ENVIRONMENTAL REPORT FOR THE TRIGA MARK III

BERKELEY RESEARCH REACTOR

prepared for

University of California, Berkeley

prepared by

Kaiser Engineers (Ca[illegible]a) Corporation

in association with

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TABLES

1. EXECUTIVE SUMMARY

The Berkel, Research Reactor (BRR) is a General Atomic TRIGA Mark III reactor which is to be decommissioned in 1988. The reactor began operations in 1966 and operated for 293 effective megawatt days. The decommissioning alternative chosen is DECON with release of the DECON area so that it can be used by the Nuclear Engineering Department and by others.

This report addresses the projected occupational and public radiation doses due to DECON activities and should be considered a supplement of the BRR Safety Analysis Report. It contains the information that is understood to be required for the decommissioning of a research reactor.

2. DESCRIPTION OF DECOMMISSIONING ACTIVITIES

2.1 INTRODUCTION

The BRR is located in the Nuclear Engineering Laboratories in Room 1140 of Etcheverry Hall on the University of California Berkeley campus. The reactor is a movable core, light water cooled and reflected reactor using uranium-zirconium hydride fuel elements. The BRR was licensed for one megawatt steady-state operation and for pulsed operation. The reactor began operations in 1966 and operated fcr a total of 293 effective megawatt days.

The University plans to decommission the BRR in early 1988 and to release the DECON area, as delineated in the BRR Decommissioning Plan (DP), for unrestricted use by the Nuclear Engineering Department and by others. The University may elect to exclude particular equipment and facilities, such as the chemical hood in Room 1140, from complete decontamination, with the provision that such equipment and facilities be released by NRC to be under the State of California Radioactive Materials License.

2.2 ACTIVITIES REQUIRED FOR DECON

Fuel will be shipped off-site following a 90-day cooling period before decommissioning activities are initiated. Removal of the fuel is described in separate documentation. The DF outlines ninc tasks to be accomplished in the sequence shown below:

Task 1	Contractor Move-in
Task 2	Initial Radiation Survey
Task 3	Installation of Confinement Barriers
Task 4	Removal of Reactor Components and Pool Liner
Task 5	Removal of Material with Potential Surface Contamination and Other Activated Materials
Task 6	Cleanup and Removal of Tools and Equipment
Task 7	Packaging and Shipment of Radioactive Waste
Task 8	Perform Termination Radiation Survey
Task 9	Demolition of Non-Activated Portion of Reactor Installation

Descriptions and analyses of the above tasks are covered in the BRR DP.

3. ENVIRONMENTAL IMPLICATIONS OF DECON

3.1 IMPLICATIONS OF DECON

A comprehensive Safety Analysis Report (SAR) was completed in February 1964. This report addressed environmental implications of routine and accident conditions related to the reactor. Since the fuel will have been removed prior to the start of DECON activities, the potential for environmental impacts will be greatly reduced.

The U.S. Nuclear Regulatory Commission (NRC) in its report, NUREG-0586, concludes the following information.

- o Based on the nearly completed data base results and on NRC staff considerations, taking account of the concerns of the State and public, and of the regulatory role the NRC must provide in protecting public health and safety, the following conclusions appear evident:

  - The technology for decommissioning nuclear facilities is well in hand. Decommissioning at the present time can be performed safely and at a reasonable cost.

  - Decommissioning of nuclear facilities is not an imminent health and safety problem. However, planning for decommissioning as an integral activity prior to commissioning is a critical item that can impact on health and safety as well as cost.

  - Decommissioning of a nuclear facility generally has a positive environmental impact.

The major adverse environmental impact of decommissioning is the commitment of small amounts of land for waste burial in exchange for reuse of the facility for other nuclear or nonnuclear purposes.

3.2 COMMITMENT OF RESOURCES

DECON activities will result in the generation of low-level radioactive waste. This waste can be categorized as:

- o Activated metal components from the reactor internals

- o Activated and contaminated concrete and other structural material

- o Radioactive miscellaneous waste

The estimated disposal volume of radioactive waste is 190 m^3 (6700 ft^3) as determined in the BRR DP.

4. HEALTH AND SAFETY IMPLICATIONS

Occupational, public, and transportation safety impacts from DECON activities are summarized in this section.

4.1 OCCUPATIONAL RADIATION DOSES

Estimates of occupational radiation doses are based on the postulated radiation dose rates in various areas of Etcheverry Hall and its environs and on the estimated staff labor required to complete the decommissioning work. Summaries of radiation doses are contained in Table 1. Also presented are estimates of worker injuries and fatalities resulting from decommissioning activities. These industrial accident estimates presented in Table 2 are based on nuclear industry experience.

