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Historic Context and Building Assessments for the Lawrence Livermore National Laboratory Built Environment

Rebecca Ann Ullrich, Michael Anne Sullivan

September 18, 2007

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Corporate History Program
Sandia National Laboratories

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Lawrence Livermore National Laboratory

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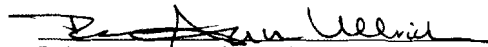
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Historic Context and Building Assessments for the Lawrence Livermore National Laboratory Built Environment

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Submitted by


Rebecca Ann Ullrich, Principal Investigator

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CONTENTS

Acknowledgments	vii	3.7 WWII Preservation Themes	29
Executive Summary	ix	3.8 WWII Buildings and Integrity	31
1. Introduction	1	4. Cold War Context	35
1.1 Organization	2	4.1 Beginnings of the Cold War	36
1.2 Methodology	3	4.2 Truman and Containment	39
1.3 NHPA Compliance	4	4.3 Eisenhower and the New Look	43
1.4 Historical Context	6	4.4 Kennedy and Flexible Response	46
1.5 Preservation Themes	9	4.5 Johnson and Assured Destruction	47
1.6 Integrity	10	4.6 Nixon and Flexible Targeting	48
2. Local Context	13	4.7 The Final Decade of the Cold War	50
2.1 Early Livermore	13	4.8 Stand-Down	50
2.2 Spanish Colonization	13	5. Post-Cold War Context	53
2.3 Mexican Period	14	5.1 Criteria Consideration G	54
2.4 The Mexican-American War	15	6. LLNL Cold War Missions and	
2.5 Mining	15	Preservation Themes	55
2.6 The Town of Livermore	16	6.1 Theme: Nuclear Weapons Design	56
2.7 Agriculture	17	6.2 Theme: Nuclear Weapons Testing	68
2.8 Industry	17	6.3 Theme: Nuclear Research	77
2.9 LLNL Local Context	19	6.4 Theme: Non-Weapons Research	98
3. WWII Context	21	6.5 Thresholds for Cold War	
3.1 NAS Livermore	21	Preservation Themes	113
3.2 Naval Air Support for WWII	23	7. Facilities	117
3.3 Naval Air Training	25	7.1 Construction Patterns	118
3.4 NAS Livermore: Flight School	26	7.2 Cold War Building Architecture	130
3.5 NAS Livermore: Operations and		7.3 Cold War Building Types	139
Testing	29	7.4 Thresholds for Integrity	141
3.6 NAS Livermore: Naval Air Reserve			
Training Center	29		

8. Conclusion	143	9.16 Building 423	237
8.1 Initial Building Review Criteria	145	9.17 Building 435	241
9. Building Assessments	155	9.18 Building 865 Complex	246
9.1 Building 121	159	9.19 Site 300, High Explosive Process Area:	
9.2 Building 162	164	Buildings 805, 806, 807, 809, 817, 825,	
9.3 Building 166	167	826, 827, and 828	252
9.4 Building 169	171	9.20 Site 300, Hydrodynamic Test Facilities:	
9.5 Building 174	175	Buildings 802A, 812A, 845A, 850,	
9.6 Building 194	182	and 851A	280
9.7 Buildings 230 and 231	193	9.21 World War II Properties:	
9.8 Building 241	198	Buildings 212, 213, 216, 217, 218, 219,	
9.9 Building 243	203	314, 315, 316, 318, 319, 404, 405, 412,	
9.10 Building 261	206	415, 419, 511, 514, 516, and 517	294
9.11 Buildings 280 and 281	211	10. Acronyms	325
9.12 Building 331	216	11. Bibliography	327
9.13 Building 332	221	11.1 Archival Sources	327
9.14 Building 381	226	11.2 Books, Reports, and Articles	327
9.15 Building 391	230		



FIGURES

Figure 1.	LLNL main site, aerial view, 2002	2	Figure 20.	Building 807, HE machining control room, 1960s	75
Figure 2.	Site 300, aerial view, 2004	3	Figure 21.	Dynamic Test Complex, Building 854, control room, 1960	76
Figure 3.	Livermore and Tesla coal mining districts, 19th century	16	Figure 22.	Building 280, Livermore Pool Type Reactor, 1958	83
Figure 4.	Carnegie Brick and Pottery Company brickworks, 1890s	18	Figure 23.	Cockcroft-Walton accelerator, Building 212	85
Figure 5.	NAS Livermore airfield, 1943	22	Figure 24.	90-inch cyclotron, Building 212	86
Figure 6.	NAS Livermore building list, 1949	24	Figure 25.	Early Q Division laser research	89
Figure 7.	Naval air cadets drilling, NAS Livermore, 1943	27	Figure 26.	Janus laser, 1974	90
Figure 8.	WAVES enlisted personnel training naval officer on Link Trainer, NAS Livermore, 1943	28	Figure 27.	Scale model of Nova laser, 1985	91
Figure 9.	NAS Livermore, cadets flying formation, 1943	28	Figure 28.	Artist's rendition, Nova Laser Fusion Facility, Building 391	91
Figure 10.	U.S. nuclear weapons complex, 1949	42	Figure 29.	AEC officials tour Building 151, Radiochemistry Laboratory, 1967	94
Figure 11.	U.S. nuclear weapons complex, 1968	48	Figure 30.	Toy Top, magnetic mirror machine, 1961	101
Figure 12.	Ruth test stand, first LLNL test shot, 1953	58	Figure 31.	Astron, induction linear accelerator, Building 431, 1963	101
Figure 13.	LLNL nuclear weapons, 1945-1989	59	Figure 32.	2X, magnetic mirror machine, Building 435, 1964	102
Figure 14.	Polaris missile with LLNL-designed W-47 nuclear warhead, 1960	64	Figure 33.	Artist's conception, TMX, 1980	103
Figure 15.	LLNL's first computer, Univac, 1953	67	Figure 34.	MFTF-B, yin-yang magnets, 1985	103
Figure 16.	Livermore Advanced Research Computer, 1960	68	Figure 35.	Tory II-A (top) and Tory II-C (bottom), ramjet engines for Project Pluto, 1961 and 1964	107
Figure 17.	XR2 machine, Site 300, bunker 812, 1955	72	Figure 36.	Sedan crater, largest Project Plowshare test shot, 320-feet deep, 1,280-foot diameter, 1961	110
Figure 18.	Building 851A, Site 300, linac, 1960	73			
Figure 19.	FXR accelerator, Building 801, Site 300, 1982	73			

