudden insertion of cold water into the core, referred to as a “cold water insertion event”. This scenario is related to a combination of negative reactivity feedback and a rapid decrease in core temperature. As shown in Table 4-5 of Chapter 4, the total isothermal temperature coefficient in the UMLRR is approximately -1.43e-4 $\Delta k/k/^{o}C$. Unquestionably, a rapid decrease in temperature would lead to an increase in reactivity. A rapid decrease in temperature could result from either of two operator actions:

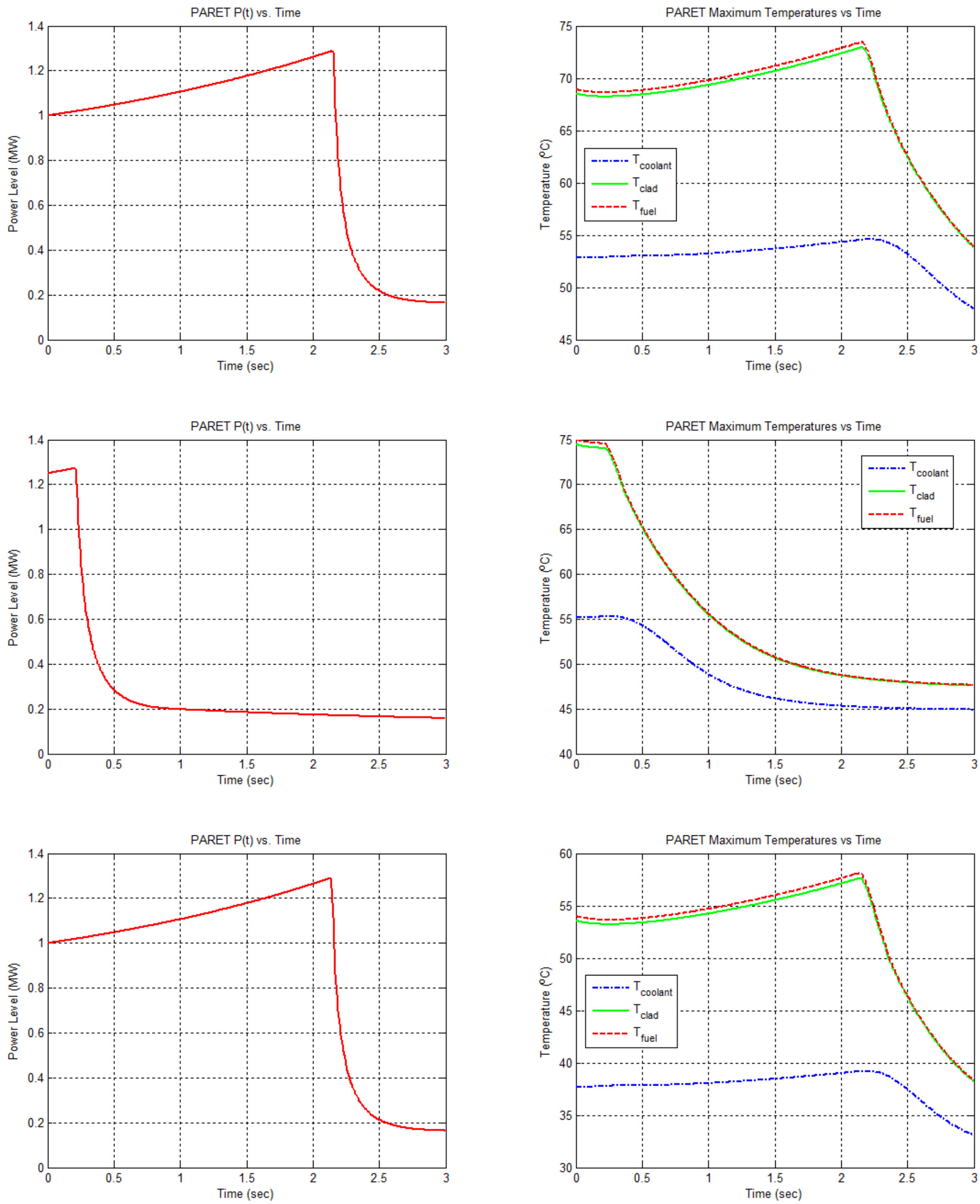


Figure 13-13: Response to 0.7 mk/s ramp in forced flow mode with various initial conditions.

Top Plots: Case 1 -- forced flow with P_o = 1.00 MW, T_{in} = 43.3 C, and Q = 1370 GPM
Middle Plots: Case 2 -- forced flow with P_o = 1.25 MW, T_{in} = 43.3 C, and Q = 1370 GPM
Bottom Plots: Case 3 -- forced flow with P_o = 1.00 MW, T_{in} = 30.0 C, and Q = [redacted] GPM

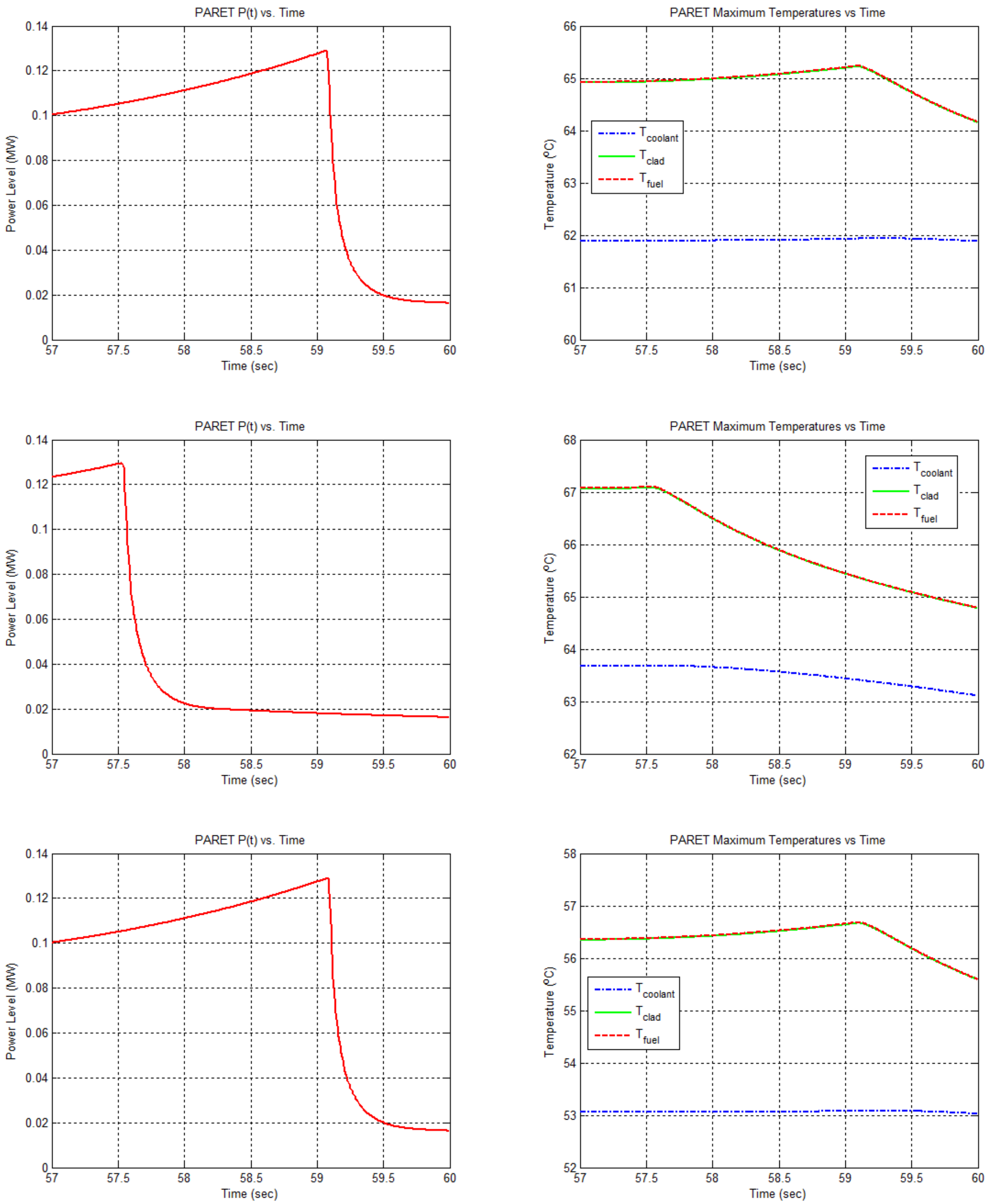


Figure 13-14: Response to 0.7 mk/s ramp in free flow mode with various initial conditions.

Top Plots: Case 4 -- natural convection flow with P_o = 100 kW and T_{in} = 43.3 C
Middle Plots: Case 5 -- natural convection flow with P_o = 125 kW and T_{in} = 43.3 C
Bottom Plots: Case 6 -- natural convection flow with P_o = 100 kW and T_{in} = 30.0 C

REDACTED FOR PUBLIC RELEASE

- Turning on the secondary cooling system during forced flow operation on a cold winter day when the sump temperature is low.
- Turning on the primary pump during natural convection operation.

To address the first scenario, it has been established in the previous section that the core transient associated with a 5 mk step change in reactivity does not exceed the UMLRR ONB safety limit (the ONB margin is actually greater than 20 ^{o}C). Using 5 mk as an upper limit and a conservative 25% safety factor on the value of the isothermal temperature coefficient, α_{ITC}, the maximum temperature change allowed can be determined as follows:

$$\Delta\rho = \alpha_{ITC}\,\Delta T$$

or

$$\Delta T_{max} = \frac{\Delta\rho_{max}}{\alpha_{ITC_{max}}} = \frac{5\times10^{-3}\ \Delta k/k}{1.25\times(-1.43\times10^{-4}\ \Delta k/k\ \text{per}\ ^{o}C)} \approx -28\ ^{o}C$$

Thus, to achieve a 5 mk positive reactivity step insertion, the core coolant temperature would have to decrease nearly instantaneously by 28 ^{o}C (82^{o}F). Such a massive rapid temperature change could not occur simply by turning on the secondary cooling system. First, the flow arrangement in the UMLRR has the primary flow entering the pool on the bulk pool side. It mixes with the approximately 75,000 gallons of water in the pool, and then enters the core channels via suction flow from the top to the bottom of the fuel. A sudden decrease in the pool inlet temperature at the nominal 1,700 gpm flow rate gets delayed by several minutes. The warmer inlet water is mixed with the existing pool water before it reaches the core inlet. Thus, a sudden decrease in core inlet temperature due to a change in pool inlet temperature is not possible with the current cross-pool flow scheme.

If the flow arrangement was ever changed to have a straight connection with the core inlet coming directly from the outlet of the heat exchanger, the magnitude of the temperature changes and the delay times involved still would prohibit any sudden large change in core inlet temperature from occurring. To demonstrate this, data from a recent energy balance experiment are shown in Figure 13-15 (note the temperature scale is in ^{o}F as recorded by the reactor instrumentation system, whereas most of the other temperature references in this report are in ^{o}C). The goal of the experiment was to measure the impact of different cooling levels, with no cooling initially, maximum cooling at the end, and with the reactor at full power during the entire experiment.

Of particular interest, is the behavior observed at t = 1.5 hours into the experiment when the secondary pump is turned on, and again at t = 2.8 hours when the cooling fans in the cooling tower are turned on. The ΔT seen in the secondary sump water due to these operator actions is approximately 25-30 ^{o}F, and on the secondary side of the heat exchanger it is approximately 20-25 ^{o}F. However, the temperature variation on the primary side of the heat exchanger and in the pool inlet temperature is less than 10 ^{o}F. In addition, although the temperature transients appear to be very rapid in the figures shown, the time scale spans 4.5 hours. In particular, with focus at t = 1.5 hours, the 8 ^{o}F change in the <u>pool inlet</u> temperature takes place over an 80-second interval. In conclusion, a large sudden decrease in <u>core inlet</u> temperature is simply not possible by turning on the secondary cooling system.

The second possible scenario for rapidly changing the core temperatures involves the primary pump being activated with the reactor initially at nominal high power conditions (i.e., 100 kW) in natural convection mode. In this flow mode, the flow rate is up through the core at only 1-2 cm/s. At this flow rate, even relatively low power levels can produce a relatively high temperature rise in the core. Then, if the pump is turned on, the warm water in the core is rapidly replaced with the cooler pool water from above the core, leading to the so-called "cold water insertion event." Thus, with negative feedback and a rapid decrease in core temperature, the pump-on event rapidly inserts positive reactivity into the system, with a subsequent rise in power over time. However, unlike the transient caused by a change on the secondary side, the pump-on transient on the primary side is relatively fast since the pump speed approaches full capacity in only a few seconds.

A PARET model was constructed to analyze this pump-on event. As in the other transient scenarios, three different cases were studied to represent various initial operating conditions, as follows:

Case 1: pump-on scenario with Po = 100 kW and Tin = 43.3 C.

Case 2: same as Case 1 with Po = 125 kW.

Case 3: pump-on scenario with the reactor initially at nominal free-flow conditions (Po = 100 kW and Tin = 30.0 C).

The summary results from these three pump-on simulations are given in Fig. 13-16. All three cases behave similarly, with the increasing flow rate causing a decrease in the system temperatures, with a subsequent positive reactivity increase and corresponding increase in power. When the power trip setpoint is reached, the blades drop and the power and temperatures drop accordingly. While these cases are similar, there are some unique details directly related to the various initial states selected for a specific case. For instance, with a scram setpoint of 125 kW for all cases, Case 2 scrams nearly instantaneous (i.e. after the 0.21 seconds associated with the instrument delay time that is input to PARET) because the reactor is assumed to be operating at its LSSS setpoint for natural convection prior to turning on the pump. In Cases 1 and 3, however, the trip occurs after about 1.8-1.9 seconds into the transient since it simply takes a little longer in these cases for P(t) to increase to the power setpoint. Similarly, the peak initial temperatures occur for Case 2, since this scenario has the highest power and inlet temperature combination of the three cases shown here. Finally, it should be noted that all the initial peak temperatures are slightly higher than expected because the PARET model limits the specification to a single initial flow rate. Since the core average value was used (which is slightly lower than expected in the hot channel) this assumption leads to slightly higher peak initial temperatures.

From a reactor safety perspective, the pump-on event leads to a relatively low-risk scenario that is significantly less severe than a step reactivity insertion. In all cases, the highest clad temperatures were associated with those seen at the initiation of the event. Following the cold water insertion associated with the pump being activated, P(t) increases briefly until the reactor scrams. During this time the clad temperatures are still decreasing due to the introduction of forced flow cooling. Based on these scenarios, it can be concluded hat a scram-protected pump-on event from steady state natural convection operation is not a limiting transient scenario for the UMLRR.

REDACTED FOR PUBLIC RELEASE

REDACTED FOR PUBLIC RELEASE

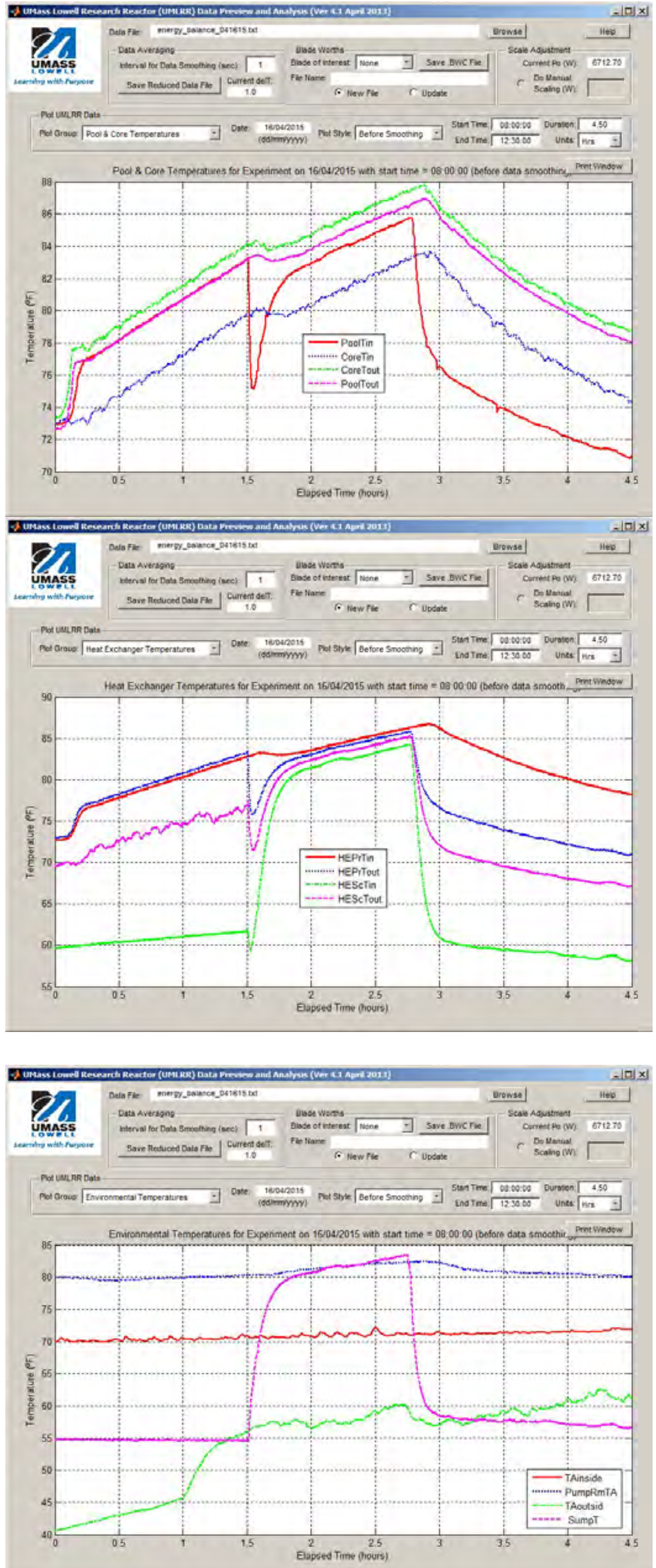


Figure 13-15: Typical temperature transients associated with the secondary side cooling system.

REDACTED FOR PUBLIC RELEASE

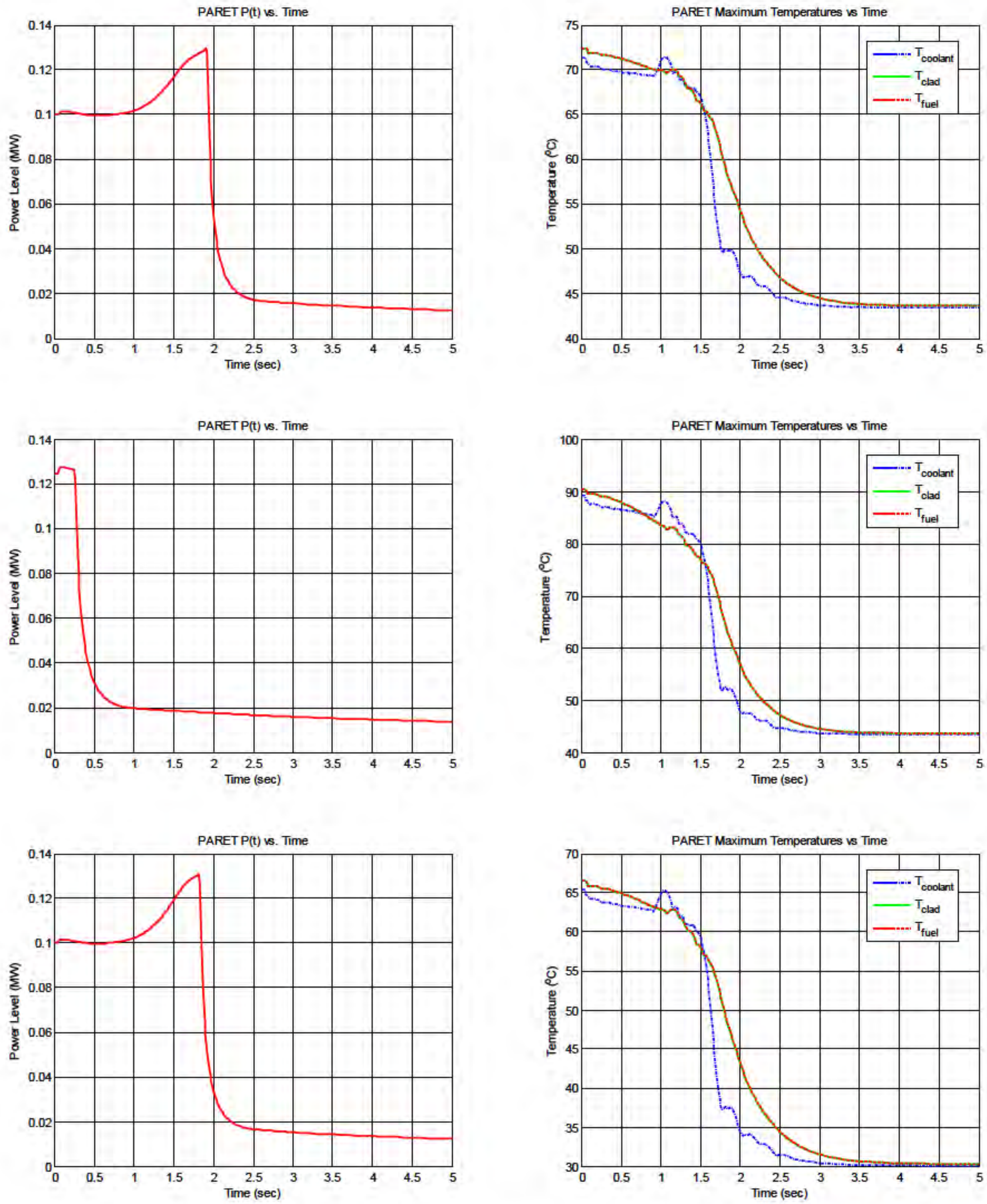


Figure 13-16: Behavior for a pump-on event from various operating conditions.

Top Plots: Case 1 -- pump-on scenario with P_o = 100 kW and T_{in} = 43.3 C
Middle Plots: Case 2 -- pump-on scenario with P_o = 125 kW and T_{in} = 43.3 C
Bottom Plots: Case 3 -- pump-on scenario with P_o = 100 kW and T_{in} = 30.0 C

REDACTED FOR PUBLIC RELEASE

13.2.3 Loss of Coolant Flow

During forced down-flow operation, the primary pump supports a nominal flow rate of about [redacted] GPM. As discussed in Chapter 4 of the SAR, a minimum of about 68% of this total flow goes through the fuel elements to remove the energy deposited via fission and radioactive decay. If, for any reason, forced flow is lost, then the downward flow ceases and upward flow is initiated by the difference in fluid density in the heated channels and the surrounding pool, which eventually reaches equilibrium natural convection flow when the buoyancy forces balance the fluid friction forces in the coolant channels. A loss of flow event could occur with a pump failure, a loss of electrical power, or an operator error. As these are credible initiating events, the consequences following a loss of flow event are evaluated to show the safety limit will not be exceeded.

As discussed in Chapter 4 and shown in Figure 4-16, the flow rate following a sudden pump-off event behaves much like a decaying exponential profile, with the flow rate going to essentially zero in about 10 seconds. This flow profile was input into PARET to drive all the loss of flow (LOF) models. Three cases, involving different combinations of P_o, T_{in}, and Q_o, were analyzed as follows:

Case 1: LOF scenario with P_o = 1.25 MW, T_{in} = 43.3 C, and Q_o = [redacted] GPM

Case 2: Same as Case 1 with Q_o = 1370 GPM

Case 3: LOF scenario with the reactor initially at nominal conditions (P_o = 1.00 MW, T_{in} = 30.0 C, and Q_o = [redacted] GPM)

The summary results from these three LOF simulations are presented in Figure 13-17. All three cases behave in a similar manner; with some specific differences that are related to the different operating states and/or initial conditions. For example, with a scram setpoint of 1370 GPM for all cases, Case 2 scrams nearly instantaneous (i.e. after the short instrument delay) because the reactor is assumed to be operating at the low-flow setpoint prior to pump failure. In Cases 1 and 3, however, the trip occurs after about 1.5 seconds into the transient since, according to Figure 4-16, the core flow rate drops to about 80% of initial capacity in about 1.5 seconds after the pump-off events starts. Similarly, the peak initial temperatures occur for Case 2, since this scenario has the highest power and lowest rate flow rate combination of the three cases shown.

Concerning the temperature profiles vs. time, these are more easily explained with the help of a mass flux vs. time curve. In particular, global and focused views of the mass flux vs. time profile are given for Case 1 in Figure 13-18. This set of curves is similar for all cases, but Case 1 was selected since it represents the most practical worst-case scenario for a LOF event where, initially, the pump flow rate is at nominal conditions ([redacted] GPM), but the power level and inlet temperature are at their LSSS values.

With pump coast down beginning at t = 0 (with a negative mass flux because the flow is down through the core), the flow rate decreases in a near-exponential fashion towards zero in about 10 seconds, and then natural convection begins, first in the hottest channel and then in all the other heated channels, with flow upward through the core. After the initial brief temperature rise due to a decreasing flow rate, and then the rapid drop due to the insertion of the blades and resultant rapid decrease in power, the core temperatures then start to increase as the flow rate decreases to zero and actually changes sign as upflow begins. At this time, there is a strong interrelationship between temperature and flow rate, since in natural convection flow, the coolant temperature and density changes are what initiates the buoyancy-driven flow, yet the coolant flow is responsible for energy removal from the fuel plates. This strong interdependence is seen in the temperature and flow rate profiles after about 10 seconds in Figures 13-17 and 13-18, respectively. Eventually the system temperatures and individual channel flow rates stabilize and then continue to decrease slowly as the internal heat source (i.e. decay heat) steadily decreases in time.

Although the flow reversal phenomena following a LOF event in the UMLRR is quite interesting in itself, the most important aspect of the above simulations from the reactor safety perspective is the relatively low temperatures that are observed. In all cases, the highest clad temperature was under 75 C, which clearly gives a significant margin to the ONB safety limit. Thus, as observed for a ramp reactivity insertion event, there is also no real possibility of reaching the onset of nucleate boiling (ONB) safety limit for a scram-protected loss of flow (LOF) transient within the UMLRR. Accordingly, a scram-protected LOF event is a non-limiting transient scenario within the UMLRR.

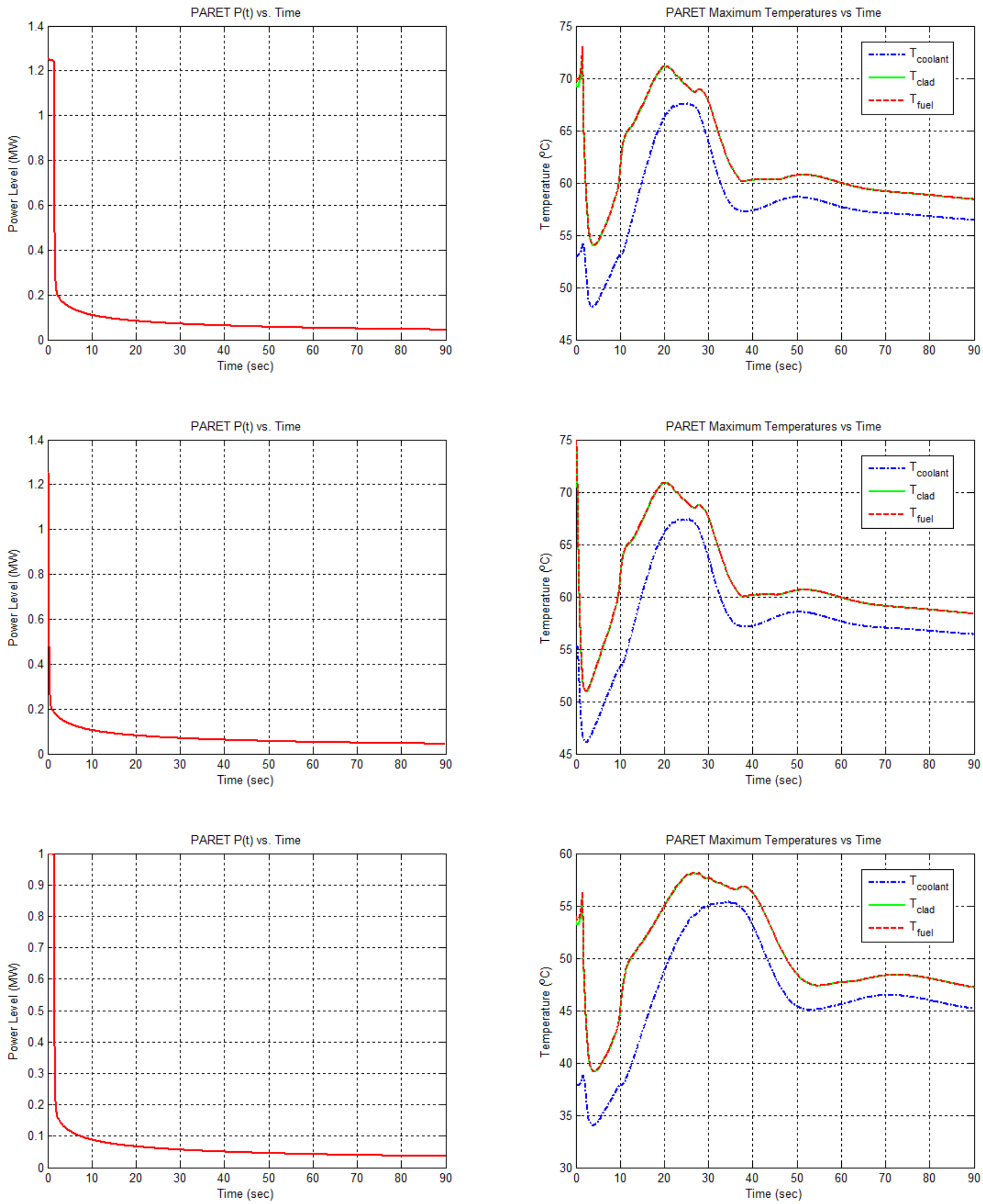


Figure 13-17: Behavior of loss of flow (LOF) transient from various operating conditions.

Top Plots: Case 1 -- LOF scenario with P_o = 1.25 MW, T_{in} = 43.3 C, and Q_o = [redacted] GPM
Middle Plots: Case 2 -- LOF scenario with P_o = 1.25 MW, T_{in} = 43.3 C, and Q_o = 1370 GPM
Bottom Plots: Case 3 -- LOF scenario with P_o = 1.00 MW, T_{in} = 30.0 C, and Q_o = [redacted] GPM

REDACTED FOR PUBLIC RELEASE

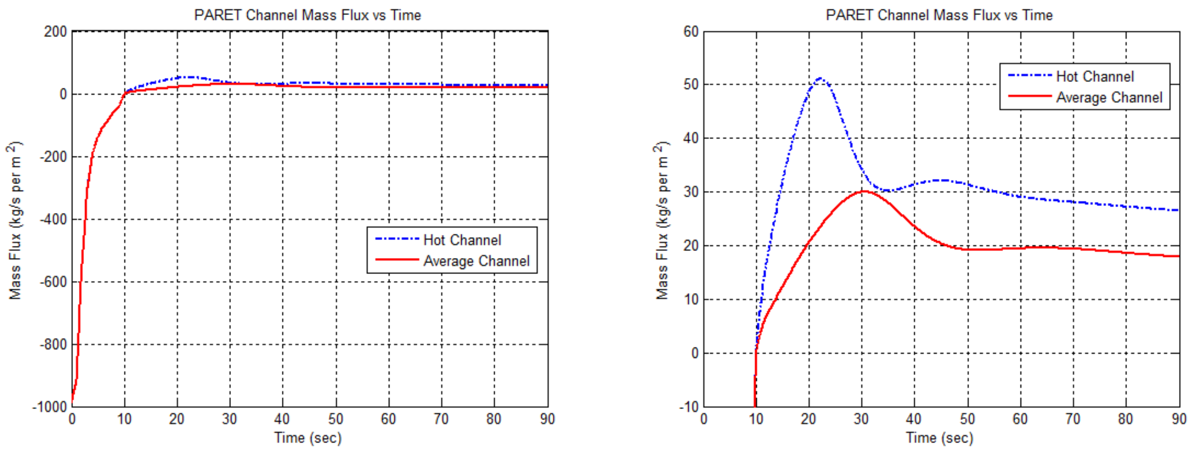


Figure 13-18: Mass flux versus time for the Case 1 LOF simulation

(left plot: global view, right plot: focused view after flow inversion)

.

13.2.4 Loss of Coolant

Although an event or sequence of events leading to a total loss of coolant accident (LOCA) from the reactor pool is difficult to imagine, it is informative to consider the consequences if all water were lost as the result of, for example, an earthquake of magnitude severely higher than any experienced in the recorded history of this area.

Work was done by Wett[xiii] in investigating the surface temperature of Oak Ridge Research Reactor (ORR) fuel elements under natural convection air cooling. This work, along with experimental results from the Low Intensity Testing Reactor (LITR) and the Livermore Pool-Type Reactor (LPTR) was correlated by Webster[xiv], whose conclusion are pertinent because the ORR, LITR, and LPTR are all light-water moderated research reactors with solid plate-type fuel (commonly called MTR or BSR type elements) which are similar to the UMLRRR fuel design. Webster states, “This analysis indicates that the LITR could be operated continuously at 3 MW and could lose the cooling water through a rupture in the reactor tank without danger of melting the fuel, even without core spray.” The conclusion that a total loss of water from the pool of the UMLRR operating at 1 MW would lead to no melting of the fuel is reasonable.

Despite the evidence cited in the preceding paragraph, safe practice demands that all reasonable precautionary measures be taken to preclude the possibility of inadvertent draining of the pool. Consequently, a “through-tube” facility present in the original design of the UMLRR was deleted because it passed beneath the core, and thus a failure in integrity of this tube could lead to drainage of the pool. For similar reasons, the prohibition of open feed pipes which extend below the core level for such services as make-up water, etc., precludes the possibility of siphoning the pool water to levels below the core.

13.2.4.1 Analysis of Unshielded Sources

Though a LOCA situation is highly improbable and the consequences would not lead to fuel damage, it is assumed for the analysis in this section that the water shield above the reactor core and the Cobalt-60 sources would be removed completely, creating the potential for both direct and indirect doses from these sources. As described in Section 4.3, the reactor pool is divided into two sections – a bulk irradiation side and a reactor stall side. The bulk irradiation side houses the Cobalt-60 sources. The stall side houses the reactor. However, the reactor can be moved on a rail system to the bulk side within minutes if needed. The two sides can be isolated by means of a water-tight pool divider gate which provides a means of isolating one side of the tank should a leak occur. In the unlikely event that the pool completely drains, a direct dose would occur for individuals in the reactor containment building who are exposed to the primary gamma rays emerging from the top of the open and empty pool. The indirect dose is attributed mainly to primary gamma rays that emerge from the open pool and scatter off the reactor building dome. The resultant scattered photons then can irradiate individuals at locations of interest.

The scope of the approach for this analysis is consistent with license documentation produced for other research reactors licensed by the NRC. This section provides a methodology for estimating the direct and indirect absorbed dose rates to tissue which are assumed to be equal to collision kerma rates to water. For the indirect dose assessment, values for absorbed dose were converted to dose equivalent using a quality factor of one. Furthermore, these dose equivalent values represent the "deep-dose equivalent" as defined in 10 CFR Part 20[xv]. Dose related quantities, such as attenuation coefficients, energy absorption coefficients, and buildup parameters were obtained from the textbook *Radiation Shielding*[xvi].

The major assumptions used in this section are:

1. The Co-60 source and the reactor core are treated as unshielded point sources at the bottom center of the reactor pool.
2. The pool enclosure is approximated as a cylinder, with a radius that provides a surface area that is similar to the actual rectangular pool, thus providing a comparable irradiation of the reactor dome by primary gamma rays that emerge from the pool surface.
3. Scattered or annihilation photons that arise from interactions of primary gamma rays within the pool enclosure were neglected.
4. Attenuation in the pool enclosure was neglected for scattered photons that traverse any part of the [redacted]
5. The reactor dome is treated as a segment of a spherical shell, constructed of iron with a uniform thickness of 1 inch rather than the actual thickness of [redacted] inches. The enhanced thickness of the dome also accounts for indirect dose due to scattered photons that emerge from the reactor dome and subsequently scatter with other surfaces within the containment vessel.
6. For the estimation of indirect dose rate, attenuation of primary gamma rays was neglected in both the air and in the reactor dome. [redacted]
7. Scattered photons that originate in the reactor dome escape the reactor dome without interacting.
8. Absorbed dose to tissue is equal to collision kerma in water.
9. The quality factor for photons is one, and dose equivalent estimates for indirect dose are for the regulatory quantity "deep-dose equivalent".
10. Buildup for the quantity air-kerma also is applicable to absorbed dose to tissue.
11. Buildup in air or iron for scattered photons is assumed to be similar to buildup for monoenergetic photons that traverse these materials.
12. The typical duration for reactor operations is 6 hours at a power level of 1 MW.

1[redacted] uncovered reactor core do not contribute significantly to dose.

13.2.4.2 Direct Dose Rates

The primary source terms for direct dose rate are the Co-60 source and the reactor core, and each will be treated individually. The Co-60 activity A is assumed to be 3.7×10^{15} Bq (100 kCi) which is the activity limit under the current license application. The Co-60 activity is treated as a point source located at the bottom of the pool that emits gamma rays with an average energy E of 1.25 MeV and yield Y of 2. The distance of closest approach for direct dose is assumed to be the height of the pool (10 m), denoted by H_P, and the intervening material is air at normal pressure (1 atm) and temperature (22 °C or 295 °K) resulting in an air density of 1.2×10^{-3} g cm^{-3}. The direct dose rate due to the Co-60 source is given by:

$$D = \frac{AYE}{4\pi H_P^2}\left(\frac{\mu_{en}}{\rho}\right)\exp(-\mu H_P)\,B(\mu H_P) \quad ,$$

where $(\mu_{en}/\rho) = 2.965\times10^{-2}$ cm^2 g^{-1} is the mass energy absorption coefficient for 1.25 MeV gamma rays in water (tissue), $\mu = 6.802\times10^{-5}$ cm^{-1} is the linear attenuation coefficient for 1.25 keV gamma rays in air, and $B(\mu H_P)$ accounts for buildup in the intervening air of thickness H_P. For this analysis it was convenient to use Berger's formula for buildup:

$$B(\mu H_P) \;=\; 1 + \; a\mu H_P \exp(+b\mu H_P) \quad ,$$

where a = 1.33 and b = 0.028 are parameter values for buildup of the quantity air-kerma for 1.25 MeV gamma rays that traverse the intervening air. It was assumed here and elsewhere in this section that buildup parameters for air-kerma are applicable to dose to tissue because the mass energy absorption coefficients for air and water are approximately equal over a broad range of photon energies.

The reactor core also will be treated as a point source, with primary gamma ray emissions from a large inventory of fission products accumulated over some prior operating schedule. In this case, it is convenient to consider the dynamic behavior of energy groups

REDACTED FOR PUBLIC RELEASE

rather than to track individual fission products over time. This approach is described in Appendix G of the reference by Shultis and Faw[xvi]. The gamma ray energy emission rate $\Gamma_j(T,t)$ from fission products in the jth group, produced by the thermal fission of U-235 and accumulated over operating duration *T*, is expressed as a function of time *t* after reactor shutdown by:

$$\Gamma_j(T,t) \ = \sum_{i=1}^{N_j} \frac{\alpha_{i,j}}{\lambda_{i,j}} \left(1 - e^{-\lambda_{i,j}\,T}\right) e^{-\lambda_{i,j}\,t} \ ,$$

where $\alpha_{i,j}$ and $\lambda_{i,j}$ are magnitude and decay parameters, respectively, for the ith source term in the jth group, and N_j is the number of source terms in the jth group. The value of N_j ranges from 9 to 14, and there are six energy groups (j = 1 to 6). The units for $\Gamma_j(T,t)$ are MeV fission^{-1}, the units for $\alpha_{i,j}$ are MeV s^{-1} fission^{-1}, the unit for $\lambda_{i,j}$ is s^{-1}, and the unit for *T* and *t* is seconds ($10^{-4} \le t \le 10^{9}$). For a constant fission rate S_F (in units of fissions s^{-1}) and the same distance of closest approach used for the Co-60 source, the direct dose rate due to the jth group of fission products in the reactor core is given by:

$$D_j(T,t) = \frac{S_F\ \Gamma_j(T,t)}{4\pi H_P^2} \left(\frac{\mu_{en}}{\rho}\right)_j \exp\left(-\mu_j H_P\right) B_j(\mu_j H_P) \ \ ,$$

where $(\mu_{en}/\rho)_j$ is the mass energy absorption coefficient in water (tissue) for the jth group, μ_j is the linear attenuation coefficient for air for the jth group, and:

$$B_j\left(\mu_j H_P\right) \ = \ 1 + \ a_j \mu_j H_P \exp\left(+b_j \mu_j H_P\right) \ \ ,$$

is Berger's formula for buildup in the intervening air, where a_j and b_j are parameters for buildup of the quantity air-kerma for the jth group. Each of the quantities: $(\mu_{en}/\rho)_j$, μ_j, a_j, and b_j were evaluated for the average gamma ray energy of the jth group.

The direct dose rate for all fission product groups is given by:

$$D(T,t) = \sum_{j=1}^{6} D_j(T,t) \ .$$

Assuming an energy recovery of 200 MeV per fission of U-235 and a reactor power level of 1 MW or 6.242×10^{18} MeV s^{-1}, the fission rate S_F is 3.121×10^{16} fissions s^{-1}. The group number and corresponding average gamma ray energy for fission products are provided in Table 13-10 below, and values for the quantities used to determine direct dose rate are provided in Table 13-11. The $\alpha_{i,j}$ and $\lambda_{i,j}$ values are provided in the reference by Shultis and Faw[xvi].

13.2.4.3 Direct Dose Rate Results

All distances were converted to the unit of cm for calculations, and a conversion factor of $10^3(3.6\times10^3/6.242\times10^7)$ mrad g MeV^{-1} s hr^{-1} was used to obtain suitable units for the direct dose rates. The direct dose rate for the Co-60 source is 1.283×10^6 mrad hr^{-1}, and the direct dose rate for the reactor core depends on the previous duration of operations T and the elapsed time t after reactor shutdown. For this analysis, there were two durations chosen for reactor operations: 6 hours (2.16×10^4 s) and infinity. The first duration is indicative of typical reactor operations, and the second duration represents a saturation condition for fission product activities in the reactor core. The use of an infinite duration for reactor operations is consistent with the Maximum Hypothetical Accident (MHA) scenario described in Section 13.2.1. The direct dose rates are listed in Table 13-12 for several values of t to indicate the trend over time, and for convenience values for t and T in the table do not have the unit of seconds. The first value for t of 27 minutes has significance as the approximate time required for a rupture in an eight-inch beam tube to cause the reactor pool to drain to the level of the horizontal center-line of the reactor core, thus exposing a significant portion of the reactor core to air[xvii].

Table 13-10: Group Number and average gamma energy Based on fission products from thermal fission of U-235.	
Group number (j)	Average energy, E_j (MeV)
1	6.25
2	4.5
3	3.5
4	2.5
5	1.5
6	0.5

Table 13-11: Values used to determine direct dose rate Based on fission products from thermal fission of U-235.				
Average energy, E_j (MeV)	$\left(\frac{\mu_{en}}{\rho}\right)_j$ for water (cm^2 g^{-1})	μ_j for air (cm^{-1})	a_j for air	b_j for air
6.25	1.788×10^{-2}	2.974×10^{-5}	0.458	−0.004
4.5	1.991×10^{-2}	3.489×10^{-5}	0.57	−0.0005
3.5	2.174×10^{-2}	3.985×10^{-5}	0.68	+0.003
2.5	2.445×10^{-2}	4.803×10^{-5}	0.86	+0.009
1.5	2.833×10^{-2}	6.190×10^{-5}	1.16	+0.021
0.5	3.299×10^{-2}	1.040×10^{-4}	2.29	+0.067

Table 13-12: Direct dose rates for fission products The direct dose rates from the thermal fission of U-235 were evaluated at a distance H_P from the reactor core and for the specified duration of reactor operations.		
Elapsed time t	Direct dose rate (mrad hr^{-1})	
	T = 6 hours	$T \rightarrow \infty$
27 min	4.880×10^{6}	8.617×10^{6}
1 hour	3.157×10^{6}	6.814×10^{6}
1 day	1.516×10^{5}	2.669×10^{6}
7 days	1.767×10^{4}	1.555×10^{6}
30 days	3.218×10^{3}	8.665×10^{5}
90 days	7.911×10^{2}	5.109×10^{5}

The inclusion of attenuation and buildup for direct dose rate calculations was necessary only for fission product group 6 (with an average gamma ray energy of 0.5 MeV). For all other groups, and for the Co-60 source as well, the calculated values for direct dose rate were not affected significantly by the inclusion of attenuation and buildup, but these factors were included to be consistent. In addition, any scattered photons or annihilation photons that arise from interactions of primary gamma rays within the pool enclosure were neglected.

13.2.4.4 Indirect Dose Rates

The indirect dose is due mainly to primary gamma rays that interact in the reactor dome by Compton scatter, thus producing scattered photons that can irradiate individuals at locations of interest. The methodology for this indirect dose assessment is provided below.

13.2.4.5 Geometry

The geometry used to estimate indirect dose rates is provided in Figure 13-19. The base of the reactor containment vessel, extending from the horizontal center-line of the reactor core to the intersection of the vertical walls and the curved dome ceiling, is modeled as a cylinder with radius R equal to [redacted] feet ([redacted]m) and height H equal t[redacted] The dome ceiling of the containment vessel is modeled as a segment of a spherical shell, with radiu[redacted] bottom center of the cylindrical base. The pool enclosure is modeled as a [redacted] to 4 m and [redacted]. The actual pool enclosure is rectangular, with a total area of 384 ft^2 or about 36 m^2 at the pool surface. For the cylindrical pool model, the pool surface area i[redacted] [redacted] which provides a comparable irradiation of the reactor dome by primary gamma rays that emerge from the pool surface. Also shown in Figure 13-19 is a location of interest P for calculating indirect dose rates, which is a horizontal distance x from the bottom center of the cylindrical base, and a height h above the horizontal center-line of the reactor core. The asterisk in Figure 13-19 indicates the location of the radiation sources, either of the Co-60 source or the reactor core, which coincides with the bottom center of the cylindrical base (i.e., the origin of the spherical shell segment). In addition, an angle [redacted] is shown that pertains

REDACTED FOR PUBLIC RELEASE

to the Compton scatter interaction, which indicates the angle of [redacted] rays that interact at an arbitrary location on the reactor dome resulting in a scattered photon that travels toward the location of interest P, and the length r indicates the distance between the location of Compton scatter and the location P. A polar angle θ also is shown with respect to a vertical (z) axis.

13.2.4.6 Primary Gamma Ray Fluence Rates Incident on the Reactor Dome

The primary source terms for indirect dose are the Co-60 source and the reactor core, and each will be treated individually. The Co-60 activity A is assumed to be [redacted] Bq as was the case for direct dose rate determination, and the Co-60 activity is treated as a point source located at the asterisk in Figure 13-19. The primary gamma ray fluence rate φ incident on the reactor dome from the Co-60 source therefore is:

$\varphi =$ [redacted]

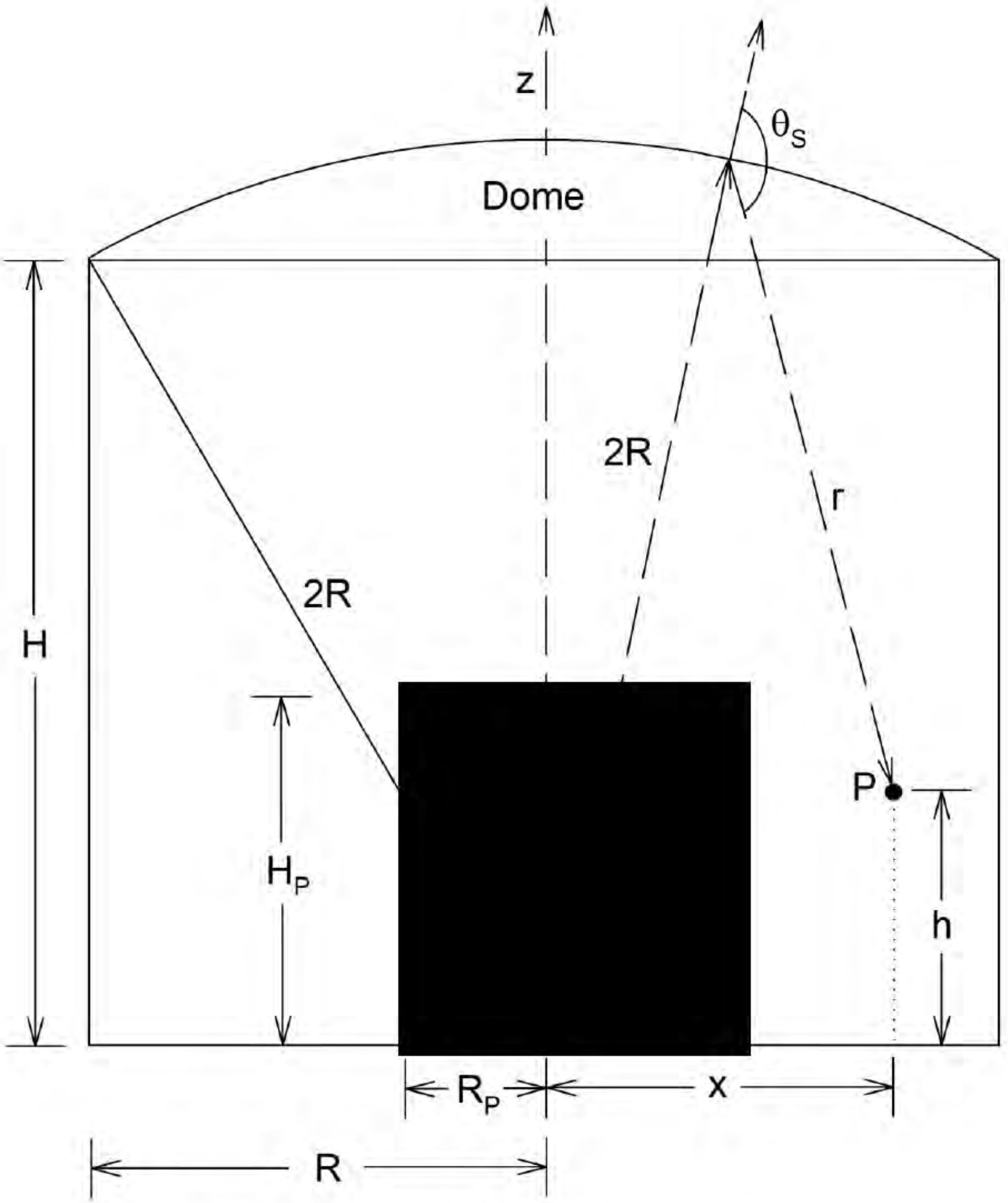


Figure 13-19: Containment vessel and pool geometry for estimated indirect dose rates

REDACTED FOR PUBLIC RELEASE

The reactor core also will be treated as a point source at the location of the asterisk in Figure 13-19, and the fission product emission will be characterized using energy groups as was used to determine direct dose rate. For a constant fission rate S_F of 3.121×10^{16} fissions s^{-1} and average group energy E_j (in MeV), the primary gamma ray fluence rate incident on the reactor dome for the jth group of fission products is given by:

$$\varphi_j(T,t) = \text{[redacted]})^2\Big) .$$

The previous expressions do not include attenuation in the intervening air of the primary gamma rays from either the Co-60 source or the reactor core, which is intended to maximize the primary gamma ray fluence rate that irradiates the reactor dome.

13.2.4.7 Scattered Photon Fluence Rates Incident on the Locations of Interest

The secondary source terms for indirect dose are scattered photons produced by the primary gamma rays from Co-60 or the reactor core that interact by Compton scatter in the reactor dome. For primary gamma rays with energy E (in MeV) that interact by Compton scatter in the reactor dome, the energy E' (in MeV) of the scattered photon is given by:

$$E' = \frac{E}{1\text{[redacted]})} ,$$

where 0.511 MeV is the rest mass energy of an electron, and θ_S is the scattering angle. The differential cross-section for the Compton scatter interaction, which provides the probability for the scattered photon with energy E' to emerge within a differential solid angle $d\Omega$ that encompasses the location of interest, also is dependent on E and θ_S and is given by:

$$\left(\frac{d\sigma}{d\Omega}\right) = \frac{r_0^2}{2}\left(\frac{E'}{E}\right)^2\left[\frac{E}{E'} + \frac{E'}{E} - 1 + (\cos\theta_S)^2\right] ,$$

where $r_0 =$ [redacted] is the classical electron radius. The units for $(d\sigma/d\Omega)$ are cm^2 steradian^{-1} electron^{-1}.

The central portion of the reactor dome is 5/8 inch steel which increases in thickness to 1 inch where the dome connects with the cylindrical base. For purposes of estimating indirect dose, the reactor dome is assumed to be iron with a uniform thickness of 1 inch, resulting in an electron areal density n_e of [redacted] electrons cm^{-2}. The assumed composition of the dome is reasonable because iron is the major component of steel. The assumed thickness of the dome is conservative because the geometry dictates that mostly the central portion of the dome is irradiated. The enhanced dome thickness, however, is assumed to account for indirect dose due to subsequent scatter from other surfaces (e.g., floors and walls) within the containment vessel for scattered photons that emerge from the reactor dome.

For a spherical coordinate system with the same origin as the spherical shell segment, an increment of reactor dome area is given by: [redacted] $\theta\, d\theta\, d\beta$, where θ is the polar angle and β is the planar angle (the angle β is not shown in Figure 13-19). The differential number of electrons available for Compton scatter at an arbitrary location on the reactor dome therefore is $n_e(2R)^2 \sin\theta\, d\theta\, d\beta$. Furthermore it is assumed that all these electrons are subject to the same primary gamma ray fluence rate (i.e., the attenuation of primary gamma rays in the reactor dome is neglected).

The cosine of the scattering angle θ_S can be determined using vector relationships. If $\overrightarrow{V_D}$ denotes a vector pointing to an arbitrary location on the reactor dome where Compton scatter occurs, and $\overrightarrow{V_P}$ denotes a vector pointing to the location of interest P, then the vector $\vec{r}$ pointing from the location of Compton scatter to the location P is given by: $\vec{r} = \overrightarrow{V_P} - \overrightarrow{V_D}$. It follows that the distance r shown in Figure 13-19 is given by $|\vec{r}|$, and $\cos\theta_S$ is given by:

$$\cos\theta_S = \frac{\overrightarrow{V_D} \cdot \vec{r}}{|\overrightarrow{V_D}|\,|\vec{r}|} ,$$

where $|\overrightarrow{V_D}| = 2R$, and the value of $\cos\theta_S$ in general depends on R, θ, β, x, and h. There are two locations of interest in the reactor containment vessel for estimating indirect dose rates: the edge of the reactor pool ($x = R_P$ and $h = H_P$) and at [redacted] or ($x = R$ and $h =$ [redacted] m), and the resultant geometry dictates that the magnitude of the scattering angle is bounded by ($\pi/2 < \theta_S \leq \pi$).

In the absence of attenuation, the differential scattered photon fluence rate at the location P due to the Compton scatter of Co-60 gamma rays in the reactor dome is given by:

$$\varphi\left(\frac{d\sigma}{d\Omega}\right)\frac{n_e}{r^2}(2R)^2 \sin\theta\, d\theta\, d\beta\ ,$$

and the same quantity for the jth group of fission products is given by:

$$\varphi_j(T,t)\left(\frac{d\sigma}{d\Omega}\right)\frac{n_e}{r^2}(2R)^2 \sin\theta\, d\theta\, d\beta\ .$$

These expressions were integrated numerically over the irradiated surface of the reactor dome to estimate the indirect dose rates, with additional factors accounting for energy fluence rate, attenuation, buildup, and energy absorption in water (tissue).

13.2.4.8 Indirect Dose Rates at the Edge of the Reactor Pool

For the indirect dose rates at the edge of the reactor pool, the scattered photons traverse only the air in the reactor containment vessel before reaching this location of interest. In this case, attenuation and buildup in air was considered for these scattered photons.