4.2 PUBLIC RADIATION DOSES FROM ROUTINE TASKS

The consequences of atmospheric releases of radioactivity during routine decommissioning tasks are presented in Table 3 and are based on NUREG/CR-1756 as adjusted to Bay Area population estimates. The radiation exposure pathways considered are direct external exposure, inhalation, and ingestion of food products.

Both the first-year doses and the 50-year committed radiation dose equivalents to total body and lungs are listed. These radiation doses are all small as compared to natural background. The dose to the maximum-exposed individual is 1.6×10^{-10} rem which is 1.6×10^{-7} percent of the average yearly background dose of 0.1 rem based on NCRP 45.

4.3 PUBLIC RADIATION DOSES FROM POSTULATED ACCIDENTS DURING DECOMMISSIONING

The consequences of postulated decommissioning accidents that result in atmospheric releases of radioactivity are calculated in NUREG/CR-1756 and presented in Table 4 following. In addition, the radiation dose to the maximum-exposed individual in an unrestricted area directly above the reactor in case of a premature loss of pool water is described below.

Etcheverry Hall is sited on a slope which allows unrestricted access above Room 1140. The nearest dose point is 32 ft above the reactor core with 25 in. of ordinary concrete shielding supplied by the roof structures. The SAR addresses a loss-of-pool water accident and the dose to an individual above the core. Since the dose rate from the irradiated fuel greatly exceeds the dose rate from the core structure and since the fuel is to be removed prior to DECON, the dose to a member of the public in case of a loss-of-pool water is greatly reduced.

Table 1
Calculated Occupational Radiation Doses

Task/Activity	Total[a] Man-hour	Exposure Man-hours	Range[b] Dose Rate Mrem/hour	Total[c] Man-rem
1. Contractor Move-in	412	84	0.2	0.017
2. Initial Radiation Survey	144	84	0.2-10	0.19
3. Installation of Confinement Barriers	472	354	0.1-0.2	0.068
4. Removal of Reactor Components and Pool Liner	808	606	2-4	1.6
5. Removal of Material with Potential Surface Contamination and Other Activated Equipment	2372	1779	2	3.56
6. Cleanup and Removal of Tools and Equipment	1140	855	0.1-2	1.2
7. Packaging and Shipment of Radioactive Waste	384	288	2	0.58
8. Perform Termination Radiation Survey	360	280	0.02	0.004
UCB Decommissioning Staff	640	480	0.5-1.0	0.36
GRAND TOTAL	6732	4810		7.7[c]

(a) Based on tasks man-hour estimates BRR DP.
(b) Based on survey data BRR and NUREG/CR-1756.
(c) Rounded to 2 digits.

Table 2
Estimated Occupational Lost-Time Injuries and Fatalities[a]

	Frequency (Accidents/10^6 man-hours)[b,c]				
Category of Effort	Lost-Time Injuries	Fatalities	Man-hours	Lost-Time Injuries	Fatalities
Heavy Construction[d]	10.0	4.2×10^{-2}	5.2×10^{3}	5.2×10^{-2}	2.2×10^{-4}
Light Construction	5.4	3.0×10^{-2}	4.8×10^{3}	2.6×10^{-2}	1.4×10^{-4}
Operational Support	2.1	2.3×10^{-2}	1.7×10^{4}	3.6×10^{-2}	3.9×10^{-4}
			2.7×10^{4}	1.1×10^{-1}	7.5×10^{-4}

(a) NUREG/CR 1756, Table 12.2-12.

(b) Estimates of man-hours, injuries, and fatalities are rounded to two significant figures.

(c) Lost-time injuries and fatality frequencies are from Operation Accidents and Radiation Exposure Experiences Within the U.S., AEC 1943-1970, WASH-1192, 1977.

(d) Heavy construction involves demolition tasks such as removal of piping, equipment, and concrete.

Table 3
Calculated Radiation Doses From Atmospheric Releases During Routine DECON Tasks [(a)]

	First-Year Dose (rem)		Fifty-Year Committed Dose Equivalent (rem)	
	Total Body	Lungs	Total Body	Lungs
Maximum-Exposed Individual	1.6×10^{-10}	4.8×10^{-10}	3.0×10^{-10}	1.3×10^{-9}
General Population[(b)]	1.3×10^{-7}	6.1×10^{-7}	2.6×10^{-7}	1.8×10^{-6}

(a) NUREG/CR-1756 (Based on Tables 12.3-1 and 12.3-2.)