Figure 37. Building 141, Storage and Handling Facility, built 1954	119	Figure 68. Looking west at Building 121, original H-shape wing, east elevation, 2003	161
Figure 38. Building 243, Pluto Assembly Building, built 1959	120	Figure 69. Looking west at Building 162, east elevation, 2003	164
Figure 39. Building 435, Project Sherwood Laboratory, built 1960	120	Figure 70. Looking southeast at Building 166, north and west elevations, 2003	167
Figure 40. Building 151, Radiochemistry Laboratory, built 1968	121	Figure 71. Looking north at Building 169, south elevation, 2003	171
Figure 41. Building 131, Engineering offices, built 1959	121	Figure 72. Looking northeast at Building 174, west and south elevations, 2003	175
Figure 42. Trailer 2425, Chemistry offices, 1963....	122	Figure 73. Building 174, original Janus laser, 1974 .	178
Figure 43. Building 311, Personnel and Plant Engineering offices, 1966	122	Figure 74. Building 174, Janus laser, 2003	179
Figure 44. Royston Plan 1968, artist's drawing, loop-road system	123	Figure 75. Building 174, Room 1103, Janus control room, 2003	180
Figure 45. Royston Plan 1968, program areas	124	Figure 76. Looking west at Building 194, east elevation, 2003	182
Figure 46. Building 3724, ICF offices, built 1975 ...	125	Figure 77. Looking north at Increment 1, Building 194, south elevation, 2003	184
Figure 47. Building 391, Nova Laser Facility, built 1978	125	Figure 78. Looking northwest at Increment 2, Building 194, south and east elevations, 2003	185
Figure 48. Building 4675, Cafeteria, built 1979	125	Figure 79. Looking west at Building 194, central wing, east elevation, 2003	186
Figure 49. Building 482, DOE offices, built 1983...	126	Figure 80. Looking south at Building 194, north wing, north elevation, 2003	186
Figure 50. Building 197, Physics laboratory, built 1984	126	Figure 81. Building 194, neutron cell and drift tube, 2003	187
Figure 51. Building 132, Physics Complex, built 1994-1995	127	Figure 82. Artist's drawing of Building 194, basement cave complex, 1967	187
Figure 52. Building 581, NIF, built 2002	127	Figure 83. 100-MeV Electron-Positron Accelerator, retrofitted magnets, 2003	189
Figure 53. Building 812, Linac, built 1955	128	Figure 84. 100-MeV Electron-Positron, beamline, 2003	189
Figure 54. Building 805, HE Assembly, built 1957 .	129	Figure 85. Building 194, Room 117A, Electron-Positron accelerator control room, 2003	190
Figure 55. Building 817, HE Press, built 1959	129	Figure 86. Looking north at Building 230, south elevation, 2003	193
Figure 56. Building 823, Radiography, built 1966 ..	129	Figure 87. Looking northeast at Building 231, west and south elevations, 2003	194
Figure 57. Wurster Hall, University of California, Berkeley, c. 1962-1964	131	Figure 88. Looking east at Building 241, west elevation, 2003	198
Figure 58. Building 111, Director's offices, built 1969	131	Figure 89. Looking northeast at Building 243, west and south elevations, 2003	203
Figure 59. San Francisco TransAmerica Pyramid, 1972	132	Figure 90. Looking south at Building 261, north elevation, 2003	206
Figure 60. Building 381, Laser Fusion Laboratory, rock façade, 2003	133	Figure 91. Looking west at Building 280, east elevation, 2003	211
Figure 61. Building 482, DOE offices, geometric doors, 2003	133	Figure 92. Looking northwest at Building 281, south elevation, 2003	212
Figure 62. Building 551, Plant Engineering/TID offices, wraparound windows, 2003	134	Figure 93. Building 280, LPTR reactor vessel, 2003	213
Figure 63. Building 481, NIF offices, glass office building, 2003	134		
Figure 64. Building 691, Fabrication Facility, geometric shaped glass windows, decorative roof trim, 2003	134		
Figure 65. Map of LLNL main site	157		
Figure 66. Map of LLNL Site 300	158		
Figure 67. Looking north at Building 121, south elevation, 2003	159		