The indirect dose rate at the edge of the reactor pool due to the Co-60 source is estimated by:

$$D = 2\int_0^{\pi} \varphi \int_0^{\theta_{max}} \left(\frac{d\sigma}{d\Omega}\right)\frac{n_e}{r^2}\, E' \left(\frac{\mu'_{en}}{\rho}\right) \exp(-\mu' r)\, B(\mu' r)\, (2R)^2 \sin\theta \, d\theta \, d\beta \ ,$$

where the factor E' defines an energy fluence rate for the scattered photons, (μ'_{en}/ρ) accounts for energy absorption in water (tissue) for the scattered photons, $\exp(-\mu' r)$ accounts for attenuation in air, and $B(\mu' r)$ accounts for buildup in air. The initial factor of 2 accounts for symmetry with respect to the planar angle β, and the upper limit of integration θ_{max} for the polar angle θ is given by:

$$\theta_{max} = \tan^{-1}\left(\frac{R_P}{H_P}\right) ,$$

which is 0.38 radians. Berger's formula was used to describe buildup in the intervening air for the scattered photons as they travel toward the edge of the pool:

$B(\mu' r) =$ [redacted]) ,

where a' and b' are parameters for buildup of the quantity air-kerma, which is assumed to be equal in magnitude to buildup for absorbed dose to tissue.

Because the scattered photons have variable energy E' which depends on the scattering angle, the following general fitting function was used to calculate the various dose quantities (μ'_{en}/ρ), μ', a', and b':

$$f(E') = c_0 + c_1 E' + c_2 (E')^2 + c_3 (E')^3 \ ,$$

where c_0, c_1, c_2, and c_3 are fitting parameters. Values for the fitting parameters for each relevant dose quantity are listed in Table 13-13 for the energy range ($0.15 \leq E' \leq 0.6$) MeV which includes all scattered photon energies traveling toward the locations of interest defined previously.

Table 13-13: Fitting parameters for dose at edge of reactor pool				
Fitting parameters for various dose quantities used to estimate indirect dose rate at the edge of the reactor pool.				
Fitting parameter	Dose quantity			
	$\left(\frac{\mu'_{en}}{\rho}\right)$ for water ($cm^2\ g^{-1}$)	μ' for air (cm^{-1})	a' for air (dimensionless)	b' for air (dimensionless)
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

The indirect dose rate at the edge of the reactor pool for the jth group of fission products is estimated by:

$$D_j(T,t) = 2\int_0^{\pi} \varphi_j(T,t) \int_0^{\theta_{max}} \left(\frac{d\sigma}{d\Omega}\right) \frac{n_e}{r^2} E' \left(\frac{\mu'_{en}}{\rho}\right) \exp(-\mu' r)\, B(\mu' r)\, (2R)^2 \sin\theta \, d\theta \, d\beta \ ,$$

and the indirect dose rate for all fission product groups is given by:

$$D(T,t) = \sum_{j=1}^{6} D_j(T,t) \ .$$

The scattered photons that are produced in the reactor dome are assumed to escape the reactor dome without interacting. Also, typical values for buildup are determined for monoenergetic sources, and it is assumed that buildup for the scattered photons that emerge from the reactor dome is similar to buildup for monoenergetic sources.

REDACTED FOR PUBLIC RELEASE

13.2.4.9 Indirect Dose Rates at the Truck Door Exterior

For the indirect dose [redacted] to be on the exterior of the [redacted], which is steel with a thickness of [redacted] inches, before reaching the location of interest. In this case, attenuation of scattered photons in the intervening air was neglected to maximize the scatted photon fluence rate incident on [redacted] Attenuation and buildup in iron was considered for scattered photons that are incident on the [redacted]. For simplicity, it was assumed that the [redacted] The path length δ [redacted] by scattered photons can be determined by similar triangles, and in general is dependent on the thickness of th[redacted] and on R, θ, β, x, and h.

The indirect dose [redacted]r due to the Co-60 source is estimated by:

$$D = 2\int_{0}^{\pi} \varphi \int_{0}^{\theta_{max}} \left(\frac{d\sigma}{d\Omega}\right)\frac{n_e}{r^2}\, E' \left(\frac{\mu'_{en}}{\rho}\right) \exp(-\mu'\delta)\, B(\mu'\delta)\, (2R)^2 \sin\theta \, d\theta \, d\beta \ ,$$

where $\exp(-\mu'\delta)$ accounts for [redacted] $B(\mu'\delta)$ accounts for buildup [redacted] Berger's formula was used to describe buildup [redacted]

$$B(\mu' r) = 1 + a'\mu' r \exp(+b'\mu' r) \ ,$$

where a' and b' are parameters for buildup of the quantity air-kerma for scattered photons that traverse the[redacted] Likewise, the following general fitting function was used to calculate the dose quantities μ', a', and b' for iron:

$$f(E') = c_0 + c_1 E' + c_2 (E')^2 + c_3 (E')^3 \ ,$$

REDACTED FOR PUBLIC RELEASE

where c_0 , c_1 , c_2 , and c_3 are fitting parameters. Values for the fitting parameters for each dose quantity are listed in Table 13-14 for the energy range ($0.15 \leq E' \leq 0.6$) MeV. The fitting parameters for (μ'_{en}/ρ) were given previously in Table 13-13.

Table 13-14: Dose Fitting Parameters			
Fitting parameters for various dose quantities used to estimate indirect dose rate at the [redacted]			
Fitting parameter	Dose quantity		
	μ' for iron (cm^{-1})	a' for iron (dimensionless)	b' for iron (dimensionless)
c_0 [redacted]	[redacted]	[redacted]	[redacted]

The indirect dose rate at the [redacted] jth group of fission products is estimated by:

$$D_j(T,t) = 2\int_0^{\pi} \varphi_j(T,t) \int_0^{\theta_{max}} \left(\frac{d\sigma}{d\Omega}\right)\frac{n_e}{r^2}\, E' \left(\frac{\mu'_{en}}{\rho}\right) \exp(-\mu'\delta)\, B(\mu'\delta)\, (2R)^2 \sin\theta \, d\theta \, d\beta \ ,$$

and the indirect dose rate for all fission product groups is given by:

$$D(T,t) = \sum_{j=1}^{6} D_j(T,t) \ .$$

Likewise, the scattered photons that are produced in the reactor dome are assumed to escape the reactor dome without interacting, and buildup for the scattered photons that are [redacted] for monoenergetic sources.

13.2.4.10 Indirect Dose Rate Results

All distances were converted to the unit of cm for calculations, and a conversion factor of [redacted] mrem g MeV^{-1} s hr^{-1} was used to obtain suitable units for the indirect dose rates. For the Co-60 source, the indirect dose rate at the edge of the reactor pool ($x = R_P$ and $h = H_P$) is [redacted] mrem hr^{-1}, and the indirect dose rate at the [redacted].

Table 13-15 contains the indirect dose rates at the edge of the reactor pool for all fission product groups and for the two durations of reactor operations considered here. Table 13-16 contains the indirect dose rates at the truck door exterior for the same durations.

Table 13-15: Indirect dose rates for fission products at pool		
The indirect dose rates from thermal fission of U-235 were evaluated at the edge of the reactor pool ($x = R_P$ and $h = H_P$) and for the specified duration of reactor operations.		
	Indirect dose rate (mrem hr^{-1})	
Elapsed time t	T = 6 hours	$T \to \infty$
27 min [redacted]	[redacted]	[redacted]

Table 13-16: Indirect dose rates for fission products at truck door		
The indirect dose rates from thermal fission of U-235 were evaluated at the [redacted] door exterior ($x = R$ and $h =$ [redacted] for the specified duration of reactor operations.		
	Indirect dose rate (mrem hr^{-1})	
Elapsed time t	T = 6 hours	$T \to \infty$
[redacted]	[redacted]	[redacted]

Indirect dose rates also were evaluated for primary gamma rays that undergo photoelectric effect and pair production interactions in the reactor dome. The photoelectric effect was assumed to occur with a K-shell electron in iron, and the subsequent atomic de-excitation would result in the emission of one fluorescent x-ray with an energy equal to the

K-shell binding energy for iron, which is about 10 keV. It was also assumed that these fluorescent x-rays escaped the reactor dome without attenuation. In this case the reactor dome becomes a source of fluorescent x-rays, but these x-rays are readily attenuated in the intervening air and therefore do not contribute to indirect dose rate at the locations of interest defined previously. The pair production interaction can occur for Co-60 and for fission product groups 1 - 5. The resultant positron was assumed to annihilate at rest in the reactor dome, such that one of the annihilation photons has the potential to deliver dose within the reactor containment vessel. It was also assumed that this annihilation photon escaped the reactor dome without attenuation. In this case the reactor dome becomes a source of 0.511 MeV annihilation photons. These photons, however, did not result in significant indirect dose rates at the locations of interest because the emission rates for the high energy gamma rays (fission product groups 1, 2, and 3), which have the largest cross-section for the pair production interaction, are relatively small.

Furthermore, indirect dose rates were evaluated for primary gamma rays that undergo an initial Compton scatter in the reactor dome and a subsequent Compton scatter with the concrete floor: either on the third floor near the reactor pool, or on the first floor near the truck door. The resultant dose rates from these double-scatter events contributed an additional 5-10% to the indirect dose rates due to single Compton scatter events with the reactor dome. Given that the magnitude of all significant indirect dose rates is proportional to the thickness of the reactor dome, the use of 1 inch for the dome thickness as stated previously results in an increase in indirect dose rate of 60% compared to that obtained using the actual dome thickness of [redacted]. This additional 60% of indirect dose rate therefore is assumed to account for double-scatter events from other surfaces in the vicinity of the locations of interest.

13.2.4.11 Summary

In the improbable event of a complete loss of coolant accident, the direct dose rates should not be realized in practice because the reactor containment building would be evacuated before the water completely drained from the reactor pool. The direct and indirect dose rates for fission products indicate a significant increase in longer lived fission products as $T \rightarrow \infty$. The indirect dose rates from fission products due to a loss of coolant accident following a typical reactor operating schedule would decay significantly after about one month, and the Co-60 source therefore presents the most significant long-term radiation hazard.

Furthermore, the indirect dose rates must decrease dramatically outside the [redacted] because as distance from the [redacted] increases the proportion increases of scattered photons from the reactor dome that intercept the wall of the containment vessel above the [redacted] The wall of the containment vessel in general is poured concrete with a thickness of [redacted] feet, with an exterior [redacted] For all cases of indirect dose considered here, the effective energy of the scattered photons is less [redacted] MeV, and photons of this energy that are obliquely incident on the containment wall, at the fluence rates considered here, will be attenuated to negligible levels. Based on the geometry used here, at a distance of about [redacted] meters from the truck door, at ground level, all scattered photons from the reactor dome are intercepted at an oblique angle by the wall of the containment vessel. The indirect dose rates at this location therefore would be negligible (i.e., [redacted]).

13.2.5 Mishandling or Malfunction of Fuel

The UMLRR fuel is summarized in Section 4.2.1 of this report. When not in the reactor core, fuel elements are stored in the fuel storage racks located underwater along the reactor pool walls. Each rack is designed to store no more than nine elements and ensures a geometry such that the calculated K_{eff} is less than [redacted] under all conditions of moderation. Fuel elements are always handled one at a time so that they are maintained in a criticality-safe configuration. The irradiated fuel is handled with a specially designed handling tool described in Section 9.2.3 of this report. The tool is designed to latch onto the fuel element end-box handle that is situated above the fuel plates. The positive latching feature is designed to prevent the inadvertent drop of an element during movement. The tool been used since 1974 and no fuel damage has occurred. If damage were to occur, or if it were suspected to have occurred, the element in question would not be utilized until an evaluation was performed. This would probably be done by visual inspection with the element underwater for shielding. Fuel clad damage due to fuel handling that leads to the release of fission products is considered highly unlikely. If such damage were to occur, the damage would most probably be limited to a deep scratch or puncture of a fuel plate. The fission product release much less than that analyzed for the MHA.

The shipment of irradiated fuel from the facility is a rare event and has only been done once due to the HEU to LEU conversion. Due to the relatively low burnup of fuel at the UMLRR, shipments of irradiated fuel are not anticipated during the next 20 year period of the license. However, should the need arise, the irradiated fuel would be loaded into and shipped using a cask approved and licensed U.S. Nuclear Regulatory Commission.

There have been no instances of fuel malfunction at the UMLRR, either with the HEU fuel from 1974 to 2000, or the present LEU fuel. The present fuel has been manufactured under a strict regimen of quality assurance and control. The UMLRR operation does not impose significant thermal stresses on the fuel. There is no mechanism (such as water-logging followed by a pulse) whereby an incipient condition could suddenly worsen. The UMLRR does not operate in a pulse mode and the temperature change of the fuel from cold shutdown to a hot operating condition is typically no more than [redacted] Water quality as described in Section 5.4 is designed to minimize corrosion.

The UMLRR radiation monitoring system described in Section 7.7 and the radiological monitoring program Section 11 of this report is designed to identify a malfunction of fuel producing a release of fission products in its incipient stages. If such should occur, the reactor would be shutdown until the malfunctioning element(s) is identified and isolated.

13.2.6 Experiment Malfunction

Experiments conducted at the UMLRR are subdivided into two general classifications: ex-core and in-core neutron irradiations. The ex-core experiments are those research projects which utilize one of the beamports, thermal column, or fast neutron irradiator. These facilities are decoupled from the reactor so that experiments in these facilities cannot affect either the thermal-hydraulic or the neutronic performance of the reactor. The in-core neutron irradiation experimental facilities include the center flux trap, radiation baskets inside the graphite reflector region, and the pneumatic tube system. These facilities are within the core itself, or in the case of the pneumatic tube, adjacent to the reactor core. The experimental facilities and their utilization program are described in greater detail in Chapter 10 of this report.

Improperly controlled experiments could potentially result in damage to the reactor, unnecessary radiation exposure to the facility staff and members of the general public, and an inadvertent release of radioactivity into the unrestricted environment. Because of this potential, there are strict procedural and Technical Specification requirements addressing the review and approval of an experiment to be placed in the reactor. These requirements are focused on ensuring that experiments remain safe. The requirements are designed to reduce the likelihood of damage to the reactor and the possibility of radioactivity releases or radiation doses which exceed the limits of 10 CFR 20, should some type of malfunction occur.

All experiments must be reviewed by the Reactor Safety Subcommittee (RSSC). The reviews assess such considerations as criticality and/or reactivity, heat generation, off-gassing and/or chemical reactions, and shielding. A favorable RSSC evaluation must conclude that malfunction of an experiment will not lead to direct failure of any reactor component or to the malfunction of other experiments. This review process is of the utmost importance in ensuring the safety of reactor experiments and has been successfully used for forty years at the UMLRR. Therefore, this approach is expected to continue as an effective measure in assuring experiment safety.

The Technical Specifications (TS 3.7) include a number of restrictions and requirements to minimize experiment hazards. Experiments containing fissile material (fueled experiments) are presently not allowed in the UMLRR core and would require a separate analysis and license amendment. The amount of explosive materials which can be irradiated, or which is allowed to generate in any experiment, has been limited to 25 milligrams of TNT-equivalent explosives in order to reduce the likelihood of damage to the reactor or pool should the explosive material detonate. The irradiation container for this material is required to be tested to ensure the no damage to the container would result from detonation of the explosive.

Reactivity limits placed on experiments ensure (1) that the rate of change of any movable experiment be such that, when the experiment is intentionally set in motion, the capacity of the reactivity control system to provide compensation is not exceeded and (2) that the magnitude of the potential reactivity worth of each unsecured experiment be less than the value of reactivity which would cause a violation of a safety limit. Section 13.2.2.1 provides the step reactivity insertion analysis for determining the reactivity limits for UMLRR experiments. A positive reactivity step insertion of 0.6% $\Delta k/k$ with the reactor operating at

REDACTED FOR PUBLIC RELEASE

LSSS values would not result in exceeding the Safety Limit. This value is then used to establish the more restrictive limit of 0.5% Δk/k for the reactivity worth of each secured experiment and for the total reactivity worth of all movable experiments in the reactor. Each movable experiment or movable parts of any individual experiment is limited further to a more restrictive maximum worth of 0.25% Δk/k.

The preceding information serves to demonstrate that the limitations and review process placed on experiments will minimize the possibility and consequences of experiment malfunctions.

13.2.7 Loss of Normal Electrical Power

The UMLRR design makes it fail-safe under the condition where electrical power is lost. Passive safety features exist so that on loss of electricity the reactor will shut down and the reactor building ventilation will be isolated. Specifically, the four reactor control blades are attached to their drives by electromagnets. On loss of power, the magnets de-energize and the blades drop into the core by gravity. The containment building ventilation valves close on loss of offsite power, thereby precluding the release of any radioactive effluent to the environment.

The UMLRR is also designed for the removal of decay heat by natural convection cooling. As shown in the analysis for Loss of Coolant Flow in Section 13.2.3, no forced convection cooling is needed upon scram of the reactor.

The UMLRR is also equipped with an emergency power system as described in Section 8.2 of this report. Its principal purpose is to provide back-up power for the control room instrumentation and for the main exhaust fan to dilute of any potential releases through the stack. In addition, the control room instrumentation is powered by an uninterruptable power supply that bridges the time required for the emergency generator to come on-line. The control blade magnet power supplies are not connected to either emergency power supply. None of the emergency supplies are required for safety purposes due to:

1. The reactor will automatically shut down upon loss of normal electrical power.
2. Visual observation that the reactor control blades are full inserted is sufficient verification that the reactor is shutdown.

3. Information on radioactive effluents is not required once the reactor is shutdown and the building ventilation is isolated.
4. Decay heat insufficient to cause fuel damage. Though not required, any residual heat removal is via natural convection within the reactor pool.
5. Battery-operated lights provide sufficient illumination for safety of personnel.

13.2.8 External Events

The UMLRR is protected from the impact of external events by the containment building, the design of which is given in Chapter 6 of this report. The UMLRR is the only 1MW reactor in the United States having a containment building. To summarize the design, it is a welded steel shell with a flat bottom, cylindrical sides, and a domed top. The flat bottom of the shell is lined with two and [redacted] feet of poured reinforced concrete and the cylindrical walls are lined with [redacted] feet of poured reinforced concrete. Beneath the flat steel bottom, a concrete pad rests on the underlying bedrock. The containment building foundation is firmly keyed to the bedrock. The building inside diameter is [redacted] feet [redacted] [redacted] From the flat steel bottom to the highest point of the domed top the distance is about 95-[redacted] m) of which the lower [redacted] m) are below grade. The shell is constructed of steel plate that is [redacted] mm) thick on the sides and [redacted] inch ([redacted] mm) thick on the dome. The building is designed withstand an internal pressure [redacted] psi above atmospheric pressure and an external pressure differential corresponding to [redacted] The reactor is housed in a pool constructed of reinforced concrete with approximately six-foot thick walls, ¼-in (6.4 mm) aluminum liner containing [redacted] gallons of water.

Meteorological and site characteristics are detailed in Chapter 2. The containment building and reactor pool effectively isolate the reactor from flooding and meteorological disturbances. The containment building and reactor pool also provide effective isolation against seismic events. The reactor protection system is equipped with a seismic sensor that will scram the reactor for seismic event equivalent [redacted] on the Modified Mercali scale. The control blades are positioned in core by shrouds (Chapter 4.2.2). Even when fully withdrawn, a portion of the blade remains in the shroud which positions and guides the blade into the reactor core upon a scram signal and prevents jamming. Even under unlikely severe seismic disturbances that may create a LOCA, the previous analyses in this chapter have

REDACTED FOR PUBLIC RELEASE

shown the reactor decay heat is insufficient to cause fuel damage. Other types of structural or systems damage may or may not occur. However, these also would not result in core damage. Specifically, the location of reactor pool penetrations, the presence of anti-siphon valves in the primary piping, adequate natural convection cooling, and the shutdown of the reactor on loss of electrical power are provisions minimizing effects due to piping damage and electrical supply losses.

The containment building and reactor pool effectively isolate the reactor from both explosions and toxic release. For an explosion to have effect, it would have to penetrate both the containment's steel shell and the two-foot thick concrete wall, propagate across the open space within the containment building, then penetrate the 5.5-foot thick biological shield that is made of high density concrete and the aluminum liner, and then still have sufficient effect to damage aluminum core box and the fuel inside. Protection against an external toxic release would be obtained my manually shutting down the ventilation and sealing the containment building.

13.2.9 Mishandling or Malfunction of Equipment

The reactor operator provides the sole means for start-up of the reactor. Once the reactor is critical, the reactor may be operated in an automatic mode that provides automatic adjustments to compensate for small reactivity changes. In either the automatic or manual mode, the reactor operator is integral to the control of the reactor and can provide a redundant factor for reactor safety by initiating a manual scram if needed. Nonetheless, operator errors are a possibility. Credible operator errors include:

1. Passive inattentiveness leading to power drift when operating in the manual mode.
2. Inadvertent continuous withdrawal of a control element while supercritical.
3. Inadvertent stop of the primary coolant pump while critical in the forced convection mode.

An increasing power drift will eventually lead to a reactor scram from any of the redundant power monitoring channels. Ramp reactivity effects and loss of coolant flow have been shown in the previous sections to have no effect leading to exceeding the safety limit. The redundancy in the reactor protection system prevents the possibility of a single-point human failure leading to an event that could exceed the safety limit. An operational error by the operator or even the loss of the operator would not result in a situation creating an accident beyond those analyzed in this chapter.

The reactor is designed so that instrument or equipment failures generally result in a reactor shutdown. The effects due to malfunction or loss of safety related instruments are presented in Chapter 7. Strict administrative and procedural controls supplement the engineering design to further increase the margins of safety.

13.3 References

[i] U.S. Nuclear Regulatory Commission, NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors; Format and Content," Published February 1996.

[ii] S.C. Hawley, R.L. Kathren, M.A. Robkin, "Analysis of Credible Accidents for Argonaut Reactors," NUREG/CR-2079, April 1981.

[iii] J. R. Lamarsh, "Introduction to Nuclear Engineering," Addison-Wesley, 1975 (p. 534).

[iv] W.L. Woodruff, D.K. Warinner, J.F. Matos, "A Radiological Consequence Analysis with HEU and LEU Fuels", IAEA TEC DOC-643, 1992.

[v] NIST Chemistry WebBook, http://webbook nist.gov

[vi] U.S. Environmental Protection Agency (EPA) Federal Guidance Report (FGR) No. 11, "Limiting Values of Radionuclide Intake and Air Concentration, and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," September 1988.

[vii] Federal Guidance Report (FGR) No. 12, "External Exposure to Radionuclides in Air, Water, and Soil," September 1993.

[viii] "MCNP — A General Monte Carlo N-Particle Transport Code, Version 5," LA-UR-03-1987, April 24, 2003 (Revised 2/1/2008), Los Alamos Laboratory.

[ix] http://www.nndc.bnl.gov/chart/chartNuc.jsp

[x] ANS-6.1.1 Working Group, M. E. Battat (Chairman), "American National Standard Neutron and Gamma-Ray Flux-to-Dose Rate Factors," ANSI/ANS-6.1.1-1977 (N666), American Nuclear Society, LaGrange Park, Illinois (1977).

[xi] S. G. Homann, F. Aluzzi, "HotSpot, Health Physics Codes Version 3.0," LLNL-SM-636474, Lawrence Livermore National Laboratory, NARAC, August 2014.

[xii] U.S. Nuclear Regulatory Commission, Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessment at Nuclear Power Plants," Revision 1, 1982.

[xiii] Wett, J. F., Jr., "Surface Temperature of Irradiated ORR Fuel Elements Cooled in Stagnant Air," USAEC Report ORNL-2892, Oak Ridge National Laboratory, March 23, 1960.

[xiv] Webster, C. C., "Water-Loss Tests in Water-Cooled and Moderated Research Reactors," Nuclear Safety, Vol. 8, No. 6, Nov.-Dec. 1967

[xv] U.S. Nuclear Regulatory Commission. Standards for Protection Against Radiation. Washington, DC: U.S. Government Printing Office; 10 CFR Part 20; 1992.

[xvi] Shultis J. and Faw R. Radiation Shielding. La Grange Park, IL: American Nuclear Society; 2000.

[xvii] University of Massachusetts Lowell Research Reactor. Final Safety Analysis Report (updated). Lowell, MA: UMLRR (NRC-50223); 1985.

Chapter 14

Technical Specifications

TECHNICAL SPECIFICATIONS
FOR THE
UNIVERSITY OF MASSACHUSETTS LOWELL
RESEARCH REACTOR

FACILITY OPERATING LICENSE NO. R-125

REDACTED FOR PUBLIC RELEASE

Contents

REDACTED FOR PUBLIC RELEASE

1. INTRODUCTION

1.1 Scope

This document constitutes the technical specifications for The University of Massachusetts Lowell Research Reactor under facility license No. R-125. The technical specifications include definitions, safety limits, limiting safety system settings, limiting conditions for operation, surveillance requirements, design features, and administrative controls. Also included are the bases for the technical specifications. The bases, which provide the technical support for the individual technical specifications, are for information purposes only. They are not part of the technical specifications, and they do not constitute limitations or requirements to which the licensee must adhere.

1.2 Application

1.2.1 Purpose

The technical specifications represent the agreement between the licensee and the U.S. Nuclear Regulatory Commission (NRC) on administrative controls, operational parameters, and equipment requirements, for safe reactor operation and for dealing with abnormal situations. They are typically derived from the safety analysis report (SAR). These specifications represent a comprehensive envelope for safe operation. The operational parameters and equipment requirements directly related to preserving this safe envelope are included.

1.2.2 Format

The format of this document is in general accordance with ANSI/ANS-15.1-2007.

1.3 Definitions

ADMINISTRATIVE CONTROLS – Those organizational and procedural requirements established by the NRC and/or the facility management.

CHANNEL – A channel is the combination of sensor, line, amplifier, and output devices that are connected for the purpose of measuring the value of a parameter.

CHANNEL CALIBRATION – A channel calibration is an adjustment of the channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures. Calibration shall encompass the entire channel, including equipment actuation, alarm, or trip and shall be deemed to include a channel test.

CHANNEL CHECK – A channel check is a qualitative verification of acceptable performance by observation of channel behavior, or by comparison of the channel with other independent channels or systems measuring the same parameter.

CHANNEL TEST – A channel test is the introduction of a signal into the channel for verification that it is operable.

CONTAINMENT – Containment is an enclosure of the facility designed to (1) be at a negative internal pressure to ensure in-leakage, (2) control the release of effluents to the environment, and (3) mitigate the consequences of certain analyzed accidents or events.

CONTAINMENT INTEGRITY – Integrity of the containment enclosure (reactor building) is said to be maintained when all isolation system equipment is either operable or secured in an isolating position.

CONTROL BLADE – See Rod, Control.

CORE CONFIGURATION – The core configuration includes the number, type, or arrangement of fuel elements, reflector elements, and regulating / control / transient rods occupying the core grid.

EXCESS REACTIVITY – Excess reactivity is that amount of reactivity that would exist if all activity control devices were moved to the maximum reactive condition from the point where the reactor is exactly critical ($k_{eff} = 1$) at reference core conditions or at a specified set of conditions.

EXPERIMENT – Any operation, hardware, or target (excluding devices such as detectors, foils, etc.) that is designed to investigate non-routine reactor characteristics or that is intended for irradiation within the pool, on or in a beamport or irradiation facility. Hardware rigidly secured to a core or shield structure so as to be a part of their design to carry out experiments is not normally considered an experiment.

LICENSE – The written authorization, by the NRC, for an individual or the organization to carry out the duties and responsibilities associated with a personnel position, material, or facility requiring licensing.

LICENSEE – An individual or organization holding a license.

MEASURED VALUE – The measured value is the value of a parameter as it appears on the output for a channel.

MOVABLE EXPERIMENT – A movable experiment is one where it is intended that all or part of the experiment may be moved in or near the core or into and out of the reactor while the reactor is operating.

OPERABLE - Operable means a component or system is capable of performing its intended function.

OPERATING – Operating means a component or system is performing its intended function.

OPERATIONS MODE – Operations mode refers to the method by which the reactor core is cooled, either natural convection mode or forced convection mode of operation.

PROTECTIVE ACTION – Protective action is the initiation of a signal or the operation of equipment within the reactor safety system in response to a parameter or condition of the reactor facility having reached a specific limit.

REACTIVITY WORTH OF AN EXPERIMENT – The reactivity worth of an experiment is the value of the reactivity change that results from the experiment, being inserted into or removed from its intended position.

REACTOR OPERATING – The reactor is operating whenever it is not secured or shut down.

REACTOR OPERATOR – An individual who is licensed by the NRC to manipulate the controls of the reactor.

REACTOR SAFETY SYSTEM – Reactor safety systems are those systems, including their associated input channels, that are designed to initiate automatic reactor protection or to provide information for initiation of manual protective action. The reactor safety system is also referred to as the reactor protection system.

REACTOR SECURED – The reactor is secured when:

(1) *Either* there is insufficient moderator available in the reactor to attain criticality or there is insufficient fissile material present in the reactor to attain criticality under optimum available conditions of moderation and reflection;

(2) *Or* the following conditions exist:

(a) The minimum number of neutron absorbing control devices are fully inserted or other safety devices are in shutdown position, as required by technical specifications;
(b) The console key switch is in the off position and the key is removed from the lock;
(c) No work is in progress involving core fuel, core structure, installed control rods, or control rod drives unless they are physically decoupled from the control rods;
(d) No experiments are being moved or serviced that have, on movement, a reactivity worth exceeding the maximum value allowed for a single experiment, or one dollar, whichever is smaller.

REACTOR SHUTDOWN – The reactor is shut down if it is subcritical by at least one dollar ($0.78\%\Delta k/k$) in the reference core condition with the reactivity worth of all installed experiments included.

REFERENCE CORE CONDITION – The condition of the core when it is at ambient temperature (cold) and the reactivity worth of xenon is negligible (<0.2% Δk/k).

RESEARCH REACTOR – The term research reactor as used in these Technical Specifications refers to the University of Massachusetts Lowell Research Reactor which is licensed by the U.S. Nuclear Regulatory Commission under license No. R-125. It is designed to support a self-sustaining neutron chain reaction for research, developmental, educational, training, and experimental purposes.

RESEARCH REACTOR FACILITY – Includes all areas within which the owner or operator directs authorized activities associated with the reactor. For the UMLRR, the research reactor facility equates to the area within the reactor building.

ROD, CONTROL – A control rod is a device fabricated from neutron-absorbing material or fuel, or both, that is used to establish neutron flux changes and to compensate for routine reactivity losses. A control rod can be coupled to its drive unit allowing it to perform a safety function when the coupling is disengaged.

ROD, REGULATING – The regulating rod is a low worth control rod, used primarily to maintain an intended power level, that need not have scram capability and may have a fueled follower. Its position may be varied manually or by a servo-controller.

SCRAM TIME – Scram time is the elapsed time between the initiation of a scram signal and a specified movement of a control or safety device.

SECURED EXPERIMENT – A secured experiment is any experiment, experimental apparatus, or component of an experiment that is held in a stationary position relative to the reactor by mechanical means. The restraining forces must be substantially greater than those to which the experiment might be subjected by hydraulic, pneumatic, buoyant, or other forces that are normal to the operating environment of the experiment, or by forces that can arise as a result of credible malfunctions.

SENIOR REACTOR OPERATOR – An individual who is licensed to direct the activities of reactor operators. Such an individual is also a reactor operator.

SHALL, SHOULD, AND MAY – The word "shall" is used to denote a requirement; the word "should" is used to denote a recommendation; and the word "may" is used to denote permission, neither a requirement nor a recommendation .

SHUTDOWN MARGIN – Shutdown margin is the minimum shutdown reactivity necessary to provide confidence that the reactor can be made subcritical by means of control and safety systems starting from any permissible operating condition and with the most reactive rod in the most reactive position, and the non-scramable rods in their most reactive positions and that the reactor will remain subcritical without further operation action.

SITE – The UMLRR site includes the reactor containment building and the attached academic building ([redacted] Hall).

SURVEILLANCE TIME INTERVALS – The maximum allowable intervals listed as follows are to provide operational flexibility only. Established frequencies shall be maintained over the long term. Any extension of these intervals shall be occasional and for a valid reason.

- 5 Year (interval not to exceed 6 years)
- Biennial (interval not to exceed 30 months)
- Annual (interval not to exceed 15 months)
- Semiannual (interval not to exceed 7-1/2 months)
- Quarterly (interval not to exceed 4 months)
- Monthly (interval not to exceed 6 weeks)
- Weekly (interval not to exceed 10 days)
- Daily (shall be done during the same working day)

TRUE VALUE – The true value is the actual value of a parameter.

UNSCHEDULED SHUTDOWN – An unscheduled shutdown is defined as any unplanned shutdown of the reactor caused by actuation of the reactor safety system, operator error, equipment malfunction, or a manual shutdown in response to conditions that could adversely affect safe operation, not including shutdowns that occur during testing or checkout operations.

End Definitions

2.0 SAFETY LIMIT AND LIMITING SAFETY SYSTEM SETTINGS

2.1 SAFETY LIMIT

Applicability:
This specification applies to the onset of nucleate boiling (ONB) at the hot spot in the hot channel of the reactor fuel, in either forced or natural convection mode of operation.

Objective:
The objective is to ensure that the integrity of the fuel cladding is maintained.

Specification:
The reactor fuel clad temperature shall be less than 118°C (244°F).

Bases:
The melting temperature of aluminum is 660°C (1220°F). Fuel damage occurs with blister formation. The blister threshold temperature for both uranium silicide and uranium aluminide fuel is above 500°C (932°F) (NUREG-1313). Establishing a maximum fuel clad temperature below 118°C (the minimum temperature for the onset of nucleate boiling – ONB), provides nearly a 400°C temperature margin before fuel blistering occurs. There is no possibility for clad or fuel damage at the Safety Limit.

2.2 LIMITING SAFETY SYSTEM SETTINGS

2.2.1 Forced Convection Mode

Applicability
This specification applies to the setpoints for the safety channels monitoring reactor thermal power, coolant flow rate, reactor coolant inlet temperature, and the height of water above the center line of the core under the condition of the forced convection mode of operation.

Objective
To ensure that automatic protective action is initiated in order to prevent the Safety Limit from being exceeded.

Specifications

(1) The Limited Safety System Setting for the reactor power level shall initiate automatic protective action at or below a measured value of 1.15 MW_t.

(2) The Limited Safety System Setting for the primary coolant flow shall initiate automatic protective action at or above a measured value of 1400 GPM.

(3) The Limited Safety System Setting for the primary coolant inlet temperature shall initiate automatic protective action at or below a measured temperature of 108 ^{o}F.

(4) The Limited Safety System Setting for pool height above the core centerline shall initiate automatic protective action at or above a measured value of 24.25 ft.

Bases
These Limiting Safety System Settings (LSSS) represent values of the interrelated variables which, if reached, shall result in an automatic protective action that will prevent the Safety Limit from being exceeded during the course of the most adverse anticipated transient. The values in this specification take into account the uncertainty in the measurement. To determine the LSSS values for this specification, steady-state and various transient conditions were analyzed, including: step reactivity addition, ramp reactivity insertion, loss of forced convection flow, and cold water insertion. Of the transient conditions analyzed, the step-reactivity addition is the most limiting condition. Using the values of the variables given above, without the uncertainty correction, and using a step-reactivity value greater than the maximum reactivity value for a single secured experiment given in Specification 3.7.1, the step-reactivity transient will not lead to ONB before the reactor protective system begins to shut down the transient (SAR 13.2.2).

2.2.2 Natural Convection Mode

Applicability
This specification applies to the setpoints for the safety channels monitoring reactor thermal power, reactor pool temperature, and the height of water above the center line of the core under the condition of the natural convection mode of operation.

Objective
To ensure that automatic protective action is initiated in order to prevent undesirable radiation levels on the surface of the pool.

Specification

(1) The Limited Safety System Setting for the reactor power level shall initiate automatic protective action at or below a measured value of 115 kW_t.

(2) The Limited Safety System Setting for the pool temperature shall initiate automatic protective action at or below a measured temperature of 108 ^{o}F.

(3) The Limited Safety System Setting for pool height above the core centerline shall initiate automatic protective action at or above a measured value of 24.25 ft.

Bases

These Limiting Safety System Settings (LSSS) represent values of the interrelated variables which, if exceeded, shall result in automatic protective actions that will prevent undesirable radiation levels on the surface of the pool due to the production and escape of ^{16}N during natural convection mode of operation. The specifications given above also ensure an adequate safety margin exists between the LSSS and the SL for natural convection. The value for the power LSSS would be much higher (248 kW, SAR Chapter4.5) if the specifications were based on the Safety Limit rather than on ^{16}N production. The ^{16}N criterion is not related to ONB which was the criterion used in establishing the Safety Limit.

End Section 2.

3.0 LIMITING CONDITIONS FOR OPERATION

3.1 REACTOR CORE PARAMETERS

3.1.1 Reactivity

Applicability
These specifications apply to the reactivity condition of the reactor and the reactivity worths of control rods, regulating rod, and experiments.

Objective
To ensure that the reactor can be safely shutdown and maintained in a safe shutdown condition at all times and that the Safety Limit will not be exceeded.

Specification
The reactor shall not be operated unless the following conditions exist:

(1) The reactor core is loaded so that the excess reactivity in the cold clean (xenon free) critical condition shall be <4.7% Δk/k.

(2) The minimum shutdown margin relative to the cold, clean (xenon free) critical condition, with the most reactive control rod in the fully withdrawn position, shall be >2.7% Δk/k.

(3) All core grid positions are filled with fuel elements, irradiation baskets, source holders, regulating rod, graphite reflector elements or grid plugs.

(4) All but 5 of the peripheral radiation baskets must contain flow restricting devices. This specification will not apply for low power operation <10 kW without forced flow.

(5) The reactivity coefficients (fuel temperature, moderator temperature, and void) shall be negative over the normal operating moderator temperature range of 20 °C to 42 °C (68 °F – 108°F).

Bases
The maximum allowed excess reactivity of provides sufficient reactivity to accommodate fuel burnup, xenon and samarium poisoning buildup, experiments, and control requirements, but gives a sufficient shutdown margin even with the highest worth rod fully withdrawn. The minimum shutdown margin ensures that the reactor can be shut down from any operating condition and will remain shutdown after cooldown and xenon decay, even if the highest worth control rod should be in the fully withdrawn position. The requirement that all grid plate positions be filled and the restriction on radiation baskets during reactor operation ensures that the quantity of primary coolant which bypasses the heat producing elements will be kept within the limits used in establishing the Safety Limit in

Chapter 13 of the SAR. This requirement does not apply under natural circulation conditions at power levels less than 10kW. The requirements for negative coefficients of reactivity ensure that any temperature rise or void caused by a reactor transient will not cause a further increase in reactivity.

3.1.2 Maximum Power Level

Applicability:
This specification applies to the reactor thermal power level.

Objective:
To ensure that the safety limit is not exceeded.

Specification:
The reactor shall not be continuously operated at a power level exceeding $1MW_t$.

Basis:
Thermal hydraulic calculations presented in Chapter 13 of the SAR demonstrate that the fuel may be safely operated at power levels up to 1.25 MW. The LSSS specification in 2.2.1.1 takes into account the reactor power measurement uncertainty. Automatic protective action would be initiated at or below that value. Momentary drifts of power level beyond $1MW_t$ would be corrected by the reactor operator.

3.2 REACTOR CONTROL AND SAFETY SYSTEMS

3.2.1 Control Blade Scram Time

Applicability
This specification applies to the elapsed time from the initiation of a scram signal to when the control rod is considered fully inserted.

Objective:
To ensure that the reactor can be shutdown within the specified period of time.

Specification
The time from initiation of a scram signal and movement of each control blade from the fully withdrawn position to 80% of the fully inserted position shall be less than one second.

Bases
The UMLRR is equipped with four control blades and one regulating rod. The control blades are connected to their drives by electromagnets and hence drop by gravity into the core upon initiation of a scram signal. The last few inches of travel are dampened to prevent damage to the control blade due to its momentum. Analyses in Chapter 13 of the SAR show that for the most limiting transient, the

peak clad temperature is well below the ONB point during the 1.0 second scram time interval. The analyses also assume only 3 of the 4 control blades are scrammed.

3.2.2 Maximum Reactivity Insertion Rate and Regulating Rod Worth

Applicability:
This specification applies to the maximum positive reactivity insertion rate by the most reactive control rod and the regulating rod simultaneously.

Objective:
To ensure that the reactor is operated safely and the safety limit is not exceeded during any credible ramp reactivity insertion.

Specification:

(1) The maximum reactivity insertion rate by the most reactive control rod and the regulating rod simultaneously shall not exceed 0.05% $\Delta k/k$ per second.

(2) The total reactivity worth of the regulating rod shall be < 0.5% $\Delta k/k$.

Basis:
The maximum reactivity insertion rate limit ensures that the safety limit will not be exceeded as a result of a continuous linear reactivity insertion. Analyses in Chapter 13.2 of the SAR show that the peak clad temperature would be well below the ONB point even under the conservative assumption that the reactor is operating at the LSSS values for power and temperature when the ramp begins and using a reactivity addition rate greater than that allowed by the specification. An analysis of a step insertion >0.5% $\Delta k/k$ also is given in Chapter 13.2 of the SAR. The analysis shows the step-reactivity transient will not lead to ONB before the reactor protective system begins to shut down the transient. Limiting the reactivity worth of the regulating rod to this value ensures that any failure of the automatic servo control system could not result in the Safety Limit being exceeded.

3.2.3 Reactor Protection System Scram Channels

Applicability
This specification applies to the reactor protection system channels.

Objective
To stipulate the minimum number of reactor protection system channels that shall be operable to ensure that the safety limit is not exceeded.

REDACTED FOR PUBLIC RELEASE

Specification

The reactor shall not be operated unless the reactor protection system channels described in the following table are operable:

		Forced Convection Mode		Natural Convection Mode	
	Channel	Function	Minimum Required	Function	Minimum Required
1.	**Reactor Period**	Scram at ≤ 3 second period	1	Scram at ≤ 3 second period	1
2.	**Reactor Power Level**	Scram at ≥ 115 MW	2	Scram at ≥115kW	2
3.	**Primary Coolant Flow Rate**	Scram at ≤1400 GPM	1	n/a	n/a
4.	**Pool Water Level**	Scram at ≤ 24.25 ft above core centerline	1	Scram at ≤ 24.25 ft above core centerline	1
5.	**Pool Inlet Temperature**	Scram ≥ 108^{o}F	1	n/a	n/a
6.	**Pool Temperature**	Scram ≥ 108^{o}F	1	Scram ≥ 108^{o}F	1
7.	**Detector High Voltage (each period and power channel)**	Scram ≤ 500 V	1	Scram ≤ 500 V	1
8.	**Seismic Disturbance**	Scram at Modified Mercali Scale IV	1	Scram at Modified Mercali Scale IV	1
9.	**Bridge Movement**	Scram if moved > 1 inch	1	Scram if moved > 1 inch	1
10.	**Manual Scram Button**	Scram if depressed	1	Scram if depressed	1
11.	**Reactor On Key Switch**	Scram at off position	1	Scram at off position	1
12.	**Drives Controls Display Watch Dog Timer**	Scram for communication loss >1 second	1	Scram for communication loss >1 second	1
13.	**Process Controls Display Watch Dog Timer**	Scram for communication loss >1 second	1	Scram for communication loss >1 second	1

Bases

The automatic protective action initiated by the reactor period channel, the reactor power level channels, the flow rate channel, the pool water level channel, the pool inlet temperature channel, and the pool temperature channel all provide redundant protection to ensure that the Safety Limit is not exceeded. Automatic protection action initiated by a detector high voltage failure, a seismic event, or the reactor bridge misalignment ensures a reactor shutdown occurs for potential instrumentation problems or unsafe conditions. The manual scram button and the "Reactor On" key switch provide two manual scram methods to shutdown the reactor if the operator determines an unsafe condition has occurred or could occur.

3.2.4 Radiological Protection Scrams

Applicability
This specification applies to reactor scrams associated with radiological protection.

Objective
Radiological protection scrams are incorporated in the scram circuit to protect personnel, the public, and the environment from possible radiation exposure.

Specification
The reactor shall not be operated unless the following radiological protection scrams described in the following table are operable.

	Channel	Function	Minimum Required
1.	Area Radiation Monitoring System	Scram on High Radiation Levels	1
2.	Thermal Column Door Open	Scram if door limit switch open	1
3.	Beamport Chamber Door Open	Scram if door limit switch open	1
4.	First Floor Airlock Integrity	Scram if both doors unsealed	1
5.	Third Floor Airlock Integrity	Scram if both doors unsealed	[redacted]
[redacted]	[redacted]	[redacted]	1

Bases
The radiological protection scrams minimize the possibility of exceeding 10 CFR Part 20 limits for radiation exposure.

3.2.5 Minimum Channels Needed for Reactor Operation

Applicability
This specification applies to channels in the reactor protection and control systems.

Objective
To stipulate the minimum number of channels that shall be operable to ensure that the reactor operator has sufficient information for safe operation of the reactor.

Specification
The reactor shall not be operated unless the channels in the following table are operable.

	Channel	Operations Mode	Minimum Required
1.	Start-up Count Rate	Both	1
2.	Reactor Period	Both	1
3.	Reactor Power Level	Both	2
4.	Primary Coolant Flow Rate	Forced	1
5.	Pool Water Level	Both	1
6.	Pool Inlet Temperature	Forced	1
7.	Pool Temperature	Both	1

Bases
The channels listed in the above table ensure that measurements of the reactor power level and the process variables are adequately displayed during reactor startup and during low-power natural convection and high-power forced convection modes of operation.

3.2.6 Reactor Control System Interlocks

Applicability
This specification applies to the reactor control system.

Objective
To stipulate the minimum number of interlocks is provided to inhibit control rod withdrawal if the limiting conditions in Specifications 3.2.3, 3.2.4, and 3.2.5 are not met.

Specification
The following interlocks to prevent rod withdrawal shall be operable:

1) Scram circuit not reset.

2) Start-up neutron count rate is $\leq$ 2 counts per second via proportional counter or $\leq$ 10 counts per second via wide range log-power module.

3) The reactor period <15 seconds.

Bases
The requirement for the scram circuit to be reset ensures that facility conditions are normal and radiological hazards are minimized. The inhibit function for startup neutron count rate ensures the required startup neutron source is sufficient and in a proper location for reactor startup, such that a minimum source multiplication count rate level is being detected. The inhibit function for the reactor period channel limits the rate of power increase when withdrawing a control rod and $K_{eff}>1$.

REDACTED FOR PUBLIC RELEASE

3.3 REACTOR COOLANT SYSTEMS

Applicability
This specification applies to the reactor primary coolant system water requirements.

Objective
The objectives are to minimize corrosion and to monitor the integrity of the fuel cladding and the cobalt-60 sources.

Specification

(1) The conductivity of the pool water shall be <10 μmho/cm.

(2) The pH of the pool water shall be between 5.0 and 8.0.

(3) The pool water shall be analyzed for gross activity and for cobalt-60. Analysis shall be capable of detecting levels of 10^{-7} μCi per milliliter. If a sample analysis reveals a significant increase of activity in the water, with respect to the previous samples, or a contamination level greater than 10^{-6} μCi of cobalt-60 per milliliter of water, prompt action shall be taken to prevent further contamination of the pool water. If the gross activity of the sample is less than 10^{-7} μCi per milliliter, specific analysis for cobalt-60 need not be performed. If remedial action is required by this section, notification will be made to the USNRC as required by Section 6.6.2.

Bases
Pool water of high purity minimizes the rate of corrosion. The purpose of pH monitoring is to ensure that corrosion of the fuel, core components, and the primary coolant loop structure is maintained within an acceptable limit. The fuel cladding, core structure, pool liner, and primary piping are all made of aluminum alloy. A portion of the primary coolant loop is constructed of stainless steel. Lower pH will reduce aluminum alloy corrosion and oxide formation. Higher pH is favored to control stainless steel corrosion. Thus, a pH range between 5 and 8 is selected for the primary coolant. Electrical conductivity is also monitored to control purity of the primary coolant. A limit of 10 μmho/cm is adopted from historic experience. Since 1974, the conductivity typically has been below 5 μmho/cm. No corrosion issues have ever been identified with either the fuel or the core structural materials. Conductivity may occasionally and briefly approach the higher limit immediately following regeneration of the water purification system. Radionuclide analysis of the pool water allows for early determination of any significant buildup of radioactivity from operation of the reactor or the cobalt-60 source.

3.4 CONTAINMENT

Applicability
This specification applies to the operation of the reactor containment building isolation system and the emergency exhaust system.

Objective
To ensure that the containment and emergency exhaust system is in operation to mitigate the consequences of possible release of radioactive materials.

Specification
Containment integrity shall be maintained for any of the following conditions:

(1) The reactor is not shutdown.

(2) Movement of irradiated fuel is being performed, except when the fuel is in a properly sealed and approved shipping container.

(3) The reactor shall not be operated unless the following equipment is operable and conditions met:

	Equipment	Function
1.	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Bases
In the unlikely event of a release of fission products, or other airborne radioactivity, the containment isolation initiation system will secure the normal ventilation exhaust fan, will bypass the normal ventilation supply up the stack, and will close the normal inlet and exhaust valves. In containment, the emergency exhaust system will tend to maintain a negative building pressure with a combination of controls intended to prevent unloading any large fraction of airborne activity if the internal building pressure is high. The emergency exhaust purges the building air through charcoal and absolute filters and controls the discharge, which is diluted by supply air, through a 100 foot stack on site. Chapter 6 of the SAR describes the system's sequence of operation. Chapter 13 provides the analysis for the maximum hypothetical accident (MHA).

REDACTED FOR PUBLIC RELEASE

3.5 VENTILATION SYSTEM

Applicability:
This specification applies to the ventilation system that exhausts building air to the outside environment.

Objective:
To provide for normal ventilation and the reduction of airborne radioactivity within the reactor building during normal reactor operation and to provide a way to turn off the main ventilation exhaust fan quickly in order to isolate the building for emergencies.

Specification:

(1) The main intake shall be operable whenever the reactor is operating.

(2) The main exhaust fan automatic and manual isolation controls shall be operable whenever the reactor is operating.

(3) The reactor may be operated with the main exhaust fan inoperable provided documented verbal concurrence from the Radiation Safety Officer is made.

Bases:
In the unlikely event of a release of fission products or other airborne radioactivity, the ventilation system will reduce radioactivity inside the reactor building or be able to be isolated. The allowance to operate the reactor without the main exhaust fan operating is dependent on the build-up of the argon-41 concentration in the building. The Radiation Safety Officer will make the determination as to the allowable concentration.

3.6 RADIATION MONITORING SYSTEMS AND EFFLUENTS

3.6.1 Radiation Monitoring

Applicability
This specification applies to the availability of radiation monitoring equipment which must be operable during reactor operation.

Objective
To ensure that radiation monitoring equipment is available for evaluation of radiation conditions in restricted and unrestricted areas.

Specification

(1) When the reactor is operating, the following minimum radiation monitors shall be operable with readouts in the control room:

(a) A stack effluent radiation monitor.

(b) A constant air monitor, located on the reactor pool level.

(c) An area radiation monitor on the reactor experimental level.

(d) An area radiation monitor over the reactor pool.

(2) The reactor shall be shut down within 15 minutes upon recognition that any of Specifications (a) through (d) is unmet, unless a portable instrument having an alarm feature capable of warning personnel of a high radiation level is substituted and readings are physically checked and recorded every 15 minutes.

(3) The facility wide radiation warning alarms shall be operable to ensure that proper emergency action is taken. The public address system may serve as a temporary substitute for the facility wide radiation alarms.

Bases
The radiation monitoring system is described in Section 7.7 of the SAR. Specification 1 provides the minimum equipment for evaluating the radiation levels within the stack effluent and within the reactor building. Specification 2 provides a reasonable time period to take corrective action after a failure of the minimum equipment is recognized. Specification 3 provides for the facility wide annunciation of elevated radiation conditions. The public address system used by the reactor operator serves as a reasonable temporary substitute for the alarms if needed.

3.6.2 Effluents

Applicability:
This specification applies to the monitoring and control of radioactive effluents from the facility.

Objectives:
To ensure that releases of liquid and airborne effluents are within 10 CFR Part 20 limits.

Specification:

(1) The concentration of radioactive liquids released into the sanitary sewer shall not exceed the limits specified in 10 CFR Part 20.

(2) The concentration of argon-41 at ground level below the point of release into the unrestricted area shall not exceed the unrestricted area effluent concentration limit in 10 CFR Part 20 for argon-41 when averaged over 1 year or 10 times the effluent concentration limit when averaged over 1 day.

(3) The concentration of argon-41 in the restricted area shall not exceed the 10 CFR Part 20 DAC for argon-41 when averaged over a 2000-hour work year.

Bases:
For specification 1, Chapter 11 of the SAR evaluates liquid releases into the sanitary sewer system. For specifications 2 & 3, Chapter 11 of the SAR evaluates the release of argon-41 in the restricted and unrestricted areas.

3.7 EXPERIMENTS

Applicability
This specification applies to experiments to be installed in the reactor and associated experimental facilities.

Objective
To prevent damage to the reactor or excessive release of radioactive materials in the event of an experiment failure.

3.7.1 Reactivity Limits

Specification

(1) The reactivity worth of experiments shall not exceed the values indicated in the following table:

Type	Single Experiment Worth	Total Worth
Movable (including pneumatic rabbit)	0.25% Δk/k	0.5% Δk/k
Secured	0.5% Δk/k	2.5% Δk/k

(2) The total reactivity worth of all experiments shall not be greater than 2.5%Δk/k.

Bases
Specification (1) ensures that the failure of a single experiment will not result in exceeding the Safety Limit. The analysis of a step insertion >0.5%Δ k/k is given in Chapter 13 of the SAR. The analysis shows the step-reactivity transient will not lead to ONB before the reactor protective system begins to shut down the transient. The total reactivity of 2.5% in Specification (2) places a reasonable upper limit on the worth of all experiments which is compatible with the allowable excess reactivity and the shutdown margin and is consistent with the functional mission of the reactor.

3.7.2 Design and Materials

Specification
The reactor shall not be operated unless the following conditions governing experiments exist:

(1) Experimental apparatus, material or equipment to be irradiated in the reactor shall not cause shadowing of the nuclear instrumentation, interference with control rods, or other perturbations which may interfere with the safe operation of the reactor.

(2) The reactor shall not be operated whenever the reactor core is in the same end of the reactor pool as any portion of the cobalt-60 source.

(3) All materials to be irradiated shall be either corrosion resistant or encapsulated within corrosion resistant containers to prevent interaction with reactor components or pool water. Corrosive materials shall be doubly encapsulated.

(4) Explosive material such as (but not limited to) gunpowder, dynamite, TNT, nitroglycerine, or PETN in quantities <25 mg may be irradiated in the reactor or experimental facilities provided out core tests indicate that, with the containment provided, no damage to the explosive containers, the reactor or the reactor components or the Co-60 Source shall occur upon detonation of the explosive.

Bases
Specification 1 and 2 minimize physical or nuclear interferences, either instrumental or procedural, between the reactor and the cobalt-60 source during reactor operation. Specifications 3 and 4 are intended to reduce the likelihood of damage to reactor components and/or radioactivity releases resulting from experiment failure. The Administrative Controls of Section 6 of these Technical Specifications also ensure the Reactor Safety Subcommittee reviews and evaluates all new experiments to determine the effects on the reactor and personnel safety.

REDACTED FOR PUBLIC RELEASE

4.0 SURVEILLANCE REQUIREMENTS

4.1 REACTOR CORE PARAMETERS

4.1.1 Excess Reactivity and Shutdown Margin

Applicability:
This specification applies to surveillance requirements for determining the reactor core excess reactivity and shutdown margin.

Objective:
To ensure that the excess reactivity and shutdown margin limits of the reactor are not exceeded.

Specification:
Excess reactivity and shutdown margin and shall be determined annually and prior to the routine operation of any new fuel configuration in the reactor core.

Bases:
A determination of excess reactivity is needed to preclude operating without adequate shutdown margin. Configuration changes to the reference core described in Chapter 13 are governed by administrative controls to ensure configurations are maintained within the envelope of conditions used to establish the Safety Limit.

4.1.2 Fuel Elements

Applicability
This specification applies to the surveillance requirements for the reactor fuel.