(b) Doses are calculated to a total population of 4.5 million people residing within a 50-mile (80 km) radius.

Table 4
Summary of Accidents and Radiation Doses to the Maximum-Exposed Individual[(a)]

Accident	Frequency of Occurrence[(b)]	First-Year Dose (rem) Total Body	First-Year Dose (rem) Lungs	50-Year Committed Dose Equivalent (rem) Total Body	50-Year Committed Dose Equivalent (rem) Lungs
Oxyacetylene Explosion	Medium	4.4×10^{-5}	1.2×10^{-3}	6.3×10^{-5}	1.6×10^{-3}
HEPA Filter Failure	Low	8.4×10^{-9}	2.4×10^{-7}	1.2×10^{-8}	3.1×10^{-7}
Severe Transportation Accident	Low	1.3×10^{-6}	4.1×10^{-4}	1.3×10^{-6}	8.3×10^{-4}
[illegible]xplosion	Low	7.6×10^{-9}	3.9×10^{-8}	7.7×10^{-9}	4.2×10^{-8}
Vacuum Filter-Bag Rupture	Medium	1.5×10^{-9}	4.3×10^{-8}	2.2×10^{-9}	5.6×10^{-8}
Minor Transportation Accident	Low	3.2×10^{-8}	1.0×10^{-5}	3.2×10^{-8}	2.1×10^{-5}
Accidental Cutting of Activated Al in Air	High	2.4×10^{-10}	6.9×10^{-9}	3.5×10^{-10}	9.1×10^{-9}
Loss-of-Pool Water	Low	4.0×10^{-1}	NA	NA	NA
Contaminated Sweeping Compound Fire	Medium	1.0×10^{-12}	5.3×10^{-12}	1.0×10^{-12}	5.7×10^{-12}
Combustible Waste Fire	High	4.8×10^{-13}	1.5×10^{-10}	4.[illegible]10^{-13}	3.2×10^{-10}

(a) NUREG/CR 1756 (Based on Table 12.3-5)

(b) The frequency of occurrence considers not only the probability of the accident but also the probability of an atmospheric release of the calculated magnitude. The frequency of occurrence is listed as "high" if the occurrence of a release of similar magnitude is $>10^{-2}$ per year, as "medium" if between 10^{-2} and 10^{-5}, as "low" if $>10^{-5}$.

In the case of loss-of-pool-water prior to dismantlement and shipment of the core structure, the calculated dose rate outside, directly above the core, is 0.2 mrad/h six months after the reactor has been shut down. This dose rate is 10 percent of the permissible level of radiation in unrestricted areas cited in 10 CFR 20.105 for non-continuous exposure. If one assumes that shielding or area control would be secured within two hours, the maximum dose to an individual would be 0.4mrad which is approximately 0.4 percent of the yearly dose from natural background.

4.4 RADIATION DOSES FROM ROUTINE TRANSPORTATION

Transportation of radioactive materials results in external radiation doses to the transportation workers and to the public along the transportation route. Table 5 adapted from NUREG/CR-1759 gives the calculated radiation doses from routine radioactive waste shipments.

4.5 RADIATION DOSES FROM POSTULATED TRANSPORTATION ACCIDENTS

Transportation accidents have a wide range of severities. Most accidents occur at low vehicle speeds and have relatively minor consequences. In general, as speed increases, accident severity also increases. However, accident severity is not a function of vehicle speed only. Other factors such as the type of accident, the kind of equipment involved, and the location of the accident can have an important bearing on accident severity.

Furthermore, damage to a package in a transportation accident is not directly related to accident severity. In a series of accidents of the same severity, or in a single accident involving a number of packages, damage to packages may vary from none to extensive. In relatively minor accidents, serious damage to packages can occur from impacts on sharp objects or from being struck by other cargo. Conversely, even in very severe accidents, damage to packages may be minimal.

The radioactive materials that are transported in Type B packages (the highly activated reactor core internals) are in solid, noncombustible forms that are not likely to become airborne in an accident. Therefore, no accident analysis of Type B packages is considered. Instead, NUREG/CR-1756 analyzes two more realistic accidents involving combustible radioactive wastes in Type A packages. Both, however, are judged to have a low frequency of occurrence. The calculated radiation doses to the lungs of the maximum-exposed individual resulting from these accidents are shown in Table 4.