Figure 94. Looking northeast at west and south elevations of Building 281, 2003	214	Figure 122. Partial view of control panel for remote machining equipment in Building 805, 2003.	260
Figure 95. Looking southeast at Building 331, north and west elevations, 2003	216	Figure 123. Looking north at the 806 Complex, south elevation, 2003	261
Figure 96. Building 331, Room 149, Cold War-era gaseous chemistry laboratory, 2003	219	Figure 124. Control panel for remote machining equipment, Building 806B, 2003	262
Figure 97. Looking west at Building 332, east elevation, 2003	221	Figure 125. Remote machining equipment, Building 806B, 2003	262
Figure 98. Looking north at Building 381, west and south wings, 2003	226	Figure 126. Looking north at Building 807, south elevation, 2003	263
Figure 99. Looking west at Building 391, east elevation, 2003	230	Figure 127. Looking northwest at Building 809, south and east elevations, 2003	264
Figure 100. Building 391, Nova target chamber, 2003.	232	Figure 128. Looking west at Building 809C, east elevation, 2003	264
Figure 101. Building 391, Nova target chamber door, 2003	233	Figure 129. Looking southwest at Building 817A, east elevation, 2003	265
Figure 102. Building 391, remains of Nova laser, 2003.	233	Figure 130. Looking north at Building 817B, south elevation, 2003	265
Figure 103. Building 391, Nova petawatt chamber, 2003.	234	Figure 131. Looking northwest at Building 817F, east elevation, 2003	266
Figure 104. Building 391, Nova control room, laser mural, 2003	235	Figure 132. Control panel for remote-controlled ovens and presses, Building 817A, 2003	266
Figure 105. Looking northwest at Building 423, south and east elevations, 2003	237	Figure 133. Isostatic presses in Building 817B, 2003	267
Figure 106. Building 423, tile pool, 2003	240	Figure 134. Ovens in Building 817F, 2003	268
Figure 107. Looking east at Building 435, west elevation, 2003	241	Figure 135. Looking northwest at Building 825, east elevation, 2003	269
Figure 108. Building 435, remains of concrete shielding pit, 2003	245	Figure 136. Building 825, frangible exterior walls, west elevation, 2003	269
Figure 109. Building 865 Complex, 2002	246	Figure 137. Looking southwest at Building 826, north and east elevations, 2003	270
Figure 110. Building 865A, north and east elevations, 2001	247	Figure 138. Looking southwest at Building 827A, north and east elevations, 2003	271
Figure 111. Building 865A, ATA cells, 2001	249	Figure 139. Looking northwest at Building 827C, south and east elevations, 2003	271
Figure 112. Building 865A, ATA tunnel, 2001.	250	Figure 140. Looking north at Building 827D, south elevation, 2003	271
Figure 113. Building 805, HE Trim Building, 1957-1958.	254	Figure 141. Looking southeast at Building 827E, west elevation, 2003	272
Figure 114. Building 806 Complex, HE Machining, 1957	254	Figure 142. Partial view of control room in Building 827A, 2003	272
Figure 115. Building 825, Chemistry Laboratory, under construction, 1957	255	Figure 143. Horizontal and vertical mixers in Building 827C, 2003	273
Figure 116. Building 807, HE Preparation, 1957	255	Figure 144. Pilot reactor vessel in Building 827D, Cell 2, 2003.	273
Figure 117. Buildings 817A and 817B, HE press facilities, 1959.	256	Figure 145. Looking southwest at Building 828A, 2003	274
Figure 118. Building 809, Radiography, 1959	256	Figure 146. Looking southwest at Building 828B, 2003	275
Figure 119. Building 825, HE Chemistry Laboratory, 1959	257	Figure 147. Looking west at Building 828C, east elevation, 2003	275
Figure 120. Building 826, HE Chemistry Laboratory, 1960	257		
Figure 121. Looking east at Building 805, west elevation, 2002	259		

Figure 148. Looking north at Building 802A, south elevation, 2003	283	Figure 169. Looking southeast at Building 212, west elevation, 2003	309
Figure 149. Original Armco arch in Increment 1 of Building 802A, 2003	284	Figure 170. Looking south at Building 212, north elevation, 2003	309
Figure 150. Looking northeast at Building 812A, south elevation, 2003	284	Figure 171. Freestanding wood laminated arches, Building 212, 2003	310
Figure 151. Building 812A firing table looking toward optics ports, north elevation, 2003	285	Figure 172. Cold War-era blockhouse, Building 212, east elevation, 2003	311
Figure 152. Looking south at Building 845A, north elevation, 2003	286	Figure 173. Cold War-era blockhouse, Building 212, west elevation, 2003	311
Figure 153. Looking west at Building 850, east elevation, 2003	287	Figure 174. Renovation for 90-inch cyclotron and Cockcroft-Walton accelerator, Building 212, 1954	312
Figure 154. Looking west at Building 851A, east elevation, 2003	288	Figure 175. Remnants of Van de Graaff accelerator, Building 212, 2003	313
Figure 155. Looking toward bull-nose of linac on Building 851A firing table, 2003	288	Figure 176. Looking southeast at Building 404, north and west elevations, 2003	314
Figure 156. Building 851A, linac, 2003	289	Figure 177. Looking west at Building 405, east elevation, 2003	314
Figure 157. Building 851A, linac control room, 2003	289	Figure 178. Looking west at Building 516, east elevation, 2003	314
Figure 158. Looking southwest at Building 216, east and north elevations, 2003	303	Figure 179. Looking east at Building 517, west elevation, 2003	315
Figure 159. Looking southeast at Building 217, west and north elevations, 2003	304	Figure 180. Looking north at Building 412, south elevation, 2003	315
Figure 160. Looking south at Building 218, north elevation, 2003	304	Figure 181. Building 419, exterior	316
Figure 161. Looking south at Building 314, north elevation, 2003	304	Figure 182. Looking southwest at Building 511, east and north elevations, 2003	317
Figure 162. Looking south at Building 315, north elevation, 2003	305	Figure 183. Looking northeast at Building 514, west and south elevations, 2003	318
Figure 163. WWII-era wainscoting, Building 217, 2003	305	Figure 184. Looking south at Building 213, north elevation, 2003	319
Figure 164. WWII-era radiator, Building 218, 2003	305	Figure 185. Looking east at Building 415, west elevation, 2003	320
Figure 165. Looking south at Building 219, north elevation, 2003	306		
Figure 166. Looking south at Building 319, north elevation, 2003	306		
Figure 167. Looking north at Building 316, south elevation, 2003	307		
Figure 168. WWII-era fireplace, Building 316, 2003	308		