Objective
To detect if there is any deterioration, corrosion, or other physical changes to the fuel elements that could lead to loss of cladding integrity.

Specification
Visual inspection of one-fifth of the in-core reactor fuel elements shall be performed every two years.

Bases
Fuel inspections at the UMLRR since 1974 have revealed no negative fuel conditions. The specification of quantity and frequency is considered adequate based upon MTR fuel history.

4.2 REACTOR CONTROL AND SAFETY SYSTEMS

4.2.1 Control Rods

Applicability
This specification applies to the surveillance requirements for the control and regulating rods.

Objective
To ensure the operability of the control and regulating rods.

Specification

(1) The reactivity worth of the regulating rod and each control rod shall be determined annually.

(2) The reactivity worth of all rods shall also be determined prior to routine operation of any new fuel configuration in the reactor core.

(3) Control rod drop and drive times and regulating rod drive time shall be determined annually, or if maintenance or modification is performed on the mechanism.

(4) The control and regulating rods shall be visually inspected annually.

Bases
The reactivity worth of the control and regulating rods is measured to ensure that the required shutdown margin is available, and to provide a means for determining the reactivity worths of experiments inserted in the core. Annual measurement of reactivity worths provides a correction for the slight variations expected because of burnup, and the required measurement after any new arrangement of fuel in the core ensures that possibly altered rod worths will be known before routine operation. The visual inspection of the regulating and control rods and the measurements of drive and drop times are made to ensure that the rods are capable of operating properly and within the considerations used in transient analyses in Chapter 13 of the SAR. Verification of operability after maintenance or modification of the control system will ensure proper reinstallation or reconnection.

4.2.2 Reactor Safety System

Applicability
This specification applies to the surveillance requirements for the Reactor Safety System.

Objective
To ensure that the Reactor Safety System channels will remain operable and will prevent the Safety Limit from being exceeded.

Specification

(1) A channel check of each channel listed in Specification 3.2.5, specific to the operating mode, shall be performed daily when the reactor is in operation.

(2) A channel test of each channel listed in Specification 3.2.5, specific to the operating mode, shall be performed prior to each day's operation, or prior to each operation extending more than one day.

(3) A channel calibration of the reactor power level channels (Linear and Log-N) shall be made annually.

(4) Thermal power level shall be verified annually.

(5) A channel calibration of the following channels shall be made annually:
a. Pool water temperature
b. Primary coolant flow rate
c. Pool water level
d. Primary coolant inlet and outlet temperature

(6) The manual scram shall be verified to be operable prior to each day's operation.

(7) Manual scrams outside of the control room, all other limit switches in the scram chain including those listed in Specification 3.2.4, and the controls displays watch dog timers shall be verified operable annually.

(8) The radiation monitoring system scram shall be verified operable annually.

(9) The interlocks listed in Specification 3.2.6 shall be verified operable annually.

(10) Any reactor protection system channel replaced or repaired shall be calibrated and undergo a channel test after installation and prior to reactor operation.

Bases
The daily channel tests and checks and periodic verifications will ensure that channels used to measure the process variables are operable. Annual calibrations

REDACTED FOR PUBLIC RELEASE

will ensure that any long term drift of the process measuring channels is corrected. Appropriate annual tests of other channels in the scram chain and control system interlocks will ensure that those functions not tested before daily operation are operable.

4.3 COOLANT SYSTEMS

Applicability
This specification applies to the surveillance requirement of monitoring the quality and the radioactivity in the pool water.

Objective
To ensure high quality pool water and to monitor the radioactivity in the pool water in order to verify the integrity of the fuel cladding and cobalt-60 sources.
Specification

(1) The conductivity of the pool water shall be measured quarterly.

(2) The pH of the pool water shall be measured quarterly.

(3) The radioactivity in the pool water shall be analyzed monthly.

Bases
Surveillance of water conductivity ensures that changes that could accelerate corrosion have not occurred. The pH and conductivity reading are administratively recorded as part of the reactor checkout procedure. Monthly radionuclide analysis of the pool water samples will allow early determination of any significant buildup of radioactivity from operation of the reactor or the cobalt-60 sources.

4.4 CONTAINMENT

Applicability
This specification applies to the surveillance requirements for the containment building.

Objective
To ensure that the containment system is operable.

Specification

(1) Building pressure will be verified prior to reactor operation and at least every eight hours during reactor operation to ensure that it is less than ambient atmospheric pressure.

REDACTED FOR PUBLIC RELEASE

(2) The containment building isolation system including the initiating system shall be tested annually. The test shall verify that valve closure is achieved in <2.5 seconds after the initial signal.

(3) Any additions or modifications to the containment building or its penetrations shall be tested to verify containment building integrity by performing an integrated leakage rate test of the containment building.

Bases
Maintaining a negative pressure ensures that any leakage into the containment building is inward. The valve closure time was chosen to be ½ the time required for a given sample of air to travel from the first to the second valve in series in the exhaust line under regular flow conditions. Based upon 40 years of data, annually provides a reasonable frequency of testing. The containment building was designed to withstand a 2.0 psig internal pressure (SAR Chapter 6). Given there is no credible accident (SAR Chapter 13) that would result in an overpressure of the building concurrent with a fission product release, performing an integrated leak rate test on a regular basis is unnecessary. In addition, the data for previous integrated leak tests performed over the past 40 years have shown the containment building integrity has always met the criteria specified in Chapter 6 of the SAR.

4.5 VENTILATION SYSTEMS

Applicability
This specification applies to the surveillance requirements for the containment building ventilation system.

Objective
To ensure that the ventilation operates as described in Chapter 6 of the SAR.

Specifications

(1) The emergency exhaust system including the initiating system shall be verified annually to be operable.

(2) The filter trains in the emergency exhaust, facilities exhaust, and pneumatic sample exhaust shall be replaced or tested biennially to verify that they are operable.

(3) The air flow rate in the stack exhaust duct shall be measured biennially.

Bases
Surveillance of the emergency exhaust system and the periodic testing or replacement of various filters will verify that these are functioning as described in Chapter 6 of the SAR. Experience over 40 years has shown that a biennial

REDACTED FOR PUBLIC RELEASE

measurement of exhaust ventilation flow rate is sufficient to detect trends.

4.6 RADIATION MONITORING EQUIPMENT

Applicability
This specification applies to the surveillance requirements for the area radiation monitoring equipment and systems for monitoring airborne radioactivity.

Objective
To ensure that the equipment used for monitoring radiation and radioactivity is operable and measuring accurately.

Specification

(1) A channel test of the radiation monitoring channels in Specification 3.6.1.1 shall be made prior to each day's operation.

(2) The radiation monitoring channels in the radiation monitoring system shall be calibrated and the trip setpoints verified when initially installed and annually thereafter.

Bases
The channel tests verify the channel operability by the introduction of a test signal. The calibration provides a complete verification of the performance of the channel. The radiation monitoring system is described in Chapter 7 of the SAR. The large number of detectors in the area radiation monitoring system ensures that if a particular monitor should malfunction or drift out of calibration, sufficient backup monitors are available for reliable information. Calibration of the area radiation monitors annually is based upon manufacturer recommendations and is sufficient to ensure the required reliability.

End Section 4

5.0 DESIGN FEATURES

5.1 SITE AND FACILITY DESCRIPTION

The reactor is housed in the reactor building, designed for containment, at 1 University Avenue, Lowell, Massachusetts, located on the north campus of the University of Massachusetts at Lowell. The reactor building is the restricted area as defined in 10 CFR Part 20. The reactor building has a minimum free volume of 335,000 ft^3 that is exhausted through a 100 ft. high stack.

5.2 REACTOR COOLANT SYSTEM

The reactor coolant system consists of an open pool containing approximately 75,000 gallons of demineralized water (H_2O), a single cooling loop containing a heat exchanger, a circulation pump, and various valves. All materials associated with the reactor coolant system are aluminum alloys, except for the stainless steel heat exchanger, and small non-corrosive components such as gaskets, filters, and valve diaphragms.

5.3 REACTOR CORE AND FUEL

5.3.1. The reactor core consists of a [redacted] array of [redacted]-inch square modules with the four corners occupied by posts. The reference core for these Technical Specifications is described in Chapter 4 of the SAR. It consists of 19 standard fuel elements and two half-elements and the central location filled with a flux trap element, as shown in Figure 4.2 of the SAR.

5.3.2. Cores from [redacted] elements to [redacted] elements may be used, consisting of the any combination of fuel elements as described in specifications 5.3.3, 5.3.4, and 5.3.5.

5.3.3 A standard fuel element shall be either:

a. A flat plate MTR-type element having plates fueled with low enrichment (<20% U-235) U_3Si_2, clad with aluminum. There shall be 18 plates per element with 16 plates containing fuel and two outside plates of aluminum. There shall be [redacted] ± 2 grams of Uranium-235 per element when new, or

b. A flat plate MTR-type element having plates fueled with low enrichment (<[redacted] U-235) UAl_x, clad with aluminum. There shall be 18 plates per element. There shall be [redacted] ± 2 grams of Uranium-235 per element when new.

5.3.4 A partial fuel element shall be the same as Specification 5.3.3.a except each plate has approximately [redacted].

5.3.5 A removable plate fuel element shall be the same as Specification 5.3.3.b, except the fuel plates are removable.

5.4 FISSIONABLE MATERIAL STORAGE

Fuel elements may be stored in any of the following locations:

(1) Un-irradiated fuel may be stored in licensed shipping containers within the restricted area.

(2) In the fuel storage racks located inside the reactor pool.

(3) In licensed shipping containers located in the restricted area or an area designated as a controlled area.

(4) In the reactor core provided the reactivity is below the shutdown margin given by Specification 3.1.2.

6.0 ADMINISTRATIVE CONTROLS

6.1 ORGANIZATION

6.1.1 Structure

The University of Massachusetts Lowell Research Reactor (UMLRR) is an integral part of the Radiation Laboratory of the University of Massachusetts Lowell (UML). The organization for the management and operation of the reactor is shown in Figure 6-1.

6.1.2 Responsibility

1. The Reactor Supervisor (Level 2) is directly responsible for the safe operation of the reactor.

2. In all matters pertaining to safe operation of the reactor and to these Technical Specifications, the Reactor Supervisor shall report to and be directly responsible to the Director of the Radiation Laboratory (Level 1).

3. The UML Radiation Safety Officer shall be responsible for radiation protection at the UMLRR and shall advise the Reactor Supervisor on all matters pertaining to radiation protection.

4. The UML Radiation Safety Officer shall report to and be directly responsible to the Director of UML Environmental and Emergency Management.

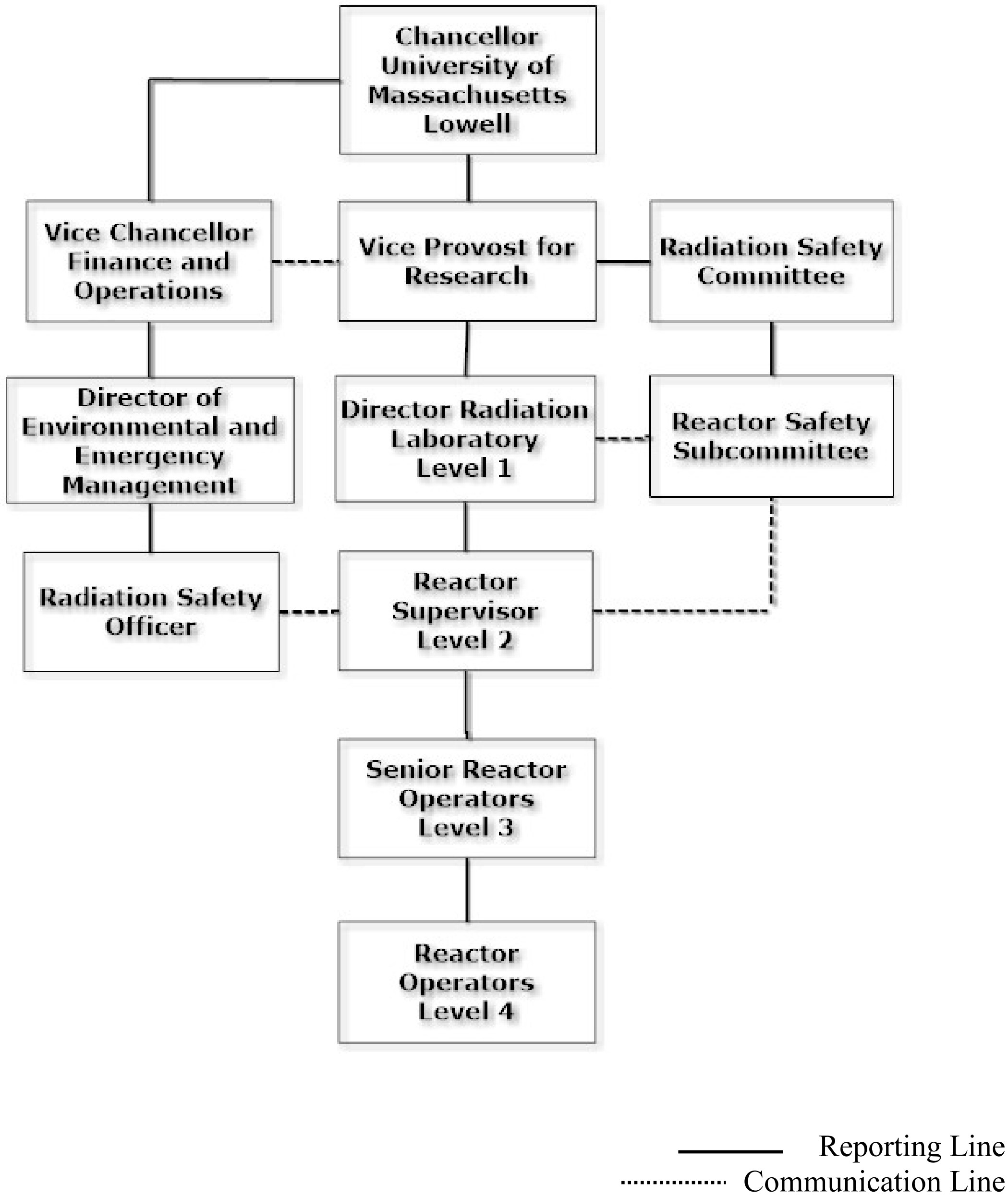

Chancellor University of Massachusetts Lowell
Vice Chancellor Finance and Operations
Vice Provost for Research
Radiation Safety Committee
Director of Environmental and Emergency Management
Director Radiation Laboratory Level 1
Reactor Safety Subcommittee
Radiation Safety Officer
Reactor Supervisor Level 2
Senior Reactor Operators Level 3
Reactor Operators Level 4
Reporting Line
Communication Line

Figure 6-1

6.1.3 Staffing

1. The following shall be the minimum staffing when the reactor is not secured:

   a. A reactor operator or senior reactor operator shall be in the control room.

   b. A second designated person shall be present at the site. This individual shall be a senior reactor operator, reactor operator or an individual able to carry out prescribed written instructions. Unexpected absence for as long as 2 hours to accommodate a personal emergency may be acceptable provided immediate action is taken to obtain a replacement.

   c. If a senior reactor operator is not on site, a senior reactor operator shall be readily available on call. "Readily available on call" means an individual who:

      1. has been specifically designated and the designation known to the operator on duty,
      2. keeps the operator on duty informed of where he/she may be rapidly contacted and the phone number, and
      3. is capable of getting to the reactor facility within a reasonable time under normal conditions (e.g., 30 minutes or within a 15-mile radius).

2. The following events require the presence of a senior reactor operator at the site:

   a. Initial startup and approach to power for each day's operation.

   b. All fuel or control-rod relocations within the reactor core region.

   c. Recovery from an unplanned or unscheduled shutdown for which documented verbal concurrence from a senior reactor operator shall be made.

6.1.4 Selection and Training of Personnel

1. The Director of the Radiation Laboratory shall be a member of the graduate faculty in a science or engineering discipline.

2. The selection, training, and requalification of operations personnel shall meet or exceed the requirements (most current revision) of American National Standard, ANSI/ANS-15.4 "Selection and Training of Personnel for Research Reactors."

6.2 REVIEW AND AUDIT

There shall be a Reactor Safety Subcommittee (RSSC) which shall review reactor operations to ensure that the facility is operated in a manner consistent with public safety and within the terms of the facility license. The RSSC shall be a subcommittee of the University Radiation Safety Committee which has overall authority in the use of all radiation sources at the University.

6.2.1 Composition and Qualifications

The RSSC shall be composed of at least five members, one of whom shall be the Radiation Safety Officer and another of whom shall be the Reactor Supervisor. Members of the RSSC shall be knowledgeable in the areas of reactor operation and radiation safety. The membership of the RSSC shall include at least two faculty members from the engineering or science disciplines. Members shall be appointed by the university Vice Provost for Research or Chancellor. The RSSC chairman shall be elected from among the membership and shall not have line responsibility for operation of the reactor.

6.2.2 Charter and Rules

The RSSC shall follow the rules specific to it under the charter and rules of the Radiation Safety Committee. Notwithstanding that charter and rules, the RSSC functions shall be conducted as follows:

1. Meetings shall be held at least once per calendar year and more frequently as circumstances warrant, consistent with effective monitoring of facility activities.

2. A meeting quorum shall consist of at least one-half of the membership where the reactor staff does not constitute a majority.

3. The RSSC may appoint a subgroup from within its membership to act on behalf of the full committee on those matters that cannot await the next meeting. The RSSC shall review the actions taken by the subcommittee at the next regular meeting.

4. Meeting minutes shall be distributed to RSSC members in a timely manner for review and approval at the next meeting.

6.2.3 Review Function

1. The RSSC shall review the following:

   a. Determination that proposed changes in equipment, systems, tests, experiments, or procedures do not require a license update, as described in 10 CFR 50.59.

b. All new procedures and major revisions thereto having safety significance and proposed changes in reactor facility equipment or systems having safety significance.

c. All new experiments or classes of experiments that could affect reactivity or result in the release of radioactivity.

d. Proposed changes in technical specifications or license.

e. Violations of technical specifications or license and violations of internal procedures having safety significance.

f. Operating abnormalities having safety significance.

g. Reportable occurrences listed in Section 6.6.2 of this document.

h. Audit reports.

2. A written report or minutes of the findings and recommendations of the RSSC shall be submitted to the Director of the Radiation Laboratory and to the RSSC members in a timely manner after a review has been completed.

6.2.4 Audit Function

1. The RSSC audit function may be performed by a member of the RSSC who does not have line responsibility for the reactor or by a consultant who is knowledgeable of reactor operations and radiation safety.

2. Audits shall be performed biennially.

3. The scope of the audit shall include, as a minimum, the following:

   a. Facility operations for conformance to the technical specifications and license conditions.
   b. The requalification program for the operating staff.
   c. The results of action taken to correct those deficiencies that may occur in the reactor facility equipment, systems, structures, or methods of operation that affect reactor safety.
   d. The reactor facility emergency plan and implementing procedures.

4. Deficiencies uncovered that affect reactor safety shall immediately be

REDACTED FOR PUBLIC RELEASE

reported to the Director of the Radiation Laboratory. A written report of the findings of the audit shall be submitted to the Director of the Radiation Laboratory and to all RSSC members within three months after the audit has been completed.

6.3 RADIATION SAFETY

1. The Radiation Protection Program shall be designed to achieve the requirements of 10 CFR 20 and shall generally conform to the guidelines in (most current revision) American National Standard, ANSI/ANS-15.11 "Radiation Protection at Research Reactor Facilities."

2. The Radiation Protection Program shall be the responsibility of the Radiation Safety Officer, having line authority as indicated in Figure 6-1.

6.4 OPERATING PROCEDURES

1 Written procedures, reviewed and approved by the Reactor Supervisor or designee, and the RSSC shall be in effect and followed for the following items. The procedures shall be adequate to ensure the safe operation of the reactor, but should not preclude the use of independent judgment and action should the situation require such.

   a. startup, operation, and shutdown of the reactor;
   b. fuel loading, unloading, and movement within the reactor;
   c. maintenance of major components of systems that could have an effect on reactor safety;
   d. surveillance checks, calibrations, and inspections required by the technical specifications or those that may have an effect on reactor safety;
   e. administrative controls for operations and maintenance and for the conduct of irradiations and experiments that could affect reactor safety or core reactivity;
   f. [redacted]
   g. use, receipt, and transfer of byproduct material, if appropriate.

2 Substantive changes to procedures shall be made with the approval of the Reactor Supervisor or designee, and the RSSC. Minor changes to procedures that do not change the original intent may be made by a senior reactor operator, but the change must be approved by the Reactor Supervisor or designee. Temporary deviations from procedures may be made by a senior reactor operator in order to deal with special or unusual circumstances or conditions. Such deviations shall be documented and reported within 24 hours or the next working day to the Reactor Supervisor or designee.

3 Written procedures for personnel radiation protection shall be reviewed and approved in accordance with the Radiation Protection Program (Specification 6.3). The procedures shall be consistent with the applicable regulations or guidelines. The radiation protection program and procedures shall include management commitment to maintain exposures and releases as low as reasonably achievable.

6.5 EXPERIMENTS REVIEW AND APPROVAL

1. An experiment using the reactor shall not be conducted until a favorable evaluation indicated in writing is rendered by the RSSC. All proposed experiments using the reactor shall be documented and included a description and a safety evaluation prepared by either the experimenter or individual(s) appointed by the Reactor Supervisor. The evaluation shall include:

   a. An estimated reactivity worth of the experiment;
   b. The integrity of the experiment, including the effect of changes in temperature, pressure, chemical composition, or radiolytic decomposition;
   c. Any physical or chemical interaction that could occur with the reactor components;
   d. Any radiation hazard that may result from the activation of materials or from external beams; and
   e. An estimate of the amount of radioactive materials produced.

2. Prior to performing any new reactor experiment, an evaluation of the experiment shall be made by the RSSC and shall consider:

   a. The purpose of the experiment;
   b. The effect of the experiment on reactor operation and the possibility and consequences of failure of some aspect of the experiment, including, where significant, chemical reactions, physical integrity, design life, proper cooling interaction with core components, and reactivity effects;
   c. Whether or not the experiment, by virtue of its nature and/or design, includes an un-reviewed safety question or constitutes a significant threat to the integrity of the core, the integrity of the reactor, or to the safety of personnel; and
   d. A procedure for the performance of the experiment.

3. An experiment that has had prior RSSC approval and has been performed safely shall be a routine experiment and requires only the approval of the Reactor Supervisor (or designee) and the Radiation Safety Officer (or designee) to be repeated. An experiment that represents a minor variation from a routine experiment, not involving safety considerations of a different kind, shall be considered the equivalent of a routine experiment and may be approved by agreement of the Reactor Supervisor (or designee) and the Radiation Safety Officer (or designee).

6.6 REQUIRED ACTIONS

6.6.1 Action To Be Taken In The Event The Safety Limit Is Exceeded

1. The reactor shall be shut down and reactor operation shall not be resumed until authorization is obtained from the NRC.

2. The safety limit violation shall be promptly reported to the Reactor Supervisor or his designee, the Director of the Radiation Laboratory, and the Chairman of the RSSC.

3. The safety limit violation shall be reported by telephone to the NRC within 24 hours.

4. A safety limit violation report shall be prepared. The report shall describe the following:

    a. The time and date of the violation, reactor status at the time of the violation, and a description of the violation.
    b. The applicable circumstances leading to the violation including, when known, the cause and contributing factors.
    c. The effect of the violation upon reactor facility components, systems, or structures and on the health and safety of personnel and the public.
    d. Corrective action to be taken to prevent recurrence.

5. The report shall be reviewed by the RSSC and shall be submitted to the NRC within 14 working days, and any follow-up report shall be submitted to the NRC when authorization is sought to resume operation of the reactor.

6.6.2 Action To Be Taken in the Event of a Reportable Occurrence

1. A reportable occurrence is any of the following conditions:

    a. Release of radioactivity from the reactor containment building above allowed limits.
    b. Operating with any safety system setting less conservative than those stated in Section 2.2 these specifications.
    c. Operating in violation of a limiting condition for operation established in Section 3.0 of these specifications unless prompt remedial action is taken as specified in Section 3.
    d. A safety system component malfunction during reactor operation that renders or could render the safety system incapable of performing its intended function.
    e. An uncontrolled or unanticipated increase in reactivity in

excess of 0.78%Δk/k (one dollar).

f. An abnormal and significant degradation in reactor fuel and/or cladding, coolant boundary, or containment boundary (excluding minor leaks).

g. An observed inadequacy in the implementation of either administrative or procedural controls, such that the inadequacy could have caused the existence or development of an unsafe condition in connection with the operation of the reactor.

2. In the event of a reportable occurrence, the following four actions shall be taken:

   a. The reactor conditions shall be returned to normal, or the reactor shall be shutdown, to correct the occurrence.
   b. The Reactor Supervisor shall be notified as soon as possible and corrective action shall be taken before resuming the operation involved.
   c. The Nuclear Regulatory Commission shall be notified.
   d. A report shall be prepared that includes the time and date of the occurrence, reactor status at the time of the occurrence, a description of the occurrence, an evaluation of the cause of the occurrence, a record of the corrective action taken, and recommendations for appropriate action to prevent or reduce the probability of recurrence. This report shall be submitted to the U. S. Nuclear Regulatory Commission and it will be reviewed by the RSSC no later than its next regularly scheduled meeting.

6.7 REPORTS

6.7.1 Operating Reports

An annual or operating report shall be submitted to the U.S. Nuclear Regulatory Commission within ninety days following the 30th of June of each year. Its content shall include:

1. A narrative summary of reactor operating experience including a tabulation showing the energy generated by the reactor (in megawatt days), the number of hours the reactor was critical, and the cumulative total energy output since initial criticality.
2. The number of emergency shutdowns and inadvertent scrams, including the reasons therefore, and where applicable, corrective actions to preclude recurrence.
3. Tabulation of major preventive and corrective maintenance operations having safety significance.
4. A summary of the safety analyses performed in connection with

changes to the facility or procedures, which affect reactor safety, and performance of tests or experiments carried out under the requirements of 10 CFR 50.59.

5. A summary of the nature and amount of radioactive effluents released or discharged to environs beyond the effective control of the owner or operator, or both, as determined at, or before, the point of such release or discharge. If the estimated average release after dilution or diffusion is <25% of the concentration allowed or recommended, a statement to this effect is sufficient.
6. A summarized result of environmental surveys performed outside the facility.
7. A summary of exposures received by facility personnel and visitors where such exposures are <25% of that allowed or recommended.

6.7.2 Special Reports

1. A report shall be made by telephone or other communication systems to the U.S. Nuclear Regulatory Commission Headquarters Operations Center within 24 hours of:

   a. Operation in violation of a safety limit.
   b. Any release of radioactivity to unrestricted areas above permissible limits, whether or not the release resulted in property damage, personal injury, or exposure.
   c. Any reportable occurrence as defined in Specification 6.6.2.

2. A written report shall be provided as a follow-up to the verbal one within 14 days of the occurrence. This report shall provide the information required by Specification 6.6.2(2). The report shall be submitted to the NRC Document Control Desk.

3. A written report shall be submitted within 30 days to the NRC Document Control Desk in the event of:

   a. A permanent change in the personnel serving as the Director of the Radiation Laboratory or Reactor Supervisor.
   b. Any significant change in the transient or accident analyses as described in the SAR.

6.8 RECORDS

6.8.1 Five-Year Record Retention

The following records shall be retained for five years or for the life of the component involved if less than five years:

1. Records of normal reactor operation including power levels and periods of operation at each power level. (Note: Excludes retention of supporting documents such as checklists, log sheets, etc., which shall be retained for a period of at least one year.)

2. Records of principal maintenance activities including inspection, repair, substitution, or replacement of principal items of equipment pertaining to nuclear safety.

3. Records of reportable occurrences.

4. Records of surveillance activities that are required by these technical specifications.

5. Records of reactor facility radiation and contamination surveys.

6. Records of experiments performed with the reactor.

7. Records of fuel inventories, receipt, and shipments.

8. Records of changes made in the operating procedures.

9. Minutes of the RSSC and audit reports including both internal audits and those performed for or by the RSSC.

6.8.2 Six-Year Record Retention
Records of individual licensed staff members indicating qualifications, experience, training, and requalification shall be retained at all times that the individual is employed or until the operator license is renewed.

6.8.3 Records To Be Retained for the Life of the Facility

1. Gaseous and liquid radioactive effluents released to the environs.

2. Off-site environmental-monitoring surveys required by the technical specifications.

3. Radiation exposure for all personnel monitored.

4. Drawings of the reactor facility.

5. Applicable annual reports, if they contain all of the required information, may be used as records in this section.

End Section 6

Table of Contents

Tables of Figures

15 Financial Qualifications

15.1 Summary

The University of Massachusetts Lowell (UML) is financially qualified to own, operate, and decommission the University of Massachusetts Lowell Research Reactor (UMLRR). Neither UML nor the UMLRR is owned, controlled, or dominated by an alien, a foreign corporation, or foreign government. None of the provisions of 10 CFR 50.33(d) apply. The UMLRR is an existing facility, therefore the issue of construction does not apply.

15.2 Fuel Cycle Costs

As indicated in Chapter 1 of this report, The Nuclear Waste Policy Act of 1982, Section 302(b)(1)(B) states that the Nuclear Regulatory Commission (NRC) may require, as a precondition to renewing an operating license for a research reactor under Section 104 of the Atomic Energy Act of 1954, as amended (the Act), that the applicant shall have [redacted] for the disposal of high-level radioactive wastes and spent nuclear fuel. The [redacted] has informed the NRC that universities and other government agencies operating non-power reactors have entered into contracts with the [redacted] which state that the [redacted] retains title to the fuel and is obligated to take the spent fuel for storage or reprocessing. The UML has established such a contract with the [redacted] (Standard Research Subcontract No. 00078293 Reactor Fuel Assistance and Fuel Elements). Subsequently, the applicable requirements of the Nuclear Waste Policy Act of 1982 are satisfied.

15.3 Financial Ability to Operate a Non-Power Reactor

Table 15-1 lists actual operating expenses and revenues for fiscal year 2015. The five year projections for fiscal years 2016-20 include a three percent adjustment for each year. Expenses are broken down by category of spending and include salaries, wages, supplies and equipment, and travel. There are two categories of salaries, each dependent on a different source of funds. University funded salaries are part of the UML operating budget. Grants and contract salaries are funded by federal grants and facility users, including commercial users. The university salaries figure does not include fringe benefits. The grants and contracts salaries include fringe and overhead costs. Student wages, supplies and equipment, and travel costs also include overhead costs.

Certain services are not included in expenses. Specifically, the UML Facilities Department provides cleaning, building maintenance, and all utilities costs. The UML Environmental and Emergency Management Department provides health physics and industrial hygiene coverage as part of overall university health and safety programs. Another category of expense that is not included in the figures shown in Table 15-1 is administrative expenses. Salaries for the Radiation Laboratory Director and university administration officials are under the university operating budget.

Revenues are derived from three sources. The university operating budget provides funding for the salaries and fringe benefits for three full-time staff. User costs for use of the reactor and gamma facilities provide the remainder of the revenues. The costs associated with these facilities are calculated based upon a cost-recovery basis plus overhead. The overhead rate varies depending on the type of user. Users include internal university, external government, and commercial. The funds derived from these users provide for additional full and part-time staff, student staff wages, supplies and equipment, and travel. While the annual revenue derived from users can vary, the university operating budget provides a fixed source of revenue for the staff and services indicated above. Should there be no revenue from users, the university operating budget provides for the minimum staffing and capital equipment costs to maintain safe operation of the facility. The 2014 Annual Financial Report for the University of Massachusetts is appended to this Chapter.

15.4 Financial Ability to Decommission the Facility

The University of Massachusetts Lowell is a state government entity. Documentation to this effect is appended to this Chapter. A statement of intent (SOI) in conformance with 10 CFR 50.75(e)(2)(iv) shall serve as the mechanism that provides reasonable assurance that funds will be available to decommission the UMLRR when necessary. The SOI assures that the University of Massachusetts Lowell will request an appropriation of funds for decommissioning sufficiently in advance of decommissioning to prevent delay of required activities. A copy of the SOI is appended to this chapter. As required by 10 CFR 50.75(e)(2)(iv), a 2015 cost estimate for decommissioning the UMLRR has been developed by a decommissioning service contractor. This estimate was in part derived using NUREG/CR-1756, Technology, Safety and Costs of Decommissioning Reference Research and Test Reactors and is appended to this chapter. The estimate in 2015 dollars is approximately $4.7 million, including contingency. A simple calculation of the estimated future cost based upon a reasonable inflation factor (3%) compounded to the end of the 20 year license results in an estimated cost of approximately $8.5M.

REDACTED FOR PUBLIC RELEASE

Table 15-1 Reactor Operating Expenses and Revenue – Five Year Forecast

EXPENSES	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020
Salaries (1)	315	324	334	344	355	365
Salaries (2)	429	442	455	469	483	497
Student Wages (2)	149	153	158	163	168	173
Supplies&Equipment	106	109	112	116	119	123
Travel/Conf	9	9	10	10	10	10
Miscellaneous	8	8	8	9	9	9
TOTAL	1016	1046	1078	1110	1144	1178
REVENUE						
University	315	324	334	344	355	365
Gamma	603	621	640	659	679	699
Reactor	98	101	104	107	110	114
TOTAL	1016	1046	1078	1110	1144	1178

(1) University Funded (does not include fringe or overhead)

(2) Grants and Contracts Funded (with fringe and overhead)

15.5 Chapter 15 Appendix

The following documents are included in this appendix:

1. 2014 Annual Financial Report for the University of Massachusetts
2. State Entity Documentation
    a. Charter Establishing University System
    b. Massachusetts General Law Establishing the University of Massachusetts
    c. US Department of Treasury Form 6166 - Tax Status
3. Signature Authority - Vice Chancellor for Administration and Finance
    a. Board of Trustees Procurement Policy
    b. Board of Trustees Management of University Funds Policy
    c. Board of Trustees Delegation of Authority Policy
    d. University of Massachusetts Lowell Signature Authority
4. Statement of Intent
5. Decommissioning Cost Estimate

2014

Annual Financial Report

UMASS

The University *of* Massachusetts

Amherst • Boston • Dartmouth • Lowell • Worcester • UMassOnline

REDACTED FOR PUBLIC RELEASE

University Administration

As of November 2014

University of Massachusetts
AMHERST • BOSTON • DARTMOUTH • LOWELL • WORCESTER • UMASSONLINE

Office of the President

December 18, 2014

To the Board of Trustees
and President Robert L. Caret

We are pleased to submit the annual Financial Report of the University of Massachusetts for the year ended June 30, 2014. The enclosed financial statements incorporate all financial activity of the University and its five campuses. This statement has been audited by an independent auditing firm and is fully represented in the financial report of the Commonwealth of Massachusetts. Detailed information about each campus is provided as supplemental information.

The financial information presented in the Financial Report is designed to aid a wide variety of readers to assess the effectiveness of the University's management of its resources in meeting its primary mission of instruction, research, and public service. This report is intended to form a comprehensive and permanent record of the finances of the University of Massachusetts, and it is submitted as the public accounting of the University's financial affairs for the fiscal year ended June 30, 2014 including comparative information as of June 30, 2013.

The University's net assets increased $203.9 million from $2.61 billion in fiscal year 2013 to $2.82 billion in fiscal year 2014. The major components of the increase are due to physical plant improvements and positive operating results due primarily to greater student fee revenues associated with increased enrollment, cost reductions, and strong market performance for the University's investments.

Each year, the Board of Trustees approves five-year targets for five key financial indicators that are likely to determine the success of the University over the long term. Those key indicators are operating margin, financial cushion, return on net assets, debt service to operations, and endowment per student. During 2014, the University met or exceeded its targets for all five indicators. Overall, the University made important progress in fiscal 2014 toward the achievement of its long-term financial objectives of growth and stability.

Respectfully submitted,

Christine M. Wilda
Senior Vice President for Administration and
Finance & Treasurer

Sarah B. Mongeau
University Controller

225 Franklin Street | 12th Floor | Boston, MA 02110 | P: (617) 287-7000 | F: (617) 287-7044
www massachusetts.edu

REDACTED FOR PUBLIC RELEASE

University of Massachusetts
2014 Annual Financial Report
Table of Contents

REDACTED FOR PUBLIC RELEASE

Grant Thornton

Grant Thornton LLP
75 State Street, 13th Floor
Boston, MA 02109-1827
T 617.723.7900
F 617.723 3640
www.GrantThornton.com

REPORT OF INDEPENDENT CERTIFIED PUBLIC ACCOUNTANTS

Board of Trustees of the
University of Massachusetts

Report on the financial statements

We have audited the accompanying financial statements of the business-type activities and the aggregate discretely presented component units, of the University of Massachusetts (the "University"), an enterprise fund of the Commonwealth of Massachusetts, as of and for the years ended June 30, 2014 and 2013, and the related notes to the financial statements, which collectively comprise the University's basic consolidated financial statements as listed in the table of contents.

Management's responsibility for the financial statements

Management is responsible for the preparation and fair presentation of these consolidated financial statements in accordance with accounting principles generally accepted in the United States of America; this includes the design, implementation, and maintenance of internal control relevant to the preparation and fair presentation of financial statements that are free from material misstatement, whether due to fraud or error.

Auditor's responsibility

Our responsibility is to express opinions on these consolidated financial statements based on our audits. We conducted our audits in accordance with auditing standards generally accepted in the United States of America and the standards applicable to financial audits contained in *Government Auditing Standards* issued by the Comptroller General of the United States. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the consolidated financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the University's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the University's internal control. Accordingly, we express no such opinion. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of significant accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

REDACTED FOR PUBLIC RELEASE

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinions.

Opinions

In our opinion, the basic consolidated financial statements referred to above present fairly, in all material respects, the respective financial position of the business-type activities and the aggregate discretely presented component units of the University of Massachusetts as of June 30, 2014 and 2013, and the respective changes in financial position and cash flows thereof for the years then ended in accordance with accounting principles generally accepted in the United States of America.

Other matters

Required supplementary information

Accounting principles generally accepted in the United States of America require that the Management's Discussion and Analysis ("MD&A) be presented to supplement the basic financial statements. Such information, although not a required part of the basic financial statements, is required by the Governmental Accounting Standards Board who considers it to be an essential part of financial reporting for placing the basic financial statements in an appropriate operational, economic, or historical context. This required supplementary information is the responsibility of management. We have applied certain limited procedures to the required supplementary information in accordance with auditing standards generally accepted in the United States of America. These limited procedures consisted of inquiries of management about the methods of preparing the information and comparing the information for consistency with management's responses to our inquiries, the basic consolidated financial statements, and other knowledge we obtained during our audit of the basic consolidated financial statements. We do not express an opinion or provide any assurance on the MD&A information because the limited procedures do not provide us with sufficient evidence to express an opinion or provide any assurance.

Grant Thornton LLP

Boston, Massachusetts
December 18, 2014

University of Massachusetts
Management's Discussion and Analysis (unaudited)
June 30, 2014

Introduction

This unaudited section of the University of Massachusetts (the "University") Annual Financial Report presents our discussion and analysis of the financial position and performance of the University and its component units during the fiscal year ended June 30, 2014 with comparative information as of June 30, 2013. This discussion and analysis has been prepared by management along with the accompanying financial statements and related footnote disclosures and should be read in conjunction with, and is qualified in its entirety by, the financial statements and footnotes. The accompanying financial statements, footnotes and this discussion are the responsibility of management.

The University of Massachusetts is a state coeducational institution for higher education with separate campuses at Amherst, Boston, Dartmouth, Lowell and Worcester all located in the Commonwealth of Massachusetts (the "Commonwealth"). The University was established in 1863 in Amherst, under the provisions of the 1862 Morrill Land Grant Acts, as the Massachusetts Agricultural College. It became known as the Massachusetts State College in 1932 and in 1947 became the University of Massachusetts. The Boston campus was opened in 1965 and the Worcester campus, Medical School, was opened in 1970. The Lowell and Dartmouth campuses (previously the University of Lowell and Southeastern Massachusetts University, respectively) were made a part of the University by a legislative act of the Commonwealth, effective September 1, 1991.

The University's mission is to provide an affordable and accessible education of high quality and to conduct programs of research and public service that advance knowledge and improve the lives of the people of the Commonwealth, the nation and the world. In the fall of 2013, the University enrolled 61,336 full-time equivalent ("FTE") students. The University is committed to providing, without discrimination, diverse program offerings to meet the needs of the whole of the state's population. The University's five campuses are geographically dispersed throughout Massachusetts and possess unique and complementary missions.

Financial Highlights

The University's combined net position increased $203.9 million from $2.61 billion in fiscal year 2013 to $2.82 billion in fiscal year 2014. The major components of the increase in fiscal year 2014 relate to investments in infrastructure and greater student fee revenues. From fiscal year 2013 to fiscal year 2014, the University's operating revenue increased by $56.5 million and operating expenditures increased by $146.1 million. The increase in operating revenue is primarily due to the increase in fee and auxiliary revenue associated with the enrollment increases and fee increases in categories other than in state undergraduates and auxiliary revenue to support related expenditures.

Using the Annual Financial Report

One of the most important questions asked about University finances is whether the University as a whole is better off or worse off as a result of the year's activities. The key to understanding this question lies within the Statement of Net Position, Statement of Revenues, Expenses and Changes in Position and the Statement of Cash Flows. These statements present financial information in a form similar to that used by private sector companies. The University's net position (the difference between assets and liabilities) is one indicator of the University's financial health. Over time, increases or decreases in net position is one indicator of the improvement or erosion of an institution's financial health when considered with non-financial facts such as enrollment levels, operating expenses, and the condition of the facilities.

The Statement of Net Position includes all assets, liabilities, as well as deferred inflows and outflows of resources of the University. It is prepared under the accrual basis of accounting, whereby revenues and assets are recognized when the services are provided and expenses and liabilities are recognized when services are incurred, regardless of when cash is exchanged. Net Position is further broken down into three categories: invested in capital assets-net of related debt, restricted and unrestricted. Amounts reported in invested in capital assets-net of related debt represent the historical cost of property and equipment, reduced by the balance of related debt outstanding and depreciation expense charged over the years. Net Position is reported as restricted when constraints are imposed by third parties, such as donors or enabling legislation. Restricted net position is either non-expendable, as in the case of endowment gifts to be held in perpetuity, or expendable, as in the case of funds to be spent on scholarships and research. All other assets are unrestricted; however, they may be committed for use under contract or designation by the Board of Trustees.

The Statement of Revenues, Expenses and Changes in Net Position presents the revenues earned or received and expenses incurred during the year. Activities are reported as either operating or non-operating. Operating revenues and expenses include tuition and fees, grant and contract activity, auxiliary enterprises and activity for the general operations of the institution not including appropriations from state and federal sources. Non-operating revenues and expenses include appropriations, capital grants and contracts, endowment, gifts, investment income, and non-operating federal grants (Pell Grants). With a public University's dependency on support from the state, Pell grants, and gifts, it is common for institutions to have operating expenses exceed operating revenues. That is because the prescribed financial reporting model classifies state appropriations, Pell grants, and gifts as non-operating revenues. The utilization of long-lived assets, referred to as capital assets, is reflected in the financial statements as depreciation expense, which amortizes the cost of a capital asset over its expected useful life.

Another important factor to consider when evaluating financial viability is the University's ability to meet financial obligations as they mature. The statement of cash flows presents information related to cash inflows and outflows summarized by operating, capital and non-capital, financing and investing activities.

REDACTED FOR PUBLIC RELEASE

The footnotes provide additional information that is essential to understanding the information provided in the external financial statements.

Reporting Entity

The financial statements report information about the University as a whole using accounting methods similar to those used by private-sector companies. The financial statements of the University are separated between University (including its blended component units) and its discretely presented Component Unit activities. The University's discretely presented Component Units (or Related Organizations) are the University of Massachusetts Foundation, Inc., and the University of Massachusetts Dartmouth Foundation, Inc.

Condensed Financial Information

University of Massachusetts
Condensed Statement of Net Position
As of June 30, 2014 and 2013
(in thousands of dollars)

	University June 30, 2014	University June 30, 2013	FY13-14 Change
ASSETS			
Current Assets	$ 592,750	$ 579,824	$ 12,926
Noncurrent Assets			
Investment in Plant Net of Accumulated Depreciation	4,064,786	3,705,517	359,269
All O her Noncurrent Assets	1,543,391	1,403,449	139,942
Total Assets	**6,200,927**	**5,688,790**	**512,137**
DEFERRED OUTFLOWS OF RESOURCES	112,880	114,286	(1,406)
LIABILITIES			
Current Liabilities	674,330	772,922	(98,592)
Noncurrent Liabili ies	2,821,182	2,415,798	405,384
Total Liabilities	**3,495,512**	**3,188,720**	**306,792**
NET POSITION			
Invested in Capital Assets Net of Related Debt	1,800,767	1,682,173	118,594
Restricted			
Nonexpendable	17,387	18,058	(671)
Expendable	174,530	156,469	18,061
Unrestricted	825,611	757,656	67,955
Total Net Position	**$ 2,818,295**	**$ 2,614,356**	**$ 203,939**

University of Massachusetts
Condensed Statement of Net Position for Related Organizations
As of June 30, 2014 and 2013
(in thousands of dollars)

	University Related Organizations June 30, 2014	University Related Organizations June 30, 2013	FY13-14 Change
ASSETS			
Current Assets	$ 1,678	$ 3,830	$ (2,152)
Noncurrent Assets			
Investment in Plant Net of Accumulated Depreciation	8,478	8,619	(141)
All Other Noncurrent Assets	454,646	391,699	62,947
Total Assets	**464,802**	**404,148**	**60,654**
LIABILITIES			
Current Liabilities	15,525	14,604	921
Noncurrent Liabilities	3,483	3,332	151
Total Liabilities	**19,008**	**17,936**	**1,072**
NET POSITION			
Invested in Capital Assets Net of Related Debt	8,477	8,619	(142)
Restricted			
Nonexpendable	309,718	290,858	18,860
Expendable	101,195	74,706	26,489
Unrestricted	26,404	12,029	14,375
Total Net Position	**$ 445,794**	**$ 386,212**	**$ 59,582**

REDACTED FOR PUBLIC RELEASE

At June 30, 2014, total University net position was $2.82 billion, an increase of $203.9 million over the $2.61 billion in net position for fiscal year 2013. The University's largest asset continues to be its net investment in its physical plant of $4.06 billion at June 30, 2014 ($3.71 billion in fiscal year 2013).

University liabilities totaled $3.49 billion at June 30, 2014, an increase of $306.8 million over fiscal year 2013. Long-term liabilities represent 81% of the total liabilities which primarily consist of bonds payable amounting to $2.62 billion at June 30, 2014.

The University's current assets as of June 30, 2014 of $592.8 million were below the current liabilities of $674.3 million, as a result the current ratio was 0.88 dollars in assets to every one dollar in liabilities. June 30, 2013 current assets of $579.9 million were below the current liabilities of $772.9 million, resulting in a current ratio of 0.75.

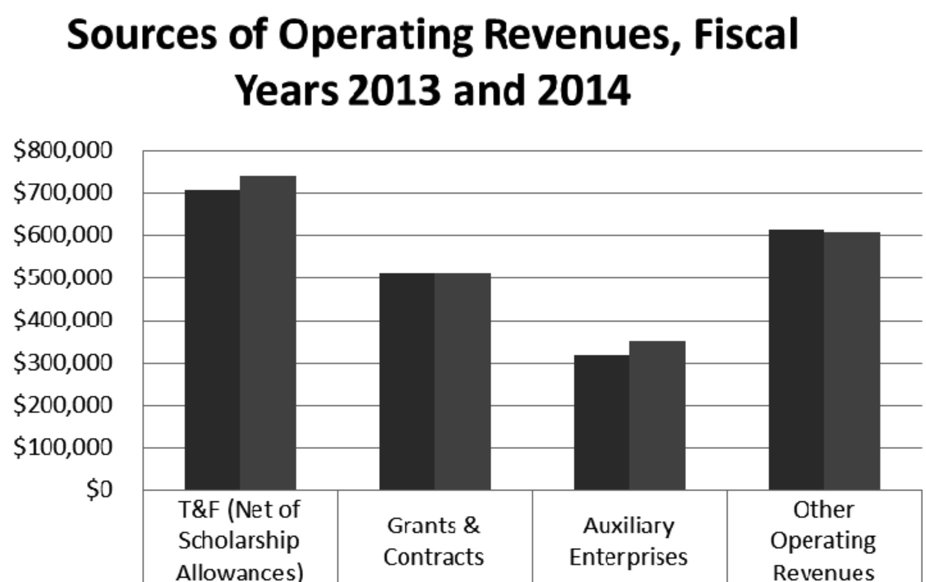
The unrestricted and restricted expendable net position totaled $1.0 billion in fiscal year 2014, which represents 36% of total operating expenditures of $2.81 billion for fiscal year 2014. The unrestricted and restricted expendable net position totaled $914.1 million in fiscal year 2013, which represents 34% of total operating expenditures of $2.66 billion.

University of Massachusetts
Condensed Statement of Revenues, Expenses, and Changes in Net Position
For the Year Ended June 30, 2014 and 2013
(in thousands of dollars)

	University June 30, 2014	University June 30, 2013	FY13-14 Change
Operating Revenues			
Tuition and Fees (net of scholarship allowances)	$ 740,116	$ 707,495	$ 32,621
Grants and Contracts	511,694	512,458	(764)
Auxiliary Enterprises	349,485	319,544	29,941
Other Operating Revenues	607,984	613,257	(5,273)
Total Operating Revenues	**2,209,279**	**2,152,754**	**56,525**
Operating Expenses	**2,809,900**	**2,663,837**	**146,063**
Operating Loss	**(600,621)**	**(511,083)**	**(89,538)**
Nonoperating Revenues / (Expenses)			
Federal Appropriations	7,020	6,774	246
State Appropriations	570,618	519,311	51,307
Interest on Indebtedness	(89,496)	(91,364)	1,868
Other Nonoperating Income	133,386	100,697	32,689
Nonoperating Federal Grants	74,279	70,586	3,693
Net Nonoperating Revenues	**695,807**	**606,004**	**89,803**
Income Before Other Revenues, Expenses, Gaines and Losses	**95,186**	**94,921**	**265**
Capital Appropriations, Grants and Other Sources	134,369	156,442	(22,073)
Disposal of Plant Facilities	(6,198)	(8,802)	2,604
Other Additions / (Deductions)	(19,418)	2,939	(22,357)
Total Other Revenues, Expenses, Gains, and Losses	**108,753**	**150,579**	**(41,826)**
Total Increase in Net Position	**203,939**	**245,500**	**(41,561)**
Net Position			
Net Position at the Beginning of the Year	2,614,356	2,389,377	224,979
*Cummulative effect of change in accounting principle ***		(20,521)	
Net Position at the Beginning of the Year, adjusted		2,368,856	
Net Position at the End of the Year	**$ 2,818,295**	**$ 2,614,356**	**$ 183,418**

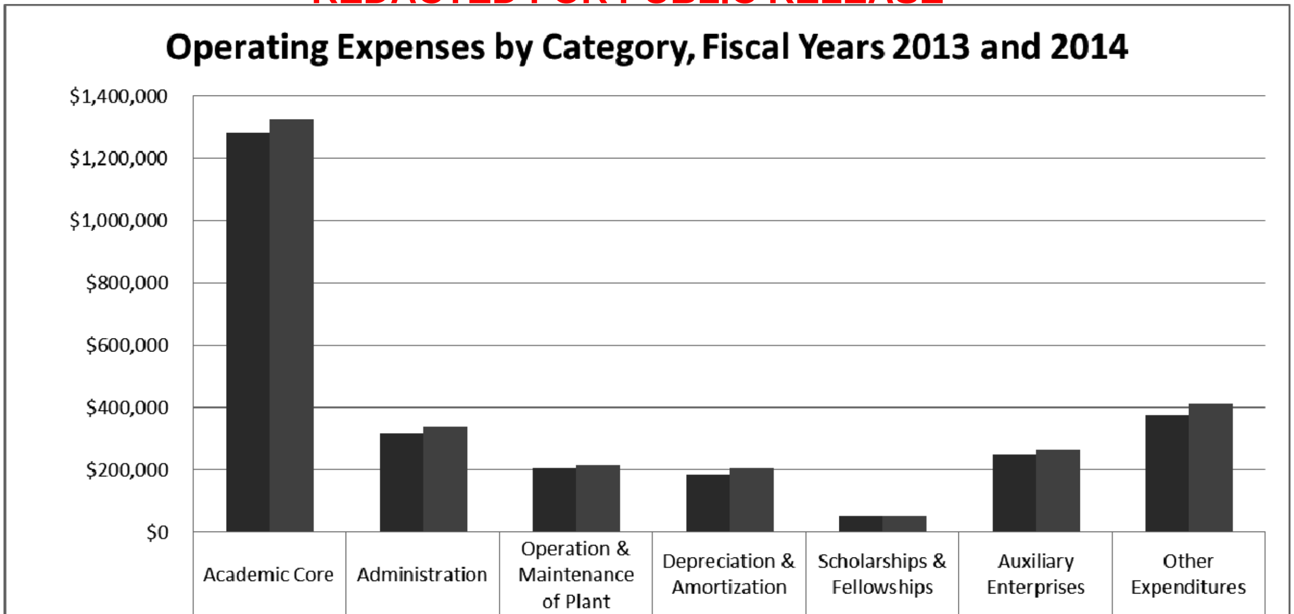
**This reflects the retroactive adoption of GASB 65. Please see *Footnote 1, Summary of Significant Accounting Policies-New GASB Pronouncements* for further details regarding this item.

University of Massachusetts Condensed Statement of Revenues, Expenses, and Changes in Net Position for University Related Organizations For the Year Ended June 30, 2014 and 2013 (in thousands of dollars)	University Related Organizations June 30, 2014	University Related Organizations June 30, 2013	FY13-14 Change
Operating Expenses	$ 11,443	$ 12,852	$ (1,409)
Operating Loss	(11,443)	(12,852)	(1,409)
Nonoperating Revenues / (Expenses)			
Other Nonoperating Income	54,982	35,152	19,830
Net Nonoperating Revenues	54,982	35,152	19,830
Income Before Other Revenues, Expenses, Gaines and Losses	43,539	22,300	21,239
Additions to Permanent Endowments	17,566	16,056	1,510
Other Additions	(1,523)	(9,979)	8,456
Total Other Revenues, Expenses, Gains, and Losses	16,043	6,077	9,966
Total Increase in Net Position	59,582	28,377	31,205
Net Position			
Net Position at the Beginning of the Year	386,212	357,835	28,377
Net Position at the End of the Year	$ 445,794	$ 386,212	$ 59,582



	T&F (Net of Scholarship Allowances)	Grants & Contracts	Auxiliary Enterprises	Other Operating Revenues
June 30, 2013	$707,495	$512,458	$319,544	$613,257
June 30, 2014	$740,116	$511,694	$349,485	$607,984

Total operating revenues for fiscal year 2014 were $2.21 billion. This represents a $56.5 million increase from the $2.15 billion in operating revenues in fiscal year 2013. The most significant sources of operating revenue for the University are tuition and fees, grants and contracts, auxiliary services and public service activities at the Worcester Medical School campus categorized in the chart above as “Other Operating Revenues”. While not classified on the financial statements as operating revenue, state appropriations serve as a primary source for funding the core mission of the University. State appropriation revenue, described in detail in a section below, is used almost exclusively to fund payroll for University employees. The chart above displays operating revenues by source for the University in fiscal years 2014 and 2013.



	Academic Core	Administration	Operation & Maintenance of Plant	Depreciation & Amortization	Scholarships & Fellowships	Auxiliary Enterprises	Other Expenditures
June 30, 2013	$1,283,125	$318,721	$203,115	$185,261	$49,731	$248,765	$375,119
June 30, 2014	$1,327,045	$339,215	$214,972	$204,233	$49,242	$265,080	$410,113

In fiscal year 2014, operating expenditures, including depreciation and amortization of $204.2 million, totaled $2.81 billion. Of this total, $1.33 billion or 47% was used to support the academic core activities of the University, including $407.4 million in research. In fiscal year 2013, operating expenditures, including depreciation and amortization of $185.3 million, totaled $2.66 billion. The chart above displays fiscal year 2014 and 2013 operating spend.