The severe transportation accident is assumed to involve rupture and fire in 40 waste containers (55-gal equivalent). The total atmospheric releases are calculated to be: 5.2×10^{-6} Ci. The calculated 50-year committed dose equivalent to the lungs of the maximum-exposed individual is 8.3×10^{-4} rem. For a minor accident, only one package is assumed to rupture and burn. In that case, 1.3×10^{-6} Ci are released. The resulting 50-year committed dose equivalents to the lungs are calculated to be 2.1×10^{-5}.

Table 5
Calculated Radiation Doses from Routine Radioactive Waste Transport[a]

Alternative/Group	Radiation Dose per Shipment (Man-rem)[a]	Number of Shipments[b]	Total Population Dose per Group (Man-rem)[c]
Truck Drivers	8.0×10^{-2}	11	8.8×10^{-1}
Garage Men	4.0×10^{-3}	11	4.4×10^{-2}
Total Worker Dose			9.2×10^{-1}
Onlookers	6.0×10^{-3}	11	6.6×10^{-2}
General Public	2.2×10^{-3}	11	2.4×10^{-2}
Total Public Dose			9.0×10^{-2}

(a) Based on NUREG/CR 1756 Table 12.4-1 and one-way trips to Beatty, Nevada, of 960 km (600 miles).

(b) Based on the waste disposal requirements discussed in the Decommissioning Plan.

(c) All doses are rounded to two significant figures.

5. DESCRIPTION OF THE STATUS OF THE FACILITY

5.1 GENERAL LOCALE

The BRR is located on the University of California Berkeley campus in Alameda County, California. The San Francisco Bay Area has a projected population of 4.5 million. The reactor site is approximately 2-1/2 miles east of the San Francisco Bay, Interstate Highway 80, and the Southern Pacific Railroad. The nearest major airport, Metropolitan Oakland International Airport, is approximately 11 miles south of the site.

5.2 FACILITY DESCRIPTION

The BRR is in Etcheverry Hall in Room 1140, which is a high bay room, containing the reactor at the east end and various research and teaching facilities distributed throughout the remainder of the room. Additional rooms are located on the north side and on the west side. The room is below grade, and the east wall is a retaining wall. There is a parking lot and a patio on the roof above Room 1140.

Room 1140 is equipped with an independent ventilation exhaust system using HEPA filters. There is also an emergency ventilation system. Room 1140 and the rest of Etcheverry Hall is of reinforced concrete construction. In addition to the existing ventilation system, a HEPA-filtered, negative pressure containment barrier surrounding the reactor will be in place during DECON activities.

5.3 ENVIRONMENTAL CHARACTERISTICS

5.3.1 Meteorology

- Predominant Wind Direction

  The most probable wind directions are west and southwest. This is to be expected, since the normal westerly winds from the Pacific Ocean have a turning component created by the East Bay and Berkeley hills. The southwest winds are predominant in all quarters with the exception of the fourth-quarter wind rose. The daytime wind roses indicate an even higher probability of winds from the west and southwest. Only in the case of the first- and fourth-quarter nighttime wind roses do the north to east components become predominant. Surface wind conditions are summarized in Appendix A of the BRR Safety Analysis Report.

  The 500-meter wind roses show a low probability of winds above 25 mph, whereas the surface wind roses indicate a very small probability of sustained wind above 22 mph.

- Temperature

  The temperatures expected in Berkeley are characterized by a rather narrow margin of variations compared with other regions of the United States. The mean daily maximum temperature is

71°F for September, with the mean daily minimum of 42°F in January. The highest recorded temperatures was 106°F for September, and the lowest recorded temperatures was 25°F for January. The mean daily annual temperature is 56.7°F. The mean daily maximum and the mean daily minimum vary at most ± 15°F from this annual mean.

- Precipitation

  The precipitation data for the Berkeley region shows a relatively short rainy season. The average mean precipitation of approximately 24 in. comes in the months of October through April. The summer months of May through September are characterized by very small average rainfall averages. The maximum mean precipitation of 4.9 in. was recorded in the month of January, with the minimum of 0.02 in. reported for July.

- Inversion Conditions

  The San Francisco Bay Area, in general, has a relatively high probability for the existence of inversion conditions. The high, overall probability of inversion conditions existing in the San Francisco Bay Area agrees with the relatively high probability of wind velocities below 10 mph. This over-all probability varies from 27% to 59%, depending on the elevation and the time of day.