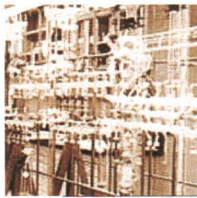


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selected buildings and equipment at LLNL. Building managers provided access to and tours of the buildings we assessed, giving as much time as we needed and answering or finding answers to our questions. We appreciate their time and patience. Jim Lane at Site 300 allowed us access to the site and to appropriate subject matter experts. Again, the goodwill extended to us was impressive and we are grateful.

LLNL technical editors Gloria Cannon, Mara Niels, Kathy O'Connor, and Penny Sanford provided painstaking review of the report at different stages. Carol Gerich and Bruce Tarter also reviewed and offered input on an early draft. Paul McGuff found photographs, directed us to potential sources of documents, provided detailed reviews, and generally supported the project with enthusiasm and professionalism. Thank you.



EXECUTIVE SUMMARY

This document was prepared to support U.S. Department of Energy / National Nuclear Security Agency (DOE/NNSA) compliance with Sections 106 and 110 of the National Historic Preservation Act (NHPA). Lawrence Livermore National Laboratory (LLNL) is a DOE/NNSA laboratory and is engaged in determining the historic status of its properties at both its main site in Livermore, California, and Site 300, its test site located eleven miles from the main site. LLNL contracted with the authors via Sandia National Laboratories (SNL) to prepare a historic context statement for properties at both sites and to provide assessments of those properties of potential historic interest.

The report contains an extensive historic context statement and the assessments of individual properties and groups of properties determined, via criteria established in the context statement, to be of potential interest. The historic context statement addresses the four contexts within which LLNL falls: Local History, World War II History (WWII), Cold War History, and

Post-Cold War History. Appropriate historic preservation themes relevant to LLNL's history are delineated within each context. In addition, thresholds are identified for historic significance within each of the contexts based on the explication and understanding of the Secretary of the Interior's Guidelines for determining eligibility for the National Register of Historic Places.

The report identifies specific research areas and events in LLNL's history that are of interest and the portions of the built environment in which they occurred. Based on that discussion, properties of potential interest are identified and assessments of them are provided. Twenty individual buildings and three areas of potential historic interest were assessed. The final recommendation is that, of these, LLNL has five individual historic buildings, two sets of historic objects, and two historic districts eligible for the National Register. All are eligible within the Cold War History context. They are listed in the table below, along with the Cold War preservation theme, period of significance, and criterion under which they are eligible.

Building or Object	Name of Properties Included	Date Built	Cold War Preservation Theme(s)	Period(s) of Significance	Criterion
Building 194	100-MeV Electron-Positron Linear Accelerator Facility	1958	Nuclear Research; Nuclear Weapons Design	1967–1969 & 1967–1984	A and C
Building 280	Livermore Pool-Type Reactor	1958	Nuclear Weapons Design; Nuclear Weapons Testing	1958–1980	A
Building 332	Plutonium Facility	1961	Nuclear Weapons Design; Nuclear Weapons Testing; Nuclear Research	1961–1989 & 1976–1989	A and C
Building 391	Nova Facility	1976	Nuclear Research	1985–1999	A and C
Building 865A	Advanced Test Accelerator	1980	Nuclear Research	1983–1990	A and C
Selected Objects in Building 174	Janus laser and control panel	1974	Nuclear Research	1972–1974	A and C
Selected Objects in Building 241	Brew furnaces in Room 1600 of Building 241	1960	Nuclear Research; Non-Weapons Research	1960–1964	A
Site 300 Process Area District	High Explosive Process Area: Buildings 805, 806A, 806B, 807, 817A, 817B, 817F, 825, 826, 827A, 827C	1957	Nuclear Weapons Design; Nuclear Weapons Testing	1957–1992	A
Site 300 Hydrodynamic Test Facilities District	Hydrodynamic Test Facilities Area: Buildings 850 and 851A	1955	Nuclear Weapons Design; Nuclear Weapons Testing	1960–1992	A for district; A and C for 851A