Public Service Activities

Other operating revenues includes Public Service Activities and consists largely of sales and services provided to third parties by the UMass Medical School campus through its Commonwealth Medicine ("CWM") programs, which provide public consulting and services in health care financing, administration and policy to federal, state and local agencies and not-for-profit health and policy organizations. Included in this category of activities are CWM revenues of $349.0 million and $358.7 million for the years ended June 30, 2014 and 2013, respectively. Included in expenditures are CWM expenditures of $318.2 million and $347.4 million for the years ended June 30, 2014 and 2013, respectively.

In addition to CWM activities, Public Service Activities also includes payments received by the Medical School for educational services it provides to its clinical affiliate UMass Memorial Health Care, Inc. ("UMass Memorial") as required by the enabling legislation enacted by the Commonwealth in 1997. Educational services revenues included in public service revenues were $163.8 million and $153.0 million for the years ended June 30, 2014 and 2013, respectively. Finally, Public Service Activity expenditures also include payments made to the Commonwealth of Massachusetts of $120 million and $65.0 million for the years ended June 30, 2014 and 2013, respectively, pursuant to requirements of legislation enacted by the State Legislature of Massachusetts.

State Appropriations

In fiscal year 2014, state appropriations represent approximately 20% of all operating and non-operating revenues. The level of state support is a key factor influencing the University's overall financial condition. Although the state appropriation is unrestricted revenue, nearly 100% of the state appropriation supports payroll and benefits for University employees.

The net state appropriation for the University increased by $51.3 million from fiscal year 2013, with the increase attributable to a higher level of State Appropriation and related fringe benefit support through the State's investment in the University's 50/50 plan. This plan, to be phased in over FY14 and FY15, has the State providing additional State Appropriation in order to bring State funding levels closer to historical amounts that will allow for the State to support 50% of the educational costs of an in state undergraduate while the student funds the remaining 50%. In return for this State investment, the University and the Board committed to freezing the in state undergraduate curriculum fee during this same time period.

In the year ended June 30, 2014 the University reported tuition revenue of approximately $34.3 million of tuition the University remits to the State Treasurer's Office for the general fund of the Commonwealth of Massachusetts. Unless otherwise permitted by the Massachusetts Legislature, the University is required to remit tuition revenue received to the Commonwealth. Therefore, the University collects student tuition on behalf of the Commonwealth and remits it to the Commonwealth's General Fund. The amount of tuition remitted to the Commonwealth was $35.1 million in fiscal year 2013. There is no direct connection between the amount of tuition revenues collected by the University and the amount of state funds appropriated in any given year.

In fiscal year 2004, a pilot program authorized by the Commonwealth enabled the Amherst campus to retain tuition for out-of-state students. This pilot program was extended indefinitely for the Amherst Campus in fiscal year 2005 and starting in fiscal year

REDACTED FOR PUBLIC RELEASE

2012 all of the University's campuses were authorized to retain tuition from out-of-state students. The amount of tuition retained by the University during 2014 and 2013 was $75.8 million and $74.5 million, respectively.

The following table details the Commonwealth operating appropriations received by the University for fiscal years ending June 30, 2014 and 2013:

	FY2014	FY2013
Gross Commonwealth Appropriations	$ 486,656	$ 447,837
Plus: Fringe Benefits*	141,881	130,005
	628,537	**577,842**
Less: Tuition Remitted	(34,325)	(35,103)
Less: Mandatory Waivers	(23,594)	(23,428)
Net Commonwealth Support	**$ 570,618**	**$ 519,311**

**The Commonwealth pays the fringe benefits for University employees paid from Commonwealth operating appropriations. Therefore, such fringe benefit support is added to the "State Appropriations" financial statement line item as presented in the above table. The University pays the Commonwealth for the fringe benefit cost of the employees paid from funding sources other than Commonwealth operating appropriations.*

Capital Appropriations from the Commonwealth

The University faces a financial challenge to maintain and upgrade its capital assets including its infrastructure, buildings and grounds. In order to have a successful capital program, the University must rely on a combination of revenue sources to fund its investment. In fiscal year 2014, there was $112.1 million of capital support provided to the University through appropriations and grants from the Commonwealth. This is consistent with capital appropriations provided in fiscal year 2013. This funding is attributed to the Commonwealth's Division of Capital Asset Management ("DCAM") which funded several large capital projects in fiscal year 2013 and 2014 through the State's Higher Education Bond Bill and Life Sciences Bond Bill, both passed in 2008 and have projects funded on each of the campuses. The University projects that although capital support will fluctuate from year to year, the level of capital appropriations from the Commonwealth will continue to be significant. Although the completion of major construction projects managed by DCAM are underway at all five of the University's campuses. The current bond support from the State has been fully programmed and therefore the University is now working to secure the next round of funding to ensure continuity of the capital program beyond FY18.

Grant and Contract Revenue

Collectively, the University's Amherst Campus and Medical School in Worcester account for approximately 77% of University grant and contract activity. The Boston, Dartmouth, and Lowell campuses continue to have significant sponsored research activity.

The following table details the University's grant and contract revenues (in thousands) for the fiscal years ended June 30, 2014 and 2013:

	FY2014	FY2013
Federal Grants and Contracts	$ 322,047	$ 334,697
State Grants and Contracts	74,996	68,794
Local Grants and Contracts	2,223	2,253
Private Grants and Contracts	112,428	106,714
Total Grants and Contracts	**$ 511,694**	**$ 512,458**

Discretely Presented Component Units

University of Massachusetts Foundation, Inc.

The combined University and Foundation endowment has increased to approximately $757.5 million at June 30, 2014 from $664.7 million at June 30, 2013.

The Foundation utilizes the pooled investment concept whereby all invested funds are in one investment pool, except for investments of certain funds that are otherwise restricted. Pooled investment funds will receive an annual distribution of 4% of the endowment fund's average market value for the preceding twelve quarters on a one year lag. Only quarters with funds on deposit shall be included in the average. In addition, a prudence rule will be utilized to limit spending from a particular endowment fund to no lower than 93% of its book value. The Foundation distributed $17.7 million (4%) and $15.1 million (4%) in fiscal years 2014 and 2013, respectively.

The total investment return of the Foundation for fiscal year 2014 was $112.2 million as compared to 2013, which, including realized and unrealized investment activity, was a net gain of approximately $64.0 million. This is consistent with investment return performance at other institutions.

University of Massachusetts Dartmouth Foundation, Inc.

Total marketable [redacted] for the Dartmouth Foundation were $53.5 million at June 30, 2014 up from $47.9 million at June 30, 2013, which are held by the University of Massachusetts Foundation, Inc. The increase was primarily due to favorable market conditions and new gifts. The Dartmouth Foundation total investment return for fiscal year 2014, including realized and unrealized investment activity, was a net gain of $4.9 million as compared to a net gain of $2.9 million in 2013.

Tuition and Fees

Due to declining State Appropriations, the University's Board of Trustees voted to increase mandatory student charges by 7.5% for resident undergraduate students for the 2011-2012 academic year and an additional 4.9% for the 2012-2013 academic year. For academic years 2013-2014 and 2014-2015, the Board of Trustees voted to freeze the mandatory curriculum fee for in state undergraduate students based on the increase to the State appropriation known as the 50/50 described above. Affordability will continue to be a priority of the University and increases in fees will be considered in conjunction with State support on an annual basis.

Enrollment

Except for the Medical School, which admits only Massachusetts residents (as required by Massachusetts Session Laws, 1987, Chapter 199, Section 99), admission to the University is open to residents of the Commonwealth and non-residents on a competitive basis. In the fall 2013 semester, Massachusetts residents accounted for approximately 82% and 54% of the University's total undergraduate and graduate enrollment, respectively. Total enrollment in the fall of 2013 was 61,336 FTE (71,941 headcount students). Enrollments at the University have shown significant increases over the last five years (53,140 FTE in fall 2008). The 15% enrollment growth is consistent with the University's efforts to increase its reach across the Commonwealth and to recruit non-resident students and is reflective of the quality education provided by the University of Massachusetts.

Degrees Awarded

The University awards four levels of degrees, as follows: associate, bachelors, masters and doctoral/professional degrees. A total of 16,447 degrees were awarded in the 2012-2013 academic year reflecting a 5% increase from the previous year. Of these awards, 66% were at the undergraduate level and 30% were at the graduate level. The remaining were associates degrees and undergraduate certificates.

Bonds Payable

As of June 30, 2014, the University had outstanding bonds of approximately $2.81 billion representing $2.48 billion of University of Massachusetts Building Authority bonds (the "Building Authority Bonds"), $59.3 million of University of Massachusetts bonds financed through the Massachusetts Health and Educational Facilities Authority which has been merged into MassDevelopment (the "UMass HEFA Bonds*"),* and $275.5 million of bonds financed through the Worcester City Campus Corporation (the "WCCC Bonds"). Bonds payable is the University's largest liability at June 30, 2014. The Building Authority's active projects include residence hall construction and renovation, renovation of general education buildings, replacement of core infrastructure, and construction of academic, laboratory, and research facilities. The proceeds from the UMass HEFA Bonds were used to create a revolving loan program and to fund the construction of two new campus centers at the Boston and Lowell campuses (funded jointly with the Commonwealth).

On March 8, 2013, the Building Authority issued $212,585,000 of Senior Series 2013-1 Project Revenue Bonds (the "2013-1 Bonds") and $71,790,000 of Senior Series 2013-2 Project Revenue Bonds (the "2013-2 Bonds"). The 2013-1 Bonds are tax-exempt and mature at various dates through 2043. The interest on the bonds is payable semi-annually each November 1st and May 1st and the interest rates on the bonds range from 2% to 5%. The 2013-2 bonds are taxable, mature at various dates through 2043 and the interest on the bonds is payable semi-annually each November 1st and May 1st. The interest rates on the bonds range from 0.43% to 2.686%. The 2013-1 Bonds and 2013-2 Bonds will be used to finance capital projects in the University's Capital Plan.

On August 8, 2013, the Authority issued its $24,640,000 Project and Refunding Revenue Bonds, Senior Series 2013-3 (the "2013-3 bonds"). The 2013-3 bonds were issued to finance and refinance a project set forth in the University's capital plan, the Edward M. Kennedy Institute for the United States Senate on the Boston campus of the University (the "EMK Project"). The proceeds of the 2013-3 bonds were used to finance the costs of such project, to fund capitalized interest on a portion of the 2013-3 Bonds, to refund a portion of the Authority's Project Revenue Bonds, Senior Series 2009-1 allocable to the construction of the EMK Project, and to pay costs of issuing the 2013-3 Bonds. The 2013-3 Bonds are due (serially) through 2043 with fixed interest rates ranging from 4.0% to 5.0%.

On August 13, 2013, the Authority issued Commercial Paper Note, Series 2013 A and 2013 B in the amount of $25.0 million for each respective series, with a total amount outstanding of $50.0 million. The maximum aggregate principal amount of commercial paper which may be outstanding at one time is $200.0 million. A portion of these notes are secured by an Irrevocable Letter of Credit ("LOC") provided by State Street Bank and Trust Company ("State Street") with respect to the $125 million Commercial Paper Notes, Series 2013 A, which expires in August of 2016. The remaining $75 million Commercial Paper Notes, Series 2013 B are secured by a Standby Liquidity Facility Agreement provided by U.S. Bank National Association, which expires in August 2016.

On February 25, 2014, the Building Authority issued $293,890,000 of Project Revenue Bonds, Senior Series 2014-1 (the "2014-1 Bonds") and $14,085,000 of Project Revenue Bonds, Senior Series 2014-2 (the "2014-2 Bonds"). The 2014-1 Bonds included a premium of $21.8 million. The 2014-1 Bonds are tax-exempt and mature at various dates through 2044. The interest on the bonds is payable semi-annually each November 1st and May 1st and the interest rates on the bonds range from 3% to 5%. The 2014-2 Bonds are federally taxable and mature at various dates through 2019. The interest on the bonds is payable semi-annually each November 1st and May 1st and interest rates on the bonds range from 0.440% to 2.109%. The 2014-1 and 2014-2 Bonds will be used to finance capital projects in the University's Capital Plan.

On June 3, 2014, the Building Authority issued $157,855,000 of Refunding Revenue Bonds, Senior Series 2014-4 (the "2014-4 Bonds"). The 2014-4 Bonds are federally taxable and mature at various dates through 2025. The interest on the bonds is payable semi-annually each November 1st and May 1st and the interest rates on the bonds range from 0.2% to 3.381%. The 2014-4 Bonds were issued to refinance the Building Authority's Refunding Revenue Bonds, Senior Series 2005-2.

Capitalized Lease Obligations

At June 30, 2014, the University had capital lease obligations with remaining principal payments of approximately $2.2 million which is a $4.3 million decrease from the remaining principal payments of $6.5 million at June 30, 2013. The capital leases primarily consist of telecommunications, software and co-generation systems, and campus energy conversions. The decrease in obligations is due to scheduled lease payments.

University Rating

The University is relying on a carefully planned and executed debt strategy to support master and strategic planning at the campuses and for the University as a whole. The University has been rewarded for its strategic planning by recent ratings upgrades. Bonds issued by the University of Massachusetts and the University of Massachusetts Building Authority are now AA, Aa2 and AA- as rated by Fitch, Moody's and Standard & Poor's rating agencies, respectively.

Limitations on Additional Indebtedness

The University may, without limit, issue additional indebtedness or request the Building Authority to issue additional indebtedness on behalf of the University so long as such indebtedness is payable from all available funds of the University. However, the University may request that the Building Authority issue additional indebtedness not payable from all available funds of the University provided that the additional indebtedness is secured by certain pledged revenues and the maximum annual debt service on all revenue indebtedness does not exceed 8% of the University's available revenues.

The Building Authority is authorized by its enabling act to issue bonds with the unconditional guarantee of the Commonwealth of Massachusetts for the punctual payment of the interest and principal payments on the guaranteed bonds. The full faith and credit of the Commonwealth are pledged for the performance of its guarantee. The enabling act, as amended, presently limits to $200 million the total principal amount of notes and bonds of the Building Authority that may be Commonwealth guaranteed and outstanding at any one time. The amount of bond obligation guaranteed by the Commonwealth at June 30, 2014 and 2013 was $125.6 million and $129.5 million, respectively.

Capital Plan

In September 2013, the University's Trustees approved a $5.5 billion five-year (fiscal years 2014-2018) update to its capital plan with $3.8 billion of projects approved to continue or commence over the next 24 months. The University generally has funded its capital plans through a combination of funding received from University operations, bonds issued by the University of Massachusetts Building Authority, MassDevelopment financing, Commonwealth appropriations, and private fundraising. The execution of many projects from the University's capital plan is from funding from the Commonwealth through the Higher Education and Life Sciences Bond Bills.

Campus	Total 5-Year Plan FY14 - FY18	Total Approved Projects (as of Sept 2014)
Amherst	$1,417,236	$1,453,445
Boston	$1,291,935	$962,585
Dartmouth	$721,328	$438,510
Lowell	$1,516,400	$865,400
Worcester	$523,598	$153,340
TOTAL	**$5,470,497**	**$3,873,280**
# of Projects	255	191

The University's five-year capital plan for fiscal years 2014-2018 includes both new projects and major projects that were previously approved by the University Trustees in prior-year capital plans. Over the last year the University has been working with the Board to enhance its policy regarding its approval of capital projects to ensure a clear process for the review and approval of projects and to provide for multiple reviews during the process so that the President's Office, Building Authority and the Board of Trustees (the Board) are actively involved. Since the capital program requires significant investment, the President's office and the Board wanted to ensure that the proper steps were in place for reviewing and approving projects so that the University continues to live within its current capital and debt policies. The capital plan is currently being reviewed and is set to go before the Board for its biennial review at the December Board meeting.

Factors Impacting Future Periods

There are a number of issues of University-wide importance that directly impact the financial operations of the University. Many of these issues, such as improving academic quality, realizing strong financial results, investing in capital assets, expanding fundraising capacity, operating more efficiently and being the most effective University for students and the Commonwealth given the available resources, and measuring performance are ongoing activities of continuous importance to the Board of Trustees and University leadership that impact the financial and budget planning each year. The level of state support, the impact of collectively bargained wage increases, and the ability of student-fee supported activities to meet inflationary pressures determine the limits of program expansion, new initiatives and strategic investments, as well as the ability of the University to meet its core mission and ongoing operational needs.

Despite challenging economic times in the Commonwealth since fiscal year 2009, the University of Massachusetts continues to focus on improving its competitive position. To meet increased student demand, boost academic credentials, and improve campus infrastructure, the University has expanded and acquired several strategic properties in the past few fiscal years:

- The Massachusetts Accelerator for Biomanufacturing (MAB) is a new 35,000 square foot bioprocessing facility located on a four acre site within the newly developed South Coast Life Sciences & Technology Park in Fall River. The facility looks to enhance the University's program offerings to assist small companies developing therapeutic biologic products with the transition from scientific protocol to large scale production processes that meet both industry and regulatory quality standards.

- In the fall of 2014, the University opened the Springfield Satellite Center to offer bachelor and master level courses associated with a variety of existing academic degrees and certificates that are already available to citizens of Greater Springfield at nearby locations and/or online. The Center will also house selected outreach, research, and economic development programs and activities.

- A satellite campus associated with the Umass Lowell, in Haverhill, is currently being explored to better serve its student population. A permanent site is being explored and a temporary site is being utilized in the current year in partnership with Northern Essex Community College.

Despite these successful acquisitions, the ability to address priority capital needs and requirements for deferred maintenance, technology, repairs and adaptation, and selected new construction projects is one of the largest challenges facing the University. Despite investing more than $2.5 billion on capital improvements over the last decade, the University's FY14-18 capital plan projects spending another $5.5 billion over the next five years. The commitment of operating funds for servicing debt and/or funding capital expenditures has an ongoing impact on the overall financial position of the University. In order to support the University's capital plan, the University of Massachusetts Building Authority will be issuing new bonds for renovations, new construction, and deferred maintenance projects at the Amherst, Boston, Dartmouth, Lowell, and Worcester campuses in support of the capital plan. The University is currently working with the Building Authority to determine the timing of the next bond issuance in support of the FY14 – FY18 Capital Plan.

The University, as well as Legislative and Executive Leadership in the Commonwealth, understand that despite the significant level of capital activity being financed through University debt, a much higher level of state support needs to be dedicated to higher education facilities. As such, the Massachusetts Legislature passed a higher education bond bill in August 2008 that was filed by Governor Patrick. The Higher Education Improvement Act authorized $2.2 billion for capital improvement spending over the next ten years at community colleges, state universities, and the University. More than $1 billion of these funds are directed to University projects exclusively. Although the financial challenges faced by the Commonwealth have slowed down the pace of this funding, the capital plans prepared by the Commonwealth's Executive Office for Administration and Finance maintain the commitment to fund $1 billion of capital activity at the University over the ten-year period from FY09-18. To date the $1 billion dedicated by the State to the University has been programmed toward funding critical capital projects at all of the campuses and we are currently working with the Commonwealth to secure additional authorizations for the future.

In addition, a major state effort to assist the Commonwealth in increasing its competitive position in the Life Sciences Industry was signed into law by the Governor on June 16, 2008. The $1 billion Life Sciences Industry Investment Act authorized $500 million of capital funding over ten years. It is anticipated that some portion of this funding, possibly as much as $242 million, will be used to support facility improvements at the University. $90 million has already been dedicated to partially fund the Sherman Center at the University's Medical School in Worcester. Additionally $95 million has been provided for a research facility at the Amherst Campus and significant capital investments in collaborative facilities and programs involving the Boston, Dartmouth, and Lowell campuses.

The impact of this increased level of state capital support from both the Higher Education Bond Bill and the Life Sciences Bond Bill is illustrated on the financial statements where capital appropriations and grants exceeded $112 million in fiscal years 2014 and 2013.

In addition to capital funding, the life sciences initiative provides a number of opportunities for the University to participate in the planning and program implementation of this important economic development effort.

The University's Boston Campus is situated on a peninsula in Boston Harbor which is also home to the John F. Kennedy Presidential Library and the Massachusetts State Archives and Commonwealth Museum. Construction is almost complete on the Edward M. Kennedy Institute for the United States Senate. The Kennedy Institute will focus on political study, training sessions for students and politicians, and historical records. The Institute will add significant prominence to the Boston Campus and the University.

Research funding for the University of Massachusetts was strong despite Federal sequestration of funds. For the University, research expenditures were $591.1 million in fiscal year 2013 and $597.5 million in fiscal year 2012. Most research at the University is externally funded, with the federal government providing a majority of the funding through the National Institutes of

Health, the National Science Foundation, and other sources. Among Massachusetts colleges and universities, UMass ranks third in research and development expenditures, behind only MIT and Harvard. The University, as well as most major public research universities across the United States, is closely monitoring the potential reduction in federal funding for research and development programs.

In recent years the online learning consortium of the University, UMassOnline, has shown significant growth in enrollments, course offerings and revenue generation benefiting the campuses and raising the profile of the University throughout this important sector of the higher education market. UMassOnline provides marketing and technology support for UMass' online offerings that enable students, professionals, and lifelong learners to take courses anywhere, anytime. With over 130 undergraduate and graduate degree, certificate and professional development programs and more than 1,500 courses available from University faculty, UMassOnline is one of the largest accredited online programs available.

For fiscal year 2014, UMass Online and the Continuing Education units at the five campuses collaboratively generated tuition revenue in excess of $85.1 million and supported 63,496 course enrollments, an increase of 8.7% for revenue and an increase of 7.3% for course enrollments as compared to fiscal year 2013.

The University continues to increase its global reach through a coordinated effort in international activities to develop partnerships and programs to bring faculty, visiting scholars and students from other countries to the University; to integrate study abroad opportunities into the undergraduate and graduate curriculum; and to encourage faculty to engage in research, teaching and service activities around the world.

The Commonwealth's fiscal year 2013 budget approved in June 2012 included a base state appropriation amount for the University equal to the base state appropriation received in fiscal year 2012. In addition to the base state appropriation, the budget also provided $25.6 million to cover the fiscal year 2013 cost of the collective bargaining increases for the University's union employees and $6.6 million of line item funding specific to the University. With state support consistent with the FY11 level despite the fact that enrollment has increased at the University by 15% over the last five years, the University's Board of Trustees approved a 4.9% tuition and fee increase for undergraduate students for the 2012-2013 academic year. In January of 2013, the Governor imposed mid-year budget reductions to bring the State budget into balance. As part of the reductions, the University received a 1% reduction equating to $4.2 million. Through working with the Legislature, the University was able to utilize revenues to meet the reduction so that there would be no impact on the fringe support provided by the State. Each campus and the central office absorbed the reduction into operations for fiscal year 2013.

The fiscal year 2014 budget approved in July 2013 included a new funding model that would have the State assume 50% of the cost to educate a Massachusetts student at the University. The 50:50 funding proposal required an investment by the Commonwealth of $39.1 million in each of the next two fiscal years, 2014 and 2015). This investment, along with the additional fringe support of $10.8 million gained from the increase in the State appropriation will provide the University with $100 million in additional appropriation over the next two fiscal years. The 2014 State budget included language (outside section 162) providing for the second year commitment to reach the goal of 50:50. This initiative has had an immediate and meaningful impact on thousands of Massachusetts residents who have not had an increase in their tuition and mandatory curriculum fees for the upcoming academic year. It also provides them with more long-term relief by allowing them to graduate and enter the workforce with less student debt. The total appropriation for fiscal year 2014 is $478.7 million. These State funds are used entirely to support salary costs and the associated fringe benefit from having employees funded using the State appropriation.

Despite increased State support for fiscal year 2014, the University continues to examine our operations and implement meaningful, financially impactful improvements wherever possible. Understanding that the current fiscal environment poses significant challenges for the University and its students, the responsibility to be a good steward of limited resources is taken seriously. The University, through its Board of Trustees, created a permanent Task Force on Efficiencies and Effectiveness charged with helping to ensure that improving quality through more efficient and effective operations continues to be a priority for the University. The Task Force, along with the President's Office and the campuses is working to promote a more standardized approach for cross campus collaboration and oversight of the entire effort, track and report progress, and quantify the benefits to the University and its campuses. Over the last few years the University has achieved measureable savings and efficiencies and expects current efforts to yield additional savings going forward.

The fiscal year 2015 budget approved in July 2014 provided for a base state appropriation of $519.0 million which represents the second installment of the 50:50 plan which began in fiscal year 2014. This investment along with the additional fringe support allowed the University to freeze the mandatory curriculum fee for the second consecutive year for in state undergraduate students. However, the State did not fund the first year of collective bargaining contracts to date that cost approximately $13 million in State support. The University continues to advocate for these funds as negotiations using State set parameters continue.

As the University begins planning for fiscal year 2016, we continue to monitor State revenues and advance work in efficiency and effectiveness efforts wherever possible. In addition, as the campuses continue to make progress on capital projects, the University is looking to the State for its next round of bond funding in support of new and deferred maintenance projects in support of the plan. Meanwhile, each campus continues their fundraising efforts and capital campaigns.

Contacting the University

This financial report is designed to provide the University, the Commonwealth, the public and other interested parties with an overview of the financial results of the University and an explanation of the University's financial condition. If you have any questions about this report or require additional information, you can contact the University by calling the University Controller, Sarah Mongeau, at (774) 455-7520 or by email at smongeau@umassp.edu.

This page is intentionally left blank

University of Massachusetts
Consolidated Statement of Net Position **REDACTED FOR PUBLIC RELEASE**
As of June 30, 2014 and 2013
(in thousands of dollars)

ASSETS	**University June 30, 2014**	**University Related Organizations June 30, 2014**	**University June 30, 2013** (adjusted)	**University Related Organizations June 30, 2013**
Current Assets				
Cash and Cash Equivalents	$63,752		$93,939	
Cash Held By State Treasurer	27,867		23,883	
Accounts, Grants and Loans Receivable, net	231,156		235,988	
Pledges Receivable, net	11,320	785	12,461	887
Short Term Investments	192,957		170,916	
Inventories, net	16,298		19,769	
Accounts Receivable from UMass Memorial	40,807		12,734	
Due From Related Organizations	181	354	230	380
Other Assets	8,412	539	9,904	2,563
Total Current Assets	**592,750**	**1,678**	**579,824**	**3,830**
Noncurrent Assets				
Cash and Cash Equivalents		1,378		1,041
Cash Held By State Treasurer	8,429		9,339	
Cash and Securities Held By Trustees	704,186		622,791	
Accounts, Grants and Loans Receivable, net	40,498		39,388	
Pledges Receivable, net	6,465	677	3,907	1,109
Investments	775,953	452,529	717,729	389,376
Other Assets	7,860	62	10,295	173
Investment In Plant, net	4,064,786	8,478	3,705,517	8,619
Total Noncurrent Assets	**5,608,177**	**463,124**	**5,108,966**	**400,318**
Total Assets	**$6,200,927**	**$464,802**	**$5,688,790**	**$404,148**
DEFERRED OUTFLOWS OF RESOURCES				
Deferred Change in Fair Value of Interest Rate Swaps	$41,082		$40,207	
Loss on Debt Refunding	71,798		74,079	
Total Deferred Outflows of Resources	$ 112,880		$ 114,286	
LIABILITIES				
Current Liabilities				
Accounts Payable	$113,650	$174	$129,238	$94
Accrued Salaries and Wages	110,464		106,016	
Accrued Compensated Absences	74,092		73,118	
Accrued Workers' Compensation	4,352		4,198	
Accrued Interest Payable	21,872		22,316	
Bonds Payable	196,608		328,126	
Capital Lease Obligations	2,232		4,302	
Accelerated variable rate debt, current	50,000			
Assets Held on behalf of Others		13,797		12,307
Accounts Payable to UMass Memorial	3,864		4,364	
Due To Related Organizations	354	181	380	230
Unearned Revenues and Credits	40,923	1,373	40,388	1,973
Advances and Deposits	6,912		7,946	
Other Liabilities	49,007		52,530	
Total Current Liabilities	**674,330**	**15,525**	**772,922**	**14,604**
Noncurrent Liabilities				
Accrued Compensated Absences	31,779		30,410	
Accrued Workers' Compensation	10,811		10,429	
Bonds Payable	2,617,149		2,213,722	
Capital Lease Obligations			2,238	
Derivative Instruments, Interest Rate Swaps	68,843		69,325	
Unearned Revenues and Credits	21,243		20,199	
Advances and Deposits	28,094		27,943	
Other Liabilities	43,263	3,483	41,532	3,332
Total Noncurrent Liabilities	**2,821,182**	**3,483**	**2,415,798**	**3,332**
Total Liabilities	**$3,495,512**	**$19,008**	**$3,188,720**	**$17,936**
Net Position:				
Invested in Capital Assets Net of Related Debt	$1,800,767	$8,477	$1,682,173	$8,619
Restricted				
Nonexpendable	17,387	309,718	18,058	290,858
Expendable	174,530	101,195	156,469	74,706
Unrestricted	825,611	26,404	757,656	12,029
Total Net Position	**$2,818,295**	**$445,794**	**$2,614,356**	**$386,212**

The accompanying notes are an integral part of the financial statements. **REDACTED FOR PUBLIC RELEASE**

University of Massachusetts
Consolidated Statement of Revenues, Expenses, and Changes in Net Position
For The Years Ended June 30, 2014 and 2013
(in thousands of dollars)

REDACTED FOR PUBLIC RELEASE

	University June 30, 2014	University Related Organizations June 30, 2014	University June 30, 2013 (adjusted)	University Related Organizations June 30, 2013
REVENUES				
Operating Revenues				
Tuition and Fees (net of scholarship allowances of $201,186 at June 30, 2014 and $189,753 at June 30, 2013)	$740,116		$707,495	
Federal Grants and Contracts	322,047		334,697	
State Grants and Contracts	74,996		68,794	
Local Grants and Contracts	2,223		2,253	
Private Grants and Contracts	112,428		106,714	
Sales and Service, Educational	21,792		19,237	
Auxiliary Enterprises	349,485		319,544	
Other Operating Revenues:				
Sales and Service, Independent Operations	44,296		46,062	
Sales and Service, Public Service Activities	448,478		447,119	
Other	93,418		100,839	
Total Operating Revenues	**2,209,279**		**2,152,754**	
EXPENSES				
Operating Expenses				
Educational and General				
Instruction	690,635		657,841	
Research	407,425		405,223	
Public Service	77,985	$11,066	74,510	$12,573
Academic Support	151,000		145,551	
Student Services	119,295		108,746	
Institutional Support	219,920		209,975	
Operation and Maintenance of Plant	214,972		203,115	
Depreciation and Amortization	204,233	200	185,261	202
Scholarships and Fellowships	49,242	177	49,731	77
Auxiliary Enterprises	265,080		248,765	
Other Expenditures				
Independent Operations	44,861		47,826	
Public Service Activities	365,252		327,293	
Total Operating Expenses	**2,809,900**	**11,443**	**2,663,837**	**12,852**
Operating Loss	**(600,621)**	**(11,443)**	**(511,083)**	**(12,852)**
NONOPERATING REVENUES/(EXPENSES)				
Federal Appropriations	7,020		6,774	
State Appropriations	570,618		519,311	
Gifts	29,013	11,063	30,044	9,452
Investment Income	86,685	42,849	56,037	24,540
Endowment Income	16,642	1,070	13,614	1,160
Interest on Indebtedness	(89,496)		(91,364)	
Nonoperating Federal Grants	74,279		70,586	
Other Nonoperating Income	1,046		1,002	
Net Nonoperating Revenues	**695,807**	**54,982**	**606,004**	**35,152**
Income Before Other Revenues, Expenses, Gains, and Losses	**95,186**	**43,539**	**94,921**	**22,300**
OTHER REVENUES, EXPENSES, GAINS, AND LOSSES				
Capital Appropria ions	112,132		112,581	
Capital Grants and Contracts	21,987		39,347	
Additions to Permanent Endowments		17,566		16,056
Net Amounts Earned/Received on Behalf of Others		(1,555)		(928)
Capital Contribution	250		4,514	
Disposal of Plant Facilities	(6,198)		(8,802)	
University Related Organization Transactions				
Other Additions/(Deductions)	(19,418)	32	2,939	(9,051)
Total Other Revenues, Expenses, Gains, and Losses	**108,753**	**16,043**	**150,579**	**6,077**
Total Increase in Net Position	**203,939**	**59,582**	**245,500**	**28,377**
NET POSITION				
Net Posi ion at Beginning of Year, as reported	2,614,356	386,212	2,389,377	357,835
Cummulative effect of change in accounting principle			(20,521)	
Net Posi ion at Beginning of Year, as adjusted			2,368,856	
Net Position at End of Year	**$2,818,295**	**$445,794**	**$2,614,356**	**$386,212**

The accompanying notes are an integral part of the financial statements.

REDACTED FOR PUBLIC RELEASE

University of Massachusetts
Consolidated Statements of Cash Flows
For The Years Ended June 30, 2014 and 2013
(in thousands of dollars)

	University June 30, 2014	University June 30, 2013
CASH FLOWS FROM OPERATING ACTIVITIES		
Tuition and Fees	$793,246	$780,540
Grants and Contracts	798,973	695,492
Payments to Suppliers	(1,273,331)	(1,038,532)
Payments to Employees	(1,298,736)	(1,292,185)
Payments for Benefits	(288,286)	(283,775)
Payments for Scholarships and Fellowships	(49,236)	(49,725)
Loans Issued to Students and Employees	(7,212)	(7,230)
Collections of Loans to Students and Employees	5,302	5,755
Auxiliary Enterprises Receipts	336,456	305,907
Sales and Service, Educational	21,613	19,372
Sales and Service, Independent Operations	49,781	69,181
Sales and Service, Public Service Activities	471,119	466,113
Net Cash Used in Operating Activities	**(440,311)**	**(329,088)**
CASH FLOWS FROM NONCAPITAL FINANCING ACTIVITIES		
State Appropriations	628,537	577,841
Tuition Remitted to the State	(34,325)	(35,103)
Federal Appropriations	7,020	6,774
Gifts and Grants for Other Than Capital Purposes	25,990	23,047
Nonoperating Federal Grants	74,279	70,586
Student Organization Agency Transac ions	31	(518)
Net Cash Provided by Noncapital Financing Activities	**701,533**	**642,627**
CASH FLOWS FROM CAPITAL AND OTHER FINANCING ACTIVITIES		
Proceeds from Capital Debt	587,555	303,752
Bond Issuance Costs Paid	(3,647)	(2,151)
Capital Appropriations	112,132	112,582
Capital Grants and Contracts	37,584	40,324
Purchases of Capital Assets and Construction	(208,444)	(273,885)
Principal Paid on Capital Debt and Leases	(257,837)	(76,347)
Interest Paid on Capital Debt and Leases	(104,441)	(95,550)
Use of Debt Proceeds on Deposit with Trustees	(357,204)	(537,050)
Net Cash Used in Capital Financing Activities	**(194,302)**	**(528,325)**
CASH FLOWS FROM INVESTING ACTIVITIES		
Proceeds from Sales and Maturities of Investments	1,141,204	1,067,591
Interest on Investments	8,959	9,172
Purchase of Investments	(1,162,801)	(1,022,629)
Net Cash (Used in)/Provided by Investing Activities	**(12,638)**	**54,134**
NET INCREASE (DECREASE) IN CASH AND CASH EQUIVALENTS	**54,282**	**(160,652)**
Cash and Cash Equivalents - Beginning of the Year	**749,952**	**910,604**
Cash and Cash Equivalents - End of Year	**$804,234**	**$749,952**
RECONCILIATION OF OPERATING LOSS TO NET CASH USED BY OPERATING ACTIVITIES		
Operating Loss	($600,621)	($511,083)
Adjustments to reconcile loss to net cash used by Operating Activities:		
Depreciation and Amortization Expense	$204,233	185,261
Changes in Assets and Liabilities:		
Receivables, net	2,305	(14,984)
Inventories	3,471	1,673
Due to/from Related Organizations	(75)	(105)
Accounts Receivable/Payable UMass Memorial	(28,573)	(6,175)
Other Assets	(16,748)	(2,090)
Accounts Payable (non-capital)	(10,550)	(7,039)
Accrued Liabilities	7,327	13,632
Deferred Revenue	1,579	(2,162)
Advances and Deposits	(883)	(962)
Other Liabilties	(1,777)	14,948
Net Cash Used in Operating Actvities	**($440,312)**	**($329,086)**
SUPPLEMENTAL DISCLOSURE OF NONCASH ACTIVITIES:		
Assets acquired and included in accounts payable and other liabilities	$56,705	$61,743
Loss on disposal of capital assets	($6,198)	(8,802)
Unrealized gain on investments	50,353	7,932

The accompanying notes are an integral part of the financial statements.

University of Massachusetts
Notes to Consolidated Financial Statements
June 30, 2014 and 2013

1. SUMMARY OF ORGANIZATION AND SIGNIFICANT ACCOUNTING POLICIES

ORGANIZATION

The consolidated financial statements herein present the financial position, results of operations, changes in net position, and cash flows of the University of Massachusetts ("the University"), a federal land grant institution. The financial statements of the University include the Amherst, Boston, Dartmouth, Lowell and Worcester Medical School campuses, and the Central Administration office of the University, Worcester City Campus Corporation ("WCCC"), the University of Massachusetts Amherst Foundation ("UMass Amherst Foundation"), as well as the University of Massachusetts Building Authority ("the Building Authority").

The Building Authority is a public instrumentality of the Commonwealth created by Chapter 773 of the Acts of 1960 (referred to as the "Enabling Act"), whose purpose is to provide dormitories, dining commons, and other buildings and structures for use by the University. WCCC is a tax exempt organization founded to support research and real property activities for the University. The UMass Amherst Foundation was established in 2003 as a tax exempt organization founded to foster and promote the growth, progress, and general welfare of the University. These component units are included in the financial statements of the University because of the significance and exclusivity of their financial relationships with the University.

The University Related Organizations column in the accompanying financial statements includes the financial information of the University's discretely presented component units. The University of Massachusetts Foundation, Inc. ("the Foundation") and the University of Massachusetts Dartmouth Foundation, Inc. ("the Dartmouth Foundation") are related tax exempt organizations founded to foster and promote the growth, progress and general welfare of the University, and are reported in a separate column to emphasize that they are Massachusetts not-for-profit organizations legally separate from the University. These component units are included as part of the University's financial statements because of the nature and the significance of their financial relationship with the University. The financial statement presentation of the discretely presented component units has been reclassified to conform to the University presentation. The financial reports of all above mentioned component units are available upon request from the University.

The University is an enterprise fund of the Commonwealth of Massachusetts ("the Commonwealth"). The financial balances and activities included in these financial statements are, therefore, also included in the Commonwealth's comprehensive annual financial report.

BASIS OF PRESENTATION

The accompanying financial statements have been prepared in accordance with accounting principles generally accepted in the United States of America as prescribed by the Governmental Accounting Standards Board ("GASB") using the economic resources measurement focus and the accrual basis of accounting. These financial statements are reported on a consolidated basis, and all intra-University transactions are eliminated.

Operating revenues consist of tuition and fees, grants and contracts, sales and services of educational activities (including royalties from licensing agreements) and auxiliary enterprise revenues. Operating expenses include salaries, wages, fringe benefits, utilities, subcontracts on grants and contracts, supplies and services, and depreciation and amortization. All other revenues and expenses of the University are reported as non-operating revenues and expenses including state general appropriations, federal appropriations, non-capital gifts, short term investment income, endowment income used in operations, interest expense, and capital additions and deductions. Other revenues, expenses, gains and losses represent all capital items, other changes in long term plant, and endowment net assets. Revenues are recognized when earned and expenses are recognized when incurred with the exception of revenue earned on certain public service activities (see Note 5). Restricted grant revenue is recognized only when all eligibility requirements have been met, that is to the extent grant revenues are expended or in the case of fixed price contracts, when the contract terms are met or completed. Contributions, including unconditional promises to give (pledges) for non-endowment or non-capital purposes, are recognized as revenues in the period received. Pledges to restricted non-expendable endowments are recognized as revenues in the period received. Conditional promises to give are not recognized until they become unconditional, that is when the conditions on which they depend are substantially met. The University applies restricted net assets first when an expense or outlay is incurred for purposes for which both restricted and unrestricted net assets are available.

The preparation of financial statements in accordance with accounting principles generally accepted in the United States of America requires management to make estimates and judgments that affect the reported amounts of assets and liabilities, and disclosures of contingencies at the date of the financial statements and revenues and expenditures recognized during the reporting period. Significant estimates include the accrual for employee compensated absences, the accrual for workers' compensation liability, the allowance for doubtful accounts, valuation of certain investments, and best estimates of selling price associated with certain multiple element arrangements. Actual results could differ from those estimates.

The University reports its financial statements as a "business-type activity" ("BTA") under GASB Statement No. 35, *Basic Financial Statements – and Management's Discussion and Analysis – for Public Colleges and Universities* (GASB 35). BTAs are defined as those that are financed in whole or in part by fees charged to external parties for goods or services.

In order to ensure observance of limitations and restrictions placed on the use of available resources, the accounts of the University are maintained internally in accordance with the principles of fund accounting. This is the procedure by which resources for various purposes are maintained in separate funds in accordance with the activities or objectives specified. GASB 35 establishes standards for external financial reporting by public colleges and universities that resources be classified into the following net position categories:

- **Invested in capital assets, net of related debt:** Capital assets, at historical cost, or fair market value on date of gift, net of accumulated depreciation and outstanding principal balances of debt attributable to the acquisition, construction or improvement of those assets.

- **Restricted Nonexpendable:** Resources subject to externally imposed stipulations that they be maintained permanently by the University.

- **Restricted Expendable:** Resources whose use by the University is subject to externally imposed stipulations. Such assets include restricted grants and contracts, the accumulated net gains/losses on true endowment funds, as well as restricted funds loaned to students, restricted gifts and endowment income, and other similar restricted funds.

- **Unrestricted**: Resources that are not subject to externally imposed stipulations. Substantially all unrestricted net assets are designated to support academic, research, auxiliary enterprises or unrestricted funds functioning as endowments, or are committed to capital construction projects.

Revenues are reported net of discounts and allowances. As a result, student financial aid expenditures are reported as an allowance against tuition and fees revenue while stipends and other payments made directly to students are recorded as scholarship and fellowship expenditures on the statements of revenues, expenses, and changes in net position, and included in supplies and services in the statements of cash flows. Discounts and allowances for tuition and fees and auxiliary enterprises are calculated using the Alternate Method which reports tuition and fee revenue net of scholarship allowances.

NEW GASB PRONOUNCEMENTS

In November of 2011, GASB issued Statement No. 60, *Accounting and Financial Reporting for Service Concession Arrangements* (GASB 60). The objective of GASB 60 is to improve financial reporting by addressing issues related to service concession arrangements (SCAs), which are a type of public-private or public-public partnership. A SCA is an arrangement between a transferor (a government) and an operator (governmental or nongovernmental entity) in which (1) the transferor conveys to an operator the right and related obligation to provide services through the use of infrastructure or another public asset (a “facility”) in exchange for significant consideration and (2) the operator collects and is compensated by fees from third parties. GASB 60 applies only to those arrangements in which specific criteria determining whether a transferor has control over the facility are met. The implementation of GASB 60 in 2013 had no impact on the University.

In June 2011, GASB issued Statement No. 63, *Financial Reporting of Deferred Outflows of Resources, Deferred Inflows of Resources, and Net Position* (GASB 63). GASB 63 provides financial reporting guidance for deferred outflows of resources and deferred inflows of resources. Concepts Statement No. 4, *Elements of Financial Statements*, introduced and defined those elements as a consumption of net assets by the government that is applicable to a future reporting period, and an acquisition of net assets by the government that is applicable to a future reporting period, respectively. Previous financial reporting standards do not include guidance for reporting those financial statement elements, which are distinct from assets and liabilities. The adoption of GASB 63 resulted in the separate presentation of deferred outflows of resources on the Statement of Net Position. Concepts Statement 4 also identifies net position as the residual of all other elements presented in a statement of financial position. GASB 63 amends the net asset reporting requirements in Statement No. 34, *Basic Financial Statements—and Management’s Discussion and Analysis—for State and Local Governments*, and other pronouncements by incorporating deferred outflows of resources and deferred inflows of resources into the definitions of the required components of the residual measure and by renaming that measure as net position, rather than net assets. The adoption of GASB 63 in 2013 required the University to change the reference of net assets to net position.

In April 2012, GASB issued Statement No. 65, *Items Previously Reported as Assets and Liabilities* (GASB 65). This Statement establishes accounting and financial reporting standards that reclassify, as deferred outflows of resources or deferred inflows of resources, certain items that were previously reported as assets and liabilities.

The University adopted GASB 65 effective July 1, 2012. In connection with the adoption of this new standard all accounts were analyzed by management in order to assess the impact on the financial statements. The implementation of this new standard resulted in the modification of the method previously used to account for the cost of issuance associated with the University’s numerous bond issuances, commitment and financing fees received by the University in connection with the bonds, and the expense and costs incurred on the bond refundings to be expensed as incurred, rather than capitalized, and amortized over the life of the debt. In accordance with the requirements of this new standard, the University’s Fiscal 2013 statement of net position and the University’s statement of revenues, expenses and changes in net position were adjusted to reflect the required adjustments. As a result, the following adjustments have been made to the University's financial statements.

As of July 1, 2012:	As Previously Reported	Adjustment	As Adjusted
Net Position	$ 2,389,376	$ (20,521)	$ 2,368,855
For the year ended June 30, 2013:			
Other Nonoperating Income/(Expense)	2,366	(1,363)	$ 1,003
Net Position at June 30, 2013	$ 2,636,241	(21,884)	$ 2,614,356

Additionally, the deferred losses on refunded bonds in the amount of $68.9 million at June 30, 2013 were reclassified from long term debt to deferred outflows of resources on the statement of net position.

CLASSIFICATION OF ASSETS AND LIABILITIES

The University presents current and non-current assets and liabilities in the statements of net position. Assets and liabilities are considered current if they mature in one year or less, or are expected to be received, used, or paid within one year or less. Investments with a maturity of greater than one year and balances that have externally imposed restrictions as to use are considered non-current. Cash Held by State Treasurer includes balances with restrictions as to use and balances that may be rolled forward for use toward the restricted purposes in future years, and such balances are classified as non-current. Cash held by trustees is presented based upon its expected period of use and the restrictions imposed on the balances by external parties.

CASH AND CASH EQUIVALENTS AND INVESTMENTS

Cash and cash equivalents consist primarily of petty cash, demand deposit accounts, money market accounts, and savings accounts, with a maturity of three months or less when purchased.

Investments are reported at their respective fair values. Short-term investments consist of deposits with original maturities of less than one year and are available for current use. Securities received as a gift are recorded at estimated fair value at the date of the gift.

Private equities and certain other non-marketable securities held by the Foundation are valued using current estimates of fair value by management based on information provided by the general partner or investment manager for the respective securities. The Foundation believes that the carrying amounts of these investments are a reasonable estimate of fair value, however, their estimated value is subject to uncertainty and therefore may differ from the value that would have been used had a ready market for such investment existed. Venture capital investments represent initial investments made to certain funds and are reported at cost until distributions are made from the funds or until market values are reported on the funds.

Investment securities are exposed to various risks, such as interest rate, market and credit risks. Due to the level of risk associated with certain investment securities, it is at least reasonably possible that changes in the values of investment securities will occur in the near term and that such changes could materially affect the amounts reported in the accompanying financial statements.

Investment income includes dividends and interest income and is recognized on the accrual basis. In computing realized gains and losses, cost is determined on a specific identification basis.

RESTRICTED GRANTS AND CONTRACTS

The University receives monies from federal and state government agencies under grants and contracts for research and other activities including medical service reimbursements. The University records the recovery of indirect costs applicable to research programs, and other activities which provide for the full or partial reimbursement of such costs, as revenue. Recovery of indirect costs for the years ended June 30, 2014 and 2013 was $114.0 million and $113.9 million, respectively, and is a component of grants and contracts revenue. The costs, both direct and indirect, charged to these grants and contracts are subject to audit by the granting agency. The University believes that any audit adjustments would not have a material effect on the University's financial statements.

PLEDGES AND ENDOWMENT SPENDING

Pledges for non-endowment purposes are presented net of amounts deemed uncollectible, and after discounting to the present value of the expected future cash flows. Because of uncertainties with regard to whether they are realizable, bequests and intentions and other conditional promises are not recognized as assets until the specified conditions are met.

The Foundation utilizes the pooled investment concept whereby all invested funds are in one investment pool, except for investments of certain funds that are otherwise restricted. Pooled investment funds will receive an annual distribution of 4% of the endowment fund's average market value for the preceding twelve quarters on a one year lag. Only quarters with funds on deposit shall be included in the average. In addition, a prudence rule will be utilized limiting spending from a particular endowment fund to no lower than 93% of its book value. The actual spending rate approved was 4% for 2014 and 2013. Future utilization of gains is dependent on market performance. Deficiencies for donor-restricted endowment funds resulting from declines in market value would be offset by an allocation from unrestricted net position to restricted expendable net position, and would be recorded in realized and unrealized gains (losses) on sale of investments. In fiscal years 2014 and 2013, the deficiencies were $0 million and $0.1 million, respectively. The Foundation believes that these adjustments are temporary and will not require permanent funding.

INVENTORIES

The University's inventories consist of books, general merchandise, central stores, vaccines, and operating supplies which are carried at the lower of cost (first-in, first-out and average cost methods) or market value.

INVESTMENT IN PLANT

Capital assets are stated at cost or fair value upon receipt as a gift. Net interest costs incurred during the construction period for major capital projects are capitalized. Repairs and maintenance costs are expensed as incurred, whereas major improvements that extend the estimated useful lives of the assets are capitalized as additions to property and equipment. Depreciation of capital assets is provided on a straight-line basis over the estimated useful lives of the respective assets. The University records a full year of depreciation in the year of acquisition. Land is not depreciated. The University does not capitalize works of art, historical treasures or library books.

Following is the range of useful lives for the University's depreciable assets:

Buildings	20-50 years
Building Improvements	3-20 years
Equipment and Furniture	3-15 years
Software	5 years
Land Improvements	20 years

COMPENSATED ABSENCES

Employees earn the right to be compensated during absences for annual vacation leave and sick leave. The accompanying statements of net position reflect an accrual for the amounts earned and ultimately payable for such benefits as of the end of the fiscal year. The accrual equates to the entire amount of vacation time earned and an actuarially determined liability for the sick leave component of compensated absences. Employees are only entitled to 20% of their sick leave balance upon retirement. The actuarial calculation utilized the probability of retirement for this estimate.

UNEARNED REVENUE

Unearned revenue consists of amounts billed or received in advance of the University providing goods or services. Unearned revenue is recognized as revenue as expenses are incurred and therefore earned.

ADVANCES AND DEPOSITS

Advances from the U.S. Government for Federal Perkins Loans to students are reported as part of advances and deposits. Future loans to students are made available only from repayments of outstanding principal amounts plus accumulated interest received thereon.

TUITION AND STATE APPROPRIATIONS

The accompanying financial statements for the years ended June 30, 2014 and 2013 present as tuition revenue approximately $34.3 million and $35.1 million, respectively, of in-state tuition received by the University and remitted to the State Treasurer's Office for the general fund of the Commonwealth of Massachusetts. The amount of tuition retained by the University related to out-of-state students during 2014 and 2013 was $75.8 million and $74.5 million, respectively. The recorded amount of State Appropriations received by the University has been reduced by a corresponding amount of tuition remitted as shown below (in thousands):

	2014	2013
Gross Commonwealth Appropriations	$486,656	$447,837
Plus: Fringe Benefits	141,881	130,005
	628,537	577,842
Less: Tuition Remitted	(34,325)	(35,103)
Less: Mandatory Waivers	(23,594)	(23,428)
Net Commonwealth support	$570,618	$519,311

AUXILIARY ENTERPRISES

Auxiliary Enterprise revenue of $349.5 million and $319.5 million for the years ended June 30, 2014 and 2013, respectively, are stated net of room and board charge allowances of $1.0 million and $0.7 million, respectively.

OTHER OPERATING REVENUES AND EXPENDITURES, SALES AND SERVICES, PUBLIC SERVICE ACTIVITIES

Public Service Activities consist largely of sales and services provided to third parties by the UMass Medical School campus under its Commonwealth Medicine ("CWM") programs, which provide public consulting and services in health care financing, administration and policy to federal, state and local agencies and not-for-profit health and policy organizations. Included in this category of activities are Commonwealth Medicine revenues of $349.0 million and $358.7 million for the years ended June 30, 2014 and 2013, respectively. Included in expenditures are Commonwealth Medicine expenditures of $318.2 million and $347.4 million for the years ended June 30, 2014 and 2013, respectively.

Public Service Activities also include payments received by the Medical School for educational services it provides to its clinical affiliate, UMass Memorial, as required by the enabling legislation enacted by the Commonwealth in 1997. Educational services revenues included in public service revenues were $163.8 million and $153.0 million for the years ended June 30, 2014, and 2013, respectively. Finally, Public Service Activity expenditures include payments made to the Commonwealth of Massachusetts of $120 million and $65 million for the years ended June 30, 2014 and 2013, respectively, pursuant to requirements of legislation enacted by the State Legislature of Massachusetts.

<u>FRINGE BENEFITS FOR CURRENT EMPLOYEES AND POST EMPLOYMENT OBLIGATIONS – PENSION AND NON-PENSION</u>

The University participates in the Commonwealth's Fringe Benefit programs, including active employee and post – employment health insurance, unemployment compensation, pension, and workers' compensation benefits. Health insurance and pension costs for active employees and retirees are paid through a fringe benefit rate charged to the University by the Commonwealth and currently the liability is borne by the Commonwealth. Consequently, no amounts have been reported by the University under applicable GASB standards. Workers' compensation costs are assessed separately based on actual University experience.

In addition to providing pension benefits, under Chapter 32A of the Massachusetts General Laws, the Commonwealth is required to provide certain health care and life insurance benefits for retired employees of the Commonwealth, housing authorities, redevelopment authorities, and certain other governmental agencies. Substantially all of the Commonwealth's employees may become eligible for these benefits if they reach retirement age while working for the Commonwealth. Eligible retirees are required to contribute a specified percentage of the health care benefit costs which is comparable to contributions required from employees. The Commonwealth is reimbursed for the cost of benefits to retirees of the eligible authorities and non-state agencies.

The Commonwealth's Group Insurance Commission ("GIC") was established by the Legislature in 1955 to provide and administer health insurance and other benefits to the Commonwealth's employees and retirees, and their dependents and survivors. The GIC also covers housing and redevelopment authorities' personnel, certain authorities and other offline agencies, retired municipal teachers from certain cities and towns and municipalities as an agent multiple employer program, accounted for as an agency fund activity of the Commonwealth, not the University.

The GIC administers a plan included within the State Retiree Benefits Trust Fund, an irrevocable trust. Any assets accumulated in excess of liabilities to pay premiums or benefits or administrative expenses are retained in that fund. The GIC's administrative costs are financed through Commonwealth appropriations and employee investment returns. The Legislature determines employees' and retirees' contribution ratios.

The GIC is a quasi-independent state agency governed by an eleven-member body ("the Commission") appointed by the Governor. The GIC is located administratively within the Executive Office of Administration and Finance, and is responsible for providing health insurance and other benefits to the Commonwealth's employees and retirees and their survivors and dependents. During the fiscal years that ended on June 30, 2014 and June 30, 2013, respectively, the GIC provided health insurance for its members through indemnity, PPO, and HMO plans. The GIC also administered carve-outs for the pharmacy benefit and mental health and substance abuse benefits for certain of its health plans. In addition to health insurance, the GIC sponsors life insurance, long-term disability insurance (for active employees only), dental and vision coverage for employees not covered by collective bargaining, a retiree discount vision plan and retiree dental plan, and finally, a pre-tax health care spending account and dependent care assistance program (for active employees only).

Pursuant [redacted] o University Medical School employees (other than those employees paid from state appropriated funds) for all periods on or after July 1, 1989. The Medical School determines the actual costs for the health insurance benefits and actuarially calculates the incurred service costs for pensions and retiree health insurance.

<u>INCOME TAX STATUS</u>

The University and the Building Authority are component units of the Commonwealth of Massachusetts and are exempt from Federal and state income tax under the doctrine of intergovernmental tax immunity found in the U.S. Constitution. The University qualifies as a public charity eligible to receive charitable contributions under Section 170(b)(1)(A)(ii) of the Internal Revenue Code, as amended (the Code). The Building Authority qualifies as a public charity under Section 170(b)(1)(A)(iv)of the Code.