- Unusual Weather Conditions

  The most unusual weather phenomenon in the San Francisco Bay Area is the frequency of ocean fogs during the summer months. The major significance of the high frequency of fog during the summer months is that stable, poor diffusion conditions will often be present. This is correlated with the high frequency of inversion conditions existing during these same summer months.

  Tornadoes rarely occur in California, and none has ever been reported in the San Francisco area. Destructive winds seldom occur and are not generally an engineering problem.

In general, the meterological conditions are similar to those parameters used in NUREG/CR-1756.

5.3.2 Geology

The site of Etcheverry Hall lies near the foot of the Berkeley hills. The surface soils consist of stiff silty clay mixed with sand and rock fragments to depths varying from 10 to 20 ft below the surface. These cover soils are derived from the bedrock present, and are considered to be fairly inert to normal chemical or physical destruction. Below the surface soil, dense fractured sandstone is found to a depth of about 45 ft below the surface. This is underlaid by dense decomposed shale and fractured sandstone.

5.3.3 Seismology

The Hayward fault runs within approximately 30 m (100 ft) of the reactor site. The last significant event on this nearby Hayward fault occured in 1868. Recent studies indicate that the probability of an earthquake on that fault again is approximately 0.03% per year. Therefore, the probability of a significant earthquake occuring during the one to two year decommissioning period is very small.

In the event an earthquake does occur, the only significant hazards would be the normal hazards of falling objects since the spent fuel, which is the major source of radioactivity, will have been removed prior to the start of the decommissioning activities.

5.3.4 Hydrology

Surface drainage and underground drainage in the area of the reactor site is down Strawberry Creek and into the Bay. This creek has a small flow rate which is dependent on how much rain has fallen in the past month. Strawberry Creek is exposed during its run across the campus but is mainly covered or flows in culverts when it goes through Berkeley on its way to the Bay. The water table will probably be above the reactor floor level on the east side of the building since the floor is about 50 ft below the grade level. All the water which will drain from under the building will go into the sub-surface drainage pipe which eventually flows into Strawberry Creek. The public water supply comes from rivers in the Sierras by way of aqueducts across the Sacramento Valley to storage reservoirs in the East Bay hills. There are no reservoirs below the elevation of the reactor site, and the nearest reservoir is over 1/2 mi away to the north.

5.3.5 Ecosystems

o Wildlife

In general, the University site supports habitats and associated wildlife that are typical of disturbed portions of the Berkeley-Oakland hills. Approximately 79 species of birds, 20 mammal species, and 19 reptile and amphibian species can be expected to occur on or near this area.

No rare, threatened, endangered, or special status species are known or expected to occur in this area.

o Vegetation

During the 19th and early 20th century, the University site was grazing land. Cattle were managed at the site through the 1950s, and the predominant land cover was native and introduced grasses and shrubs.

The vegetation within the site can generally be classified into the following seven major types:

- Baccharis brushland
- Coastal sagebrush scrub
- Oak-bay woodland
- Introduced annual grassland/disturbed/ruderal
- Introduced Eucalyptus plantation
- Introduced Monterey pine plantations
- Landscape plantings about roads and buildings

5.3.6 Noise Standards

There are no applicable State of California or Federal Noise Standards that would apply to the decommissioning other than personnel exposure. The City of Berkeley, in December 1982, passed a notarized ordinance which applies, among other items, to continually operating equipment such as mechanical equipment. For example, the City of Berkeley ordinance which applies to R-1 and R-2 residential districts allows 55 dBA daytime sound levels (7:00 a.m. to 10:00 p.m.) and 45 dBA nighttime sound levels (10:00 p.m. to 7:00 a.m.) incident upon the property receiving the sound. These sound levels are not to be exceeded for more than 30 minutes in any hour; thus L_{50} noise level measurement is appropriate as a base for comparison with the steady-state noise generated by operation of mechanical equipment.

6. STATUS OF COMPLIANCE

The regulatory framework and applicable regulations, regulatory guidelines, standards, and informed guidelines are specified in the BRR DP. Engineering controls and implementation of the occupational and Radiation Protection Program will ensure compliance with applicable environmental quality standards during DECON activities.

7. ADVERSE IMPACT INFORMATION

DECON activities as implemented at the BRR should have minor adverse impact. Theses include an occupational dose burden which is well within regulatory guidelines, a modest cost compared to commissioning and operational cost, and the irreversible commitment of a small amount of land at a commercial low-level radioactive waste burial facility.

8. REFERENCES

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