1. INTRODUCTION

Lawrence Livermore National Laboratory (LLNL) is a U.S. Department of Energy (DOE) national laboratory operated by the University of California.¹ LLNL's primary mission is the design and maintenance of nuclear weapons for the U.S. stockpile. In addition to its function as a nuclear weapons laboratory, LLNL conducts cutting edge research in physics, chemistry, environmental studies, computation, engineering, and biomedical science.²

¹ Lawrence Livermore National Laboratory was originally a division of the University of California Radiation Laboratory (UCRL). From its inception in 1952, it was identified as the University of California Radiation Laboratory, Livermore. In 1958, after the death of Ernest O. Lawrence, the name was changed to Lawrence Radiation Laboratory. In 1971, it became a separate entity from the Berkeley site and was renamed the Lawrence Livermore Laboratory. In 1979, Congress designated it a national laboratory and it became Lawrence Livermore National Laboratory. See University of California, Lawrence Livermore National Laboratory, *Lawrence Livermore National Laboratory: A Concise History, 1952–2000*, UCRL-TB-133100 (Livermore: University of California, Lawrence Livermore National Laboratory, 2000). For clarity, it will hereafter be referred to as LLNL.

² For an official description of LLNL's current mission and organization, see LLNL website, www.llnl.gov; and Charles R. Loeber, *Building the Bombs: A History of the Nuclear Weapons Complex*, SAND2002-0307P (Albuquerque: Sandia National Laboratories, 2002), 173.

LLNL is located forty-eight miles east of San Francisco in Alameda County, California. The main site is situated on 821 acres and includes approximately 500 buildings and structures totaling six million gross square feet. The LLNL main site is depicted in figure 1.

LLNL also maintains a 7,000-acre high explosives (HE) test area designated as Site 300. It is located fifteen miles southeast of the city of Livermore, in Alameda and San Joaquin counties. Site 300 includes approximately 200 buildings and structures totaling 400,000 gross square feet.³ Site 300 is depicted in figure 2.

This report supports the DOE's efforts to evaluate potential historic properties at LLNL in compliance with the National Historic Preservation Act (NHPA). It is designed to aid DOE in consultation with the State Historic Preservation Office (SHPO) in determining whether future undertakings will affect historic properties at LLNL.

³ Paul McGuff, "Lawrence Livermore National Laboratory World War II and Later Historic Context and National Register Assessment: Scope of Work" (Livermore: Lawrence Livermore National Laboratory, 2002), 1.

This context statement is not a comprehensive history of LLNL. Rather, it is an articulation of the context within which LLNL's built environment should be understood and evaluated. Specifically, it outlines the Local, WWII, Cold War, and Post-Cold War historic contexts for evaluating properties at LLNL for eligibility for the National Register. It includes a focused study of LLNL's built environment and how it represents larger historical trends at the local, national, and international level.

1.1 Organization

The report is organized into nine sections. The first section includes an introduction, review of the NHPA criteria and process, and a brief overview of the historic contexts relevant to the assessment of LLNL properties. The next four sections (2–5) explicate the four relevant historic contexts: Local History (Section 2), WWII History (Section 3), Cold War History (Section 4), and Post-Cold War History (Section 5). Section 6 delineates LLNL history and establishes relevant historic



Figure 1. LLNL main site, aerial view, 2002.⁴

⁴ LLNL aerial, LLNL Technical Information Department (TID), 2002.

preservation themes. Section 7 discusses the facilities at LLNL and defines building types and thresholds for historic integrity. Section 8 is the conclusion of the context statement. The assessments of buildings and objects of potential interest are provided in Section 9, with recommendations of eligibility for the National Register. Acronyms used in

the report are listed in Section 10, and the bibliography is Section 11.

1.2 Methodology

The following standard historical methodologies were used in compiling this context statement.



Figure 2. Site 300, aerial view, 2004.⁵

⁵ Site 300 aerial, TID, 2004.

1.2.1 Building Tours

The authors of this report received an initial four-day tour of LLNL, including the main campus in Livermore and Site 300 near Tracy. The tour focused on the external features of LLNL buildings and identification of the various building types used. Also apparent were the different styles and periods of construction.

The authors also conducted four additional week-long research trips and received more extensive building tours of properties identified as of potential historic interest. More extensive building tours included an examination of the interior, including any significant equipment or objects.

1.2.2 Documentary Research

The authors conducted an extensive review of both published and manuscript primary sources pertaining to the construction history of buildings at LLNL and the more general history of the institution. Published scientific literature on the various programs at LLNL proved particularly useful, as did documentary collections in the LLNL Archives, LLNL Reports Library, LLNL Plant Engineering Library, and the Lawrence Berkeley National Laboratory (LBNL) Archives.

The architectural drawings and floor plans of LLNL buildings provided important information regarding construction history, building materials, architects and engineers, and the different activities that took place in the buildings over the years. Original research reports, photographs, facility manuals, safety reviews, equipment manuals, incident reports, and design proposals offered additional information regarding

the types of activities undertaken in LLNL buildings.

The authors also used primary documents to reconstruct the association between programs and individual buildings at LLNL. Annual reports, development plans, memoranda from the Director's Office Administrative Files, informal historical overviews of LLNL, and articles from the various LLNL in-house publications were particularly useful for this purpose.