The Worcester City Campus Corporation (WCCC), and the University Related Organizations are organizations described in Section 501(c)(3) of the Code, and are generally exempt from income taxes pursuant to Section 501(a) of the Code. WCCC and the University Related Organizations are required to assess uncertain tax positions and have determined that there were no such positions that are material to the financial statements.

COMPARATIVE INFORMATION AND RECLASSIFICATIONS

The University's financial statements include prior year comparative information. Certain reclassifications were made in prior year to conform to current year presentation. These amounts were determined to be immaterial to the financial statements by management.

2. CASH AND CASH EQUIVALENTS AND INVESTMENTS

The University's investments are made in accordance with the Investment Policy and Guidelines Statement Operating Cash Portfolio adopted in May 2005 and later amended in June 2009 by the Board of Trustees (the Investment Policy) and the Statement of Investment and Spending Policies of the University of Massachusetts Foundation, Inc. The goals of these documents are to preserve capital, provide liquidity, and generate investment income. The University of Massachusetts has statutory authority under Massachusetts General Laws Chapter 75 to collect, manage and disburse trust funds of the University.

Investments are reported at their respective fair values. The values of publicly traded fixed income and equity securities are based upon quoted market prices at the close of business on the last day of the fiscal year. Private equities and certain other non-marketable securities are valued using current estimates in fair value by management based on information provided by the general partner or investment manager for the respective securities. Investments in units of non-publicly traded pooled funds are valued at the unit value determined by the fund's administrator based on quoted market prices of the underlying investments. Private equities and other non-marketable securities represent approximately 27.4% and 24.5% of the University's investments at June 30, 2014 and 2013, respectively.

Custodial Credit Risk - Custodial Credit Risk is the risk that, in the event of a failure of the counterparty, the University would not be able to recover the value of its deposits, investments or collateral securities that were in the possession of an outside party. The University does not have a formal policy related to mitigation of custodial credit risk. Deposits are exposed to custodial risk if they are uninsured and uncollateralized. Investment securities are exposed to custodial credit risk if they are uninsured or not registered in the name of the University and are held by either the counterparty or the counterparty's trust department or agent but not in the University's name. As of June 30, 2014 and 2013, all cash and investment accounts were held on behalf of the University by the Trustees, in the Trustees' name.

The University maintains depository, payroll, disbursement, receipt, and imprest accounts. In addition to bank account deposits, the University held money market instruments which are classified as investments. Interest bearing and money market accounts carry Federal Deposit Insurance Corporation (FDIC) insurance up to $250,000 per account. None of the accounts are collateralized above the FDIC insured amounts. The University also invested in individual CDs and BNY Mellon's CDARS program. These funds are invested in individual CDs in $250,000 increments and are therefore fully insured by the FDIC.

At June 30, 2014 and 2013, the carrying amounts, bank balances and FDIC insured amounts were as follows (in thousands):

	2014			2013		
	Book Balance	Bank Balance	FDIC Insured	Book Balance	Bank Balance	FDIC Insured
Depository Accounts	57,360	65,410	1,007	73,056	86,519	5,938
Certificates of Deposit	650	650	400	30,650	30,650	30,400
Money Market	180,601	180,601	2,251	129,004	129,004	2,251
Total	238,611	246,661	3,658	232,710	246,173	38,589

At June 30, 2014 the University held a carrying and fair market value of $743.2 million in non-money market investments compared to a carrying and fair market value of $723.5 million at June 30, 2013. In the event of negligence due to the University's custodian and/or investment manager(s), it is expected that investment balances of $743.2 million and $723.5 million at June 30, 2014 and 2013, respectively, would be fully recovered. However, these amounts are subject to both interest rate risk and credit risk.

Concentration of Credit Risk - Concentration of credit risk is assumed to arise when the amount of investments that the University has with one issuer exceeds 5% or more of the total value of the University's investments. The University does not have a formal policy for concentration of credit risk.

As of June 30, 2014 and June 30, 2013, respectively, there is no concentration of investments with one issuer of the University portfolio, excluding U. S. Government guaranteed obligations, which exceed 5% of the portfolio.

Credit Risk - Credit risk is the risk that the University will lose money because of the default of the security issuer or investment counterparty. The University's Investment Policy and Guidelines Statement allows each portfolio manager full discretion within the parameters of the investment guidelines specific to that manager.

The table below presents the fair value (in thousands) and average credit quality of the fixed income component of the University's investment portfolio as of June 30, 2014 and 2013, respectively:

Asset Class	June 30, 2014 Fair Value	Average Credit Quality	June 30, 2013 Fair Value	Average Credit Quality
Short duration	$240,550	AAA	$230,161	AAA
Intermediate duration	$282,030	A	$282,837	A

The table below presents the fair value (in thousands) by credit quality of the rated debt investments component of the University's investment portfolio as of June 30, 2014 and 2013, respectively:

Rated Debt Investments - 2014
(in thousands)

		S&P Quality Ratings							
	Fair Value	AAA	AA	A	BBB	BB	B	<B	Unrated
U.S Agencies	$ 12,195	$ -	$ 12,195	$ -	$ -	$ -	$ -	$ -	$ -
U.S Government	34,522	-	34,522	-	-	-	-	-	-
Foreign Govn't Bonds	-	-	-	-	-	-	-	-	-
Certificates of Deposit	500	500	-	-	-	-	-	-	-
Corporate Debt	90,284	17,627	12,830	24,742	22,199	-	131	1,426	11,329
Municipal/Public Bonds	4,253	-	1,614	1,500	1,139	-	-	-	-
Bond Mutual Funds	152,806	56,581	6,657	19,463	31,222	15,940	11,282	3,375	8,286
Money Market Funds	228,021	225,764	-	-	-	-	-	-	2,257
	$ 522,581	$ 300,472	$ 67,818	$ 45,705	$ 54,560	$ 15,940	$ 11,413	$ 4,801	$ 21,872

Rated Debt Investments - 2013
(in thousands)

		S&P Quality Ratings							
	Fair Value	AAA	AA	A	BBB	BB	B	<B	Unrated
U.S Agencies	$ 20,463	$ -	$ 20,463	$ -	$ -	$ -	$ -	$ -	$ -
U.S Government	20,334	-	19,218	1,116	-	-	-	-	-
Certificates of Deposit	30,500	30,500	-	-	-	-	-	-	-
Corporate Debt	99,737	20,886	11,087	36,377	15,602	966	353	1,851	12,615
Municipal/Public Bonds	2,248	-	289	1,959	-	-	-	-	-
Bond Mutual Funds	173,923	66,575	11,235	25,369	40,202	15,299	8,310	1,238	5,695
Money Market Funds	165,793	165,183	222	-	-	-	-	-	388
	$ 512,998	$ 283,144	$ 62,514	$ 64,821	$ 55,804	$ 16,265	$ 8,663	$ 3,089	$ 18,698

Interest Rate Risk - Interest rate risk is the risk that changes in interest rates will adversely affect the fair market value of an investment. The University's Investment Policy and Guidelines Statement establishes targets for the preferred duration of the fixed income component of the investment portfolio by asset class by limiting investments through targeted allocations to different asset classes.

The table below shows the allocation for each asset class and the fair value (in thousands) for each as of June 30, 2014 and 2013, respectively:

Asset Class	6/30/14 Allocation	6/30/14 Fair Value	6/30/13 Allocation	6/30/13 Fair Value
Short Duration	25%	$240,551	26%	$230,161
Intermediate Duration	29%	282,030	32%	282,837
Alternative Assets	27%	265,499	25%	217,442
Equities	15%	147,500	14%	130,175
Commodities	3%	24,592	2%	21,020
Real Estate	1%	8,738	1%	7,010

Investments - 2014
(in thousands)

Investment Type:	Investment Maturity (in Years)				
Debt Securities	Fair Value	Less than 1	1 to 5	6 to 10	More than 10
US Agencies	$ 12,195	$ 4,307	$ 3,999	$ 825	$ 3,064
US Government	34,522	-	29,557	4,965	-
Certificates of Deposit	500	500	-	-	-
Corporate Debt	90,284	7,722	40,361	14,119	28,082
Municipal/Public Bonds	4,253	-	4,017	236	-
Bond Mutual Funds	152,806	17,395	81,561	36,503	17,347
Money Market Mutual Funds	228,021	228,021	-	-	-
Sub Total Debt	$ 522,581	$ 257,945	$ 159,495	$ 56,648	$ 48,493

Other Investments	
Alternative Assets	$ 265,499
Equity Securities- International	81,358
Equity Securities- Domestic	66,142
Commodities	24,592
Real Estate	8,738
Grand Total	$ 968,910

Investments - 2013
(in thousands)

Investment Type:	Investment Maturity (in Years)				
Debt Securities	Fair Value	Less than 1	1 to 5	6 to 10	More than 10
US Agencies	$ 20,463	$ 5,611	$ 5,103	$ 881	$ 8,868
US Government	20,334	-	12,333	8,001	-
Certificates of Deposit	30,500	30,500	-	-	-
Corporate Debt	99,737	13,083	51,898	10,726	24,030
Municipal/Public Bonds	2,248	470	1,489	289	-
Bond Mutual Funds	173,923	14,704	72,774	47,857	38,588
Money Market Mutual Funds	165,793	165,793	-	-	-
Sub Total Debt	$ 512,998	$ 230,161	$ 143,597	$ 67,754	$ 71,486

Other Investments	
Alternative Assets	$ 217,442
Equity Securities- International	21,020
Equity Securities- Domestic	71,086
Commodities	59,089
Real Estate	7,010
Grand Total	$ 888,645

3. CASH HELD BY STATE TREASURER

Accounts payable, accrued salaries and outlays for future capital projects to be funded from state-appropriated funds totaled approximately $36.5 million at June 30, 2014 and $33.2 million at June 30, 2013. The University has recorded a comparable amount of cash held by the State Treasurer for the benefit of the University, which will be subsequently utilized to pay for such liabilities. The cash is held in the State Treasurer's pooled cash account. The Commonwealth requires all bank deposits in excess of insurance coverage by the FDIC to be collateralized with a perfected pledge of eligible collateral. Eligible collateral must be pledged in an amount equal to 102% of the amount of the deposits that exceed FDIC insurance. Sufficient collateral to cover total Commonwealth deposits in excess of the FDIC insured amount must be pledged and held in safekeeping by a custodian that is approved by and under the control of the Treasurer and Receiver – General.

4. CASH AND SECURITIES HELD BY TRUSTEES

Cash and securities held by trustees primarily consist of unspent bond proceeds, amounts held for the future payment of debt service on such borrowings and designated funds. At June 30, 2014 and June 30, 2013 there are investments of $0 and $7,000, respectively, available from Master Lease agreements entered into by the University for capital asset purchases at the Amherst and Boston campuses. Additionally, there is $3 million and $13.6 million, respectively, available from the Revolving Loan Fund established with 2000 Series A bond proceeds issued to acquire and implement enterprise resource planning technology along with other projects (see Note 8) and $701.1 million and $608.5 million, respectively, held by trustees related to the Building Authority.

Pursuant to Trust Agreements between the Building Authority and its bond trustees, all funds deposited with those trustees (approximately $700 million at June 30, 2014 and $600 million at June 30, 2013) shall be continuously maintained for the benefit of the Building Authority and Registered owners of the Bonds. All investments shall be (a) held with a bank or trust company approved by the Trustees and the Building Authority, as custodians, or (b) in such other manner as may be required or permitted by applicable state and Federal laws and regulations. Investments shall consist of (a) direct obligations of, or obligations which are unconditionally guaranteed by the United States of America, or any other agency or corporation which has been created pursuant to an act of Congress of the United States as an agency or instrumentality thereof; or (b) other marketable securities eligible as collateral for the deposit of trust funds under regulations of the Comptroller of the Currency having a market value not less than the amount of such deposit. Direct obligations of, or obligations which are unconditionally guaranteed by the United States of America or any other agency or corporation which has been created pursuant to an act of Congress of the United States as an agency or instrumentality thereof, may be subject to repurchase upon demand by the owner pursuant to a repurchase agreement with a bank or trust company.

Cash Deposits – Custodial Credit Risk The Building Authority holds a majority of its cash and cash equivalents in high quality money market mutual funds that invest in securities that are permitted investments under the Building Authority's Enabling Act or in money market mutual funds that have been specifically permitted by state legislation. The Building Authority's cash and cash equivalents consisted of the following as of June 30, 2014 and 2013 (in thousands):

	2014	2013
Cash	$ 4,406	$ 5,130
Permitted money market accounts ("MMA")	691,381	518,739
Total cash and cash equivalents	$ 695,787	$ 523,869

Custodial credit risk is the risk that, in the event of a bank failure, the Building Authority will not be able to recover its deposits or will not be able to recover collateral securities that are in the possession of an outside party. The Building Authority does not have a deposit policy for custodial credit risk. As of June 30, 2014, the bank balances of uninsured deposits totaled $4,1 million. For purposes of disclosure under GASB Statement No. 40, *Deposit and Investment Risk Disclosures*, money market accounts investing in debt securities are considered investments and therefore, are included in the investment disclosures that follow.

Investments

As of June 30, 2014, the Building Authority's investments consisted of the following:

	Investment Maturities (in Years)			
	Fair value	Less than 1	1 to 5	6 to 10
Investment type				
Debt Securities				
Repurchase Agreements	$ 5,318			$ 5,318
MoneyMarket funds	691,381	691,381		
Total	$ 696,699	$ 691,381	$ -	$ 5,318

As of June 30, 2013, the Building Authority's investments consisted of the following:

	Investment Maturities (in Years)			
	Fair value	Less than 1	1 to 5	6 to 10
Investment type				
Debt Securities				
US Treasuries	$ 10,324	$ 10,324	$ -	$ -
US Agencies	69,461	50,383	19,078	-
Repurchase Agreements	5,318	-	-	5,318
MoneyMarket funds	518,739	518,739	-	-
Total	$ 603,842	$ 579,446	$ 19,078	$ 5,318

Because money market funds are highly liquid, they are presented as investments with maturities of less than one year.

Interest Rate Risk The Building Authority does not have a formal investment policy that limits investment maturities as a means of managing its exposure to fair value losses arising from increasing interest rates. Generally, the Building Authority holds its investments until maturity.

Credit Risk Credit risk is the risk that an issuer of an investment will not fulfill its obligation to the holder of the investment. The risk is measured by the assignment of a rating by a nationally recognized statistical rating organization.

The Enabling Act specifies the permitted investments of the Building Authority. These permitted investments include direct obligations of or obligations which are unconditionally guaranteed by the United States of America ("Treasuries"), obligations of an agency or organization created pursuant to an act of Congress of the United States as an agency or instrumentality thereof ("Agencies"), time deposits or certificate of deposits fully secured by Treasuries or Agencies, and Treasuries and Agencies subject to repurchase agreements. Other legislation allows the Building Authority to invest in the Massachusetts Municipal Depository Trust (the "MMDT"), a money market account sponsored by the Treasurer of the Commonwealth and managed by Federated Investors, Inc. Additionally, the Building Authority's Bond Trustee invests some of the Building Authority's funds in money market accounts that are permitted and collateralized by Treasuries.

No credit risk disclosures are required under GASB 40 relating to the Building Authority's investment in Treasuries. The Building Authority's investments in Agencies are highly rated by Standard & Poor's Rating Services and Moody's Investors Service, Inc. The Building Authority's investments in repurchase agreements are not rated but are fully collateralized by Treasuries and Agencies. MMDT is unrated.

Custodial Credit Risk Custodial credit risk for investments is the risk that, in the event of the failure of the counterparty to a transaction, a government will not be able to recover the value of investment or collateral securities that are in the possession of an outside party. The Building Authority's Enabling Act does not contain legal or policy requirements that would limit the exposure to custodial credit risk except that interest-bearing time deposits or certificates of deposit of banking institutions or trust companies must be continuously and fully secured by Treasuries or Agencies.

Custodial credit risk generally applies only to direct investments in marketable securities. Custodial credit risk does not apply to indirect investment in securities through the use of mutual funds or government investment pools, such as MMDT. Direct investments in marketable securities are held by the Building Authority's Bond Trustee as the Building Authority's agent. In accordance with the Building Authority's repurchase agreements, collateral for the agreements is held in segregated accounts with market values between 100% and 105% of the repurchase price, depending on the type of asset used as security and the specific repurchase agreement.

Concentrations of Credit Risk The Building Authority places no limit on the amount it may invest in any one issuer. As of June 30, 2014, the Building Authority had 98.6% of its investments in MMDT. As of June 30, 2013, the Building Authority had 5.9% of its investments with the Federal Home Loan Mortgage Corporation and 85.1% of its investments in MMDT.

5. ACCOUNTS, GRANTS AND LOANS RECEIVABLE

Accounts, grants and loans receivable as of June 30, 2014 and 2013 are as follows (in thousands):

	2014	2013
Student Accounts Receivable	$ 53,383	$ 51,449
Less allowance for uncollectible accounts	(21,814)	(18,319)
	31,569	33,130
Grants and Contracts Receivable	82,157	85,028
Less allowance for uncollectible accounts	(1,151)	(2,989)
	81,006	82,039
Student Loans Receivable	46,869	44,257
Less allowance for uncollectible accounts	(296)	(302)
	46,573	43,955
Commonwealth Medicine	65,586	64,094
Less allowance for uncollectible accounts	(824)	(825)
	64,762	63,269
Other	48,154	53,537
Less allowance for uncollectible accounts	(410)	(554)
	47,744	52,983
Total, net	271,654	275,376
Less current portion, net	(231,156)	(235,988)
Long-term, net	$ 40,498	$ 39,388

UMASS MEMORIAL

The University and UMass Memorial have the following ongoing agreements:

- UMass Memorial has been granted the right to occupy portions of the University's Worcester Medical School campus for a period of 99 years and UMass Memorial has agreed to share responsibility for various capital and operating expenses relating to the occupied premises. UMass Memorial has also agreed to contribute to capital improvements to shared facilities.

- UMass Memorial has agreed to make certain payments to the University and its related organizations, including: 1) an annual fee of $12.0 million (plus an inflation adjustment), for 99 years as long as the University continues to operate a medical school; and 2) a participation payment based on a percentage of net operating income of UMass Memorial for which revenue is recognized by the University when the amounts are received.

The University is reimbursed by, and reimburses UMass Memorial for shared services, cross-funded employees, and other agreed upon activities provided and purchased. For the years ended June 30, 2014 and 2013, the reimbursements for services provided to UMass Memorial were $107.1 million and $124.0 million, respectively. Included in these amounts are payroll paid by the University on behalf of UMass Memorial in an agency capacity in the amount of $62.8 million and $73.8 million for fiscal years 2014 and 2013, respectively. At June 30, 2014 and 2013, the University has recorded a receivable in the amount of $38.8 million and $12.7 million, respectively from UMass Memorial which includes $23.8 million and $5.8 million, respectively, in payroll and related fringe charges. The University has recorded a payable at June 30, 2014 of $3.9 million primarily for cross-funded payroll. At June 30, 2013, the University had a payable of $4.4 million for amounts due to UMass Memorial primarily consisting of a prepayment for educational services, capital projects and cross-funded payroll.

6. RELATED ORGANIZATIONS

Related party activity with the Foundation includes loan agreements and investments of the University's endowment assets and Intermediate Term Investment Fund (ITIF) with the Foundation. As of June 30, 2014, the net position of the Foundation included as related organizations in the accompanying financial statements of the University are $455.1 million, of which $423.0 million are restricted funds and $32.1 million are unrestricted funds. During the fiscal year ended June 30, 2014, the University received $21.6 million from the Foundation, and $13.1 million to the Foundation of which $3.4 million related to the establishment of quasi-endowment. At June 30, 2014, the University's investments include $346.1 million of endowment funds held in a custodial relationship at the Foundation, and $295.7 million in ITIF.

As of June 30, 2013, the net position of the Foundation included as related organizations in the accompanying financial statements of the University were $394.3 million, of which $366.7 million were restricted funds and $27.5 million were unrestricted funds. During the fiscal year ended June 30, 2013, the University received $49.9 million from the Foundation, and disbursed $121.8 million to the Foundation of which $52.1 million related to the establishment of quasi-endowment. At June 30, 2013, the University's investments include $311.4 million of endowment funds held in a custodial relationship at the Foundation, and $272.5 million in ITIF.

The University leases office space from the Foundation for an annual rent of approximately $0.5 million.

The Building Authority and the Commonwealth have entered into various lease agreements under which the Commonwealth leases to the Building Authority certain property for nominal amounts.

In August 2005, the Building Authority executed a contract with UMass Management, LLC, a wholly owned subsidiary of ClubCorp USA, Inc., to provide management services for The University of Massachusetts Club ("the Club"), a private social club for alumni and friends of the University. Under the contract, the Authority is responsible for approving the budgets and operating plans of the Club as presented by the Manager. The Building Authority is responsible for any shortfall in the operating budget and will benefit from any operating profits. The contract calls for a minimum management fee payable to the Manager of $0.2 million or four percent of the operating revenues, as defined by the contract, whichever is greater. Additionally, the Manager receives a percentage of the Club initiation fees and 25 percent of operating profits, as defined by the contract. The contract term is 10 years and can be terminated by the Building Authority if the Building Authority decides to close the Club for a minimum of 18 months. The Building Authority is the tenant on the sublease for the Club space and the lease does not terminate should the Building Authority close the Club. The Authority had provided operating support for the Club of $0.2 million for both years ending June 30, 2014 and 2013.

7. INVESTMENT IN PLANT

Investment in plant activity for the year ended June 30, 2014 is comprised of the following (in thousands):

University:	Beginning Balance	Additions/ Adjustments	Retirements/ Adjustments	Ending Balance
Buildings and Improvements	$4,058,559	$643,091	($7,001)	$4,694,649
Equipment and Furniture	587,478	35,542	(13,234)	609,786
Software	134,558	2,374	(28)	136,904
Library Books	93,091		(8,776)	84,315
	4,873,686	681,007	(29,039)	5,525,654
Accumulated Depreciation	(2,122,993)	(200,256)	14,122	(2,309,127)
Sub-Total	2,750,693	480,751	(14,917)	3,216,527
Land	65,886	3,484	(518)	68,852
Construction in Progress	888,937	589,512	(699,042)	779,407
Sub-Total	954,823	592,996	(699,560)	848,259
Total	$3,705,516	$1,073,747	($714,477)	$4,064,786

University Related Organizations:	Beginning Balance	Additions/ Adjustments	Retirements/ Adjustments	Ending Balance
Buildings and Improvements	$7,942			$7,942
Equipment and Furniture	168			168
	8,110			8,110
Accumulated Depreciation	(851)	($202)		(1,053)
Sub-Total	7,259	(202)		7,057
Land	1,360	61		1,421
Total	$8,619	($141)		$8,478

Investment in plant activity for the year ended June 30, 2013 is comprised of the following (in thousands):

University:	Beginning Balance	Additions/ Adjustments	Retirements/ Adjustments	Ending Balance
Buildings and Improvements	$3,322,211	$754,586	($18,238)	$4,058,559
Equipment and Furniture	604,487	30,339	(47,348)	587,478
Software	134,082	4,036	(3,560)	134,558
Library Books	101,618	-	(8,527)	93,091
	4,162,398	788,961	(77,673)	4,873,686
Accumulated Depreciation	(1,990,577)	(182,252)	49,836	(2,122,993)
Sub-Total	2,171,821	606,709	(27,837)	2,750,693
Land	57,831	8,055	-	65,886
Construction in Progress	868,534	583,748	(563,344)	888,938
Sub-Total	926,365	591,803	(563,344)	954,824
Total	$3,098,186	$1,198,512	($591,181)	$3,705,517

University Related Organizations:	Beginning Balance	Additions/ Adjustments	Retirements/ Adjustments	Ending Balance
Buildings and Improvements	$7,942	-	-	$7,942
Equipment and Furniture	170	-	($2)	168
	8,112	-	(2)	8,110
Accumulated Depreciation	(650)	($201)	-	(851)
Sub-Total	7,462	(201)	(2)	7,259
Land	1,360	-	-	1,360
Total	$8,822	($201)	($2)	$8,619

At June 30, 2014 and 2013, investment in plant included capital lease assets of $54.6 million and $54.6 million, respectively, net of accumulated depreciation on capital lease assets of $52.3 million and $48.1 million, respectively (see Note 9).

The University has capitalized interest on borrowings, net of interest earned on related debt reserve funds, during the construction period of major capital projects. Capitalized interest is added to the cost of the underlying assets being constructed, and is amortized over the useful lives of the assets. For the years ended June 30, 2014 and 2013, the University capitalized net interest costs of $29.7 million and $27.4 million respectively.

8. BONDS PAYABLE

Amounts Outstanding at June 30, 2014 are as follows (in thousands)

Issue Borrowing	Original Borrowing	Maturity Date	Interest Rate	Amount Outstanding
University of Massachusetts Building Authority:				
Series 2003-1	$ 137,970	2014	3.875-5.25%	$ 6,155
Series 2004-A	96,025	2015	4.2-4.5%	4,575
Series 2004-1	183,965	2016	5.25%	16,600
Series 2005-1	25,595	2016	5.0%	5,480
Series 2005-2	212,550	2025	5.0%	25,200
Series 2008-A	26,580	2038	variable	21,930
Series 2008-1	232,545	2038	variable	194,530
Series 2008-2	120,560	2038	4.0-5.0%	105,725
Series 2009-1	247,810	2039	3.0-5.0%	198,670
Series 2009-2	271,855	2039	6.423-6.573%	271,855
Series 2009-3	28,570	2039	5.283-6.173%	27,250
Series 2010-1	118,985	2020	5.0%	96,645
Series 2010-2	430,320	2040	3.8-5.45%	430,320
Series 2010-3	3,005	2040	5.75%	2,880
Series 2011-1	135,040	2034	variable	131,090
Series 2011-2	101,700	2034	variable	99,135
Series 2013-1	212,585	2043	2.00%-5.00%	212,585
Series 2013-2	71,790	2043	.43-2.686%	71,790
Series 2013-3	24,640	2043	4.0% - 5.0%	24,640
Series 2014-1	293,890	2045	3.0% - 5.0%	293,890
Series 2014-2	14,085	2020	.44%-2.1%	14,085
Series 2014-4	157,855	2026	.20% - 3.381%	157,855
				2,412,885
			Unamortized Bond Premium	64,807
			SUBTOTAL	2,477,692
University of Massachusetts HEFA/MDFA:				
2000 Series A	$ 20,000	2030	variable	20,000
2007 Series D	10,435	2031	3.5-4.25%	9,395
Series 2011	29,970	2034	2.5-4.0%	28,880
				58,275
			Unamortized Bond Premium	1,056
				59,331
WCCC HEFA/MDFA:				
Series 2005-D	$ 99,325	2029	5.0-5.25%	73,033
Series 2007-E	118,750	2036	3.5-5.0%	104,348
Series 2007-F	101,745	2036	4.0-5.0%	80,893
Series 2011	10,495	2023	2.0-5.0%	8,819
				267,093
			Unamortized Bond Premium	8,398
			SUBTOTAL	275,491
MDFA:				
Clean Renewable Energy Bonds	$ 1,625	2027	3.5%	1,243
			TOTAL	$ 2,813,757

Bond Payable activity for the year ended June 30, 2014 is summarized as follows (in thousands):

	Beginning Balance	Additions/ Amortization	Retirements/ Repayments	Ending Balance
University of Massachusetts Building Authority:				
Series 2003-1	$ 12,035	-	$ (5,880)	$ 6,155
Series 2004-A	6,715	-	(2,140)	4,575
Series 2004-1	24,500	-	(7,900)	16,600
Series 2005-1	8,020	-	(2,540)	5,480
Series 2005-2	180,195	-	(154,995)	25,200
Series 2006-2	2,760	-	(2,760)	-
Series 2008-A	22,795	-	(865)	21,930
Series 2008-1	201,655	-	(7,125)	194,530
Series 2008-2	108,300	-	(2,575)	105,725
Series 2009-1	216,870	-	(18,200)	198,670
Series 2009-2	271,855	-		271,855
Series 2009-3	27,715	-	(465)	27,250
Series 2010-1	107,950	-	(11,305)	96,645
Series 2010-2	430,320	-		430,320
Series 2010-3	2,925	-	(45)	2,880
Series 2011-1	132,450	-	(1,360)	131,090
Series 2011-2	100,020	-	(885)	99,135
Series 2013-1	212,585	-	-	212,585
Series 2013-2	71,790	-	-	71,790
Series 2013-3	-	24,640	-	24,640
Series 2014-1	-	293,890	-	293,890
Series 2014-2	-	14,085	-	14,085
Series 2014-4	-	157,855	-	157,855
Plus: unamortized bond premium	54,033	10,774	-	64,807
Subtotal	2,195,488	501,244	(219,040)	2,477,692
UMass HEFA/MDFA:				
2000 Series A	20,000	-	-	20,000
2007 Series D	9,750	-	(355)	9,395
Series 2011	29,810	-	(930)	28,880
Plus: unamortized bond premium	1,161	-	(105)	1,056
Subtotal	60,721		(1,390)	59,331
WCCC HEFA/MDFA:				
WCCC 2005 Series D	81,860	-	(8,826)	73,034
WCCC 2007 Series E	108,135	-	(3,787)	104,348
WCCC 2007 Series F	87,110	-	(6,217)	80,893
Series 2011	9,765	-	(946)	8,819
Plus: unamortized bond premium	8,889	-	(491)	8,398
Subtotal	295,759	-	(20,267)	275,492
MDFA: Clean Renewable Energy Bonds	1,338	-	(96)	1,242
Total	$ 2,553,306	$ 501,244	$ (240,793)	$ 2,813,757

Principal and interest, which is estimated using rates in effect at June 30, 2014, on bonds payable for the next five fiscal years and in subsequent five-year periods are as follows (in thousands):

Fiscal Year	Principal	Interest
2015	$ 87,321	$ 108,792
2016	92,261	105,353
2017	94,796	102,580
2018	95,381	99,603
2019	100,456	96,356
2020-2024	525,588	424,214
2025-2029	483,982	327,128
2030-2034	417,320	242,843
2035-2039	492,430	141,492
2040-2044	327,130	42,592
2045-2049	22,831	837
Total	$ 2,739,496	$ 1,691,790

Bond payable activity for the year ended June 30, 2013 is summarized as follows (in thousands):

	Beginning Balance	Additions/ Amortization	Retirements/ Repayments	Ending Balance
University of Massachusetts Building Authority:				
Series 2003-1	$ 17,665		$ (5,630)	$ 12,035
Series 2004-A	8,765		(2,050)	6,715
Series 2004-1	32,195		(7,695)	24,500
Series 2005-1	10,440		(2,420)	8,020
Series 2005-2	189,645		(9,450)	180,195
Series 2006-2	5,375		(2,615)	2,760
Series 2008-A	23,630		(835)	22,795
Series 2008-1	208,515		(6,860)	201,655
Series 2008-2	110,750		(2,450)	108,300
Series 2009-1	228,665		(11,795)	216,870
Series 2009-2	271,855			271,855
Series 2009-3	28,155		(440)	27,715
Series 2010-1	114,275		(6,325)	107,950
Series 2010-2	430,320			430,320
Series 2010-3	2,965		(40)	2,925
Series 2011-1	133,765		(1,315)	132,450
Series 2011-2	100,875		(855)	100,020
Series 2013-1		212,585		212,585
Series 2013-2		71,790		71,790
Plus: unamortized bond premium	35,946	19,376	(1,290)	54,032
Subtotal	1,953,801	303,751	(62,065)	2,195,487
UMass HEFA/MDFA:				
2000 Series A	20,000			20,000
2002 Series C	740		(740)	-
2007 Series D	10,090		(340)	9,750
Series 2011	29,970		(160)	29,810
Plus: unamortized bond premium	1,161		(49)	1,112
Subtotal	61,961		(1,289)	60,672
WCCC HEFA/MDFA:				
WCCC 2005 Series D	84,895		(3,035)	81,860
WCCC 2007 Series E	110,520		(2,385)	108,135
WCCC 2007 Series F	89,695		(2,585)	87,110
Series 2011	10,495		(730)	9,765
Plus: unamortized bond premium	9,381		(492)	8,889
Less: deferred loss on refunding	(12,129)	721		(11,408)
Subtotal	292,857	721	(9,227)	284,351
MDFA: Clean Renewable Energy Bonds	1,434		(96)	1,338
Total	$ 2,310,053	$ 304,472	$ (72,677)	$ 2,541,848

University of Massachusetts Building Authority

The bond agreements related to the Building Authority bonds generally provide that the net revenues of the Building Authority are pledged as collateral on the bonds and also provide for the establishment of bond reserve funds, bond funds, and maintenance reserve funds.

The University is obligated under its contracts for financial assistance, management and services with the Building Authority to collect rates, rents, fees and other charges with respect to such facilities sufficient to pay principal and interest on the Building Authority's bonds and certain other costs such as insurance on such facilities.

Pursuant to the authority given by the Building Authority's enabling act, the Commonwealth, acting by and through the Trustees of the University, has guaranteed the payment of principal and interest on the Building Authority's bonds. (The guarantee is a general obligation of the Commonwealth to which the full faith and credit of the Commonwealth are pledged. As is generally the case with other general obligations of the Commonwealth, funds with which to honor the guarantee, should it be called upon, will be provided by Commonwealth appropriation). The Building Authority's enabling act provides that the outstanding principal amount of notes and bonds of the Building Authority guaranteed by the Commonwealth cannot exceed $200 million. The amount of bond obligations guaranteed by the Commonwealth was $125.6 million and $129.5 million at June 30, 2014 and June 30, 2013, respectively.

When the Building Authority no longer has any bonds outstanding, its properties revert to the Commonwealth, and all its funds (other than funds pledged to bondholders) are required to be paid into the Treasury of the Commonwealth.

Variable Rate Bonds On April 23, 2013, the Authority entered into a standby bond purchase agreement with J.P. Morgan Chase Bank, N.A. ("J.P. Morgan") which requires J.P. Morgan to purchase bonds that are tendered and not remarketed. Under the terms of the J.P. Morgan standby bond purchase agreement, the Authority is required to pay J.P. Morgan in quarterly installments a facility fee in the amount of 25 basis points (or higher, under certain circumstances) of the commitment amount. Fees accrued by the Authority in connection with the J.P. Morgan agreement totaled $0.5 million and $0.1 million for the year ended June 30, 2014 and June 30, 2013, respectively. The agreement expires in April 2016 and may be extended if a mutual interest exists between both the Authority and J.P. Morgan. Previously, the 2008-1 bonds were supported with an irrevocable direct pay letter of credit (the "Lloyds LOC") issued by Lloyds TSB Bank PLC. Fees accrued by the Authority in connection with the Lloyds LOC totaled $0.5 million for the year ended June 30, 2013.

On April 16, 2013, the Authority entered into a standby bond purchase agreement with Barclays Bank PLC ("Barclays") which requires Barclays to purchase bonds that are tendered and not remarketed. Under the terms of the Barclays standby bond purchase agreement, the Authority is required to pay Barclays in quarterly installments a facility fee in the amount of 32.5 basis points (or higher, under certain circumstances) of the commitment amount. The agreement expires in April 2016 and may be extended if a mutual interest exists between both the Authority and Barclays. Fees accrued by the Authority in connection with the Barclays agreement totaled $0.1 million and $0.1 million for the year ended June 30, 2014 and June 30, 2013, respectively. Previously, the 2008-A bonds were supported by a standby bond purchase agreement with Bank of America, N.A. ("BofA"). Fees accrued by the Authority in connection with BofA standby bond purchase agreement totaled $24,800 for the year ended June 30, 2013.

The 2011-1 bonds are supported by a standby bond purchase agreement with Wells Fargo Bank, N.A. ("Wells") which requires Wells to purchase bonds tendered and not remarketed in an amount not to exceed the principal on the bonds plus accrued interest up to 185 days at an annual interest rate not to exceed 12 percent. The standby purchase agreement expired on June 9, 2014 and was extended until June 9, 2017. Under the agreement, the Authority was required to pay Wells in quarterly installments a facility fee in the amount of 40 basis points (or higher, under certain circumstances) of the initial commitment. The initial commitment under the agreement was set at $143.3 million and was subject to adjustment from time to time in accordance with the provisions of the agreement. Under the first amendment to the standby purchase agreement, the Authority is required to pay Wells in quarterly installments a facility fee in the amount of 25 basis points (or higher, under certain circumstances) of the initial commitment. The initial commitment under the first amendment to the standby purchase agreement was set at $139.1 million and is subject to adjustment from time to time in accordance with the provisions of the agreement. Fees accrued by the Authority in connection with the Wells agreement totaled $0.6 million and $0.7 million for the years ended June 30, 2014 and 2013, respectively.

Window Bonds In fiscal year 2011, the Authority issued its 2011-2 bonds in a variable rate Window Bond mode. As with the Authority's other variable rate bonds, the Window Bondholders can tender the bonds at any time. However, unlike the Authority's other variable rate bonds where the bondholders will receive payment on any tendered bonds 7 days from the tender, Window Bondholders are not required to receive funds for the tender until after a 30 day remarketing period and an additional 180 day funding window period. Due to this 210 day funding period, the Authority is not required to obtain any type of liquidity support for the 2011-2 bonds and the bonds are considered supported with self-liquidity. Window Bondholders receive an interest rate on the Window Bonds at a fixed spread over the Securities Industry and Financial Markets Association Municipal Swap Index™ ("SIFMA"). The initial spread to the SIFMA index is 9 basis points (.09%).

Bond Refundings In fiscal year 2014, the Authority refunded $5.4 million of its 2009-1 series bonds with 2013-3 series bonds. The Authority also refunded $146.2 million of its 2005-2 series bonds with 2014-4 series bonds. Accordingly, the Authority deposited into trust accounts funds sufficient to provide for all future debt service payments on the refunded bonds until the bonds are called. These advanced refunded bonds are considered defeased and, accordingly, the liability for the bonds payable and the assets held to repay the debt are not recorded in the Authority's financial statements.

In connection with the Authority's prior advanced refundings, the Authority recorded a difference between the reacquisition price and the net carrying amount of the refunded debt of approximately $84.5 million. This balance is being reported as a component of deferred outflows, loss on debt refunding, and will be amortized as an increase in interest expense over the remaining term of the original life of the refunded bonds. These refundings reduced the Authority's debt service payments in future years by approximately $36.9 million and resulted in an economic gain (the present value of the savings) of approximately $25.5 million.

Bond Premium and Issuance Expenses In connection with the Authority's bond issues, the Authority received premiums at issuance totaling approximately $109.7 million. The Authority amortizes the premiums received as a reduction in interest expense over the life of the respective bond issue.

In connection with the Authority's bond issues, the Authority incurred certain issuance costs associated with the bond offerings. In fiscal years 2014 and 2013 these costs amounted to $3.6 million and $2.2 million, respectively, and were expensed in accordance with the provisions of GASB Statement No 65.

Interest Rate Swaps The Authority uses derivative instruments to attempt to manage the impact of interest rate changes on its cash flows and net position by mitigating its exposure to certain market risks associated with operations, and does not use derivative instruments for trading or speculative purposes.

The Authority's contracts are evaluated pursuant to GASB Statement No. 53, *Accounting and Financial Reporting for Derivative Instruments* ("GASB No. 53") to determine whether they meet the definition of derivative instruments, and if so, whether they effectively hedge the expected cash flows associated with interest rate risk exposures. The Authority applies hedge accounting for derivative instruments that are deemed effective hedges and under GASB No. 53 are referred to as hedging derivative instruments. Under hedge accounting, the fair value of the hedging derivative instruments are reported as a deferred inflow or deferred outflow in the statement of net position until the contract is settled or terminated.

All settlement payments or receipts related to hedging derivative instruments are recorded as interest expense in the period settled.

The Authority's hedging derivative instruments at June 30, 2014 and 2013 were as follows:

	Fair Value June 30, 2013	Net Change in Fair Value	Fair Value June 30, 2014	Type of Hedge	Financial Statement Classification
Series 2008-1 Swap	$ (28,125)	$ 192	$ (27,933)	Cash Flow	Deferred outflow
Series 2008-A Swap	(3,232)	32	(3,200)	Cash Flow	Deferred outflow
Series 2006-1 Swap	(37,969)	259	(37,710)	Cash Flow	Deferred outflow
Total	$ (69,326)	$ 483	$ (68,843)		

The terms of the Authority's financial derivative instruments that were outstanding at June 30, 2014 are summarized in the table below:

	Type	Effective Date	Termination Date	Rate Authority Pays	Authority Receives	Original Notional Value
Series 2008-1 Swap	Synthetic Fixed	May 1, 2008	May 1, 2038	3.388%	70% of 1-Month LIBOR	$ 232,545
Series 2008-A Swap	Synthetic Fixed	Nov 13, 2008	May 1, 2038	3.378%	70% of 1-Month LIBOR	$ 26,580
Series 2006-1 Swap	Synthetic Fixed	Apr. 20, 2006	Nov. 1, 2034	3.482%	60% of 3-Month LIBOR + .18%	$ 243,830

Fair Values - The fair values of the swaps are estimated using the zero-coupon method. This method calculates the future net settlement payments required by the agreements, assuming the current forward rates implied by the yield curve correctly anticipate future spot interest rates. These payments are then discounted using the spot rate implied by the current yield curve for hypothetical zero-coupon bonds due on the date of each future net settlement on the agreements. As of June 30, 2014 and 2013, the Authority's swaps had a negative fair value of $68,800,000 and $69,300,000, respectively, and as such are presented as a deferred outflow.

Credit risk - As of June 30, 2014, the Authority was not exposed to credit risk on the swaps as the fair value was negative. Since changes in interest rates affect the fair values of swap agreements, it is possible that the swap agreements with negative fair values become positive which would expose the Authority to credit risk. To mitigate the potential for credit risk, when a counterparty has a positive fair value and if the counterparty's credit quality falls below A3/A/A, the fair value of the swap will be fully collateralized by the counterparty with U.S. Government Securities or U. S. Government Agency Securities. Collateral posted by the counterparty will be held by a third-party custodian.

The credit ratings for the Authority's counterparties at June 30, 2014 are as follows:

	Credit Ratings		
	Moody's	S & P	Fitch
UBS AG	A2	A	A
Deutsche Bank AG	A2	A	A+
Citi Bank NA	A2	A	A

Basis risk - The Authority is exposed to basis risk on its pay-fixed interest rate swaps because the variable-rate payment received by the Authority (a percent of LIBOR) on these hedging derivative instruments is based on indexes other than the actual interest rates the Authority pays on its hedged variable rate debt. Should the relationship between LIBOR and the actual variable rate interest payments on the bonds converge, the expected cost savings may not materialize. The terms of the related hedging fixed rate swap transactions are summarized in the chart above.

Termination risk - The Authority's swaps are governed under the International Swap Dealers Association Master Agreement (the "Master Agreement"), which includes standard termination events, such as failure to pay and bankruptcy. Additionally, the Master Agreement was amended so that the swap may be terminated by the Authority if the counterparty's credit quality rating falls below certain levels or the counterparty fails to have a rating. Further, the swap may be terminated by the counterparties if the long-term, unsecured, unenhanced senior debt rating of any bonds issued by the Authority is withdrawn, suspended or falls below certain levels or the Authority fails to have a rating. The Authority or the counterparties may terminate the swaps if the other party fails to perform under the terms of the contract. The Authority may also terminate the swaps at its option. If the swap is terminated, the variable-rate bonds would no longer carry a synthetic fixed interest rate and the Authority's interest payment will be based solely upon the rate required by the related bonds as issued. When a termination event occurs, a mark-to-market (or "fair market value") calculation is performed to determine whether the Authority is owed or must pay cash to close out the swap position. A negative fair value means the Authority would incur a loss and need to make a termination payment to settle the swap position. A positive fair value means the Authority would realize a gain and receive a termination payment in settlement of the swap position.

Contingencies - All of the Authority's swaps include provisions that require the Authority to post collateral in the event its credit rating falls below certain levels. In the event the Authority is rated A2 by Moody's Investors Service or A by Standard & Poor's, the Authority would need to post collateral equal to amounts above the fair value of its swaps in liability positions above $10,000,000. In the event the Authority is not rated or rated below A3 by Moody's Investors Service or below A- by Standard & Poor's, the Authority must post collateral in the amount of the fair value of the swaps in liability positions. The collateral posted is to be in the form of cash obligations guaranteed by the U.S. Treasury, or negotiable debt obligations issued by the Federal Home Loan Mortgage Association or the Federal National Mortgage Association. If the Authority does not post collateral, the derivative instrument may be terminated by the counterparty. The University's credit rating is Aa2 from Moody's Investors Service, AA from Fitch Ratings, and AA- from Standard and Poor's at June 30, 2014; therefore, no collateral has been posted.

Termination of Hedge Accounting - In June of 2011, the Authority undertook an advance refunding of the 2008-3 and 2008-4 variable rate bonds hedged by the Series 2006-1 Swap. As part of the refunding, the Series 2006-1 swap was re-assigned to a new underlying notional (the 2011-1 and 2011-2 Bonds) with identical terms. This refunding and reassignment effectively terminated the original hedge. At June 30, 2011, the Series 2006-1 Swap was considered a hedging derivative instrument. In accordance with GASB No. 53, at the time of a termination event related to an advance refunding of the hedged debt, the balance of the amounts in deferred outflows is to be included in the net carrying amount of the refunded debt for the purposes of calculating the deferred loss on refunding. The balance of the deferred outflows that was included in the net carrying amount of the refunded debt at the time of the refunding was $22,200,000. The change in fair value of the Series 2006-1 Swap from the refunding date to June 30, 2014 is reported as a deferred outflow as the swap was determined to be effective at June 30, 2014.

Swap payments and associated debt. Using rates as of June 30, 2014, the debt service requirements of the variable-rate debt and net swap payments, assuming current interest rates remain the same for their term, were as follows:

Fiscal Year Ending June 30,	Principal	Interest	Interest Rate Swaps, Net	Total
2015	$ 10,430	$ 381	$ 14,251	$ 25,062
2016	10,845	374	13,932	25,151
2017	11,625	365	13,536	25,526
2018	11,770	358	13,182	25,310
2019	12,215	349	12,800	25,364
2020-2024	139,770	1,465	53,568	194,803
2025-2029	149,550	767	29,068	179,385
2030-2034	90,205	212	8,344	98,761
2035-2039	9,570	8	361	9,939
Total	$ 445,980	$ 4,279	$ 159,042	$ 609,301

As actual rates vary, variable-rate bond interest payments and net swap payments will vary.

MassDevelopment

Effective October 1, 2010, Massachusetts Health and Educational Facilities Authority ("MHEFA") was merged into the Massachusetts Development Finance Agency ("MassDevelopment"), a body politic and corporate and a public instrumentality of The Commonwealth of Massachusetts. As of such date, MHEFA has dissolved and all of its rights, powers and duties, and properties were exercised and performed by MassDevelopment and any and all obligations and liabilities of MHEFA have become obligations and liabilities of MassDevelopment.

University of Massachusetts Series A, D and 2011

The University, through MassDevelopment, has issued bonds in order to construct new student centers on the Boston and Lowell campuses; to create a pool of funds to acquire telecommunications, electronics, computer, office, research, equipment and administrative systems; and to fund the related renovation costs and to refund previously issued bonds.

Variable Rate Debt In March 2000, the University issued $40.0 million of MHEFA Variable Rate Demand Revenue Bonds, University of Massachusetts Issue, Series A (the "Series A Bonds") to create a pool of funds from which the University could finance and refinance the acquisition of certain equipment and related renovation costs at the various University campuses on a revolving basis throughout the term of the Series A Bonds. The Series A Bonds were remarketed on April 1, 2013 and now bear interest at the long term rate of 0.70%. The newest long term rate period will end on March 31, 2016 and the Remarketed Series A Bonds will be subject to mandatory tender for purchase on April 1, 2016. The purchase price of the bonds will be paid from the remarketing of such bonds. However, if the remarketing proceeds are insufficient, the University will be obligated to purchase the bonds tendered, up to an aggregate principal amount of $20.0 million. The Remarketed Series A Bonds will mature on November 1, 2030 and are subject to mandatory purchase prior to maturity as described above. Interest on the Remarketed Series A Bonds in the newest long-term rate period is payable on October 1 and April 1. The Remarketed Series A Bonds are considered a reissuance for federal tax purposes. The Remarketed Series A Bonds are not supported by any insurance policy, liquidity facility or other credit enhancement. The Remarketed Series A Bonds are a general obligation of the University payable from all funds of the University permitted to be applied thereto. The University's unrestricted net assets, previously referred to as the expendable fund balance, secure the obligations of the University with respect to the Remarketed Series A Bonds. The University is required to certify annually that there are sufficient funds in the unrestricted net assets to cover the debt service on the Remarketed Series A Bonds. At June 30, 2014 and 2013, the outstanding principal balance on the Bonds is $20.0 million.

Debt covenants The University of Massachusetts Series A, D, and 2011 bonds include a covenant for the maintenance of a debt service fund as outlined in the related debt agreement. The University is required to make deposits in this debt service fund on or before the twenty-fifth day of each March and September.

Refundings In November 2011, the University issued $30.0 million of Massachusetts Development Finance Agency Revenue Refunding Bonds (the "Series 2011 Bonds"). The University deposited the proceeds into an irrevocable trust fund to provide for payment of the MHEFA Revenue Bonds, University of Massachusetts Issue, 2002 Series C (the "Series C Bonds"). This payment was made as a lump sum in October 2012. The Series 2011 bonds were issued at a premium of $1.2 million. These bonds bear interest at various fixed rates ranging from 2.5% to 4.0% and mature on October 1, 2034. At June 30, 2014, the aggregate principal payments outstanding on these bonds were $28.8 million. As a result of the change in future payments, the University will reduce its aggregate debt service payments by approximately $4.8 million and achieve an economic gain of $3.4 million.

In January 2007, the University issued $10.4 million of MHEFA Revenue Bonds, University of Massachusetts Issue Series D. The proceeds from this issuance were used to advance refund a portion of the MHEFA Revenue Bonds, University of Massachusetts Issue, 2001 Series B (the "Series B Bonds"). These advance refunded bonds were defeased, and accordingly, the liability for the bonds payable and the assets held to repay the debt have not been included in the University's financial statements.

Worcester City Campus Corporation Series D, E, F and 2011

The Worcester City Campus Corporation (WCCC) through MassDevelopment has issued bonds to finance the construction or acquisition of the Lazare Research Building, South Road parking garage, Ambulatory Care Center ("ACC"), two buildings housing the operations of MassBiologics, Two Biotech Park, and to refund previously issued bonds.

Refundings In November 2011, WCCC issued $10.5 million of Massachusetts Development Finance Agency Revenue Refunding Bonds (the "WCCC Series 2011 Bonds"). The WCCC Series 2011 Bonds were issued at a premium of $1.1 million. These bonds bear interest at various fixed rates ranging from 2.00% to 5.00% and mature October 1, 2023. At June 30, 2014 and 2013, the aggregate principal payments outstanding on these bonds were $9.0 million and $9.8 million, respectively. The proceeds of the WCCC Series 2011 Bonds were used to refund the remaining outstanding portion of the MHEFA Revenue Bonds, WCCC Issue (University of Massachusetts Project), 2001 Series B (the "WCCC Series B Bonds"), which were used to finance the construction of a parking garage and the acquisition and installation of equipment at the Lazare Research Building.

In January 2007, WCCC issued $118.8 million of MHEFA Revenue Bonds, WCCC Issue (University of Massachusetts Project), 2007 Series E (the "Series E Bonds"). The Series E Bonds were issued at a premium of $3.9 million. The Corporation deposited $32.4 million of the proceeds into an irrevocable trust fund to provide for partial advanced refunding of outstanding MHEFA WCCC Series B Revenue Bonds. In accordance with the applicable guidance, a portion of the WCCC Series B Bonds totaling $30.8 million and the related irrevocable trust has been derecognized by the Corporation. At June 30, 2014 and June 30, 2013, the aggregate principal payments outstanding on the Series E Bonds were $105.7 million and $108.1 million, respectively.

In January 2007, WCCC issued $101.7 million of MHEFA Revenue Bonds, WCCC Issue (University of Massachusetts Project), 2007 Series F (the "Series F Bonds"). The Series F Bonds were issued at a premium of $2.8 million. These bonds bear interest at various fixed rates ranging from 4.00% to 5.00% and mature October 1, 2036. At June 30, 2014 and June 30, 2013, the aggregate principal payments outstanding on this portion of the Series F Bonds were $29.1 million and $29.8 million, respectively. The remaining portion of the bonds bear interest at various fixed rates ranging from 4.00% to 4.50% and mature October 1, 2031. At June 30, 2014 and 2013, the aggregate principal payments outstanding on this portion of the Series F Bonds were $55.3 million and $57.4 million, respectively.

In April 2005, WCCC issued $99.3 million of MHEFA Revenue Bonds, WCCC Issue (University of Massachusetts Project), 2005 Series D (the "WCCC Series D Bonds"). The Corporation deposited the proceeds into an irrevocable trust fund to provide for payment of the MHEFA Revenue Bonds, WCCC Issue (University of Massachusetts Project), 2000 Series A (the "WCCC Series A Bonds"). In accordance with the applicable guidance, the WCCC Series A Bonds and the related irrevocable trust were derecognized by the Corporation. These bonds bear interest at various fixed rates ranging from 3.00% to 5.25% per year and mature October 1, 2029. The WCCC Series D Bonds were issued at a premium of $4.1 million. At June 30, 2014 and 2013, the aggregate principal payment outstanding on the WCCC Series D Bonds was $78.7 million and $81.9 million, respectively. The proceeds from the WCCC Series A Bonds were previously used to fund the construction of the Lazare Research Building.

These advanced refunded bonds are considered defeased and, accordingly, the liability for the bonds payable and the assets held to repay the debt have not been included in the University's financial statements.

Pledged Revenues WCCC is obligated under the terms of indebtedness to make debt service payments from revenues received from certain facility leases. Total applicable pledged revenues were $6.6 million for fiscal years 2014 and 2013, respectively.

Clean Renewable Energy Bonds

During 2011, the University entered into an Energy Services agreement for Solar Panel construction with the Commonwealth's Division of Capital Asset Management and Century Bank and Trust Company. The financing arrangement includes $1.6 million in Clean Renewable Energy Bonds as of June 30, 2014 and 2013.

9. LEASES

The University leases certain equipment and facilities under operating leases with terms exceeding one year, which are cancelable at the University's option with 30 days notice. The rent expense related to these operating leases amounted to approximately $22.1 million and $16.8 million for the years ended June 30, 2014 and 2013, respectively. The master leases primarily consist of telecommunications, software, and co-generation systems. The University also leases space to third party tenants. During 2014 and 2013, the amount reported as rental income was $21.0 million and $17.7 million, respectively.

The following presents a schedule of future minimum payments under capital and non-cancelable operating leases and a schedule of principal and interest payments on capital lease obligations for the next five years and in subsequent five-year periods for the University as of June 30, 2014 (in thousands):

	University Capital Leases			
Year	Master Leases	Other Leases	Total	Operating Leases
2015	2,186	86	2,272	14,700
2016	-	-	-	15,657
2017	-	-	-	13,725
2018				12,326
2019 and thereafter	-	-	-	130,142
Total Payments	2,186	86	2,272	$186,550
Less: Amount representing interest	(38)	(2)	(40)	
Present Value of Minimum Lease Payments	$2,148	$84	$2,232	

June 30, 2014	University Capital Lease Obligations	
Year	Principal	Interest
2015	$2,232	$40
2016		
Total Payments	$2,232	$40

10. OTHER LONG-TERM LIABILITIES

During the year ended June 30, 2014 the following changes occurred in long-term liabilities as recorded in the statements of net position (in thousands):

	Beginning Balance	Additions/ Adjustments	Reductions/ Adjustments	Ending Balance
University:				
Capital lease obligations	$2,238	-	($2,238)	-
Compensated absences	30,410	1,369	-	31,779
Workers' compensation	10,429	382	-	10,811
Unearned revenues and credits	20,199	10,542	(9,498)	21,243
Advances and deposits	27,943	694	(543)	28,094
Other Liabilities	41,532	5,312	(3,581)	43,263
University Related Organization:				
Other Liabilities	$3,332	$ 151	-	$3,483

During the year ended June 30, 2013 the following changes occurred in long-term liabilities as recorded in the statement of net position (in thousands):

	Beginning Balance	Additions/ Adjustments	Reductions/ Adjustments	Ending Balance
University:				
Capital lease obligations	$6,539	$ -	($4,301)	$2,238
Compensated absences	30,820	-	(410)	30,410
Workers' compensation	9,805	624	-	10,429
Unearned revenues and credits	16,501	10,354	(6,656)	20,199
Advances and deposits	26,698	1,486	(241)	27,943
Other Liabilities	18,993	23,184	(645)	41,532
University Related Organization:				
Other Liabilities	$3,487	$ -	($155)	$3,332

11. FRINGE BENEFITS

Expenditures for the years ended June 30, 2014 and 2013 include $244.6 million and $229.5 million, respectively, for the employer portion of fringe benefit costs (pension expense, health insurance for active employees and retirees, and unemployment compensation) that was paid directly by the Commonwealth of Massachusetts. Of this amount, $102.8 million for 2014 and $99.5 million for 2013 was reimbursed to the Commonwealth and $141.9 million and $130.0 million, respectively, is included in revenue as state appropriations.