1.2.3 Secondary Literature Review

To supplement the primary research, the authors conducted a search of the relevant history of science, secondary literature on nuclear weapons development, and nuclear research. A literature review of the Local, WWII, and Cold War historiography helped determine the relevant historical contexts to assist in the evaluation of LLNL buildings.

1.3 NHPA Compliance

The NHPA of 1966 (as amended) provides for the protection and the preservation of historic properties significant to the U.S. national heritage.⁶ As a federal agency, DOE is obligated under the NHPA to consider the effects of its activities on historic properties. To comply with this requirement, the agency must determine if any of its properties are eligible for the National Register and document or manage them appropriately.

To fulfill its responsibilities under the NHPA, a Programmatic Agreement was developed among the DOE/NNSA, the

⁶ For more information on the NHPA, see *National Historic Preservation Act, U.S. Code*, vol. 16, sec. 470 (1966), as amended; and Advisory Council on Historic Preservation, *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities* (Washington, D.C.: Government Printing Office (GPO), 1991).

Advisory Council on Historic Preservation (ACHP), the California SHPO, and LLNL. The Programmatic Agreement is designed to work as a guideline for NNSA to achieve compliance with Section 106 of the NHPA for all present and future actions until management plans are completed and this interim Programmatic Agreement is superseded by an agreement to implement the plans. The Programmatic Agreement was fully signed on July 11, 2003. Provisions of the Programmatic Agreement would serve as components of mitigation measures, should they be required.

1.3.1 Section 106

Section 106 of the NHPA obligates any agency licensing or using federal money for any undertaking (renovations, new construction, or demolition) to consider ways to reduce or eliminate negative impact to a historic property. If the property is determined to be eligible for the National Register, the agency must take into account the effects of the undertaking. Possible mitigation alternatives include but are not limited to preservation of the structure in place or documentation of the structure by the standards of the Historic American Building Survey/Historic American Engineering Record (HABS/HAER).

1.3.2 Section 110

Section 110 of the NHPA requires agencies in possession of potential historic properties to develop a preservation program for the identification, evaluation, nomination, and protection of historic properties. Section 110 emphasizes a comprehensive approach to the preservation effort.

This report is part of DOE's efforts to establish a comprehensive historic preservation program at LLNL to assist in the identification, evaluation, and nomination of historic properties for the National Register. The creation of a historic context statement for LLNL is a first step in the identification process required for NHPA compliance.

1.3.3 NHPA Criteria

Properties are considered eligible for the National Register if they meet one or more of the following criteria, meet any applicable consideration, and retain integrity. Integrity is the ability of a property to convey its historic significance now.

- **Criterion A:** A property is associated with events that have made a significant contribution to the broad patterns of our history.
- **Criterion B:** A property is associated with the lives of persons significant in our past.
- **Criterion C:** A property embodies the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction.
- **Criterion D:** The property yields, or may be likely to yield, important information in prehistory or history.⁷

⁷ U.S. Department of the Interior, National Park Service, Interagency Resource Division, *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation* (Washington, D.C.: GPO, 1991).

1.3.4 Criteria Consideration G

The criteria for evaluation of potential historic properties also include seven characteristics that automatically disqualify buildings and structures from eligibility to the National Register.⁸

Among these disqualifying characteristics is youth. Fifty years is generally considered the least amount of time to gain perspective on a building's historical significance. Thus, buildings and structures less than fifty years of age are generally not considered eligible for the National Register.

However, under Criteria Consideration G, properties under fifty years of age can be considered eligible for the National Register if it can be demonstrated that they are of exceptional significance. Thus, although the majority of structures at LLNL would normally be excluded from eligibility for the National Register because they are less than fifty years of age, they may be found eligible if they demonstrate exceptional historical significance.

1.3.5 Period of Historic Significance

A property is rarely found to be significant for its entire history. The association of historic events with the property is considered finite. As part of the assessment and determination of eligibility, the period of historic significance must be defined, identifying the "span of time during which significant events and activities occurred."⁹

⁸ For a full list of the characteristics that automatically disqualify buildings from eligibility to the National Register, see *ibid.*, 2.

⁹ U.S. Department of the Interior, National Park Service, Interagency Resources Division, *National Register Bulletin 39: Researching a Historic Property* (Washington, D.C.: GPO, 1995).

1.4 Historical Context

To determine if properties are eligible for the National Register under any of the above criteria, it is first necessary to identify the local, state, national, and/or international historic contexts that might give a property significance.¹⁰ In other words, it is necessary to determine which broader historical events, themes, or trends give a property meaning and importance.

LLNL has four potential contexts that may be represented in its physical structures: Local history, WWII history, Cold War history, and Post-Cold War history. The first context pertains to regional events and trends that may be represented by LLNL properties. The other three contexts frame both national and international events and trends that may be represented in the built environment of LLNL.

1.4.1 Local Context

Local context refers to the events or trends of a town, state, or region in the United States that may give a property historic significance.

The land that LLNL is built upon, as well as the structures and buildings at the site, represent the events and history of both the town of Livermore and the state of California.