12. MEDICAL SCHOOL LEARNING CONTRACTS

The University's Medical School enters into learning contracts with certain medical students. These contracts give students the option of deferring a portion of their tuition until after residency training, and canceling all or a portion of their tuition if they practice primary care medicine for two or four full years (depending on conditions) in the Commonwealth. The University does not record as revenue the portion of tuition deferred under these learning contracts until actual cash repayments are received. The cumulative amount granted under such learning contracts plus accrued interest totaled $68.6 million and $66.3 million at June 30, 2014 and 2013, respectively. Cumulative repayments totaled approximately $51.2 million and $48.8 million as of June 30, 2014 and 2013, respectively.

13. RETIREMENT PLANS

The Commonwealth of Massachusetts is statutorily responsible for the pension benefit of University employees who participate in the Massachusetts State Employees' Retirement System ("MSERS"). MSERS, a single employer defined benefit public employee retirement system, is administered by the Massachusetts State Retirement Board and covers substantially all non-student employees. Massachusetts General Laws establish the benefit and contribution requirements. These requirements provide for a superannuation retirement allowance benefit up to a maximum of 80% of the average of a member's highest consecutive three years of regular compensation, if membership started before April 2, 2012, or of the average of a member's highest consecutive five years of regular compensation, if membership started after April 2, 2012. Benefit payments are based upon a member's age, length of creditable service, and group creditable service and group classification. The authority for amending these provisions rests with the Legislature. Members become vested after ten years of creditable service. A superannuation retirement allowance may be received upon the completion of twenty years of service (at any age), or upon reaching the age of 55 with 10 years of service, if membership started before April 2, 2012, or upon reaching age 60 with ten years of service, if membership started on or after April 2, 2012. Members contribute 5%, 7%, 8% and 9% of regular compensation for membership start dates prior to January 1, 1975, from January 1, 1975 to December 31, 1983, from January 1, 1984 to June 30, 1996 and on or after July 1, 1996, respectively. Employees whose membership began on or after January 1,1979 also contribute an additional 2% of regular compensation in excess of $30,000.

The University makes contributions on behalf of the employees through a fringe benefit charge assessed by the Commonwealth. Such pension expense amounted to approximately $ 63.6 million and $52.2 million for the years ended June 30, 2014 and 2013, respectively. Annual covered payroll approximated 76.4% and 75.4% for the years ended June 30, 2014 and 2013, respectively of annual total payroll for the University. SERS does not issue stand-alone financial statements; however, SERS financial information is contained in the Commonwealth Comprehensive Annual Financial Report and can be obtained by contacting the State Comptroller, One Ashburton Place, 9th Floor, Boston, MA 02108.

Non-vested faculty and certain other employees of the University can opt out of MSERS and participate in a defined contribution plan, the Massachusetts Optional Retirement Program ("ORP"), administered by the Commonwealth's Department of Higher Education. At June 30, 2014 and 2013, there were approximately 4,031 and 4,433 University employees, respectively participating in ORP. Employees contribute at the same rate as members in SERS do and the Commonwealth matches 5% of employee contributions. The Commonwealth contributed $8.9 million and $8.7 million in 2014 and 2013, respectively. University employees contributed $28.0 million and $20.6 million in 2014 and 2013, respectively.

The MSERS and ORP retirement contributions of employees who become members of MSERS or ORP after January 1, 2011 are subject to a state compensation limit. Effective January 1, 2011, the University established a defined contribution plan, the University of Massachusetts 401(a) Retirement Gap Plan ("the Gap Plan"), administered by the University's Treasury Office.

Employees with MSERS or ORP membership dates after January 1, 2011 are eligible employees for the Gap Plan. Eligible employees begin participation in the Gap Plan when their regular compensation exceeds the state compensation limit in effect for the plan year, at which point their contributions to MSERS or ORP are required to stop for the remainder of the plan year. Employee contributions to the Gap Plan are mandatory and at the same rate as MSERS and ORP; the University contributes 5%. At June 30, 2014 plan assets totaled approximately $506,000.

14. CONCENTRATION OF CREDIT RISK (Other than Cash and Investments)

The financial instrument that potentially subjects the University to concentrations of credit risk is the receivable from UMass Memorial Medical Center (UMMMC) which is uncollateralized. The receivable from UMass Memorial represents 12.2% and 4.4% of total accounts receivable for the University at June 30, 2014 and 2013, respectively. The University also had uncollateralized receivables from three other organizations comprising approximately 4.8%, 6.5% and 6.0% of the total outstanding receivables at June 30, 2014 and 5.8%, 5.5% and 5.7% of the total outstanding receivables at June 30, 2013.

15. COMMITMENTS AND CONTINGENCIES

The Building Authority, University, and WCCC have outstanding purchase commitments under construction contracts and real estate agreements in amounts aggregating approximately $148.2 million and $171.1 million at June 30, 2014 and 2013, respectively. In connection with the investments in certain limited partnership agreements, the Foundation has $22.4 million and $26.5 million in committed calls as of June 30, 2014 and 2013, respectively, which are scheduled to be funded over a number of years. The University has entered an Energy Performance Contract that is being managed by the Commonwealth's Division of Capital Asset Management (DCAM) under its Clean Energy Investment Program. This project includes 32 energy conservation measures. The installation costs will be incurred over 2 phases with Phase 1 being approximately $18.0 million and Phase 2 being approximately $13.5 million. The term of these transactions is 20 years. The University has a commitment to the Commonwealth for Clean Energy Investment Program Funds used through June 30, 2014 and 2013 in the amount of $29.7 million and $30.2 million, respectively.

The University, as an agency of the Commonwealth, is self-insured for property loss exposure, subject to appropriation from the state legislature. However, properties owned by the University of Massachusetts Building Authority located on a campus of the University, such as the Mullins Center, dining commons, and most dormitories, are insured by the Building Authority. In addition, certain properties owned by other University Related Organizations and leased to the University are insured by the related organization. The University and its employees are protected against tort claims through sovereign immunity under Chapter 258 of the Massachusetts General Laws. The University maintains certain liability insurance policies, including Commercial General Liability, leased Automotive Liability, Directors and Officers and Comprehensive Crime policies. Employees of the University are covered for Worker's Compensation protection under Chapter 152 of the Massachusetts General Laws. The University has recorded a liability for future expected costs of its workers' compensation claims of approximately $15.1 million as of June 30, 2014 and $14.6 million as of June 30, 2013. Estimated future payments related to such costs have been discounted at a rate of 4.0%.

The University is a defendant in various lawsuits and is subject to various contractual matters; however, University management is of the opinion that the ultimate outcome of all litigation or potential contractual obligations will not have a material effect on the financial position, financial results or cash flows of the University.

From time to time the University and/or its affiliated organizations are subject to audits of programs that are funded through either federal and/or state agencies. The University is aware that the Office of the Inspector General for the U.S. Department of Health and Human Services performed an audit of Medicaid Supplemental Revenues ("MSR") received by UMMMC, the final report for which was issued December 2009. Portions of this report continue to be contested and the final outcome of this audit is currently unknown. Dependent on the final outcome, UMMMC may be required to repay any MSR received deemed to be disallowed as a result of the audit. Dependent on that outcome, the University, consistent with the Agreement for Medical Educational Services, made part of the Definitive Agreement between the University and UMMMC, and its subsequent amendments and the indemnification provisions in these Agreements, may be required to indemnify UMMMC for a portion of any amounts due. Although the final outcome of this audit is currently unknown, and management believes that as of the date of the financial statements it is not probable that a liability exists, management concludes it is reasonably possible that amounts could be repaid and that those amounts may be material to the University's financial position and results of operations.

Five Universities in the Commonwealth of Massachusetts jointly formed the Massachusetts Green High Performance Computing Center, Inc. (MGHPCC) and MGHPCC Holyoke, Inc. in May 2010 and April 2012, respectively, to construct and operate a research computing center located in Holyoke, Massachusetts. MGHPCC and MGHPCC Holyoke, Inc. are tax-exempt organizations under Internal Revenue Code section 501(c) (3). Each respective university agreed to contribute $10.0 million and as of June 30, 2013, each university had contributed the required amounts. The University's unamortized $8.0 million investment is included in its Statement of Financial Position within Other Assets.

16. SUBSEQUENT EVENTS

On July 3, 2014, the Authority issued its $67.4 million Refunding Revenue Bonds, Senior Series 2014-3 (the "2014-3 bonds"). The 2014-3 bonds were issued to refinance the University's Worcester City Campus Corporation 2005-Series D bonds and to pay costs of issuing the 2014-3 bonds. The 2014-3 bonds are due (serially) through 2030 and the interest rate ranges from 2.0% to 5.0%.

On July 8, 2014, the Authority extended $25.0 million of Series 2013-A commercial paper and issued an additional $15.0 million of Series 2013-A commercial paper. The Authority also extended $25.0 million of Series 2013-B commercial paper and issued an additional $10.0 million of Series B commercial paper.

On July 17, 2014, the Authority entered into a lease, as lessee, with One Beacon Street Limited Partnership, as lessor, for space at One Beacon Street, Boston, Massachusetts to be used primarily as office space by the Authority, the UMASS Club and the University. The lease begins July 15, 2015 and ends December 31, 2030.

For purposes of determining the effects of subsequent events on these financial statements, management has evaluated events subsequent to June 30, 2014 and through December 18, 2014, the date on which the financial statements were available to be issued.

REDACTED FOR PUBLIC RELEASE

University of Massachusetts
2014 Annual Financial Report
Supplemental Financial Information
Table of Contents

REDACTED FOR PUBLIC RELEASE

Grant Thornton

REPORT OF INDEPENDENT CERTIFIED PUBLIC ACCOUNTANTS

Grant Thornton LLP
75 State Street, 13th Floor
Boston, MA 02109-1827

T 617.723.7900
F 617.723 3640
www.GrantThornton.com

Board of Trustees of the
University of Massachusetts

Report on the financial statements

We have audited, in accordance with auditing standards generally accepted in the United States of America and the standards applicable to financial statement audits contained in *Government Auditing Standards* issued by the Comptroller of the United States, the business-type activities and the aggregate discretely presented component units of the University of Massachusetts (the "University"), an enterprise fund of the Commonwealth of Massachusetts, as of and for the years ended June 30, 2014 and 2013, and our report thereon dated December 18, 2014 expressed an unmodified opinion on these basic consolidated financial statements as a whole.

The accompanying supplementary schedules of Supplemental Financial Information for University campuses and University related organizations is presented for purposes of additional analysis and is not a required part of the basic consolidated financial statements. Such supplementary information is the responsibility of management and was derived from and relates directly to the underlying accounting and other records used to prepare the basic consolidated financial statements. The information has been subjected to the auditing procedures applied in the audits of the basic consolidate financial statement and certain additional procedures. These additional procedures included comparing and reconciling information directly to the underlying accounting and other records used to prepare the basic consolidated financial statements or to the basic consolidated financial statement themselves, and other additional procedures in accordance with auditing standards generally accepted in the United States of America. In our opinion, the supplementary information is fairly stated, in all material respects, in relation to the basic consolidated financial statements as a whole.

Grant Thornton LLP

Boston, Massachusetts
December 18, 2014

University of Massachusetts
CENTRAL ADMINISTRATION
Statements of Net Position
As of June 30, 2014 and 2013
(in thousands of dollars)

	June 30, 2014	June 30, 2013 (adjusted)
ASSETS		
Current Assets		
Cash and Cash Equivalents	$10,717	$13,554
Cash Held By State Treasurer	3,297	542
Accounts, Grants and Loans Receivable, net	2,487	2,996
Short Term Investments	46,347	41,890
Due From Other Campuses	207	500
Other Assets	3,964	4,268
Total Current Assets	67,019	63,750
Noncurrent Assets		
Cash and Securities Held By Trustees	29,940	44,470
Cash Held By State Treasurer	1,904	
Investments	121,329	121,082
Other Assets	7,120	8,129
Investment In Plant, net	91,930	54,762
Total Noncurrent Assets	252,223	228,443
Total Assets	$319,242	$292,193
DEFERRED OUTFLOWS OF RESOURCES		
Loss on Debt Refinancing	$482	$5,134
LIABILITIES		
Current Liabilities		
Accounts Payable	$10,011	$7,125
Accrued Salaries and Wages	1,748	1,566
Accrued Compensated Absences	4,332	3,991
Accrued Interest Payable	597	453
Bonds Payable		16,770
Due To Campuses	46,748	50,290
Due To Related Organizations	400	539
Unearned Revenues and Credits	1,634	1,243
Advances and Deposits	710	942
Other Liabilities	5,671	3,609
Total Current Liabilities	71,851	86,528
Noncurrent Liabilities		
Accrued Compensated Absences	553	475
Bonds Payable	80,712	56,488
Unearned Revenues and Credits	62	5
Other Liabilities	10,446	5,134
Total Noncurrent Liabilities	91,773	62,102
Total Liabilities	$163,624	$148,630
Net Position:		
Invested in Capital Assets Net of Related Debt	$15,953	$20,312
Restricted		
Nonexpendable	1,606	2,206
Expendable	31,302	24,372
Unrestricted	107,239	101,807
Total Net Position	$156,100	$148,697

University of Massachusetts
CENTRAL ADMINISTRATION
Statements of Revenues, Expenses and Changes in Net Position
For The Years Ended June 30, 2014 and 2013
(in thousands of dollars)

	June 30, 2014	June 30, 2013 (adjusted)
REVENUES		
Operating Revenues		
Tuition and Fees	$6,330	$7,024
Federal Grants and Contracts	4,172	2,450
State Grants and Contracts	4,615	2,983
Local Grants and Contracts	119	173
Private Grants and Contracts	3,174	3,691
Sales and Service, Educational	2,067	2,023
Allocation from Campuses	68,831	60,710
Other Operating Revenues:		
Other	3,874	8,772
Total Operating Revenues	**93,182**	**87,826**
EXPENSES		
Operating Expenses		
Educational and General		
Instruction	10,414	12,507
Research	5,159	3,084
Public Service	2,823	1,144
Institutional Support	61,850	60,064
Operation and Maintenance of Plant	449	6,288
Scolarships and Fellowships	6	6
Depreciation and Amortization	5,987	5,641
Total Operating Expenses	**86,688**	**88,734**
Operating Income/(Loss)	**6,494**	**(908)**
NONOPERATING REVENUES/(EXPENSES)		
State Appropriations		10,847
Investment Return	8,310	4,760
Endowment Return	233	224
Interest on Indebtedness	(103)	(680)
Other Nonoperating Income	32	345
Net Nonoperating Revenues	**8,472**	**15,496**
Income Before Other Revenues, Expenses, Gains, and Losses	**14,966**	**14,588**
OTHER REVENUES, EXPENSES, GAINS, AND LOSSES		
Capital Appropriations	5,200	
Other Additions/(Deductions)	(12,764)	1,327
Total Other Revenues, Expenses, Gains, and Losses	**(7,564)**	**1,327**
Total Increase in Net Position	**7,402**	**15,915**
NET POSITION		
Net Position at Beginning of Year, as reported	148,698	133,049
Cummulative effect of change in accounting principle		(266)
Net Position at Beginning of Year, as adjusted	148,698	132,783
Net Position at End of Year	**156,100**	**148,698**

REDACTED FOR PUBLIC RELEASE

University of Massachusetts
AMHERST CAMPUS
Statements of Net Position
As of June 30, 2014 and 2013
(in thousands of dollars)

	June 30, 2014	June 30, 2013 (adjusted)
ASSETS		
Current Assets		
Cash and Cash Equivalents	$28,998	$27,226
Cash Held By State Treasurer	10,920	11,299
Accounts, Grants and Loans Receivable, net	45,219	36,083
Pledges Receivable, net	2,090	1,761
Short Term Investments	68,440	57,465
Inventories, net	4,651	5,196
Due From Other Campuses	21,511	23,276
Other Assets	501	605
Total Current Assets	182,330	162,911
Noncurrent Assets		
Cash Held By State Treasurer	1,508	4,738
Cash and Securities Held By Trustees	155,484	155,081
Accounts, Grants and Loans Receivable, net	18,904	18,852
Pledges Receivable,net	3,481	2,318
Investments	276,025	249,222
Other Assets		5
Investment In Plant, net	1,605,787	1,472,369
Total Noncurrent Assets	2,061,189	1,902,585
Total Assets	$2,243,519	$2,065,496
DEFERRED OUTFLOWS OF RESOURCES		
Deferred Change in Fair Value of Interest Rate Swaps	$28,199	$27,820
Loss on Debt Refunding	38,242	36,565
Total Deferred Outflows of Resources	$ 66,441	$ 64,385
LIABILITIES		
Current Liabilities		
Accounts Payable	$44,759	$51,032
Accrued Salaries and Wages	44,575	42,386
Accrued Compensated Absences	24,713	24,305
Accrued Workers' Compensation	1,927	2,020
Accrued Interest Payable	5,709	6,501
Bonds Payable	84,950	147,295
Accelerated variable rate debt, current	16,300	
Capital Lease Obligations	2,148	4,184
Unearned Revenues and Credits	14,035	13,426
Advances and Deposits	1,149	690
Other Liabilities	6,666	8,034
Total Current Liabilities	246,931	299,873
Noncurrent Liabilities		
Accrued Compensated Absences	12,345	11,876
Accrued Workers' Compensation	4,787	5,017
Bonds Payable	789,293	667,466
Deriva ive Instrument , Interest Rate Swap	41,552	41,838
Capital Lease Obligations		2,148
Unearned Revenues and Credits	11,827	11,307
Advances and Deposits	13,386	13,348
Total Noncurrent Liabilities	873,190	753,000
Total Liabilities	$1,120,121	$1,052,873
Net Position:		
Invested in Capital Assets Net of Related Debt	$851,475	$777,589
Restricted		
Nonexpendable	3,973	3,971
Expendable	52,821	48,526
Unrestricted	281,570	246,922
Total Net Position	$1,189,839	$1,077,008

REDACTED FOR PUBLIC RELEASE

REDACTED FOR PUBLIC RELEASE

University of Massachusetts
AMHERST CAMPUS
Statements of Revenues, Expenses and Changes in Net Position
As of June 30, 2014 and 2013
(in thousands of dollars)

	June 30, 2014	June 30, 2013 (adjusted)
REVENUES		
Operating Revenues		
Tuition and Fees (net of scholarship allowances of $ 95,477 at June 30, 2014 and $89,345 at June 30, 2013)	$337,767	$323,331
Federal Grants and Contracts	98,157	97,930
State Grants and Contracts	15,753	12,734
Local Grants and Contracts	346	316
Private Grants and Contracts	30,950	30,547
Sales and Service, Educational	8,089	8,615
Auxiliary Enterprises	214,759	195,577
Other Operating Revenues:		
Other	16,137	19,225
Total Operating Revenues	**721,958**	**688,275**
EXPENSES		
Operating Expenses		
Educational and General		
Instruction	312,844	294,707
Research	108,825	103,727
Public Service	26,140	24,882
Academic Support	58,108	56,305
Student Services	52,163	49,763
Institutional Support	64,305	59,033
Operation and Maintenance of Plant	84,162	77,610
Depreciation and Amortization	82,687	71,594
Scholarships and Fellowships	20,991	22,115
Auxiliary Enterprises	174,666	164,212
Total Operating Expenses	**984,891**	**923,948**
Operating Loss	**(262,933)**	**(235,673)**
NONOPERATING REVENUES/(EXPENSES)		
Federal Appropriations	7,020	6,774
State Appropriations	272,676	241,423
Gifts	16,139	13,950
Investment Return	29,868	19,471
Endowment Return	8,424	6,258
Interest on Indebtedness	(25,609)	(25,427)
Nonoperating Federal Grants	25,338	23,867
Other Nonoperating Income	(2)	(477)
Net Nonoperating Revenues	**333,854**	**285,839**
Income Before Other Revenues, Expenses, Gains, and Losses	**70,921**	**50,166**
OTHER REVENUES, EXPENSES, GAINS, AND LOSSES		
Capital Appropriations	46,191	52,934
Capital Grants and Contracts	8,473	3,226
Disposal of Plant Facilities	(4,053)	(3,978)
Other Additions/(Deductions)	(8,701)	(2,718)
Total Other Revenues, Expenses, Gains, and Losses	**41,910**	**49,464**
Total Increase in Net Position	**112,831**	**99,630**
NET POSITION		
Net Position at Beginning of Year, as reported	1,077,008	983,791
Cummulative effect of change in accounting principle		(6,413)
Net Position at the Beginning of the Year, as adjusted	1,077,008	977,378
Net Position at End of Year	**$1,189,839**	**$1,077,008**

REDACTED FOR PUBLIC RELEASE

REDACTED FOR PUBLIC RELEASE

University of Massachusetts
BOSTON CAMPUS
Statements of Net Position
As of June 30, 2014 and 2013
(in thousands of dollars)

	June 30, 2014	June 30, 2013 (adjusted)
ASSETS		
Current Assets		
Cash and Cash Equivalents	$5,308	$7,951
Cash Held By State Treasurer	3,817	3,649
Accounts, Grants and Loans Receivable, net	24,323	22,803
Pledges Receivable, net	684	331
Short Term Investments	24,648	23,983
Inventories, net	811	766
Due From Other Campuses	4,900	5,617
Other Assets	194	298
Total Current Assets	64,685	65,398
Noncurrent Assets		
Cash Held By State Treasurer	1,377	885
Cash and Securities Held By Trustees	349,620	302,781
Accounts, Grants and Loans Receivable, net	8,321	7,696
Pledges Receivable, net	1,514	718
Investments	97,566	94,117
Other Assets		376
Investment In Plant, net	401,843	302,084
Total Noncurrent Assets	860,241	708,657
Total Assets	$924,926	$774,055
DEFERRED OUTFLOWS OF RESOURCES		
Deferred Change in Fair Value of Interest Rate Swaps	$1,218	$1,102
Loss on Debt Refunding	7,336	7,028
Total Deferred Outflows of Resources	$ 8,554	$ 8,130
LIABILITIES		
Current Liabilities		
Accounts Payable	$12,682	$14,902
Accrued Salaries and Wages	19,515	17,764
Accrued Compensated Absences	11,484	10,827
Accrued Workers' Compensation	424	328
Accrued Interest Payable	3,889	3,657
Bonds Payable	23,968	37,172
Accelerated variable rate debt, current	306	
Capital Lease Obligations	84	118
Unearned Revenues and Credits	4,875	5,585
Advances and Deposits	2,250	2,001
Other Liabilities	5,243	6,101
Total Current Liabilities	84,720	98,455
Noncurrent Liabilities		
Accrued Compensated Absences	4,230	3,978
Accrued Workers' Compensation	1,054	816
Bonds Payable	476,603	367,350
Capital Lease Obligations		90
Derivative Instrument, Interest Rate Swap	4,412	4,442
Unearned Revenues and Credits	1,478	783
Advances and Deposits	4,420	4,545
Other Liabilities	1,775	1,889
Total Noncurrent Liabilities	493,972	383,893
Total Liabilities	$578,692	$482,348
Net Position:		
Invested in Capital Assets Net of Related Debt	$237,546	$187,018
Restricted		
Nonexpendable	6,699	6,673
Expendable	22,222	18,387
Unrestricted	88,321	87,759
Total Net Position	$354,788	$299,837

REDACTED FOR PUBLIC RELEASE

University of Massachusetts
BOSTON CAMPUS
Statements of Revenues, Expenses and Changes in Net Position
For The Years Ended June 30, 2014 and 2013
(in thousands of dollars)

	June 30, 2014	June 30, 2013 (adjusted)
REVENUES		
Operating Revenues		
Tuition and Fees (net of scholarship allowances of $33,020 at June 30, 2014 and $31,413 at June 30, 2013)	$160,317	$153,084
Federal Grants and Contracts	26,730	27,142
State Grants and Contracts	10,151	10,089
Local Grants and Contracts	724	1,127
Private Grants and Contracts	9,830	10,832
Sales and Service, Educational	3,433	3,000
Auxiliary Enterprises	9,981	9,743
Other Operating Revenues:		
Other	998	749
Total Operating Revenues	**222,164**	**215,766**
EXPENSES		
Operating Expenses		
Educational and General		
Instruction	140,539	130,378
Research	29,176	30,465
Public Service	11,478	11,015
Academic Support	29,014	28,876
Student Services	22,867	20,782
Institutional Support	46,159	40,376
Operation and Maintenance of Plant	25,238	22,692
Depreciation and Amortization	13,284	12,770
Scholarships and Fellowships	11,654	11,832
Auxiliary Enterprises	11,353	10,565
Total Operating Expenses	**340,762**	**319,751**
Operating Loss	**(118,598)**	**(103,985)**
NONOPERATING REVENUES/(EXPENSES)		
State Appropriations	100,553	89,435
Gifts	4,535	3,767
Investment Return	11,306	8,692
Endowment Return	1,997	1,718
Interest on Indebtedness	(6,665)	(9,570)
Nonoperating Federal Grants	21,173	20,817
Other Nonoperating Income/(Expense)	275	(636)
Net Nonoperating Revenues	**133,174**	**114,223**
Income Before Other Revenues, Expenses, Gains, and Losses	**14,576**	**10,238**
OTHER REVENUES, EXPENSES, GAINS, AND LOSSES		
Capital Appropriations	42,978	26,401
Capital Grants and Contracts	1,856	
Disposal of Plant Facilities	(1,157)	(1,039)
Other Additions/(Deductions)	(3,302)	(2,029)
Total Other Revenues, Expenses, Gains, and Losses	**40,375**	**23,333**
Total Increase in Net Position	**54,951**	**33,571**
NET POSITION		
Net Position at Beginning of Year, as reported	299,837	268,958
Cummulative Effect of Accounting Principle		(2,692)
Net Position at the Beginning of Year, as adjusted	299,837	266,266
Net Position at End of Year	**354,788**	**299,837**

University of Massachusetts
DARTMOUTH CAMPUS
Statements of Net Position
As of June 30, 2014 and 2013
(in thousands of dollars)

	June 30, 2014	June 30, 2013 (adjusted)
ASSETS		
Current Assets		
Cash and Cash Equivalents	$1,023	$2,412
Cash Held By State Treasurer	2,895	1,680
Accounts, Grants and Loans Receivable, net	12,306	23,753
Short Term Investments	3,172	3,879
Inventories, net		792
Due From Other Campuses	1,141	1,310
Due From Related Organizations	181	230
O her Assets	280	32
Total Current Assets	20,998	34,088
Noncurrent Assets		
Cash Held By State Treasurer	2,118	766
Cash and Securities Held By Trustees	49,581	54,725
Accounts, Grants and Loans Receivable, net	2,638	2,340
Investments	13,200	14,666
O her Assets		7
Investment In Plant, net	335,741	318,533
Total Noncurrent Assets	403,278	391,037
Total Assets	$424,276	$425,125
DEFERRED OUTFLOWS OF RESOURCES		
Deferred Change in Fair Value of Interest Rate Swaps	$5,845	$5,496
Loss on Debt Refunding	23,148	21,474
Total Deferred Outflows of Resources	$ 28,993	$ 26,970
LIABILITIES		
Current Liabilities		
Accounts Payable	$5,861	$6,490
Accrued Salaries and Wages	11,069	10,357
Accrued Compensated Absences	5,918	5,829
Accrued Workers' Compensation	536	344
Accrued Interest Payable	1,308	1,505
Bonds Payable	46,765	89,332
Accelerated variable rate debt, current	102	
Due To Other Campuses	200	500
Unearned Revenues and Credits	1,739	1,147
Advances and Deposits	1,171	1,191
O her Liabilities	1,562	3,660
Total Current Liabilities	76,231	120,355
Noncurrent Liabilities		
Accrued Compensated Absences	3,829	3,724
Accrued Workers' Compensation	1,331	855
Bonds Payable	177,684	145,287
Deriva ive Instrument, Interest Rate Swap	15,408	15,522
Unearned Revenues and Credits	54	295
Advances and Deposits	3,032	2,749
O her Liabilities	29,720	30,255
Total Noncurrent Liabilities	231,058	198,687
Total Liabilities	$307,289	$319,042
Net Position:		
Invested in Capital Assets Net of Related Debt	$136,286	$118,144
Restricted		
Expendable	8,999	7,516
Unrestricted	695	7,393
Total Net Position	$145,980	$133,053

University of Massachusetts
DARTMOUTH CAMPUS
Statements of Revenues, Expenses and Changes in Net Position
For The Years Ended June 30, 2014 and 2013
(in thousands of dollars)

	June 30, 2014	June 30, 2013 (adjusted)
REVENUES		
Operating Revenues		
Tuition and Fees (net of scholarship allowances of $ 33,161 at June 30, 2014 and $31,279 June 30, 2013)	$72,885	$76,821
Federal Grants and Contracts	8,632	9,421
State Grants and Contracts	5,683	6,268
Local Grants and Contracts	577	315
Private Grants and Contracts	4,000	3,850
Sales and Service, Educational	125	125
Auxiliary Enterprises	48,220	48,405
Other Operating Revenues:		
Other	5,932	5,079
Total Operating Revenues	**146,054**	**150,284**
EXPENSES		
Operating Expenses		
Educational and General		
Instruction	68,583	68,426
Research	17,013	18,274
Public Service	4,503	5,513
Academic Support	26,073	25,687
Student Services	11,574	10,971
Institutional Support	17,600	14,104
Operation and Maintenance of Plant	25,015	19,604
Depreciation and Amortization	15,064	13,438
Scholarships and Fellowships	6,659	6,011
Auxiliary Enterprises	30,424	30,055
Total Operating Expenses	**222,508**	**212,083**
Operating Loss	**(76,454)**	**(61,799)**
NONOPERATING REVENUES/(EXPENSES)		
State Appropriations	64,633	57,242
Investment Return	2,602	2,190
Endowment Income	1,733	1,509
Interest on Indebtedness	(8,617)	(8,434)
Nonoperating Federal Grants	11,987	10,492
Other Nonoperating Income	587	685
Net Nonoperating Revenues	**72,925**	**63,684**
Income/(Loss) Before Other Revenues, Expenses, Gains, and Losses	**(3,529)**	**1,885**
OTHER REVENUES, EXPENSES, GAINS, AND LOSSES		
Capital Appropriations	14,556	16,037
Capital Grants and Contracts	5,815	13,813
Disposal of Plant Facilities	(1,293)	(1,140)
Other Additions/(Deductions)	(2,622)	(593)
Total Other Revenues, Expenses, Gains, and Losses	**16,456**	**28,117**
Total Increase in Net Position	**12,927**	**30,002**
NET POSITION		
Net Position at Beginning of Year, as reported	133,053	105,585
Cummulative effect of change in accounting principle		(2,534)
Net Position at Beginning of Year, as adjusted		103,051
Net Position at End of Year	**$145,980**	**133,053**

REDACTED FOR PUBLIC RELEASE

University of Massachusetts
LOWELL CAMPUS
Statements of Net Position
As of June 30, 2014 and 2013
(in thousands of dollars)

	June 30, 2014	June 30, 2013 (adjusted)
ASSETS		
Current Assets		
Cash and Cash Equivalents	$5,718	$6,996
Cash Held By State Treasurer	5,345	5,088
Accounts, Grants and Loans Receivable, net	29,338	31,100
Pledges Receivable, net	1,001	659
Short Term Investments	23,842	17,186
Due From Other Campuses	5,235	5,732
O her Assets	616	706
Total Current Assets	71,095	67,467
Noncurrent Assets		
Cash Held By State Treasurer	1,099	2,787
Cash and Securities Held By Trustees	114,045	35,345
Accounts, Grants and Loans Receivable, net	5,009	4,874
Pledges Receivable, net	1,470	871
Investments	78,339	64,665
O her Assets	740	1,777
Investment In Plant, net	574,746	478,769
Total Noncurrent Assets	775,448	589,088
Total Assets	$846,543	$656,555
DEFERRED OUTFLOWS OF RESOURCES		
Deferred Change in Fair Value of Interest Rate Swaps	$5,820	$5,789
Loss on Debt Refunding	2,590	3,878
Total Deferred Outflows of Resources	$ 8,410	$ 9,667
LIABILITIES		
Current Liabilities		
Accounts Payable	$16,111	$17,910
Accrued Salaries and Wages	17,652	16,402
Accrued Compensated Absences	9,253	8,676
Accrued Workers' Compensation	462	404
Accrued Interest Payable	3,260	2,856
Bonds Payable	20,947	20,272
Accelerated variable rate debt, current	33,292	
Unearned Revenues and Credits	6,377	4,388
Advances and Deposits	1,365	1,516
O her Liabilities	12,065	7,919
Total Current Liabilities	120,784	80,343
Noncurrent Liabilities		
Accrued Compensated Absences	5,239	5,014
Accrued Workers' Compensation	1,147	1,003
Bonds Payable	411,125	281,451
Deriva ive Instruments, Interest Rate Swap	7,471	7,523
Unearned Revenues and Credits	1,297	3,238
Advances and Deposits	3,808	3,854
O her Liabilities	250	250
Total Noncurrent Liabilities	430,337	302,333
Total Liabilities	$551,121	$382,676
Net Position:		
Invested in Capital Assets Net of Related Debt	$199,226	$193,871
Restricted		
Nonexpendable	3,957	4,185
Expendable	20,485	14,946
Unrestricted	80,164	70,544
Total Net Position	$303,832	$283,546

REDACTED FOR PUBLIC RELEASE

REDACTED FOR PUBLIC RELEASE

University of Massachusetts
LOWELL CAMPUS
Statements of Revenues, Expenses and Changes in Net Position
For The Years Ended June 30, 2014 and 2013
(in thousands of dollars)

	June 30, 2014	June 30, 2013 (adjusted)
REVENUES		
Operating Revenues		
Tuition and Fees (net of scholarship allowances of $ 37,245 at June 30, 2014 and $34,956 at June 30, 2013)	$152,563	$139,748
Federal Grants and Contracts	24,362	23,151
State Grants and Contracts	5,121	5,091
Local Grants and Contracts	457	322
Private Grants and Contracts	10,073	10,160
Sales and Service, Educational	33	129
Auxiliary Enterprises	45,101	36,188
Other Operating Revenues:		
Other	6,726	6,046
Total Operating Revenues	**244,436**	**220,835**
EXPENSES		
Operating Expenses		
Educational and General		
Instruction	111,203	105,148
Research	36,624	35,921
Public Service	830	1,321
Academic Support	26,112	22,656
Student Services	27,033	21,280
Institutional Support	43,222	39,316
Operation and Maintenance of Plant	34,453	30,056
Depreciation and Amortization	23,926	19,657
Scholarships and Fellowships	9,932	9,767
Auxiliary Enterprises	26,276	21,176
Total Operating Expenses	**339,611**	**306,298**
Operating Loss	**(95,175)**	**(85,463)**
NONOPERATING REVENUES/(EXPENSES)		
State Appropriations	88,136	79,228
Gifts	3,484	2,170
Investment Return	8,284	6,440
Endowment Return	1,720	1,554
Interest on Indebtedness	(12,311)	(9,625)
Nonoperating Federal Grants	15,781	15,410
Other Nonoperating Income/(Expense)	8	(239)
Net Nonoperating Revenues	**105,102**	**94,938**
Income/(Loss) Before Other Revenues, Expenses, Gains, and Losses	**9,927**	**9,475**
OTHER REVENUES, EXPENSES, GAINS, AND LOSSES		
Capital Appropriations	2,788	17,164
Capital Grants and Contracts	5,843	5,613
Capital Contribution		3,000
Disposal of Plant Facilities	1,550	(1,388)
Other Additions/(Deductions)	178	(379)
Total Other Revenues, Expenses, Gains, and Losses	**10,359**	**24,010**
Total Increase in Net Position	**20,286**	**33,485**
NET POSITION		
Net Position at Beginning of Year, as reported	283,546	251,973
Cummulative effect of change in accounting principle		(1,912)
Net Position at Beinning of Year, as adjusted		250,061
Net Position at End of Year	**$303,832**	**283,546**

REDACTED FOR PUBLIC RELEASE

University of Massachusetts
WORCESTER CAMPUS
Statements of Net Position
As of June 30, 2014 and 2013
(in thousands of dollars)

	Worcester Campus June 30, 2014	Worcester Campus June 30, 2013	Worcester City Campus Corporation June 30, 2014	Worcester City Campus Corporation June 30, 2013	Eliminations June 30, 2014	Eliminations June 30, 2013	Combined Totals Memorandum Only June 30, 2014	Combined Totals Memorandum Only June 30, 2013
ASSETS		(adjusted)		(adjusted)				(adjusted)
Current Assets								
Cash and Cash Equivalents	$5,742	$8,696	$6,246	$27,104			$11,988	$35,800
Cash Held By State Treasurer	1,593	1,625					1,593	1,625
Accounts, Grants and Loans Receivable, net	115,344	118,558	2,139	695			117,483	119,253
Pledges Receivable, net	7,545	9,710					7,545	9,710
Short Term Investments	26,508	26,513					26,508	26,513
Inventories, net	10,836	13,015					10,836	13,015
Accounts Receivable UMass Memorial	38,762	12,690	2,045	44			40,807	12,734
Due From Other Campuses	13,960	14,355					13,960	14,355
Due From Related Organizations	3,881	1,907	81,623	48,343	(85,504)	(49,711)		539
Other Assets	2,529	3,456	328	539			2,857	3,995
Total Current Assets	226,700	210,525	92,381	76,725	(85,504)	(49,711)	233,577	237,539
Noncurrent Assets								
Cash Held By State Treasurer	423	163					423	163
Cash and Securities Held By Trustees	5,484	30,365	32	24			5,516	30,389
Accounts, Grants and Loans Receivable, net	5,626	5,626					5,626	5,626
Investments	189,494	173,977					189,494	173,977
Investment In Plant, net	659,834	664,682	394,905	414,318			1,054,739	1,079,000
Total Noncurrent Assets	860,861	874,813	394,937	414,342			1,255,798	1,289,155
Total Assets	$1,087,561	$1,085,338	$487,318	$491,067	($85,504)	($49,711)	$1,489,375	$1,526,694
DEFERRED OUTFLOWS OF RESOURCES								
Deferred Outflows of Resources								
LIABILITIES								
Current Liabilities								
Accounts Payable	$19,932	$27,562	$4,294	$4,217			$24,226	$31,779
Accrued Salaries and Wages	15,905	17,541					15,905	17,541
Accrued Compensated Absences	18,392	19,490					18,392	19,490
Accrued Workers' Compensation	1,003	1,102					1,003	1,102
Accrued Interest Payable	3,651	3,697	3,458	3,647			7,109	7,344
Bonds Payable	8,781	8,195	11,197	9,090			19,978	17,285
Accounts Payable UMass Memorial	3,864	4,364					3,864	4,364
Due to Related Organizations	81,974	48,184	3,484	1,907	(85,504)	(49,711)	(46)	380
Due to Other Campuses	6						6	
Unearned Revenues and Credits	12,263	14,599					12,263	14,599
Advances and Deposits	267	1,606					267	1,606
Other Liabilities	14,114	19,759	3,686	3,448			17,800	23,207
Total Current Liabilities	180,152	166,099	26,119	22,309	(85,504)	(49,711)	120,767	138,697
Noncurrent Liabilities								
Accrued Compensated Absences	5,583	5,343					5,583	5,343
Accrued Workers' Compensation	2,492	2,738					2,492	2,738
Bonds Payable	387,218	390,198	294,514	305,482			681,732	695,680
Unearned Revenues and Credits	6,525	4,571					6,525	4,571
Advances and Deposits	3,448	3,447					3,448	3,447
Other Liabilities	603	3,500	469	504			1,072	4,004
Total Noncurrent Liabilities	405,869	409,797	294,983	305,986			700,852	715,783
Total Liabilities	$586,021	$575,896	$321,102	$328,295	($85,504)	($49,711)	$821,619	$854,480
Net Position:								
Invested in Capital Assets Net of Related Debt	$272,937	$288,219	$87,344	$97,020			$360,281	$385,239
Restricted								
Nonexpendable	1,152	1,023					1,152	1,023
Expendable	38,674	39,775	27	2,947			38,701	42,722
Unrestricted	188,777	180,425	78,845	62,805			267,622	243,230
Total Net Position	$501,540	$509,442	$166,216	$162,772			$667,756	$672,214

University of Massachusetts
WORCESTER CAMPUS
Statements of Revenues, Expenses and Changes in Net Position
For The Years Ended June 30, 2014 and June 30, 2013
(in thousands of dollars)

	Worcester Campus June 30, 2014	Worcester Campus June 30, 2013	Worcester City City Campus Corporation June 30, 2014	Worcester City City Campus Corporation June 30, 2013	Eliminations June 30, 2014	Eliminations June 30, 2013	Combined Totals Memorandum Only June 30, 2014	Combined Totals Memorandum Only June 30, 2013
REVENUES								
Operating Revenues								
Tuition and Fees (net of scholarship allowances of $2,283 at June 30, 2014 and $2,760 at June 30, 2013)	$16,245	$14,367					$16,245	$14,367
Federal Grants and Contracts	159,994	174,603					159,994	174,603
State Grants and Contracts	35,930	33,140					35,930	33,140
Private Grants and Contracts	55,070	48,391					55,070	48,391
Sales and Service, Educational	8,045	5,345					8,045	5,345
Auxiliary Enterprises	31,424	33,101				(3,470)	31,424	29,631
Other Operating Revenues:								
Sales and Service, Independent Operations	44,296	46,062					44,296	46,062
Sales and Service, Public Service Activities	446,557	446,925	44,908	33,277	(42,987)	(33,083)	448,478	447,119
Other	37,384	42,674	59,110	57,238	(36,743)	(38,944)	59,751	60,968
Total Operating Revenues	**834,945**	**844,608**	**104,018**	**90,515**	**(79,730)**	**(75,497)**	**859,233**	**859,626**
EXPENSES								
Operating Expenses								
Educational and General								
Instruction	53,538	53,969			(72)	(74)	53,466	53,895
Research	213,221	215,744			(90)	(86)	213,131	215,658
Public Service	32,211	30,657					32,211	30,657
Academic Support	11,693	12,129			(102)	(102)	11,591	12,027
Student Services	5,760	5,950					5,760	5,950
Institutional Support	55,909	58,067			(294)	(275)	55,615	57,792
Operation and Maintenance of Plant	45,695	50,956	24,382	26,100	(24,422)	(30,191)	45,655	46,865
Depreciation and Amortization	43,157	41,582	20,128	20,579			63,285	62,161
Auxiliary Enterprises	24,161	24,557			(1,800)	(1,800)	22,361	22,757
Other Expenditures								
Independent Operations	51,461	54,434			(6,600)	(6,608)	44,861	47,826
Public Service Activities	367,226	334,845	44,376	28,809	(46,350)	(36,361)	365,252	327,293
Total Operating Expenses	**904,032**	**882,890**	**88,886**	**75,488**	**(79,730)**	**(75,497)**	**913,188**	**882,881**
Operating Income/(Loss)	**(69,087)**	**(38,282)**	**15,132**	**15,027**			**(53,955)**	**(23,255)**
NONOPERATING REVENUES/(EXPENSES)								
State Appropriations	44,620	41,136					44,620	41,136
Gifts	4,855	10,157					4,855	10,157
Investment Return	25,858	13,933	457	551			26,315	14,484
Endowment Return	2,535	2,351					2,535	2,351
Interest on Indebtedness	(21,871)	(23,759)	(14,320)	(13,869)			(36,191)	(37,628)
Other Nonoperating Income	146	1,385		(59)			146	1,326
Net Nonoperating Revenues	**56,143**	**45,203**	**(13,863)**	**(13,377)**			**42,280**	**31,826**
Income/(Loss) Before Other Revenues, Expenses, Gains, and Losses	**(12,944)**	**6,921**	**1,269**	**1,650**			**(11,675)**	**8,571**
OTHER REVENUES, EXPENSES, GAINS, AND LOSSES								
Capital Appropriations	419	45					419	45
Capital Grants and Contracts		16,695						16,695
Disposal of Plant Facilities	(1,179)	(1,248)	(66)	(9)			(1,245)	(1,257)
Contributions for Capital Expenditures	(4,976)		5,226	1,514			250	1,514
Other Additions/Deductions	10,778	8,548	(2,985)	(1,216)			7,793	7,332
Total Other Revenues, Expenses, Gains, and Losses	**5,042**	**24,040**	**2,175**	**289**			**7,217**	**24,329**
Total Increase in Net Position	**(7,902)**	**30,961**	**3,444**	**1,939**			**(4,458)**	**32,900**
NET POSITION								
Net Position at Beginning of Year, as reported	509,442	482,328	162,772	163,691			672,214	646,019
Cummulative effect of change in accounting principle		(3,847)		(2,858)				(6,705)
Net Position at Beginning of Year, as adjusted		478,481	162,772	160,833				639,314
Net Position at End of Year	**$501,540**	**509,442**	**$166,216**	**162,772**			**$667,756**	**672,214**

REDACTED FOR PUBLIC RELEASE

Combining Statements of Net Position for University Related Organizations as of June 30, 2014 and 2013
(in thousands of dollars)

Supplemental Schedule I

ASSETS	**Total June 30, 2014**	**Eliminations and Adjustments June 30, 2014**	**The University of Massachusetts Foundation, Inc. June 30, 2014**	**University of Massachusetts Dartmouth Foundation, Inc. June 30, 2014**	**Total June 30, 2013**	**Eliminations and Adjustments June 30, 2013**	**The University of Massachusetts Foundation, Inc. June 30, 2013**	**University of Massachusetts Dartmouth Foundation, Inc. June 30, 2013**
Current Assets								
Accounts, Grants and Loans Receivable, net								
Pledges Receivable, net	$785	($6,368)	$6,045	$1,108	$887	($6,114)	$6,513	$488
Due From Related Organizations	354	354			380	380		
Other Assets	539		535	4	2,563		2,550	13
Total Current Assets	**1,678**	**(6,014)**	**6,580**	**1,112**	**3,830**	**(5,734)**	**9,063**	**501**
Noncurrent Assets								
Cash and Cash Equivalents	1,378		158	1,220	1,041		81	960
Pledges Receivable, net	677	(12,676)	10,634	2,719	1,109	(9,333)	8,978	1,464
Investments	452,529	(692,318)	1,091,312	53,535	389,376	(628,633)	970,061	47,948
Other Assets	62			62	173		113	60
Investment In Plant, net	8,478		8,478		8,619		8,619	
Total Noncurrent Assets	**463,124**	**(704,994)**	**1,110,582**	**57,536**	**400,318**	**(637,966)**	**987,852**	**50,432**
Total Assets	**$464,802**	**($711,008)**	**$1,117,162**	**$58,648**	**$404,148**	**($643,700)**	**$996,915**	**$50,933**
LIABILITIES								
Current Liabilities								
Accounts Payable	$174		$154	$20	$ 94		$13	$81
Due To Related Organizations	181	$ (5,954)		6,135	230	($5,409)		5,639
Assets Held on Behalf of the University		(643,224)	643,224		0	(585,005)	585,005	
Assets Held on Behalf of Others	13,797		13,797		12,307		12,307	
Unearned Revenues and Credits	1,373		1,373		1,973		1,973	
Total Current Liabilities	**15,525**	**(649,178)**	**658,548**	**6,155**	**14,604**	**(590,414)**	**599,298**	**5,720**
Noncurrent Liabilities								
Other Liabilities	3,483		3,483		3,332		3,332	
Total Noncurrent Liabilities	**3,483**		**3,483**		**3,332**	**0**	**3,332**	
Total Liabilities	**$19,008**	**($649,178)**	**$662,031**	**$6,155**	**$17,936**	**($590,414)**	**$602,630**	**$5,720**
Net Position:								
Invested in Capital Assets Net of Related Debt	$8,477	$8,477			$ 8,619	$8,619		
Restricted								
Nonexpendable	309,718	(47,808)	$324,579	$32,947	290,858	(43,525)	$303,973	$30,410
Expendable	101,195	(14,022)	98,409	16,808	74,706	(9,761)	71,889	12,578
Unrestricted	26,404	(8,477)	32,143	2,738	12,029	(8,619)	18,423	2,225
Total Net Position	**$445,794**	**($61,830)**	**$455,131**	**$52,493**	**$386,212**	**($53,286)**	**$394,285**	**$45,213**

REDACTED FOR PUBLIC RELEASE

Combining Statements of Revenues, Expenses, and Changes in Net Position for University Related Organizations
For The Years Ended June 30, 2014 and 2013
(in thousands of dollars)

Supplemental Schedule II

	Total June 30, 2014	Eliminations and Adjustments June 30, 2014	The University of Massachusetts Foundation, Inc. June 30, 2014	University of Massachusetts Dartmouth Foundation, Inc. June 30, 2014	Total June 30, 2013	Eliminations and Adjustments June 30, 2013	The University of Massachusetts Foundation, Inc. June 30, 2013	University of Massachusetts Dartmouth Foundation, Inc. June 30, 2013
EXPENSES								
Operating Expenses								
Educational and General								
Public Service	$11,066	($658)	$8,872	$2,852	$12,573	($732)	$10,308	$2,997
Depreciation	200		200		202		202	
Scholarships and Fellowships	177	(1,326)	642	861	77	(1,175)	561	691
Total Operating Expenses	**11,443**	**(1,984)**	**9,714**	**3,713**	**12,852**	**(1,907)**	**11,071**	**3,688**
Operating Income/(Loss)	**(11,443)**	**1,984**	**(9,714)**	**(3,713)**	**(12,852)**	**1,907**	**(11,071)**	**(3,688)**
NONOPERATING REVENUES/(EXPENSES)								
Gifts	11,063	(2,019)	6,257	6,825	9,452	217	6,300	2,935
Investment Income	42,849	(65,246)	103,882	4,213	24,540	(35,589)	57,662	2,467
Endowment Income	1,070	(16,625)	17,695		1,160	(13,936)	15,096	
Net Nonoperating Revenues	**54,982**	**(83,890)**	**127,834**	**11,038**	**35,152**	**(49,308)**	**79,058**	**5,402**
Income/(Loss) Before Other Revenues, Expenses, Gains, and Losses	**43,539**	**(81,906)**	**118,120**	**7,325**	**22,300**	**(47,401)**	**67,987**	**1,714**
OTHER REVENUES, EXPENSES, GAINS, AND LOSSES								
Additions to Permanent Endowments	17,566	(1,746)	19,312		16,056	(844)	16,457	443
Less: Amounts Earned/Received on Behalf of the University		54,746	(54,746)			(637)	637	
Less: Amounts Earned/Received on Behalf of Others	(1,555)		(1,555)		(928)		(928)	
Distribution to University		20,268	(20,268)			46,764	(46,764)	
Other Additions/Deductions	32	94	(17)	(45)	(9,051)	(1,656)	(8,554)	1,159
Total Other Revenues, Expenses, Gains, and Losses	**16,043**	**73,362**	**(57,274)**	**(45)**	**6,077**	**43,627**	**(39,152)**	**1,602**
Total Increase/(Decrease) in Net Assets	**59,582**	**(8,544)**	**60,846**	**7,280**	**28,377**	**(3,774)**	**28,835**	**3,316**
NET POSITION								
Net Position at Beginning of Year	386,212	(53,286)	394,285	45,213	357,835	(49,512)	365,450	41,897
Net Position at End of Year	**$445,794**	**($61,830)**	**$455,131**	**$52,493**	**$386,212**	**($53,286)**	**$394,285**	**$45,213**

Chapter 15

Appendix

State Entity Documentation

[CHAPTER 220 .]

Commonwealth of Massachusetts.

In the Year One Thousand Eight*Hundred and*Sixty-three.

AN ACT

to incorporate the Trustees of the Massachusetts Agricultural College.

Be it enacted by the Senate and House of Representatives in General Court assembled and by the authority of the same, as follows:—

SECTION 1. Marshall P. Wilder, of Dorchester, Charles G. Davis, of Plymouth, Nathan Durfee, of Fall River, John Brooks, of Princeton, Henry Colt, of Pittsfield, William S. Southworth, of Lowell, Charles C. Sewall, of Medfield, Paoli Lathrop, of South Hadley, Phinehas Stedman, of Chicopee, Allen W. Dodge, of Hamilton, George Marston, of Barnstable, William B. Washburn, of Greenfield, Henry L. Whiting, of Tisbury, John B. King, of Nantucket, their associates and successors, are hereby constituted a body corporate, by the name of the trustees of the Massachusetts Agricultural College, the leading object of which shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in order to

REDACTED FOR PUBLIC RELEASE

promote the liberal and practical education of the industrial classes, in the several pursuits and professions of life, to be located as hereinafter provided; and they and their successors, and such as shall be duly elected members of said corporation, shall be and remain a body corporate by that name forever. And for the orderly conducting of the business of said corporation the said trustees shall have power and authority, from time to time, as occasion may require, to elect a president, vice president, secretary, and treasurer, and such other officers of said corporation as may be found necessary, and to declare the duties and tenures of their respective offices; and also to remove any trustee from the same corporation, when in their judgment he shall be rendered incapable, by age or otherwise, of discharging the duties of his office, or shall neglect or refuse to perform the same; and whenever vacancies shall occur in the board of trustees the legislature shall fill the same: provided, nevertheless, that the number of members shall never be greater than fourteen, exclusive of the governor of the Commonwealth, the secretary of the Board of Education, the secretary of the board of agriculture, and the president of the faculty, each of whom shall be, ex officio, a member of said corporation. Section 2. The said corporation shall have full power and authority to determine at what times and places their meetings shall be holden, and the manner of notifying the trustees to convene at such meetings; and also,

REDACTED FOR PUBLIC RELEASE

from time to time, to elect a president of said college, and such professors, tutors, instructors and other officers of said college, as they shall judge most for the interest thereof, and to determine the duties, salaries, emoluments, responsibilities and tenures, of their several offices. And the said corporation are further impowered to purchase, or erect and keep in repair, such houses and other buildings, as they shall judge necessary for the said college; and also to make and ordain, as occasion may require, reasonable rules, orders and by-laws, not repugnant to the constitution and laws of this Commonwealth, with reasonable penalties for the good government of the said college, and for the regulation of their own body; and also to determine and regulate the course of instruction in said college, and to confer such appropriate degrees as they may determine and prescribe: provided, nevertheless, that no corporate business shall be transacted at any meeting, unless one half, at least, of the trustees are present. Section 3. The said corporation may have a common seal, which they may alter or renew at their pleasure, and all deeds sealed with the seal of said corporation, and signed by their order, shall, when made in their corporate name, be considered in law as the deeds of said corporation; and said corporation may sue and be sued in all actions real, personal or mixed, and may prosecute the same to final judgment and execution,

REDACTED FOR PUBLIC RELEASE

by the name of the Trustees of the Massachusetts Agricultural College; and said corporation shall be capable of taking and holding, in fee simple or any less estate, by gift, grant, bequest, devise, or otherwise, any lands, tenements, or other estate, real or personal: provided, that the clear annual income of the same shall not exceed thirty thousand dollars. Section 4. The clear rents and profits of all the estate, real and personal, of which the said corporation shall be seized and possessed, shall be appropriated to the uses of said college in such manner as shall most effectually promote the objects declared in the first section of this act, and as may be recommended from time to time, by the said corporation: they conforming to the will of any donor or donors in the application of any estate, which may be given, devised, or bequeathed, for any particular object connected with the college. Section 5. The legislature of this Commonwealth may grant any further powers to, or alter, limit, annul or restrain, any of the powers vested by this act in the said corporation, as shall be found necessary to promote the best interests of the said college; and more especially may appoint and establish overseers or visitors of the said college, with all necessary powers for the better aid, preservation and government thereof. The said corporation shall make an annual report of its condition, financial and otherwise, to the legislature, at the commencement of its session. Section 6. The board of trustees shall determine

REDACTED FOR PUBLIC RELEASE

the location of said college, in some suitable place, within the limits of this Commonwealth, and shall purchase or obtain by gift, grant, or otherwise, in connection therewith, a tract of land containing at least one hundred acres, to be used as an experimental farm, or otherwise, so as best to promote the objects of the institution; and in establishing the by-laws and regulations of said college, they shall make such provision for the manual labor of the students on said farm, as they may deem just and reasonable. The location, plan of organization, government and course of study, prescribed for the college, shall be subject to the approval of the legislature. Section 7. One tenth part of all the moneys which may be received by the state treasurer, from the sale of land scrip, by virtue of the provisions of the one hundred and thirtieth chapter of the acts of the thirty-seventh congress, at the second session thereof, approved July second, eighteen hundred and sixty-two, and of the laws of this Commonwealth, shall be paid to said college, and appropriated towards the purchase of said site or farm: provided, nevertheless, that the said college shall first secure, by valid subscriptions or otherwise, the further sum of seventy-five thousand dollars, for the purpose of erecting suitable buildings thereon; and upon satisfactory evidence that this proviso has been complied with, the governor is authorized, from time to time, to draw his warrants therefor. Section 8. When the said college shall have been duly organized, located and established, as and for the purposes specified in this act, there shall be appropriated and paid to its treasurer, each year, on the warrant of the governor, two thirds of the annual interest or income which may be received from the fund created under and by virtue of the act of Congress named in the seventh section of this act, and the laws of this Commonwealth accepting the provisions thereof, and relating to the same. Section 9. In the event of a dissolution of said corporation by its voluntary act, at any time, the real and personal property belonging to the corporation shall revert and belong to the Commonwealth, to be held by the same, and be disposed of as it may see fit, in the advancement of education in agriculture and the mechanic arts. The legislature shall have authority at any time to withhold the portion of the interest or income from said fund provided in this act, whenever the corporation shall cease or fail to maintain a college within the provisions and spirit of this act, and the before mentioned act of Congress, or for any cause which they deem sufficient.

House of Representatives, April 28, 1863.

Passed to be enacted, Alex. H. Bullock Speaker.

In Senate, April 28 1863.

Passed to be enacted, J. E. Field President.

April 29th " 1863.

Approved,

John A. Andrew.

REDACTED FOR PUBLIC RELEASE

The Commonwealth of Massachusetts

Office of the Secretary

Boston, March 26, 1909.

A true copy.

Witness the Great Seal
of The Commonwealth.

Wm. M. Olin

Secretary.
F.G.K.

ADMINISTRATION

Caption editorially supplied

TABLE

Showing where the subject matter of the sections stricken out by St.1962, c. 648, can be found in the new sections enacted thereby.

Chapter 75 Former Sections	Chapter 75 Present Sections	Chapter 75 Former Sections	Chapter 75 Present Sections
1	1	9	12
2	2	10	3
3	4	10A	9
4	5	11	2
5	8	12	2
5A	11	13	14
6	6, 10	14, 15	2
7	11	31	31
8	15	32	—

Section 32, relating to the admission of an Israeli student to the department of agriculture at the university, was derived from St.1960, c. 493.

Cross References

Bay State Skills Corporation Act, see c. 40*I*, § 1 et seq.
College Student Loan Authority, see c. 15C, § 1 et seq.
New England Educational Loan Marketing Corporation Act, see c. 15B, § 1 et seq.

Law Review Commentaries

Education. Richard G. Huber, 9 Annual Survey of Mass. Law, Boston College, p. 252 (1962).

United States Supreme Court

Admissions policies, see De Funis v. Odegaard, 1975, 94 S.Ct. 1704, 416 U.S. 312, 40 L.Ed.2d 164.

Special admissions programs of colleges, see Regents of University of California v. Bakke, 1978, 98 S.Ct. 2733, 438 U.S. 265, 57 L.Ed.2d 750.

§ 1. Status; governing body

There shall be a University of Massachusetts which shall continue as a state institution within the department of education but not under its control and shall be governed solely by the board of trustees established under section twenty of chapter fifteen. In addition to the authority, responsibility, powers and duties specifically conferred by this chapter, the board of trustees shall have all authority, responsibility, rights, privileges, powers and duties customarily and traditionally exercised by governing boards of institutions of higher learn-

REDACTED FOR PUBLIC RELEASE

ing. In exercising such authority, responsibility, powers and duties said board shall not in the management of the affairs of the university be subject to, or superseded in any such authority by, any other state board, bureau, department or commission, except as herein provided.

Added by St.1962, c. 648, § 1. Amended by St.1969, c. 396, § 7.

Historical Note

St.1969, c. 396, § 7, approved June 8, 1969, in the first sentence, substituted "There shall be a" for "The state university shall be the".

Prior Laws:

St.1863, c. 220, § 1.
St.1864, c. 223, § 1.
St.1911, c. 311.
St.1918, c. 262, § 1.
St.1931, c. 144, § 2.
G.L.1932 (Ter.Ed.) c. 75, § 1.
St.1947, c. 344, § 6.

Library References

Colleges and Universities ⚷1, 7.

C.J.S. Colleges and Universities §§ 1, 2, 16 et seq.

Notes of Decisions

In general 1
Lodging accommodations 3
Small business purchasing program 4
Sovereign immunity 2

1. In general

Under this section and §§ 8, 11 and 12 of this chapter, Trustees of the University of Massachusetts had authority to enter into designated lease and tenancies at will without obtaining approval of Superintendent of Buildings, Commissioner of Administration and of Governor and without their inclusion on a schedule filed by the Budget Director with House and Senate Committee on Ways and Means and the Commonwealth had obligation to pay rent in accordance with their terms. Opinion of Justices to Governor (1973) 294 N.E.2d 346, 363 Mass. 889.

The extension of the authority of the board of trustees for the University of Massachusetts into the areas of budget and purchasing recognizes that academic freedom is intimately related to fiscal independence. Op.Atty.Gen., March 21, 1977, p. 137.

University of Massachusetts had autonomous authority to adopt rules and regulations notwithstanding provisions of State Administrative Procedure Act (c. 30A, § 1 et seq.). Op.Atty.Gen., Jan. 9, 1975, p. 94.

University of Massachusetts had autonomous authority under this chapter to enter into lease for term of years for new office space with rental to be paid from state appropriations, notwithstanding provisions of c. 8, § 10A (repealed), since it was intention of legislature to give trustees complete discretion in management and administration of university, and because this chapter impliedly repealed c. 8, § 10A (repealed), insofar as they were in conflict. Op. Atty.Gen., July 19, 1972, p. 40.

University of Massachusetts had autonomous authority under this chapter to enter into oral tenancy-at-will for additional office space with funds to be paid from state appropriations, notwithstanding provisions of c. 8, § 10A (repealed) and St.1971, c. 719, since those latter provisions had been impliedly repealed by this chapter insofar as they conflicted. Id.

REDACTED FOR PUBLIC RELEASE

University of Massachusetts had autonomous authority under this chapter to enter into lease for terms of years for new office space with rental to be paid from state appropriations, notwithstanding provisions of St.1971, c. 719, since c. 719 was premised upon mechanics of c. 8, § 10A (repealed) which had been impliedly repealed with respect to board of trustees by this chapter. Id.

The trustees of the University of Massachusetts had the authority to enter into collective bargaining with an appropriate bargaining unit representing its non-professional employees in accordance with c. 149, § 178F (repealed: see, now, c. 150E, § 1 et seq.). Op.Atty.Gen., Dec. 17, 1969, p. 86.

2. Sovereign immunity

For purposes of action brought against Commonwealth and University of Massachusetts board of trustees, as statutory entity, for injuries sustained in fall at state university, trustees were one and same party as Commonwealth. Hannigan v. New Gamma-Delta Chapter of Kappa Sigma Fraternity, Inc. (1975) 327 N.E.2d 882, 367 Mass. 658.

Action brought against Commonwealth and University of Massachusetts board of trustees, as statutory entity to recover for injuries sustained in fall at state university was barred by doctrine of sovereign immunity. Id.

3. Lodging accommodations

Lodging accommodations provided at the University of Massachusetts Campus Center clearly constitute "lodging accommodations" at "a state institution" and are, therefore, exempt from the room occupancy excise imposed by c. 64G, § 1 et seq. Op.Atty.Gen., April 12, 1976, p. 156.

4. Small business purchasing program

The University of Massachusetts is not a purchasing agency within the definition of St.1976, c. 484, and is not subject to small business purchasing program. Op.Atty.Gen., March 21, 1977, p. 137.

The University of Massachusetts is not subject to the small business purchasing program established under St. 1976, c. 484, since the program would interfere with physical autonomy of the university. Id.

§ 2. Purpose; courses of instruction; standards; powers of trustees

The major purpose of the university shall be to provide, without discrimination, education programs, research, extension, and continuing education services in the liberal arts and sciences and in the professions, and in those professional areas normally requiring either education beyond four years of undergraduate training or a basic or advanced degree beyond the bachelor's level, with exclusive jurisdiction in agriculture. The university shall offer the adult education services of the university extension program. The university may establish branches and may take under its jurisdiction other elements of the state system of higher education with the approval of all boards of trustees involved and the board of higher education. The university shall have general authority to award an earned doctoral degree, either independently or jointly with any other public institution of higher education operated by the commonwealth in accordance with joint programs approved by the board of higher education and the board of trustees of the university and the board of trustees of such other public institution. To this end, the trustees shall maintain high educational standards at the university and shall, subject only to such general authority in the board of higher education, have complete authority to establish, locate, support, consolidate or abolish classes, courses, curricula, departments, divisions, schools or colleges of the university wherever and whenever required in meeting the needs of the commonwealth in the fields of public higher education. A branch of the university shall be established at such place in or in the vicinity of the city of Boston as the trustees may deem conducive to the accomplishment of the aforesaid purposes and shall be there maintained so long as the trustees may deem necessary or desirable. The trustees shall establish for the university the qualifications and standards for admission, promotion and graduation and shall award academic degrees and diplomas and confer honors as is customary in American universities, except to the extent any such exercise might be inconsistent with determinations of the board of higher education delineating functions and programs for institutions and segments of institutions of public higher education. The trustees may confer such honorary degrees as they deem appropriate.

Added by St.1962, c. 648, § 1. Amended by St.1962, c. 787, § 2; St.1964, c. 562, § 1; St.1965, c. 572, § 31; St.1969, c. 396, § 8.

Historical Note

St.1962, c. 787, § 2, approved July 27, 1962, inserted "medicine," in the first sentence.

St.1964, c. 562, § 1, an emergency act approved June 18, 1964, inserted the fifth sentence.

Section 2 of St.1964, c. 562, made an appropriation for the formulation and establishment of an educational program in or in the vicinity of Boston.

St.1965, c. 572, § 31, approved June 28, 1965, rewrote the section, which prior thereto read:

"The major purpose of the university shall be to provide without discrimination educational opportunity in such fields of higher education as the trustees may determine including, but not limited to, arts and sciences, engineering, business administration, agriculture, home economics, education, medicine, nursing, physical education, and military science. It shall provide such other services to the commonwealth, appropriate to its purposes, as the trustees may determine or as are provided by law. The university shall be the commonwealth's major center for research, graduate and professional education, and for dissemination of knowledge. To this end, the trustees shall maintain high educational standards at the university and shall have complete authority to establish, locate, support, consolidate or abolish classes, courses, curricula, departments, divisions, schools or colleges of the university wherever and whenever required in meeting the needs of the commonwealth in the fields of public higher education. A branch of the university shall be established at such place in or in the vicinity of the city of Boston as the trustees may deem

REDACTED FOR PUBLIC RELEASE

REDACTED FOR PUBLIC RELEASE

DEPARTMENT OF THE TREASURY
INTERNAL REVENUE SERVICE
PHILADELPHIA, PA 19255

CERTIFICATION
PROGRAM

Date: May 11, 2015

000290

Taxpayer: UNIVERSITY OF MASSACHUSETTS
TIN: 04-3167352
Tax Year: 2015

I certify that the above-named entity is a State, or political subdivision of a State, or an agency, instrumentality, or public educational organization of a State or political subdivision, which is exempt from U.S. tax under the Internal Revenue Code, and is a resident of the United States of America for purposes of U.S. taxation.

Nancy J. Aiello

Nancy J. Aiello
Field Director, Accounts Management

Form 6166 (Rev. 6-2008)
Catalog Number 43134V

REDACTED FOR PUBLIC RELEASE

Chapter 15

Appendix

Signature Authority Documentation

Doc. T92-031, as amended
(Appendix A)
Passed by the BoT
6/3/92
Revised 12/4/96
Revised 8/7/02
Revised 6/12/08
Revised 6/8/11
Revised 9/17/14

UNIVERSITY OF MASSACHUSETTS
PROCUREMENT POLICY

I. INTRODUCTION

The purpose of this policy is to govern the procurement of all goods, materials, commodities, and services by the University, including but not limited to, design services, vehicles, equipment, library materials, software, and real property, whether by purchase order, contract, license, lease, or other form of agreement. In accordance with the provisions of Sections 3 and 13 of Chapter 75 of the General Laws, as amended, all purchases irrespective of source of funds, under the provisions of said Section 13 shall be governed by this policy subject to subsequent amendment, revision, or repeal, from time to time, by the Trustees.

This policy shall apply to each campus and to the President's Office, as well as to multi-campus or system-wide agreements. This policy shall not supersede any of the provisions of the Senior Vice President for Administration & Finance and Treasurer's Delegations, Doc. T97-014. All University employees must follow Doc. T08-028, the Policy on Codes of Conduct for University/Vendor Relationships.

All persons responsible for procuring goods and services governed by this policy shall confer with the General Counsel as advisable in order to assure compliance with these terms.

II. POLICY STATEMENT

A. Competitive Procurement Practices:

The University shall obtain all goods and services covered by this policy at the best over-all value to the University as is consistent with the quantity, quality, durability, availability, serviceability, and other factors affecting service and use as required by the using department of the University. In complying with this policy, the cost of acquisition and the delivery time required shall be considered as well as the cost of the item being purchased. All procurements must (1) have prior approval of the relevant Purchasing Department; and (2) must follow delegation and signatory authority in accordance with University policies and campus/President's Office procedures and guidelines to bind the University.

To maximize vendor competition and volume discount purchases, departments shall make use of Campus, University, State, or Massachusetts Higher Education Consortium publicly bid contracts whenever appropriate and practicable. Contracts of other consortia and group purchasing organizations may also be utilized when approved by the University Purchasing

Council based on evidence of the consortia's sound competitive and ethical procurement practices.

To encourage open and fair competition, advertisement for and receipt of competitive bids shall be used whenever practicable, or when required by law. The University's commitment to the principles of Affirmative Action shall be applied to purchasing with the objective of: (i) achieving and fostering greater participation in University procurement activity by minority-owned small business, small disadvantaged business, women-owned small business, HUBZone small business, Veteran-owned small business, and service-disabled Veteran-owned small business enterprises and (ii) encouraging socially or economically disadvantaged business owners to respond to invitations to bid on University business.

B. Delegations of Authority:

1. **To the President**, with authority to re-delegate to the Senior Vice President for Administration & Finance and Treasurer, or any member of the President's Office as the President may determine:

    a. Authority to require the campuses to utilize a system-wide or multi-campus procurement for any purchase covered by this policy. The President shall issue standards for when a system-wide or multi-campus procurement for purchases is required. A Chancellor who believes such procurement would not be in the best interest of his/her campus shall be entitled to request not to participate in such procurement, but the President shall make the final decision.

2. **To the President,** for President's Office, and multi-campus or system-wide procurements, with authority to re-delegate to the Senior Vice President for Administration & Finance and Treasurer, and/or such other designees as the President shall determine:

    a. Authority to enter into and execute agreements for goods, materials and commodities.

    b. Authority to enter into and execute Sub-contract(s), Consultant contract(s), and Services contract(s) as provided in the Procurement Standards.

    c. Authority to enter into and execute contracts for labor and materials for repair or construction, including design services, of real property used by the President's Office subject to any applicable requirements under G.L. ch.7C, G.L. ch.30, or G.L. ch.149.

    d. Authority to enter into and execute agreements relating to the use of real property by the President's Office.

    e. Authority to enter into and execute agreements for the use of President's Office real property by non-affiliated entities which do not exceed five years, including any renewals or options for renewal. Any dispositions of University real property must comply with the University's Capital Planning, Land and Facilities Use Policy, Doc. T93-122 and with the Treasurer's Delegations, Doc. T97-014. All agreements relating to real property must be approved by the General Counsel prior to execution.

    f. Authority to enter into and execute agreements for use of University real property by non-affiliated entities which exceed five years upon Board of Trustees approval and any necessary campus approvals. Any dispositions of University real property must comply with the University's Capital Planning, Land and Facilities Use Policy, Doc. T93-122 and with the Treasurer's Delegations, Doc. T97-014. All agreements relating to real property must be approved by the General Counsel prior to execution.

g. Authority to enter into and execute agreements for use of President's Office real property by affiliated entities which do not exceed twenty (20) years, including any renewals or options for renewal. Any dispositions of University real property must comply with the University's Capital Planning, Land and Facilities Use Policy, Doc. T93-122 and with the Treasurer's Delegations, Doc. T97-014. All agreements for real property must be approved by the General Counsel prior to execution.

h. Authority to enter into and execute leases or licenses for any items, including but not limited to, equipment, vehicles, software, and library materials including electronic journals. Procurement of information technology, hardware/software, or peripherals must comply with the Information Technology Acquisition Policy, Doc. T08-086.

3. **To the Chancellors,** for campus procurements with authority to re-delegate to such campus personnel as the Chancellor may determine:

a. Authority to enter into and execute agreements for goods, materials and commodities.

b. Authority to enter into Sub-contract(s), Consultant contract(s), and Service contract(s) necessary for campus services as provided in the Procurement Standards.

c. Authority to enter into and execute contracts for labor and materials for repair or construction, including design services, of real property used by the campus, subject to any applicable requirements under G.L. ch.7C, G.L. ch.30, or G.L. ch.149.

d. Authority to enter into and execute agreements relating to the use of real property by the campus.

e. Authority to enter into and execute agreements for use of campus real property by non-affiliated entities which do not exceed five (5) years, including any renewals or options for renewal. Any dispositions of University real property must comply with the University's Capital Planning, Land and Facilities Use, Doc. T93-122 and with the Treasurer's Delegations, Doc. T97-014. All agreements for real property must be approved by the General Counsel prior to execution.

f. Authority to enter into and execute agreements for use of campus real property by affiliated entities which do not exceed twenty (20) years, including any renewals or options for renewal. Any dispositions of University real property must comply with the University's Capital Planning, Land and Facilities Use Policy, Doc. T93-122 and with the Treasurer's Delegations, Doc. T97-014. All agreements for real property must be approved by the General Counsel prior to execution.

g. Authority to enter into and execute leases or licenses for any items, including but not limited to, equipment, vehicles, software, and library materials including electronic journals. Procurement of information technology, hardware/software, or peripherals must comply with the Information Technology Acquisition Policy, Doc. T08-086.

4. **To the General Counsel,** with authority to re-delegate to an attorney in the General Counsel's office as the General Counsel may determine, authority to enter into Legal services agreements for attorneys or law firms to provide legal services for the University, as defined in the Procurement Standards. Any such attorney and/or law firm shall work under the continuing supervision of the General Counsel.

All sub-delegations of authority pursuant to this policy shall be made in writing and forwarded to the office of the Senior Vice President for Administration & Finance and Treasurer and to the General Counsel.

C. Legal Review:

1. The General Counsel shall review the following agreements and contracts, including multi-campus or system-wide procurements, entered into by the President's Office, or the campuses, which are required under this Policy and identified under the Procurement Standards prior to execution. Review by the General Counsel's office under this policy and the Procurement Standards is in addition to any other internal approvals that may be required under other University policies.

   a. Agreements relating to any interest in real property.

   b. Sub-contracts, consultant or services contracts as defined in the Procurement Standards.

   c. Contracts for lobbying services.

   d. Amendments, contracts or agreements which contain language that conflicts with, modifies, deletes, adds to, or otherwise alters the University's standard contract terms and conditions.

Legal review of additional contracts or agreements may be required pursuant to standards developed pursuant to this Policy. Review by the General Counsel's office under this policy and the Procurement Standards is in addition to any other internal approvals that may be required under other University policies.

2. The responsible procurement or contracting official for a campus or the President's Office shall confer with the General Counsel when advisable to assure compliance with this Policy.

III. THE STANDARDS

The President shall issue standards for the implementation of this policy. The Senior Vice President for Administration & Finance and Treasurer shall recommend such standards for the President's action. The Senior Vice President for Administration & Finance and Treasurer shall confer on a regular basis with the Purchasing Council and the General Counsel to determine whether revisions to the standards are appropriate to comply with University policies or law, and to assure that the University is using best practices to secure its goods and services.

ADMINISTRATIVE STANDARDS FOR THE PROCUREMENT POLICY (Doc. T92-031, Appendix A)

I. INTRODUCTION

The purpose of this policy is to govern the procurement of all goods, materials, commodities, and services by the University, including but not limited to, design services, vehicles, equipment, library materials, software, and real property, whether by purchase order, contract, license, lease, or other form of agreement. In accordance with the provisions of Sections 3 and 13 of Chapter 75 of the General Laws, as amended, all purchases irrespective of source of funds, under the provisions of said Section 13 shall be governed by this policy subject to subsequent amendment, revision, or repeal, from time to time, by the Trustees.

This policy shall apply to each campus and to the President's Office, as well as to multi-campus or system-wide agreements. This policy shall not supersede any of the provisions of the Senior Vice President for Administration & Finance and Treasurer's Delegations, Doc. T97-014. All University employees must follow Doc. T08-028, the Policy on Codes of Conduct for University/Vendor Relationships.

All persons responsible for procuring goods and services governed by this policy shall confer with the General Counsel as advisable in order to assure compliance with these terms.

II. POLICY STATEMENT

A. Competitive Procurement Practices:

The University shall obtain all goods and services covered by this policy at the best over-all value to the University as is consistent with the quantity, quality, durability, availability, serviceability, and other factors affecting service and use as required by the using department of the University. In complying with this policy, the cost of acquisition and the delivery time required shall be considered as well as the cost of the item being purchased. All procurements must (1) have prior approval of the relevant Purchasing Department; and (2) must follow appropriate delegation and signatory authority in accordance with University policies and campus/President's Office procedures and guidelines to bind the University.

To maximize vendor competition and volume discount purchases, departments shall make use of Campus, University, State, or Massachusetts Higher Education Consortium publicly bid contracts whenever appropriate and practicable. Contracts of other consortia and group purchasing organizations may also be utilized when approved by the University Purchasing Council based on evidence of the consortia's sound competitive and ethical procurement practices.

To encourage open and fair competition, advertisement for and receipt of competitive bids shall be used whenever practicable, or when required by law. The University's commitment to the principles of Affirmative Action shall be applied to purchasing with the objective of: (i) achieving and fostering greater participation in University procurement activity by minority-owned small business, small disadvantaged business, women-owned small business, HUBZone small business, Veteran-owned small business, and service-disabled Veteran-owned small

REDACTED FOR PUBLIC RELEASE

business enterprises and (ii) encouraging socially or economically disadvantaged business owners to respond to invitations to bid on University business.

B. Delegations of Authority:

1. **To the President**, with authority to re-delegate to the Senior Vice President for Administration & Finance and Treasurer, or any member of the President's Office as the President may determine:

   a. Authority to require the campuses to utilize a system-wide or multi-campus procurement for any purchase covered by this policy. The President shall issue standards for when a system-wide or multi-campus procurement for purchases is required. A Chancellor who believes such procurement would not be in the best interest of his/her campus shall be entitled to request not to participate in such procurement, but the President shall make the final decision.

2. **To the President,** for President's Office, and multi-campus or system-wide procurements, with authority to re-delegate to the Treasurer, and/or such other designees as the President shall determine:

   a. Authority to enter into and execute agreements for goods, materials and commodities.

   b. Authority to enter into and execute Sub-contract(s), Consultant contract(s), and Services contract(s) as provided in the Procurement Standards.

   c. Authority to enter into and execute contracts for labor and materials for repair or construction, including design services, of real property used by the President's Office subject to any applicable requirements under G.L. ch.7C, G.L. ch.30, or G.L. ch.149.

   d. Authority to enter into and execute agreements relating to the use of real property by the President's Office.

   e. Authority to enter into and execute agreements for the use of President's Office real property by non-affiliated entities which do not exceed five years, including any renewals or options for renewal. Any dispositions of University real property must comply with the University's Capital Planning, Land and Facilities Use Policy, Doc. T93-122 and with the Treasurer's Delegations, Doc. T97-014. All agreements relating to real property must be approved by the General Counsel prior to execution.

   f. Authority to enter into and execute agreements for use of University real property by non-affiliated entities which exceed five years upon Board of Trustees approval and any necessary campus approvals. Any dispositions of University real property must comply with the University's Capital Planning, Land and Facilities Use Policy, Doc. T93-122 and with the Treasurer's Delegations, Doc. T97-014. All agreements relating to real property must be approved by the General Counsel prior to execution.

   g. Authority to enter into and execute agreements for use of President's Office real property by affiliated entities which do not exceed twenty (20) years, including any renewals or options for renewal. Any dispositions of University real property must comply with the University's Capital Planning, Land and Facilities Use Policy, Doc.

REDACTED FOR PUBLIC RELEASE

T93-122 and with the Treasurer's Delegations, Doc. T97-014. All agreements for real property must be approved by the General Counsel prior to execution.

h. Authority to enter into and execute leases or licenses for any items, including but not limited to, equipment, vehicles, software, and library materials including electronic journals. Procurement of information technology, hardware/software, or peripherals must comply with the Information Technology Acquisition Policy, Doc. T08-086.

3. **To the Chancellors,** for campus procurements with authority to re-delegate to such campus personnel as the Chancellor may determine:

a. Authority to enter into and execute agreements for goods, materials and commodities.

b. Authority to enter into Sub-contract(s), Consultant contract(s), and Service contract(s) necessary for campus services as provided in the Procurement Standards.

c. Authority to enter into and execute contracts for labor and materials for repair or construction, including design services, of real property used by the campus, subject to any applicable requirements under G.L. ch.7C, G.L. ch.30, or G.L. ch.149.

d. Authority to enter into and execute agreements relating to the use of real property by the campus.

e. Authority to enter into and execute agreements for use of campus real property by non-affiliated entities which do not exceed five (5) years, including any renewals or options for renewal. Any dispositions of University real property must comply with the University's Capital Planning, Land and Facilities Use Policy, Doc. T93-122 and with the Treasurer's Delegations, Doc. T97-014. All agreements for real property must be approved by the General Counsel prior to execution.

f. Authority to enter into and execute agreements for use of campus real property by affiliated entities which do not exceed twenty (20) years, including any renewals or options for renewal. Any dispositions of University real property must comply with the University's Capital Planning, Land and Facilities Use Policy, Doc. T93-122 and with the Treasurer's Delegations, Doc. T97-014. All agreements for real property must be approved by the General Counsel prior to execution.

g. Authority to enter into and execute leases or licenses for any items, including but not limited to, equipment, vehicles, software, and library materials including electronic journals. Procurement of information technology, hardware/software, or peripherals must comply with the Information Technology Acquisition Policy, Doc. T08-086.

4. **To the General Counsel,** with authority to re-delegate to an attorney in the General Counsel's office as the General Counsel may determine, authority to enter into Legal services agreements for attorneys or law firms to provide legal services for the University, as defined in the Procurement Standards. Any such attorney and/or law firm shall work under the continuing supervision of the General Counsel.

All sub-delegations of authority pursuant to this policy shall be made in writing and forwarded to the office of the Senior Vice President for Administration & Finance and Treasurer and to the General Counsel.

C. Legal Review:

1. The General Counsel shall review the following agreements and contracts, including multi-campus or system-wide procurements, entered into by the President's Office, or the campuses, which are required under this Policy and identified under the Procurement Standards prior to execution. Review by the General Counsel's office under this policy and the Procurement Standards is in addition to any other internal approvals that may be required under other University policies.

   a. Agreements relating to any interest in real property.

   b. Sub-contracts, consultant or services contracts as defined in the Procurement Standards.

   c. Contracts for lobbying services.

   d. Amendments, contracts or agreements which contain language that conflicts with, modifies, deletes, adds to, or otherwise alters the University's standard contract terms and conditions.

   Legal review of additional contracts or agreements may be required pursuant to standards developed pursuant to this Policy. Review by the General Counsel's office under this policy and the Procurement Standards is in addition to any other internal approvals that may be required under other University policies.

2. The responsible procurement or contracting official for a campus or the President's Office shall confer with the General Counsel when advisable to assure compliance with this Policy.

III. STANDARDS STATEMENT

A. Procurement Administration

The Senior Vice President for Administration & Finance and Treasurer, under the direction of the President, is designated as the officer of the University responsible for issuing procurement standards applicable to the five campuses and the President's Office, and to multi-campus or system-wide procurements. The General Counsel's Office in conjunction with the Procurement Council shall regularly review these Standards and propose any changes to the Senior Vice President for Administration & Finance and Treasurer. The Procurement Council shall consist of the chief procurement/purchasing officer of each campus and the President's Office, and shall meet at least annually to discuss system-wide procurement issues and to maximize economies through cooperative efforts.

Each campus and the President's Office shall maintain a central procurement department. Each Chancellor may delegate responsibility for developing procedures to implement, review, monitor, and enforce approved purchasing policies.

All procurements of goods, materials, commodities, and services by the University, including but not limited to, vehicles, equipment, library materials, software, design services, or real property, whether procured by purchase order, contract, license, lease, or other form of agreement (collectively “Procurements”) regardless of the source of funds must comply with the University’s Procurement Policy, Doc. T92-031 as amended and these Standards.

These Standards shall apply to any University sub-contracts for services or consultants entered into to meet the University’s contractual obligations to third parties.

All Procurements must (1) comply with campus procurement procedures and (2) must follow appropriate delegation and signatory authority in accordance University policies and campus or President’s Office procedures to bind the University.

B. Definitions. Chief procurement/purchasing officers should consult with the General Counsel’s office if clarification is needed for any of these definitions.

1. Consultant services: Services provided by an individual, company, or entity in a specific specialized field(s) with little or no University direction or supervision. Consultant services shall include lobbying services as defined by state or federal law.

2. Contract: The University’s contract for services including consultant services, purchase order, or any other written, legally binding agreement between the University and an external individual or entity.

3. Independent Contractors: Contracts with individuals engaged to perform services or consultant services for or on behalf of the University under a Contract or Sub-contract, other than in an employment status, and minimally supervised by University personnel. These individuals engaged must meet the requirements for independent contractors under state and federal law, including G.L. ch.149, section 148B. Questions or guidance concerning independent contractor status should be directed to Human Resources.

4. Legal services: Attorneys or law firms retained to provide legal advice or representation for the University, a campus, or University employees in matters relating to their official duties. Any legal counsel retained by the University on a permanent, temporary, or consultant basis shall be approved and retained by, and subject to the continuing supervision of, the General Counsel of the University, pursuant to the vote of the Board of Trustees, May 1, 1974.

5. Services: Duties, work, or activities performed by an individual, company, or entity for the University under a written contract; or on behalf of the University under a written sub-contract; or performed by the University for a third party under a written contract. Services as defined in this subsection shall not include consultant or legal services.

6. Sub-contracts: The University, through the President’s Office, or any campus may enter into contracts with other persons or entities, including other governmental agencies, by which the University agrees to provide services. In order to fulfill these contractual obligations, the University may enter into sub-contracts with persons or firms. These sub-contracts shall be subject to the Procurement Policy and any standards or campus

guidelines developed pursuant to the Procurement Policy in the same manner as if the University were procuring goods and services for itself, unless other contractual terms apply.

C. Competitive Procurement

Competitive procurement is the acquisition of Procurements through fair and open competition. Acceptable methods of competitive procurement include invitations to bid, requests for proposals, requests for quotes, or a combination of these (collectively "Invitations").

Invitations shall be written in a manner to encourage fair and open competition. All Invitations issued shall include specifications and all contractual terms and conditions applicable to the particular procurement. Invitations may include language for the submission of samples that may be examined, tested, and analyzed to determine if they meet the stated specifications provided for in the Invitations.

1. Procurement specifications should be written in clear, simple language and provide an accurate description of the physical, technical, or functional characteristics of the Procurement. Procurement specifications shall be as detailed as practical presenting a clear statement of the required standards of workmanship, materials, services and/or performance of the Procurement to be procured. Specifications shall set out the essential characteristics of the Procurement being procured so that potential responders are responding to the Invitations on the same terms,

2. Invitations shall include the contractual terms and conditions relative to the Procurement being procured. All responders must be advised of those specific terms and conditions required by the University and which will not be negotiable.

3. Invitations for Procurements shall be posted on a publicly displayed bulletin board at the respective University campus, or University campus website and when deemed desirable, or as required by law, may be advertised in newspapers and trade journals in the State, Comm-Buys or other appropriate public internet websites. Advertisement for design and building construction must be in compliance with G.L. ch.7C, G.L. ch.149 and G.L. ch.30, section 39M.

4. University personnel responsible for purchasing shall, to the greatest extent possible, inform themselves of prices and specifications of items available through the Commonwealth of Massachusetts, Operational Services Division ("OSD") and its contract price agreements and may utilize those agreements whenever it would be to the advantage of the University. When utilizing OSD, for Procurements, other consortia, or group purchasing organizations, the University must comply with the procedures and terms and conditions set forth for the procurement; including any requirements for obtaining quotes from multiple vendors.

5. Contracts of other consortia and group purchasing organizations may also be utilized when approved by the University Purchasing Council based on evidence of consortia's sound competitive and ethical procurement practices whenever it would be to the advantage of the University

6. When practicable, requisitions and orders shall be grouped to take advantage of quantity discounts.

7. Competitive Procurement is required for purchases of materials, goods, commodities, leases (including equipment or real property) and licenses (including software, electronic journals, or real property) which exceed ten thousand dollars ($10,000) per fiscal year; and for services contracts including consultant contracts, and sub-contracts which exceed fifty thousand dollars ($50,000) per fiscal year.

8. All Labor and Materials construction projects must be bid in compliance with G.L. ch.149 and G.L. ch.30, section 39M.

9. Services for Building Projects (as defined in ch.7C) must be bid in compliance with G.L. ch.7C.

D. Exceptions to Competitive Procurement

Subject to the Procurement Policy, procurements made without advertising or some competitive procurement process should be limited to:

1. Purchases of materials, goods, commodities, leases (including equipment or real property) or licenses (including software or real property) less than ten thousand dollars ($10,000) in value.

2. The best over-all value based on a minimum of two with a preferred three quotes for purchases of materials, goods, commodities, leases (including equipment or real property) and licenses (including software) between ten thousand dollars ($10,000) and fifty thousand dollars ($50,000) in value.

3. Consultant, services contracts, or sub-contracts with fees of fifty thousand dollars ($50,000) or less per fiscal year.

4. Those instances where competitive bidding would be impracticable; and in all such instances, any department requesting the procurement must provide a written memorandum of "No Bid Justification," which must include the benefits and circumstances for procurement without competitive bidding. In those instances where competitive bidding is impossible and would have no practical value because of the nature of the Procurement, the campus chief procurement officer or chief purchasing officer, at his/her discretion, may determine whether a "No Bid Justification" is necessary.

E. Procedures

1. A University standard contract form agreement shall be used whenever possible for procuring consultant or other services under the Procurement Policy.

2. A purchase order may be used for procuring services, including consultant and sub-contract services with projected fees of ten thousand dollars ($10,000) or less per fiscal year.

3. A purchase order may be used for Procurements publicly administered by the Commonwealth of Massachusetts, Operational Services Division.

4. A University standard amendment form or an amendment in substantially the same form as the University standard amendment form shall be used whenever possible when amending a contract or sub-contract.

5. Change orders should be made in accordance with the terms of a contract or sub-contract. A change order is a written order issued by a duly authorized individual who approves a change in the work, contract time and/or amount in accordance with the terms of the written contract.

6. Contracts for consultant or other services should include the University's insurance requirements identifying the appropriate insurance coverages required under the contract.

7. When a procurement of services, regardless of dollar value, for maintaining, disclosing, transmitting, accessing, using, or storing personal information or personally identifiable information (PI) as defined under state or federal law, or protected health information (PHI) as defined under the Health Insurance Portability and Accountability Act of 1996 as amended, the campus may need to either enter into an additional agreement or provide sufficient language in the existing agreement that outlines the obligations of a party in safeguarding PI or PHI from unauthorized disclosure or use. Questions about potential liabilities or other legal concerns should be directed to the Office of General Counsel.

8. A campus must notify the President or designee about any proposed campus contract for consultant services which will exceed $300,000 annually.

F. Legal Consultation and Review

1. Legal Review: Prior review and approval by the General Counsel's office is required for the following agreements.

   a. Agreements relating to any interest in real property.

   b. Sub-contracts, consultant or other service contracts which exceed $100,000 per fiscal year.

   c Contracts for lobbying services.

   d. Amendments which contain language that conflicts with, modifies, deletes, adds to, or otherwise alters the University's standard contract terms and conditions.

In addition to the preceding, the General Counsel's Office may review any agreement, including; but not limited to contracts, sub-contracts, or consultant contracts and amendments, which a campus reasonably believes requires legal review.

2. Exceptions to Required Legal Review:

   a. The purchase of services for the necessary and routine operations or daily activities of the University and/or the repair or maintenance of University property or facilities.

3. Consultation: The General Counsel's office should be consulted regarding any interpretation or application of these Standards or the Procurement Policy. Attorneys in the office can provide review and advice for any aspect of procurement, including development of Invitations/RFP/RFQ, responses from bidders, post-award de-briefs and protests, proposed contract terms, and negotiations.

   Attorneys in the General Counsel's office should be consulted regarding any contractual terms implicating the University's trademarks, copyrights, or intellectual property, or any terms which may require the University to indemnify, hold harmless, warranty, or otherwise agree to protect a third party from risk of loss in any respect.

G. Contract Best Practices. University employees should review the University's "Contracting Best Practices" document. See below.

8 Tips:
For
Reviewing Vendor Contracts

1. Preamble

Always start by reviewing the preamble to the contract. Make sure the University and the Vendor are properly identified as parties to the contract by their legal names. Use "University of Massachusetts _________ " inserting the campus name. Do not use the Department or School name. The University is not a corporation, non-profit entity, or political subdivision. It is a "public institution of higher education within the Commonwealth of Massachusetts." Legally speaking, it is an "agency" of the Commonwealth. Make sure that each party uses a physical legal address and not a P.O. Box. The Vendor should be identified by its full legal name, including the designation of the Vendor's form of business entity (e.g. "Inc." for a corporation, "LLC" for a limited liability company). If the Vendor is an individual acting as a sole proprietor, the Vendor should be identified by that individual's first and last name.

2. Laws or Jurisdiction of Another State

Many contracts require the application of laws from another state or require the University to agree that it may be sued outside of Massachusetts. This language is often found under headings such as Applicable Law, Governing Law or Choice of Law. The laws and the jurisdiction of the Commonwealth of Massachusetts should always be substituted for that of any other state. The proper procedure for correcting such language is to:

a) Request the Vendor remove the state's name and insert Massachusetts as the governing law and jurisdiction;

b) If the Vendor will not accept the change from its chosen state to Massachusetts, request that the choice of law and/or Jurisdiction section remain silent: that is, agree not to have a choice of law section and have the Vendor remove the clause entirely;

c) If the Vendor refuses to accept any of the above changes consult with the Office of the General Counsel ("OGC").

3. Arbitration Clauses

If the Vendor requests an arbitration clause be included in the contract and you consent to having an arbitration clause included, it is recommended that you not accept a "non-binding" arbitration clause. Binding arbitration clauses may be acceptable so long as (1) the language does not require the arbitration to be conducted outside of Massachusetts or in accordance with another state or country's laws and (2) the arbitration clause also includes language requiring the parties to participate in mediation prior to requesting arbitration.

a) The proper procedure for correcting arbitration clauses containing unacceptable requirements is to:

REDACTED FOR PUBLIC RELEASE

i. request the Vendor remove any language requiring arbitration be conducted outside of Massachusetts;

ii. request the Vendor to remove any language requiring arbitration be conducted in accordance with another state or country's laws;

iii. if the Vendor refuses to remove the above said requirements please consult with OGC.

b) The proper procedure for correcting arbitration clauses that do not include mediation language is to:

i. request the Vendor add the following language:

Mandatory Mediation. In the event a dispute shall arise between the parties to this [Contract, Agreement, etc.], the parties will make a good faith attempt to resolve any and all claims and disputes by submitting them to mediation before resorting to arbitration. The mediation will involve no formal court procedures or rules of evidence and the mediator shall not have the power to render a binding decision or force an agreement on the parties. The mediation of any claim or dispute must be conducted by a mediator who has had both training and experience as a mediator of commercial matters. Within thirty (30) days after the selection of the mediator, the parties will meet with the mediator for one (1) mediation session of at least four (4) hours.

If the claim or dispute cannot be settled during such mediation session or mutually agreed continuation of the session, either party may give the mediator and the other party to the claim or dispute written notice declaring the end of the mediation process. All discussions connected with this mediation provision will be confidential and treated as compromise and settlement discussions. Nothing disclosed in such discussions, which is not independently discoverable, may be used for any purpose in any later proceeding. The parties agree to share equally in the costs of the mediation.

ii. if the Vendor refuses to add the above said language please consult with OGC.

c) Any language suggesting the prevailing party shall be entitled to recover its legal costs and attorney's fees should be removed. The proper procedure is to request the Vendor remove such language.

4. Confidentiality and Non-Disclosure Clauses

Pursuant to the Massachusetts Public Records Law (M.G.L. Ch. 66 §10), the public has the right to review, inspect and copy University records unless a specific exemption allows the withholding of a record. The existence of a service or goods contract in and of itself can never be confidential. The proper procedure for correcting the inclusion of a Confidentiality and/or Non-Disclosure clause is to:

a) Unless absolutely required, request that any Confidentiality and/or Non-Disclosure clause(s) be deleted;

REDACTED FOR PUBLIC RELEASE

b) If the Vendor will not accept the deletion of such a clause, request that the following language be inserted at the beginning of the clause: "To the extent permissible under Massachusetts Law…"

Some contracts require the University to provide notice if they are going to disclose the terms of the contract or other documents relating to a contract. Such language should be deleted. The Massachusetts Public Records statute does not require the University to provide any notice prior to disclosing documents or to seek prior authorization from the Vendor to disclose a document in accordance with the statute. If the Vendor requires notice you should consult with OGC.

Some types of contracts involve proprietary interests and/or trade secrets that may require a Confidentiality and/or Non-Disclosure clause to protect such interests. If the Vendor believes that a Confidentiality and/or Non-Disclosure clause is necessary in this instance, please consult with OGC.

5. Legal Fees and Cost of Enforcement

Have the Vendor remove any clause(s) obligating the University to pay legal fees or other costs relative to the enforcement of a contract. The University will only pay legal fees ordered by a court. The proper procedure for correcting such language is to:

a) Request the Vendor remove any language or clause which suggests that a party is entitled to costs incurred in the enforcement of the contract;

b) Request the Vendor remove any language or clause which suggests that the prevailing party shall be entitled to recover court costs and attorney's fees in the event of litigation or arbitration;

c) If a party refuses to strike such language or clause, consult with OGC.

6. Automatic Renewal

The University should not agree to language that creates an automatic renewal of a contract for an additional term. Contracts should be periodically reviewed for consistency with University policy, law, and business interests prior to any renewal; therefore, renewal options should always be at the University's discretion. The proper procedure for correcting such language is to:

a) Request the Vendor to remove the automatic renewal language and replace it with language that allows the University to renew the contract at its option e.g., "The University may, by providing written notice no later than thirty (30) days before expiration of the initial term, renew this [Contract, Agreement, etc.] for an addition term of [*insert time period*]."

7. Terms Requiring University to Indemnify Contracting Party

The University, as a public entity cannot indemnify Vendors or other parties to the contract as the University is prohibited from pledging the credit of the Commonwealth without the approval of a two-thirds vote of the Massachusetts Legislature. *See* Article 62 of the Massachusetts Constitution, as amended. The Massachusetts courts have construed statutory authorizations for public entities to enter into contracts as not authorizing indemnity clauses. *Lovering v. Beaudette*, 30 Mass.App.Ct. 665, 669 (1991); *Raisman v. Cunningham, Inc.*, Civil Action No. 93-5070-G

(Super. Ct. 1995). The proper procedure is to request the Vendor to delete the clause(s) in its entirety.
If a Vendor refuses to remove the clause(s), consult with OGC.

8. Amendments

Confirm the contract contains a provision requiring that amendments be in writing and signed by both parties. If not, request that the Vendor include the below language as a separate numbered paragraph near the end—before the signature lines.

Amendments. No amendment to this Agreement shall be effective unless in writing and signed by authorized representatives of both parties and complies with all other regulations and requirements of law.

Doc. T92-031
Passed by the BoT
6/3/92
Revised 6/8/94
Revised 6/7/95
Revised 8/24/05

UNIVERSITY OF MASSACHUSETTS
POLICY FOR MANAGEMENT OF UNIVERSITY FUNDS

1. PURPOSE

The University of Massachusetts *Policy for Management of University Funds* describes procedures to establish and administer all funds as authorized by Section 11 of Chapter 75 of the Massachusetts General Laws, as amended.

2. APPLICABILITY

This policy applies to all campuses and components of the University of Massachusetts and shall include any and all financial resources allocated, negotiated, earned or collected by the University to further the missions of research, teaching and public service including those funds appropriated by the Commonwealth of Massachusetts.

3. EXPENDITURE AUTHORITY

The Board of Trustees delegates to the President, each Chancellor, the Senior Vice President for Administration, Finance, and Technology and Treasurer, the Vice Chancellors for Administration and Finance, the Controllers and their designees, the authority to authorize payments on the University systems on behalf of the University. Any such payments must be consistent with the policies and procedures of the University and adhere to reasonable and prudent business principals.

4. EXPENDITURE OF FUNDS

All funds, regardless of the source or the manner in which they are acquired, are considered to be University Funds. The interpretation of this policy as well as the expenditure of these funds are based solely on reasonable and prudent actions by University employees expending public funds. All University employees should exercise their fiduciary responsibility in a manner consistent with the confidence and trust granted to them by the Board of Trustees in disbursement of these funds.

The President and Chancellors are responsible for the overall fiscal integrity of the University. The Vice Chancellors for Administration and Finance and the Senior Vice President for Administration, Finance, and Technology and Treasurer are operationally responsible for all transactions affecting both the Financial Records System and the fiscal status of the University.

Fund expenditures must meet the following minimum guidelines and criteria. These criteria represent the minimum acceptable standards, and campus guidelines may be more, but not less, restrictive.

REDACTED FOR PUBLIC RELEASE

VICE CHANCELLORS FOR ADMINISTRATION AND FINANCE CONTROLLERS

LITIGATION CLAIMS

Executive Task Force
December 19, 1991

1. General Counsel of the University or his designee may settle claims of up to $20,000 on behalf of any campus of the University;

2. Such settlements will be paid from campus funds under the jurisdiction of the Campus Chancellor and staff;

3. At the point of settlement, in effect, before a final commitment is made the Campus Chancellor will be asked to approve the settlement;

4. Once the Campus Chancellor has approved a settlement and such a settlement is agreed upon, Counsel will request the Campus Vice Chancellor for Administration and Finance to provide Counsel with the settlement payment;

5. Settlements exceeding $20,000 will process through the appropriate state financing, procedures involving the State Comptroller and State Administration and Finance.

6. This policy in no ways absolves the State from overall responsibility in those instances where legitimate claims can be made on State appropriated resources. The purpose of the policy is to allow a mechanism where small settlements can be quickly resolved and payment made.

POLICY FOR THE MANAGEMENT OF UNIVERSITY FUNDS AND ASSOCIATED POLICIES AND DELEGATIONS

Passed by the Board
June 3, 1992

To approve the University's Policy for the Management of University Funds (Doc. T92-031), as described in the executive summary, which includes the following delegations of authority:

To delegate to the President, each Chancellor, the Vice President for Management and Fiscal Affairs/Treasurer, the Vice Chancellors for Administration and Finance, and the Controllers and their designees, the authority to authorize payments on the University systems on behalf of the University consistent with Doc. T92-031.

REDACTED FOR PUBLIC RELEASE

REDACTED FOR PUBLIC RELEASE

University of Massachusetts
UMASS Lowell
Learning with Purpose

University Crossing
220 Pawtucket Street, Suite 400
Lowell, MA 01854-5120
tel. 978-934-2206
fax: 978-934-3000
email: Joanne_Yestramski@uml.edu

Joanne Yestramski
Vice Chancellor for Finance
and Operations

OFFICE OF FINANCE AND OPERATIONS

September 18, 2015

Christine Wilda
Senior Vice President for Administration & Finance
and Treasurer
University of Massachusetts
333 South Street
Shrewsbury, MA 01545

Dear Christine,

In accordance with the University of Massachusetts Procurement Policy, attached is an updated delegation of signature authority for the UMass Lowell campus.

If you have any questions regarding this matrix, please feel free to contact me.

Sincerely,

Joanne Yestramski
Vice Chancellor for Finance and Operations

JLY:ss
Attachment

cc: UMass General Counsel

REDACTED FOR PUBLIC RELEASE

September 2015

UNIVERSITY OF MASSACHUSETTS LOWELL

CHANCELLOR'S DELEGATION OF SIGNATURE AUTHORITY*

(Non-Personnel)

UMASS LOWELL Name	Professional Services performed by Consultants - Standard University Contract Required (1)	Contracts for labor and materials (Construction - M.G.L c.149 and M.G.L. c. 30, §39M (2)	Lease of University Real Property to Others ≤ 5 years (3) (4)	Lease of Third Party Equipment & Real Property (3)	Sponsored Programs Grants - Applications, Proposals, Awards, MOU's, CDA's, MTA's, ISA's	Non-Sponsored Programs Licenses , ISA's, MOU's, non-research CDA's (5)	Operational Services
Chen, Julie Vice Provost for Research	≤$50,000				X		
Concino, Linda Director, Grants & Contracts Admin.	< $10,000				X		
Durkin, Michael Dir. of Procurement Svcs	≤$100,000	≤$1,000,000		≤$100,000			$500,000
Evans, Brenda (6) Dean of Student Affairs & Event Svcs	≤$25,000						
Hopole, Thomas Chief Procurement Officer	≤$300,000	≤$3,000,000	No Limit	No Limit		X	No Limit
Moloney, Jacqueline Chancellor	No Limit	No limit	No Limit	No Limit	X	X	No Limit
Nolan, Gary Senior Strategic Sourcing Manager	≤$50,000			$50,000			≤$50,000
O'Riordan, Steven Assoc. Vice Chancellor	≤$300,000	≤$3,000,000	No Limit	No Limit	X	X	No Limit
Pierson, Don Provost	≤$50,000				X	X	
Tziotziouras, Heather Procurement Specialist		$25,000		$25,000			
Yestramski, Joanne Vice Chancellor	No Limit	No limit	No Limit	No Limit	X	X	No Limit

REDACTED FOR PUBLIC RELEASE

*Delegation of Signature Authority does not supersede procurement requirements of BOT Policy T92-031, Appendix A. Enforcement of BOT Policy is delegated to Chief Procurement Officer.

(1) General Counsel must review all agreements > $100,000. Campus must provide prior notice to President's Office of all Consultant Services >$300,000.
(2) All construction projects > $250,000 require DCAM/UMBA management or delegation (case by case under $2M)
(3) Agreements relating to any interest in real property-require General Counsel review.
(4) Any Lease of University Real Property exceeding 5 years requires President approval.
(5) CIO must review all Information Technology requisitions in accordance with BOT Policy T08-086.
(6) Those related to Student Activities under limits designated by the V.C. for Finance & Operations

CDA: Confidentiality Disclosure Agreement (CVIP)
MTA: Material Transfer Agreement (CVIP)
ISA: Interdepartmental Service Agreement
MOU: Memorandum of Understanding

Chapter 15

Appendix

Statement of Intent

REDACTED FOR PUBLIC RELEASE

Joanne Yestramski Vice Chancellor for Finance and Operations

University of Massachusetts
UMASS Lowell

Learning with Purpose

University Crossing
220 Pawtucket Street, Suite 400
Lowell, MA 01854-5120
tel. 978-934-2206
fax: 978-934-3000
email: Joanne_Yestramski@uml.edu

OFFICE OF FINANCE AND OPERATIONS

NRC Document Control Desk
U.S. Nuclear Regulatory
Commission Washington, D.C.
20555

Re: Docket Number 50-223

STATEMENT OF INTENT

As Chief Financial Officer of the University Massachusetts Lowell, I exercise express authority and responsibility to request from the Commonwealth of Massachusetts funds for decommissioning activities associated with operations authorized by U.S. Nuclear Regulatory Commission License No. R-125. This authority is established by the University of Massachusetts Board of Trustees resolution of June 3, 1992, accepting the Policy for the Management of University Funds and Associated Policies and Delegations.

Within this authority, I intend to request that funds be made available when necessary to decommission the University Massachusetts Lowell Research Reactor, located in Lowell, Massachusetts. The current 2015 estimate for these costs is $4.7 million. I intend to request and obtain these funds sufficiently in advance of decommissioning to prevent delay of required activities.

A copy of the Resolution and Board Policy T92-031 are attached as evidence that I am authorized to represent the University of Massachusetts Lowell in this transaction.

Joanne Yestramski
Joanne Yestramski
Vice Chancellor Finance & Operations
University Massachusetts Lowell
October 15, 2015

Attachments

cc: Vice Provost for Research Julie Chen
Associate Vice Chancellor Steve O'Riordan
Radiation Laboratory Director Partha Chowdhury

REDACTED FOR PUBLIC RELEASE

Chapter 15

Appendix

Decommissioning Estimate

REDACTED FOR PUBLIC RELEASE

Decommissioning Cost Estimate for the University of Massachusetts Lowell Research Reactor - 2015

Technical Support Document No. 15-050

Originated by: ______________________________
William Cash, Senior Health Physicist

Reviewed by: __________Roderick Knight__________________________
Roderick Knight, Certified Cost Professional

Reviewed by: ______________________________
Adam Kryskow, CHP

Approved by: ______________________________
Greg Babineau, Director of Radiological Services

Prepared by

Radiation Safety & Control Services, Inc.

91 Portsmouth Avenue
Stratham, NH 03885-2468
1-855-35-ALARA
(603) 778-2871 (Outside USA)
www.radsafety.com

June 24, 2015

RSCS
Radiation Safety & Control Services

REDACTED FOR PUBLIC RELEASE

1.0 Executive Summary

Radiation Safety & Control Services (RSCS) provided an independent cost estimate for decommissioning of the University of Massachusetts Lowell research reactor. This cost estimate was prepared using realistic waste volume estimates and current waste disposal cost values. Specific and general site descriptions were used in determining decontamination and demolition approaches. Included in these cost estimates are historical and current operating experiences associated with the reactor facility.

The estimate includes itemized costs for manpower, equipment services, indirect costs, radioactive waste volume reduction, packaging, shipping, and burial activities. Decommissioning Plan development and final status surveys are included. The overall assumption for the scope of the cost estimate is a complete removal of all contaminated and potentially contaminated components and structures both within the reactor facility and in the associated reactor support components outside the reactor containment structure itself. The estimated decommissioning based on 2015 cost terms is $4,723,855. This estimate does not include the cost associated with nuclear fuel removal and transport to a DOE (Department of Energy) facility.

This decommissioning cost estimate is only meant for budgetary use purposes. A significant portion of the decommissioning costs is attributed to the disposal of radioactive waste. These costs are very time dependent and subject to unpredictable changes that should be evaluated on a recurrent basis.

2.0 Introduction

The University of Massachusetts Lowell operates a swimming pool type research reactor on the university campus located in the city of Lowell, MA (Site Map, Attachment A). The Nuclear Regulatory Commission issued an operating license for this facility in December, 1974 (License # R-125) to the original Lowell Technological Institute (Lowell Tech). They merged with Lowell State in 1975 to form the University of Lowell. In 1991 the campus became part of the University of Massachusetts system.