The Livermore-Amador Valley where LLNL is situated has had a long and varied history, including Spanish exploration and settlement, U.S. annexation and statehood, mining, early industry, and ranching. However, most traces of these early events have

¹⁰ U.S. Department of the Interior, *National Register Bulletin 15*, 9.

vanished from the area in general and there are no apparent traces on land currently occupied by LLNL. Any remnants of this long-ago past are properly recorded by the methods of archaeology.¹¹

As a physical entity, the LLNL main site had its beginnings as a U.S. Naval Air Station (NAS) during WWII. In 1950, Ernest O. Lawrence, the director of the University of California Radiation Laboratory (UCRL), in collaboration with California Research and Development Corporation (CR&D), a subsidiary of Standard Oil Company, acquired buildings at NAS Livermore for a research project sponsored by the Atomic Energy Commission (AEC). CR&D established Livermore Research Laboratory at NAS Livermore and built an accelerator, the Material Test Accelerator (MTA), designed to produce fissionable materials.

In 1952, Lawrence and Edward Teller, a physicist from the Manhattan Project, convinced the AEC to establish a second nuclear weapons laboratory at NAS Livermore to assist Los Alamos National Laboratory (LANL) with the development of thermonuclear weapons.¹² The AEC agreed, in part because UCRL and CR&D already had an established project located there. In 1954,

the AEC cancelled its contract with CR&D. The newly established LLNL took over CR&D's remaining equipment and facilities.

As LLNL grew, so too did the town of Livermore. In 1952, when E. O. Lawrence first established LLNL, Livermore was a quiet agricultural town with a population of only 4,000. The main economic activity in the region for over 100 years had been the production of "wine, flowers, and cattle."¹³ By 1960, the staff of LLNL alone had increased to 4,248 people and the population of Livermore had grown to 16,058.¹⁴

Today, LLNL employs over 8,000 people and has a budget of approximately \$950 million.¹⁵ The city of Livermore is home to some 75,735 residents and has a diversified economic base that includes agriculture, science, and technology.¹⁶ LLNL has been actively involved in the growth and development of the Livermore economy and community during the twentieth century.

In addition to its role in local history, LLNL also reflects the post-WWII growth and transformation of the western United States. After WWII, many western states expanded dramatically as a result of increased federal spending on defense-related activities.

¹¹ For an archaeological assessment of LLNL property, see Colin Busby, D. Garaventa, and L. Kobori, *A Cultural Resource Inventory of Lawrence Livermore National Laboratory's Site 300, Alameda and San Joaquin Counties, California* (Turlock: California Archeological Inventory, Central California Information Center, Stanislaus State University, 1981); and William Self Associates, *Documentation and Assessment of the History of Lawrence Livermore National Laboratory Livermore Facility, and Site Ca-SJO-173H, the Carnegie Town Site at Lawrence Livermore National Laboratory Site 300, Alameda and San Joaquin Counties, California* (Livermore: Lawrence Livermore National Laboratory, 1992).

¹² Los Alamos National Laboratory (LANL) will be referred to throughout this report by its current name. Like LLNL, it went through several name changes. Originally LANL went by the name Los Alamos Scientific Laboratory. It also became a national laboratory in 1979.

¹³ Unpublished history of Livermore's beginnings, 1967, Lawrence Livermore National Laboratory Archives, Livermore, California, 4 (hereafter cited as LLNL Archives).

¹⁴ Figures on population and personnel are from University of California, Lawrence Livermore Laboratory, *Status Report: Fiscal Years 1960 and 1961* (Berkeley: University of California, 1961), 113; and Rebecca Ullrich, *Cold War Context Statement: Sandia National Laboratories California Site*, SAND2003-0112 (Albuquerque: Sandia National Laboratories, 2003), 11.

¹⁵ "Brief History of Lawrence Livermore National Laboratory: The Beginnings," LLNL website, www.llnl.gov, 1.

¹⁶ Marshall Kamena, "Greetings From the City of Livermore," *Livermore California* (Livermore: Livermore Chamber of Commerce, 2002), 8.

California received a substantial portion of these federal, military, and space contracts. In particular, LLNL reflects the post-war growth and development of California as a result of defense monies.¹⁷

LLNL as a whole is significant in the context of the growth and development of both Livermore and California. However, it is unlikely that any individual building or set of structures at LLNL represents the Laboratory's impact on either local or state history. Nevertheless, a more detailed review of local history will be included in this report as a guide for the assessment of local significance in LLNL buildings.

1.4.2 WWII Context

WWII was both a national and international historic event of epic proportions. It engulfed all of Western and Eastern Europe as well as much of Asia. The United States joined the war on the side of the Allies in 1941 after the Japanese military attacked the American naval base at Pearl Harbor, Hawaii, on December 7.

Both the U.S. Army and Navy increased air patrols on the west coast to prevent any further attacks by the Japanese. A series of installations was constructed in the west to support naval training and operations. In 1942, the U.S. Navy built NAS Livermore in California to accommodate the high volume of air traffic in the San Francisco area and ease the crowded conditions at the Oakland airfield.¹⁸ During WWII, the navy first trained pilots at NAS Livermore and then

supported Pacific operations. At the war's end, the facility was decommissioned.

LLNL still retains several NAS Livermore buildings, including: a hangar, barracks, field house, training classrooms, and store-rooms. These buildings require a historic assessment.

The role that NAS Livermore played during WWII was clearly limited to the training of naval pilots and the support that naval air stations, in particular NAS Livermore, gave to the U.S. war effort. WWII buildings at LLNL would be deemed historically significant only to the extent they still represent this specific WWII legacy.