The reactor is attached to the Nuclear Center whose name changed in the early 1980's to the [redacted] Building. Other radioactive material licensing activities associated with university research are performed under a State of Massachusetts broad scope license not specifically tied to the reactor license activities.

Scope

The scope of this report is to present up-to-date costs estimated for the decommissioning of the University of Massachusetts Lowell Reactor. The specific areas covered by this estimate include;

- The reactor components
- Support structures and components
- Contaminated and activated structures and components
- Associated components and facilities both inside and outside the reactor containment structure

The estimate is prepared as an update of the previous cost estimates, and provides an independent assessment of those costs. The estimate includes activities related to decommissioning planning, historical site radiological assessment, and removal of hardware, components, structures and miscellaneous materials as necessary to reduce the levels of residual radioactivity to below the guidance values in accordance with the NRC criteria for license termination in subpart E of 10 CFR 20, and the additional criteria imposed by the State of Massachusetts per 105 CMR 120

Decommissioning costs are directly related to the degree of remediation required and the amount of radioactive waste generated. The data for the volume of radioactive waste generated was estimated on data provided from facility drawings, radiological data provided, and previous experience with decommissioning activities associated with both reactor and non-reactor facilities. Final status surveys are included in this cost estimate as well as any groundwater contamination assessments.

Cost estimates are based in part on the approach presented in NUREG/CR-1756, Technology, Safety and Costs of Decommissioning Reference Nuclear Research and Test Reactor (Ref.7.4). The costs assume the scope includes removal of all contaminated, potentially contaminated and activated components. The costs **do not** cover the following;

- Dismantle and demolition of non-contaminated portions of the facility that have been verified as free of radioactive material.
- Other radiological facilities not related to the reactor operations
- Reactor fuel removal, transport, and disposal at the DOE facility
- Removal and disposal of underwater Co-60 irradiator

2.1 Estimate Approach

This cost estimate is a bottoms up estimate. Material quantities were determined from site drawings, site specific documents such as the USAR and the knowledge of site personnel. Unit removal factors were developed based on RSMeans and decommissioning experience. RSMeans is an industry standard costing methodology based on unit prices established for labor, materials, equipment including overhead and direct labor cost. These factors were married to the material quantities to determine person-hours, crew-hours and waste volumes. Site specific labor rates were applied to the work crew to determine removal costs. Site specific packaging, transportation and disposal costs were applied to the various waste streams to determine disposal costs. A project management staff was developed for this project and assumed to be on-site for the duration of the project, approximately 16 months.

2.2 Assumptions and Basis

The following assumptions and bases were used to develop the cost estimate.

- The reactor fuel will be removed and transported to DOE prior to start of decommissioning physical activities.
- The remaining reactor facilities will be decontaminated and free released. The dismantling and demolition for this remainder is not part of the decommissioning costs.
- Some of the uncontaminated or decontaminated materials have intrinsic value
- The use of radioactive material is well controlled and contaminated areas are minimal to non-existent.
- Activated equipment will be shipped directly to the burial site.
- Pool water will be processed via normal operating procedures.
- Components will be removed via disconnecting/unbolting when possible.
- Detailed material takeoff was performed for all the structural concrete.
- Costs, man-hours and durations were built up from the material quantities and cost and schedule information from 2015 RS Means Building Construction Cost Data.
- Dose rates will be sufficiently low to allow all work to be performed in the pool after the fuel and control elements have been removed.
- All costs used in the DCE calculations apply to June 18, 2015.

- The costs of required safety analyses and safety measures to protect the general public, the environment, and the onsite workforce are included in the cost estimate.
- The decommissioning will be performed under the current NRC and State regulations.
- Radiation exposures to occupational workers and members of the public during the decommissioning process will meet the limits required by 10 CFR 20.
- Residual radioactivity remaining at the site following decommissioning will meet the limits specified in 10 CFR 20 Subpart E for unrestricted license termination and State rules described in 105 CMR 120.
- The cost estimate is a Class 3 estimate as defined by the AACEI.
- The estimate is unconstrained with respect to funding.
- Post-D&D work such as site maintenance and long term surface and ground water monitoring are not included in this estimate.
- Most of the contaminated piping, components, and structural material will qualify as LSA-I, II, or III as described in Title 49 of the Code of Federal Regulations, and will be packaged as required by 49 CFR 173 Subpart I-Class 7 (Radioactive), and as necessary when demonstrated to qualify as its own shipping containers. Waste packaging and transport costs for these items are based on specific commodity waste evaluations.
- Contractor and craft workers will have use of the site and facilities for training, tool storage, cafeteria, and work break facilities.
- Contaminated equipment will be sent to the burial site or decontaminated on-site and surveyed for unrestricted release.
- [redacted] on-decommissioning management and staff will be supplied by the University separate from these costs.
- Currently both Class C and greater than Class C material has a facility in Texas available for disposal if any of this material is determined to be present. Based on our independent Monte-Carlo activation analysis, there is not expected to be any of this class of material (outside of the fuel itself).
- All staffing in support of dismantling, demolition, surveying, decontamination, packaging, indirect management are all part of this cost estimation.
- Equipment associated with the demolition and decontamination effort will be supplied by the contracted services and is part of this cost estimate.

3.0 General Site Description and Decommissioning Plans

Construction for this facility was started in the summer of 1966. The reactor is located on the University's North Campus. General layout and orientation drawings for the facility and adjacent structures are included in Attachment A. The open pool 1.0 MW_{Th} reactor is a light water moderated and cooled, graphite and water reflected, heterogeneous reactor. The fuel was originally enriched to 93% U-235, but has subsequently be converted to a low enriched uranium fuel in 2000.

The decommissioning process will begin with the reactor being placed in a "Possession-Only-Status" (POS) through an amendment to the USNRC operating license R-125. This status will initially result in all normal facility services and non-operating functions to remain active. This includes:

- [redacted]
- Radiological controls and monitoring equipment,
- Nuclear material control and accountability programs,
- Effluent monitoring, water chemistry and make-up.

The proposed action for this decommissioning involves decontamination and decommissioning of the reactor facility after detailed decommissioning plans have been developed. This process is expected to proceed immediately upon receipt of the POS license. This plan schedule is based on University management decisions of cost and community expectations. SAFSTOR and ENTOMB options are not currently planned or factored into this cost estimate. This is consistent with the NRC requirement in 10 CFR 50.82(b)(1)(i) providing for non-power reactor decommissioning without significant delay following permanent shutdown.

The general decommissioning plan activities would include the following assuming used fuel has been removed and transported to a DOE off-site facility;

- Continued operation and maintenance of the pool water demineralizer system until no longer required.
- Removal of pool water cooling system, delay tank, and heat exchangers.
- Decontamination of any contaminated areas.
- Dismantlement, decontamination or packaging as low-level radioactive waste (LLRW) reactor components including demineralizer, bioshield, pool liner, beam ports, graphite moderator, and reactor support structure.
- Shipment of LLRW currently on site and generated as part of decommissioning process to off-site facility.

- Performance surveys to confirm the facility status of remaining components and structures.
- Final status survey plan and completion of survey.
- License termination (POS).

All decommissioning activities will be administratively controlled to minimize the risk of inadvertent exposures, prevent uncontrolled release of contaminated material, and use of standard radiological work permits as a practiced control of work to maintain exposures ALARA. Performance of physical work will be done in accordance with approved procedures and a USNRC approved Decommissioning Plan. Cost estimates include the use of containment structures, tents, and contamination barriers as necessary to prevent the spread of radioactive material.

4.0 Decommissioning Criteria

A site visit was performed by RSCS as well as interviews with current and former operating personnel to gather physical and radiological data to support this cost estimate.

4.1 Radionuclides of Interest

NUREG/CR-1756 provides a detailed list of radionuclides that might be expected from a decommissioning of a research reactor. Current operating history and radioanalysis of demineralizer regenerative waste indicate Co-60 as the principle radionuclide transported out of the core activated components to other reactor components. To a lesser extent, H-3 exists in bulk quantity in the pool water with current levels of about 700 pCi/L. Other radionuclides are expected as part of the activated aluminum components (reactor core support structure, beam ports, pool liner, etc.), activated stainless steel structures, activated lead components, and activated graphite components. The resultant isotopic mix for these structures depends to a large extent on the actual metal alloy constituents that make up the original supplied materials. For the purposes of this report, the most generic or prevalent material compositions were assumed during Monte-Carlo activation analysis. Final determination of the isotopic make-up will depend on Monte-Carlo predictions as well as actual sample analysis of specified components during the dismantling and transportation phases.

From NUREG/CR-1756 some expected component radionuclides are identified below for various activated components.

TABLE 8.1-4. Reference Radionuclide Inventory 2, Neutron-Activated Aluminum[(a)] in the Reference Research Reactor

Radionuclide	Radioactivity Concentration at Shutdown (Ci/m^3)	Fractional Radioactivity at Decay Times of: Shutdown	10 Years	30 Years	50 Years	100 Years
^{46}Sc	9.80×10^{-2} (b)	1.74×10^{-4}	-- (c)	--	--	--
^{54}Mn	3.90×10^{0} (b)	6.93×10^{-3}	1.15×10^{-6}	--	--	--
^{55}Fe	2.77×10^{2} (b)	4.93×10^{-1}	3.74×10^{-2}	2.22×10^{-4}	1.31×10^{-6}	--
^{60}Co	1.36×10^{-1} (b)	2.42×10^{-4}	6.48×10^{-6}	4.68×10^{-6}	3.37×10^{-7}	4.70×10^{-10}
^{63}Ni	3.37×10^{-2} (b)	6.00×10^{-5}	5.67×10^{-5}	4.94×10^{-5}	4.30×10^{-5}	3.04×10^{-5}
^{65}Zn	2.81×10^{2} (d)	5.00×10^{-1}	1.62×10^{-5}	--	--	--
Totals	5.62×10^{2}	1.00	3.75×10^{-2}	2.76×10^{-4}	4.46×10^{-5}	3.04×10^{-5}

TABLE 8.1-5. Reference Radionuclide Inventory 3, Activated Biological Shield Concrete in the Reference Research Reactor[(a)]

Radionuclide	Radioactivity Concentration at Shutdown (Ci/m^3)	Fractional Radioactivity at Decay Times of:[(b)] Shutdown	10 Years	30 Years	50 Years	100 Years
^{39}Ar	5.4×10^{-4}	1.1×10^{-3}	1.1×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	8.8×10^{-4}
^{41}Ca	9.8×10^{-5}	2.0×10^{-4}	2.0×10^{-4}	2.0×10^{-4}	2.0×10^{-4}	2.0×10^{-4}
^{45}Ca	4.9×10^{-2}	1.0×10^{-1}	2.3×10^{-8}	--[(c)]	--	--
^{54}Mn	2.4×10^{-3}	4.8×10^{-3}	1.0×10^{-6}	--	--	--
^{55}Fe	4.2×10^{-1}	8.6×10^{-1}	6.6×10^{-2}	3.9×10^{-4}	2.3×10^{-6}	--
^{60}Co	9.3×10^{-3}	1.9×10^{-2}	5.2×10^{-3}	3.7×10^{-4}	2.7×10^{-5}	3.7×10^{-8}
^{59}Ni	1.7×10^{-5}	3.4×10^{-5}	3.4×10^{-5}	3.4×10^{-5}	3.4×10^{-5}	3.4×10^{-5}
^{63}Ni	2.0×10^{-3}	4.0×10^{-3}	3.8×10^{-3}	3.3×10^{-3}	2.8×10^{-3}	2.0×10^{-3}
Totals	4.9×10^{-1}	1.0	7.7×10^{-2}	5.3×10^{-3}	4.1×10^{-3}	3.1×10^{-3}

TABLE 8.1-3. Reference Radionuclide Inventory 1, Neutron-Activated Stainless Steel[(a)] in the Reference Research Reactor

Radionuclide	Radioactivity Concentration at Shutdown (Ci/m^3)	Fractional Radioactivity at Decay Times of: Shutdown	10 Years	30 Years	50 Years	100 Years
^{14}C	9.22×10^{0}(b)	1.75×10^{-5}	1.75×10^{-5}	1.74×10^{-5}	1.74×10^{-5}	1.73×10^{-5}
^{51}Cr	1.27×10^{5}(b)	2.41×10^{-1}	--[(c)]	--	--	--
^{54}Mn	1.61×10^{4}(d)	2.09×10^{-2}	3.49×10^{-6}	2.15×10^{-5}	1.27×10^{-7}	--
^{55}Fe	2.52×10^{4}(d)	4.76 x 10-2	3.63×10^{-2}	2.15×10^{-5}	1.27×10^{-7}	--
^{59}Fe	2.41×10^{3}(b)	4.56×10^{-3}	--	--	--	--
^{58}Co	1.03×10^{5}(e)	1.28×10^{-1}	--	--	--	--
^{60}Co	2.88×10^{5}(e)	5.45×10^{-1}	$6.33 \times 1\text{-}^{-2}$	4.56×10^{-3}	3.28×10^{-4}	4.58×10^{-7}
^{59}Ni	5.59×10^{1}(d)	1.06×10^{-4}	1.06×10^{-4}	1.06×10^{-4}	1.06×10^{-4}	1.06×10^{-4}
^{63}Ni	6.40×10^{3}(d)	1.21×10^{-2}	1.14×10^{-2}	9.82×10^{-3}	9.07×10^{-3}	6.41×10^{-3}
^{93m}Nb	1.02×10^{-2}(b)	2.25×10^{-8}	1.35×10^{-8}	4.88×10^{-9}	1.76×10^{-7}	1.38×10^{-10}
^{94}Nb	1.32×10^{-1}(b)	2.50×10^{-7}	2.50×10^{-7}	2.50×10^{-7}	2.50×10^{-7}	1.38×10^{-7}
^{95}Nb	1.06×10^{1}(b)	2.00×10^{-5}	--	--	--	--
Totals	5.61×10^{5}	1.00	1.11×10^{-1}	1.45×10^{-2}	9.52×10^{-3}	6.53×10^{-3}

In addition, significant amounts of C-14, S-35, Co-60, Cs-134, Eu-152 and Eu-154 are expected to be present in activated graphite components associated with the moderator. Significant amounts of Fe-55, Ni-63, Zn-65, Sb-124, and Pb-205 are expected to be present in activated lead components associated with the thermal column and Fast Neutron Irradiator. At this time, there is no evidence of transuranic activity, however experience dictates that small quantities of tramped uranium may deposit some of these alpha emitters in locations not currently accessed or surveyed. The potential exists for some transuranic activity present in portions of the reactor core, open pool deposits and cooling system.

4.2 Radiological Criteria and License Termination

The overall objective is to remediate the facilities to a condition that corresponds to a calculated dose to the public of less than [redacted] mrem/y from applicable pathways (per State of Mass requirements). Derived concentration guideline levels (DCGL) will be developed as defined in MARSSIM (Ref. 7.6). These activities are part of the site survey process and factored into the cost analysis. In addition, potential contamination of the local site hydrology will be investigated as part of this decommissioning process. This will include demolition and investigation of underground subsurface structures for the potential for contamination.

4.3 Facility Description

The facility includes the reactor building (containment structure), subsurface components, and some support components and structures in the [redacted] Building.

4.3.1 Reactor Building

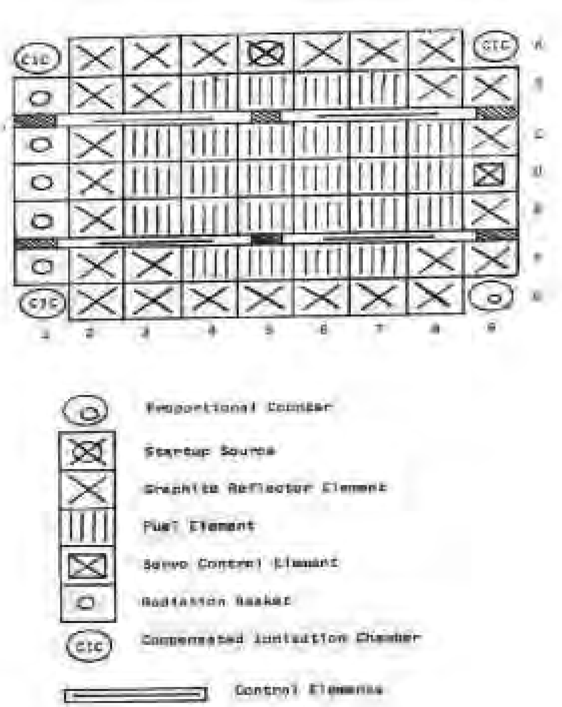
The containment structure is a welded steel shell and flat bottom cylindrical sides, and domed top. The flat bottom of the shell is lined with [redacted] of poured concrete. The cylindrical walls are [redacted] feet of poured concrete to serve as ballistics and radiation shield, and to support an overhead polar crane. The structure is a total of [redacted] [redacted] [redacted] tall with [redacted] feet being below grade. The internal diameter of the structure is [redacted] feet. There are two air lock doors that separate this structure form the rest of the [redacted] Building and provide the access to the containment structure.

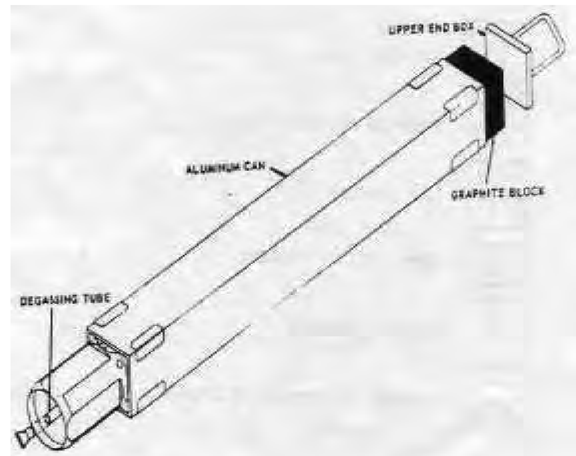
4.3.2 Reactor Core and Pool

The reactor core consists of a [redacted] element LEU (Low Enriched Uranium) core configuration containing [redacted] full fuel elements and [redacted] partial elements within a [redacted] grid arrangement. Four safety blades subdivide the fuel element array into [redacted] sections including graphite reflectors. The core is comprised of aluminum clad fuel elements. The reflector element is a reactor grade graphite block contained in an aluminum can to reduce neutron leakage from the core (see below).

The reactor bridge provides a means of supporting the reactor core and core suspension frame (see drawing Attachment A). The bridge allows the core to be positions at a desired positon within the pool. The core suspension frame is suspended from the lower reactor bridge and is an aluminum rectangle column built of four square corner posts forming the rigid structure. The core box is attached to the lower end of the suspension frame. Stiffeners are provided as necessary on three sides of the frame.

The reactor pool is comprised of two principle sections, a stall pool and a bulk irradiation pool. Each pool is equipped with primary cooling connections as necessary for power operation. The stall pool is used for full rated power operation. The overall dimensions of the pool is [redacted]t long and is lined with aluminum plate ¼ inch thick in most locations (penetration areas have localized thicker plating). The pool walls are constructed of aggregate concrete. There is a pool gate provided to separate the two pools (5 ½ ft wide by 27 ft high).





There is a thermal column and two additional beam ports provided to the core for experimental use. The thermal column provides thermal neutrons for experimental use. The assembly is embedded in the reactor bioshield and filled with graphite blocks (4 x 4 square column).

A Fast Neutron Irradiator is also located near the core to provide fast neutrons for experimental use. The assembly consists primarily of lead and borated aluminum.

In addition there is a pneumatic rabbit core delivery system located in the reactor building basement and provides proximity to the core for experimental use.

4.3.3 Auxiliary Equipment

The reactor cooling and water conditioning system consists of four [redacted] inch aluminum cooling lines and return lines. The cooling lines are directed through a delay tank for N-16 decay, and then through coolant pumps to a secondary heat exchanger. There has not been any system leakage identified between the primary cooling loop and the secondary water cooling. In addition, there is a [redacted] retention tank [redacted] to the [redacted] for storage of pool draindown (approximately [redacted]). The tank is constructed of reinforced concrete and lined with polyvinylchloride sheets. The cleanup system consists of a demineralizer that is regenerated into a sump for processing to holdup tanks located in the basement of the [redacted] Building (See drawing in Attachment A).

In addition there is a remote grapple Hot Cell facility that provide access to the pool through a water tight door as necessary. This facility is currently not contaminated, and is used for some limited irradiation activities. There is also a gamma cave with access to the underwater Co-60 irradiation sources.

The building ventilation system consist of both supply and exhaust ducting that encircle the reactor building, and exhaust through an external exhaust stack. Operationally, the radioisotope released is exclusively Ar-41 (inert noble gas). As such, the demolition and disposal of these components should be limited, at most, to localized contamination inlets.

There is currently very limited volumes of radioactive waste that have been accumulated in the basement of the reactor building. This consists primarily of removed older components or experimental equipment (e.g. old beam ports). The accumulated volume of this equipment is not materially significant to the cost estimate.

4.4 Outside Areas

There are no specific outside of the reactor building support facilities other than those identified above associated with the basement of the [redacted] Building, the underground retention tank, and liquid radioactive waste processing from the reactor building sump. None of these adjacent facilities are included in the decommissioning costs other than the associated reactor components.

Removal, excavation and surveying of areas around the reactor building sump and outside retention tank are factored into the estimate. There is also some potential for localized monitoring of the ground water to verify no measurable contamination of the aquifer has occurred.

5.0 Estimation Methods

The following is the detailed summary of the factors and cost considerations that influenced the decommissioning cost. A detailed breakdown of the unit cost basis is contained in the Attachment B.

		Total Cost
Grand Total with Contingency		**$4,723,855**
Contingency =		$944,771
Total		$3,779,084
UNDISTRIBUTED COSTS		$1,974,702
1.1	Project Management	$1,779,046
1.1.1	Project Management	$1,299,886
1.1.2	Project Management Per Diem	$479,160
1.2	Equipment & Materials	$195,656
ACTIVITIES		$1,804,382
1.3	Project Engineering	$24,904
1.3.1	Procedure Development and Review - Offsite	$12,452
1.3.2	Preparation of QA and Safety Documents - Offsite (in parallel with 1.3.1)	$12,452
1.4	Site Mobilization and General Employee Training (GET)	$27,135
1.4.1	Site Mobilization	$7,557
1.4.2	General Employee Training	$15,512
1.4.3	Site Specific Training	$4,066
1.5	Site Preparation (Labor costs included in Undistributed costs)	$5,574
1.5.1	Initial Site Survey	$2,033
1.5.2	Setup work areas	$3,541
1.5.2.1	Setup boundaries, install HEPA filters & seal off ventilation openings	$2,016
1.5.2.2	Establish staging area	$508
1.5.2.3	Setup Rad & Non-Rad Segregation/Packaging Stations	$1,016
1.6	Disconnect all utilities to work areas.	$17,033
1.6.1	Electrical	$6,016
1.6.2	Ventilation	$5,508
1.6.3	Piping	$5,508
1.7	Drain Pool - Performed by site personnel	$0
1.8	Remove Reactor	$171,643
1.9	Remove Systems	$755,181
1.10	Decontaminate Building	$719,365
1.11	Final Building Release Survey	$70,984
1.12	Decontamination Crew Demobilization	$12,564

A copy of the detailed spreadsheet cost analysis is provided in Attachment D.

5.1 Cost Modifying Factors

PPE (personnel protective equipment) and contamination controls can significantly affect the productivity costs of dismantling, packaging and disposal activities. This includes items such as respiratory protection, remote handling equipment, localized ventilation, and intrusive radiological monitoring of the work. These factors typically take a graded approach based on expected radiological hazards. Outside of the reactor core components and fuel pool clean-up, most of the protective requirements should only routine radiological controls and monitoring.

5.2 Monte-Carlo Activation Analysis

Los Alamos National Laboratories' (LANL) transport code Monte-Carlo N-Particle 6 version 1.0 (MCNP6) was used to determine the residual activity in all pertinent reactor components and adjacent structures. This analysis was heavily based on prior research at the University of Massachusetts at Lowell, specifically research done by John R. White et al *Preliminary Characterization of the Irradiation Facilities Within the LEU-Fueled UMass Lowell Research Reactor*. This document provided nominal neutron fluence rates at various components with which the MCNP6 simulations were benchmarked and scaled accordingly. Additionally, neutron energy distributions were compared with those simulated by RSCS to provide more confidence to activation results.

5.2.1 Monte-Carlo General Information

MCNP6 is a general purpose, continuous-energy, time-dependent radiation transport code that uses Monte Carlo techniques to track several particle types through broad energy ranges. It offers single and coupled transport of nearly all particle types using the latest nuclear cross section libraries, and uses physics models for particle types and energies where tabular data does not exist. MCNP6 was originally developed by LANL and is currently distributed by Oak Ridge National Laboratory's Radiation Safety Information Computational Center.

The Monte Carlo technique provides a framework to solve the Boltzmann equation using repeated random sampling. It is useful in the evaluation of radiological conditions for realistic geometries where general analytical techniques are inadequate. Transport of a particle starts with determining the spatial trajectory, energy and path length from a randomly sampled probability distribution. Particle interactions and transformations are determined by randomly sampling cross-section data files. Tracking the passage of a large history of particles through matter can therefore lead to information about physical quantities, such as particle fluence, dose rate, or levels of activation/interaction.

5.2.2 Simulation Tally and Activation Equations

The particle fluence tally (type F4) was used to collect all the data necessary in this study. The F4 tally gives the average particle track length through a volume of interest. The sum of the contributions to a particular volume gives the average flux through the cell as:

$$F4\left\{\frac{particles\ cm}{cm^3\ \mathrm{SP}}\right\} = \frac{1}{V}\int dE \int dt \int dV \int d\Omega\, \psi(\vec{r}, \hat{\Omega}, E, t)$$

{ } denotes units
V = Cell or tally volume
$\vec{r}$ = Particle position vector
$\hat{\Omega}$ = Direction vector
E = Particle energy
t = Time
SP = MCNP6 source particle, neutron

The F4 tally was modified using built-in MCNP6 FM multipliers to provide activation atoms per component as:

$$P\left\{\frac{activation\ atoms}{\mathrm{SP}\ cm^3}\right\} = F4\left\{\frac{particles\ cm}{cm^3\ \mathrm{SP}}\right\} * \rho\left\{\frac{target\ atoms}{barns\ \ cm}\right\} * \sigma_c\left\{\frac{barns}{target\ atoms}\right\}$$

{ } denotes units
P = Production term of an individual nuclide
ρ = Atomic density of the target atoms, user defined
σ_c = Energy-dependent reaction cross-sections, built-in to MCNP6

This result is multiplied by the decay constant of the resultant radioisotope to determine the production rate in terms of volumetric activity. Conversion constants are used to provide the specific activity in units of Ci m^{-3} hr^{-1}.

$$P_{SA}\left\{\frac{Ci}{hr\ m^3}\right\} = P\left\{\frac{activation\ atoms}{cm^3\ \mathrm{SP}}\right\} * \lambda\left\{\frac{1}{hr}\right\} * 1E6\left\{\frac{cm^3}{m^3}\right\} * 2.7E^{-}11\left\{\frac{Ci}{Bq}\right\}$$

{ } denotes units
P_{SA} = Production term of specific activity
λ = Decay constant of an individual nuclide

This is used in conjunction with the averaged operation of the reactor (from 1975 through 2014, [redacted] per year) to determine the weekly production rate.

$$P_{SA\_wk}\left\{\frac{Ci}{m^3\ wk}\right\} = P_{SA}\left\{\frac{Ci}{hr\ m^3}\right\} * U\left\{\frac{hr}{wk}\right\}$$

{ } denotes units
P_{SA_wk} = Production term of specific activity per week
U = Reactor operation per week

The final expected specific activity as a function of the total expected service period and the delay before decommissioning activities commence is determined by applying the following production equation:

$$SA(T,t)\left\{\frac{Ci}{m^3}\right\} = P_{SA_{wk}}\left\{\frac{Ci}{m^3\ wk}\right\} * \frac{1}{\lambda}\{s\} * \left(1 - e^{-\lambda T}\right) * e^{-\lambda t} * 1.65E^{-}6\left\{\frac{wk}{s}\right\}$$

{ } denotes units
T = Service life of the cyclotron, 39 years
t = Delay between final cyclotron use and decommissioning activities, 90 days

The final activation activities were compared with the most restrictive NRC waste classification limits (found in 10CFR61.55 Table 1 and 10CFR61.55 Table 2). No isotopes breached any limits necessitating classification higher than Class A, nor did any sum of the fraction analyses. A summary table for specific components and various generic location/material combinations is provided in Attachment C.

Furthermore, the concrete was analyzed with depth and it was determined that even conservative estimations allow for the vast majority of the concrete surrounding the pool to be disposed of as clean waste.

5.3 Radioactive Waste Volume Estimates

The assumptions that constitute waste volume generation are based on a number of assumptions. These included detailed estimates of volumes of material (i.e. reactor components and structures) that have potential for being contaminated or activated by core flux. Assumptions are then made based on known current radiological conditions of the facility, previous radiological history of the facility (e.g. systems used, leakage, etc.), and expectations based on past experience of the degree of suggest of remediation methods to reduce waste volume. Attachment B contains assumptions related to this estimate.

5.4 Radioactive Waste Disposal Costs

A significant portion of the overall decommissioning cost is attributed to the burial of the radioactive waste. Cost estimates are based on volume expected from the decommissioning efforts and estimated unit pricing for disposal. All waste is assumed to be Class A waste, and is separated by type and packaging restraints. This estimate includes the following direct waste costs, packaging, and transportation costs. Attachment B contains assumptions related to this estimate.

5.5 Remediation Methods

Much of the disposal and decommissioning costs are reduced by the use of remediation methods to minimize the volume of waste disposal. Some preplanned activities include hydrolasing of the pool liner, underwater vacuuming as necessary for the pool floor (if necessary), scrabbler or shot blasting of the concrete surfaces, and hands on decontamination as necessary. Additional methods may be employed as warranted by the specific cost-benefit waste disposal versus manpower and equipment demands.

Planned remediation activities include;

- General facility clean-up and removal of all incidental equipment, materials both radioactive and no-radioactive.
- Remove all equipment and materials not associated with the reactor operation (e.g. hot cell, Co-60 irradiator, experimental set up, etc.), survey and decontaminate as necessary.
- Remove pool water, core components, suspension bridge, clean pool surfaces, remove activated components of pool, graphite shield block, and beam ports.
- Remove cooling and demineralizer systems. Survey and decontaminate as necessary to minimize burial costs.
- Remove contaminated concrete surfaces as necessary. Demolish as necessary to verify underlying surfaces are free of radioactive materials.
- Remove all other equipment and support components associated with the decommissioning efforts inside the reactor building.
- Remove outside support components (tanks, stack, etc.), survey and decontaminate as necessary.
- Remove any underground structures, survey and decontaminate as necessary.
- Perform necessary ground excavation, groundwater monitoring to verify limited residual activity remaining in accordance with 105 CMR 120.

5.6 Unit Costs

A number of unit cost factors were used to generate this cost estimate. The major breakdown being staff and direct labor costs. The details are included in Attachment B.

5.7 Final Surveys

Final license termination survey costs are estimated based on previous decommissioning experience and the requirements identified in NUREG-1757 (Ref 7.7). The number of sample points for the various areas being surveyed and the type of survey being performed were considered and based on direct experience with other decommissioning efforts. Attachment D contains the details of the cost breakdown of this activity.

6.0 References

6.1 University of Massachusetts Lowell, Final Safety Analysis Report, FSAR.

6.2 10 CFR 20, Subpart E, Radiological Criteria for License Termination.

6.3 State of Massachusetts 105 CMR 120.244 – 120.249, Radiological Criteria for License Termination.

6.4 NUREG/CR-1756, Technology, Safety and Costs of Decommissioning Reference Nuclear Research and Test Reactor, 1982.

6.5 10 CFR 50.82, Termination of License

6.6 MARSSIM, Multi-Agency Radiation Survey and Site Remediation Manual, Rev. 1, NUREG-1575.

6.7 Consolidated Decommissioning Guidance, NUREG-1757, September, 2006.

6.8 John R. White et al, *Preliminary Characterization of the Irradiation Facilities Within the LEU-Fueled UMass Lowell Research Reactor,* 2000.

6.9 X.-5. M. C. Team, "MCNP - A General Monte Carlo N-Particle Transport Code, Version 5, Volume I: Overview and Theory," Los Alamos Report LA-UR-03-1987, 2003.

6.10 National Council on Radiation Protection and Measurements, "Radiation Protection For Particle Accelerator Facilities," Bethesda, 2005.

6.11 Los Alamos National Laboratory, "MCNP6 User's Manual Version 1.0 LA-CP-13-00634, Rev. 0," 2013.

6.12 Pacific Northwest National Laboratory, "Compendium of Material Composition Data for Radiation Transport Modeling," 2011.

6.13 U.S. Nuclear Regulatory Commission, "10 CFR 61.55 Waste Classification," 2001.

Attachment A

Facility Drawings

<u>Site Location Lowell MA.</u>

Figure 2.2 Map of Lowell Area

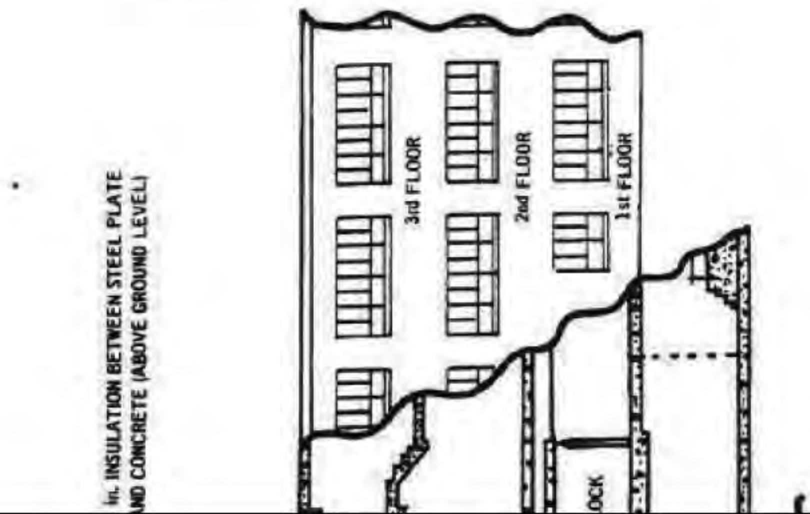
Site Map

[redacted]

Building site Orientation

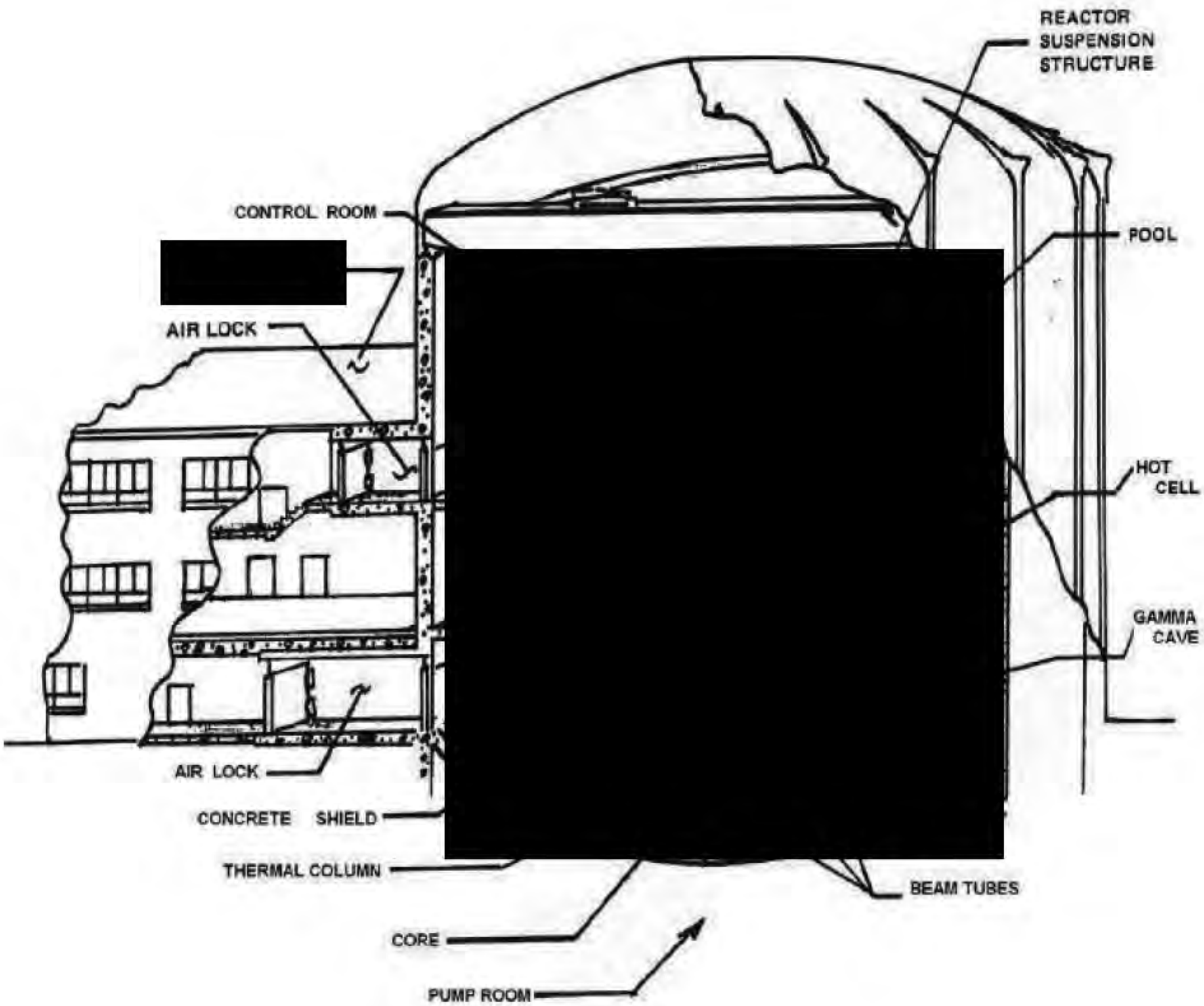
[redacted]

Elevation View of Containment Structure

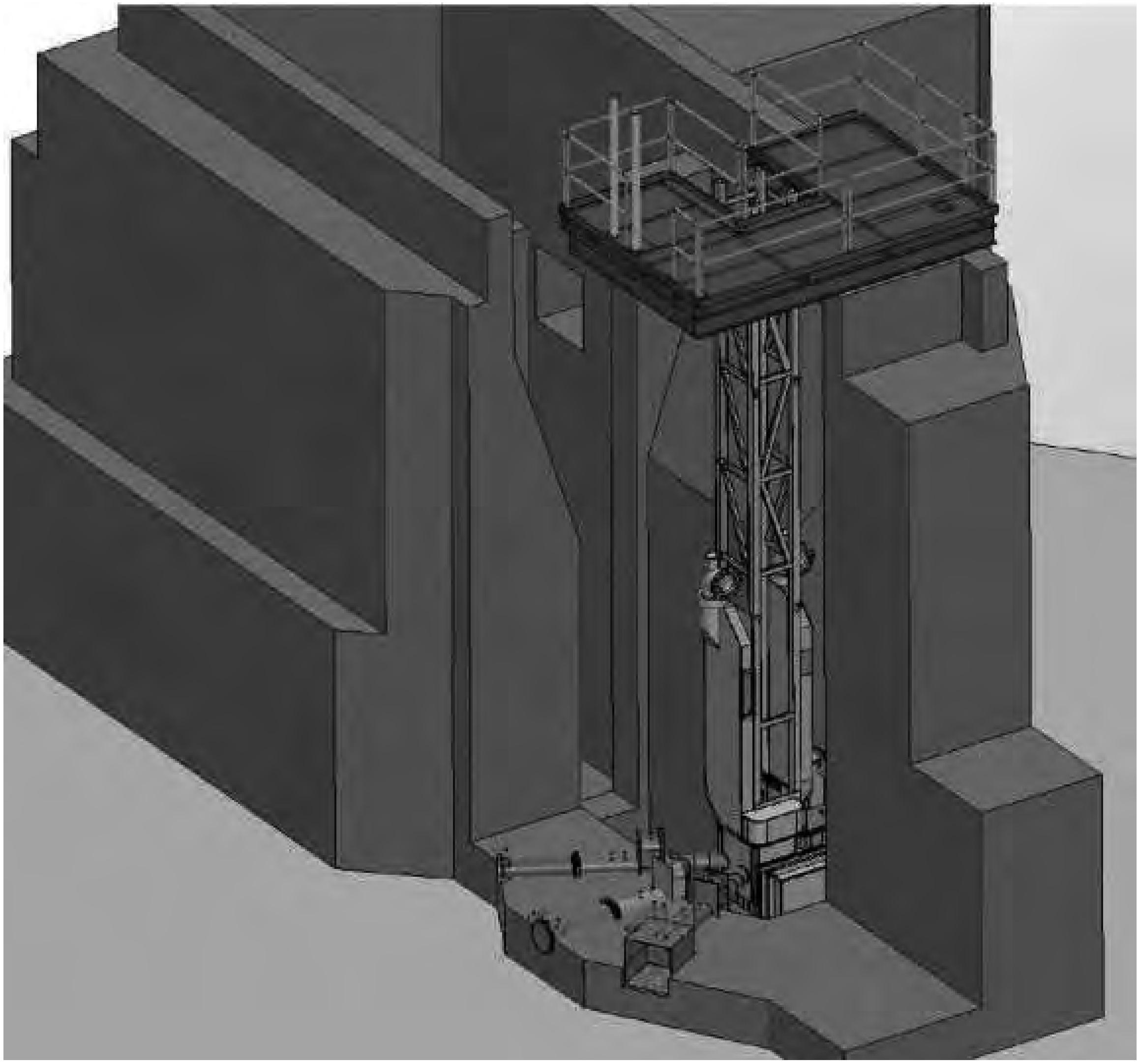


[redacted]

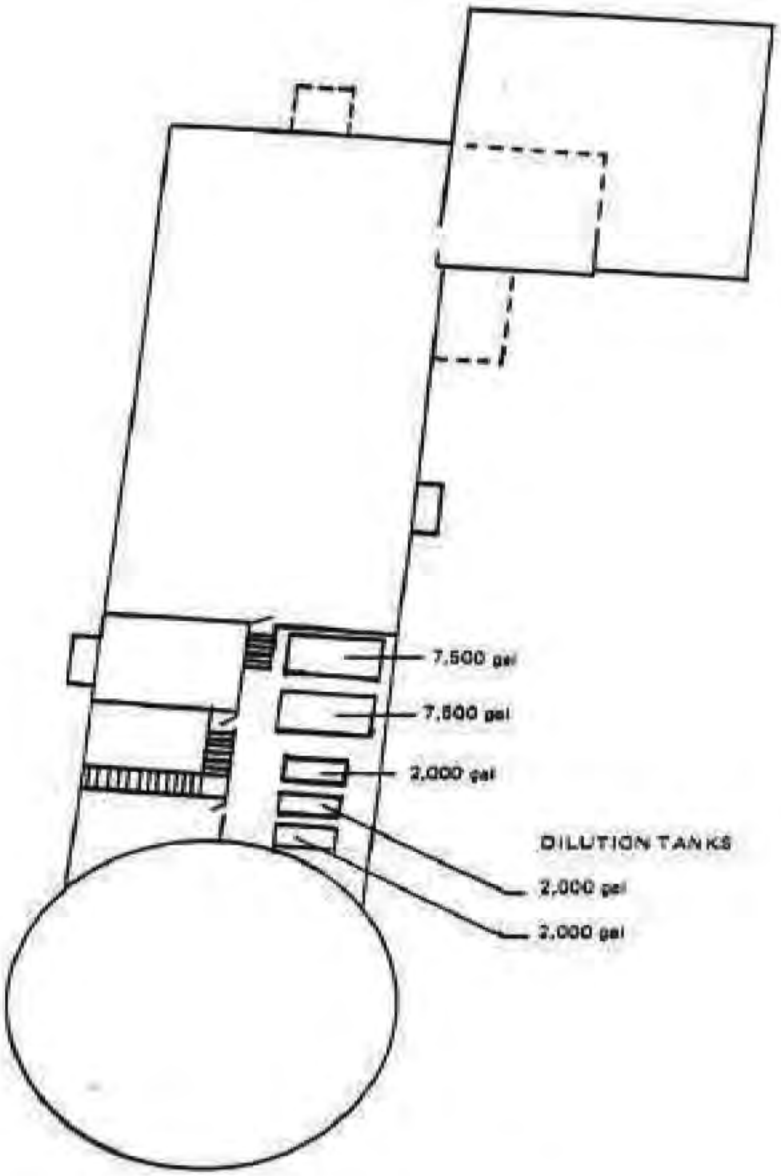
3D Elevation View of Containment Structure



Rx Core Arrangement



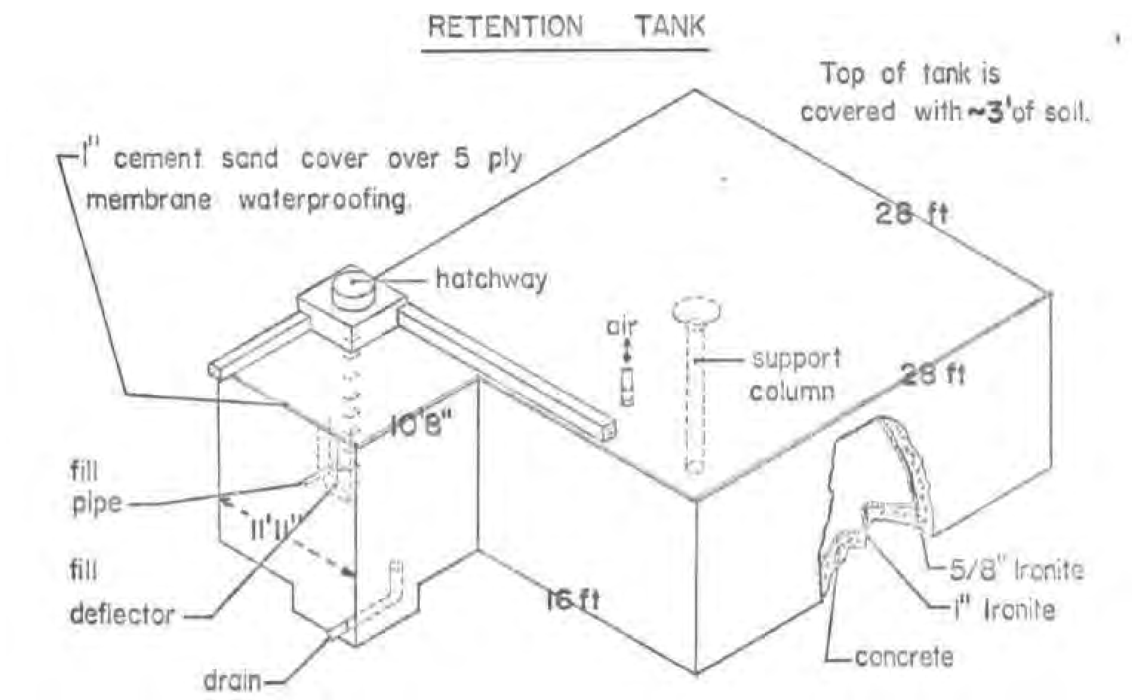
[redacted] Building Basement Rad Waste Tanks



[redacted]

REDACTED FOR PUBLIC RELEASE

Retention Tank Arrangement



Attachment B

Detailed Cost Basis

Waste Volume Estimates Summary

Inventory	Cuft
Remove Reactor (Activated)	0.24
Control Elements	0.07
Remove Startup Source	4.94
Remove Graphite reflector elements	0.20
Remove Proportional Counter	0.17
Remove Servo Control Element	1.02
Remove Rad Basket	0.61
Remove Compensated Ionization Chamber	2.00
Remove Grid Box	6.93
Remove Frame	1.44
Remove Bracing	0.24
Remove Systems	
Piping	
Primary	331.22
Cleanup	43.11
Drains, sumps	3.40
Rabbit	15.95
Drains	17.02
Lab drains	5.67
Hot cell F/V	0.43
Beamport F/V	0.71
Beam Tubes	374.40
Beam Tubes	174.20
Thermal Column	
Pb plate	0.98
in-pool col	62.40
in wall col	104.00
Shield door	65.00
Vessels	
Heat Exchanger	137.84
Cleanup demineralizer	73.51
Remove and package resin	26.00
Decon [redacted] building fiberglass tanks	4.88
Decon [redacted] building SS tanks	0.68
Decon Holdup tank	0.00
Post filter	8.17
Skimmer	8.17
Decontaminate Building	
Remove sludge from pool	3.90
Decontaminate Liner	0.00
Remove 1/4" Liner	94.90
Remove 1" Liner	5.42
Remove contaminated concrete	273.00
Remove Retention Tank liner - liner to be removed to survey concrete	20.80
Scabble Retention Tank contaminated concrete - 190 sq ft	20.80
Scabble Sump contaminated concrete - 300 sq ft	10.40
Remove Lead (FNI)	5.2
Remove Stainless	3.90

REDACTED FOR PUBLIC RELEASE

Unit Waste Cost Basis

		Note 1	Note 1	Note 3,5	Note 2,3	Note 4
			30 cu yd	B25	30 cu yd	
		containers	containers	boxes	containers	
		Resin Waste	Clean Waste	Activated Waste	LSA Waste	Lead
Waste volume, cu. ft/box		37.00	810.00	96.00	810.00	
Container weight limit			40,000	10,000	40,000	
Container, $/box		325.00		$1,400.00		
Transportation, $ per box		$950 00		$1,600.00	$5,000 00	
Disposal, $/box		$6,475 00		$79,200.00		
Disposal, $/lb			$0 00			$5.75
Disposal, $ ea.						
Tax						
Note 1.	$175.00	/cu. ft.				
Note 2.	$475.00	/cu. ft. for concrete				
Note 3	Provided					
Note 4	Assumed to be an all inclusive rate					
Note 5	$825.00	/cu. ft. for concrete				

Staff and Labor Costs

		Per Diem	Combined
Staff	**Rate**	**Rate, $/day**	**Rate, $/hour**
Project Manager	$145.00	$198.00	$179.65
Project Safety Manager	$0.00	$0.00	$0.00
Project Specialist	$100.00	$198.00	$134.65
Health Physicist	$125.00	$198.00	$159.65
Site Supervisor	$0.00	$0.00	$0.00
RP Supervisor	$95.00	$198.00	$129.65
Admin Assistant	$30.00	$198.00	$64.65
Project Control Specialist	$0.00	$0.00	$0.00
HP Tech	$75.00	$198.00	$109.65

Labor Category:	Decon Tech.	Equip Operator
Allowance/perdiem $/day	$0	
Days/wk paid	7	7
Work hours/wk	40	40
work hourly rate adjustment	$0.00	$0.00
Unadjusted rate	$45.00	$74.10
Adjusted to include 10 hrs OT		
Labor Rate ($/hr):	$45.00	$74.10

REDACTED FOR PUBLIC RELEASE

Technology Costs Basis

TECHNOLOGIES (COST > $500)	QUANTITY	UNIT COST			TOTAL COST
HEPA filter systems	1	$4,667			$4,667
Replacement filters	4	$715			$2,860
Respirator	9	$321			$2,889
Rad/Vac wet-dry high eff. vacuum	2	$4,072			$8,144
Rad/Vac wet-dry high eff. vacuum filters	5	$450			$2,250
Reciprocating Saws	2	$1,309			$2,618
Pneumatic chipping hammers	0	$1,280			$0
Chipping hammer blades	0	$35			$0
Purchase an air compressor:	1	$1,369			$1,369
Jackhammer	0	$1,233			$0
Jackhammer Chisels	0	$30			$0
Safety glasses	10	$11.96			$120
Fall protection - harness	4	$142.00			$568
Fall protection - lanyard	4	$218.00			$872
Hardhats	10	$42 50			$425
Hard hat hearing protection	10	$40.15			$402
Trailer rental	1	$438.50	per month	2 00	$877.00
Phone and computer hook-up	1	$300.00	per month	2 00	$600.00
Front end loader, wheeled	1	$8,177.16	per month	2 00	$16,354.33
Hydraulic hammer for excavator	0	$9,698.00	per month		$0.00
Excavator	0	$25,688.00	per month		$0.00
Grapple for excavator	0	$2,350.00	per month		$0.00
Scaffolding	1	$3,766.08	per month	2 00	$7,532.16
Dump trucks excavation and backfill	0	$20,407.00	per month		$0.00
Rental cars	2	$800.00	per month	2 00	$3,200.00
Water tank Trailer	0	$3,416.00	per month		$0.00
Dust Boss DB 60	0	$850.00	per week		$0.00
Dust Boss DB 60 transport	0	$3,000.00	Round trip		$0.00
Shot Blaster	0	$3,404.00	per month		$0.00
Floor Shaver	0	$8,487.20	per month		$0.00
Wall Shaver	0	$15,913.50	per month		$0.00
Core Drill & Bits	0	$10,609.00			$0.00
Man lift	1	$5,030.75	per month	2 00	$10,061.50
Crane rental for building removal	0	$26,413.09	per month	2 00	$0.00
Consumables	Cost	Units	Unit Cost		
Coveralls	$164.50	25	$6.58	Grainger Supply	
Hoods w/ coveralls			$0.00		
Shoe covers	$49 50	25	$1.98	Grainger Supply	
Latex gloves	$120.00	100	$1.20	Grainger Supply	
Rubber overshoes	$35 50	1	$35.50	Grainger Supply	

REDACTED FOR PUBLIC RELEASE

Attachment C

Activation Summary Table

All numbers in Curie per m^3.

	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]					[redacted]					
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]				
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]						
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]						
[redacted]									[redacted]	
[redacted]					[redacted]					
[redacted]		[redacted]		[redacted]	[redacted]	[redacted]				
[redacted]			[redacted]	[redacted]						
[redacted]				[redacted]						
[redacted]		[redacted]	[redacted]	[redacted]						
[redacted]		[redacted]	[redacted]	[redacted]						
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]					
[redacted]		[redacted]	[redacted]	[redacted]						
[redacted]									[redacted]	
[redacted]	[redacted]								[redacted]	[redacted]
[redacted]	[redacted]								[redacted]	[redacted]
[redacted]									[redacted]	[redacted]
[redacted]	[redacted]								[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]		[redacted]	[redacted]
[redacted]				[redacted]	[redacted]				[redacted]	[redacted]
[redacted]									[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]				[redacted]	[redacted]
[redacted]							[redacted]	[redacted]	[redacted]	[redacted]
[redacted]					[redacted]		[redacted]	[redacted]	[redacted]	[redacted]
[redacted]									[redacted]	[redacted]

	Aluminum near Core	Concrete near Core (inner 6 in.)	Concrete Remainder	Concrete near Beam Tubes	Graphite in Thermal Column	Graphite in the Core	Lead in Thermal Column	Lead in Fast Neutron Irr.	Steel in the Core	Steel in the Fast Neutron Irradiator
[redacted]	[redacted]						[redacted]	[redacted]		
[redacted]	[redacted]						[redacted]	[redacted]		
[redacted]							[redacted]	[redacted]		
[redacted]									[redacted]	[redacted]
[redacted]									[redacted]	[redacted]
[redacted]							[redacted]	[redacted]		
[redacted]							[redacted]	[redacted]		
[redacted]			[redacted]		[redacted]	[redacted]				
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]				
[redacted]			[redacted]	[redacted]	[redacted]	[redacted]				
[redacted]							[redacted]	[redacted]		
[redacted]							[redacted]	[redacted]		
[redacted]							[redacted]	[redacted]		
[redacted]							[redacted]	[redacted]		

Attachment D

Detailed Summary Spreadsheet

Numb [redacted]

[redacted]

ACTIVITIES								2,846		2,852	13,600	1,864	26	15	18	$44,100	$716,927	$926,105	$7,750	$53,294	$82,200	$1,830,375
[redacted]																						

REDACTED FOR PUBLIC RELEASE

1.8	Remove Reactor				B	352	1.00	352.00	1760	0	0		18		$89 443	$0	$0		$82 200	$171 643
								Vol. Reduc.	Adjusted		# of									

[redacted]

[redacted]