1.4.3 Cold War Context

The primary historic context for assessing the significance of LLNL buildings is the Cold War. The Cold War, although still a fairly recent event in U.S. history, has been universally recognized both by professional historians and cultural resource professionals as an event of exceptional significance within the nation's history.¹⁹

The Cold War spanned the forty-six years from 1945 to 1991 and encompassed a series of events, policy decisions, and conflicts between the United States and the Soviet Union over the economic and political orientation of various countries in Europe, Asia, and the Middle East. In essence, the United States and the Soviet Union had

¹⁷ Gerald Nash, *The American West Transformed: The Impact of the Second World War* (Lincoln: The University of Nebraska Press, 1985); and Ullrich, *Cold War Context Statement*, 11.

¹⁸ Steve Wofford, "Livermore Naval Air Station History," unpublished manuscript, LLNL Archives, 1.

¹⁹ U.S. Department of Defense, *Coming in from the Cold: Military Heritage in the Cold War: Report on the Department of Defense Legacy Cold War Project* (Washington, D.C.: Department of Defense, 1994); Rebecca Ullrich, *Sandia In the Cold War: A Statement of Historic Context for Sandia National Laboratories/New Mexico*, draft (Albuquerque: Sandia National Laboratories, 2000); and Kris C. Mitchell, *Rhetoric to Reality: A Cold War Context Statement for the Pantex Plant, 1951–1991*, draft (Amarillo: U.S. Department of Energy, Pantex Plant, 2001).

incompatible and conflicting visions for the fate of the post-war world. The United States was wedded to a world that closely mirrored its capitalist and democratic economic and political structure, while the Soviet Union hoped for a world that resembled its communist political and economic structure.²⁰

The Cold War dominated almost every aspect of American life—diplomatic, military, social, economic, scientific, and political. Nevertheless, for the purposes of this report, only two aspects of Cold War history are relevant—the history of the arms race and the more general history of nuclear science.

LLNL was established as a direct response to U.S. policy makers' Cold War concern over the 1949 Soviet detonation of its first nuclear weapon. In 1952, the AEC designated LLNL as a second nuclear weapons design laboratory. LLNL's original mission was to develop a deliverable thermonuclear weapon and to support LANL nuclear weapons design and testing programs. As LLNL's mission evolved, it also incorporated more general scientific nuclear research as part of the U.S. push to maintain scientific, nuclear, and technological superiority over the Soviet Union. Most of the buildings at LLNL were built during this time frame.

²⁰ The literature on the Cold War is immense. Some good general studies include Walter LaFeber, *America, Russia, and the Cold War, 1945–1985* (New York: Alfred A. Knopf, 1985); Martin McCauley, *Russia, America, and the Cold War* (New York: Longman, 1998); and Charles Morris, *Iron Destinies, Lost Opportunities: A History of the Arms Race Between the U.S. and the USSR, 1945–1987* (New York: Harper and Row, 1988). Studies exploring the relationship between Cold War policy and the nuclear arms race include Gregg Herken, *Counsels of War* (New York: Alfred A. Knopf, 1985); and Scott D. Sagan, *Moving Targets: Nuclear Strategy and National Security* (Princeton: Princeton University Press, 1989).

LLNL's origins and mission place it within the context of the Cold War and, more specifically, within the context of the nuclear arms race and the technological and scientific advance of nuclear science.

Buildings at LLNL will be found historically significant to the extent that they reflect these specific Cold War legacies.

1.4.4 Post-Cold War Context

With the end of the Cold War and the cessation of nuclear testing, LLNL's mission emphasis evolved, from weapons development to nuclear science research, stockpile surveillance and safety, non-proliferation, and other scientific and technological aspects of national security.

Assessing the historical significance of LLNL's properties in the post-Cold War context is difficult. The post-Cold War period, from 1991 to the present, is very recent history. The events of recent years have barely begun to form a coherent historical narrative, and the significance of particular developments is difficult to discern. Nevertheless, an attempt to identify possible themes of historic significance will be explored. It is likely that LLNL's current role in stockpile surveillance and non-proliferation will be seen as noteworthy in the future.

1.5 Preservation Themes

Within the broad patterns of historic context are more narrow themes that specifically apply to the LLNL district, building, or structure that is being assessed.

Local (Livermore and California), WWII, Cold War, and Post-Cold War history are the most relevant historic contexts to frame the historic assessment of LLNL's properties.

Within each broad historic context the following themes represent LLNL's potential contribution and/or relationship to these larger events:

Local History

- Ranching
- Viticulture
- Early industrial development

WWII History

- Naval pilot training
- NAS support of the U.S. war effort

Cold War History

- Nuclear Weapons Design
 - *Weapons Design*
 - *Computing*
- Nuclear Weapons Testing
 - *Nuclear Testing*
 - *High Explosives Testing*
- Nuclear Research
 - *Nuclear Physics Research*
 - *Nuclear Chemistry Research*
 - *Nuclear Materials Research*
- Non-weapons Research
 - *Nuclear Energy Research*
 - *Nuclear Propulsion Research*
 - *Plowshare*
 - *Biomedical Research*

Post-Cold War Themes

- Nuclear Weapons Design
 - *Computing*
- Nuclear Weapons Testing
 - *High Explosives Testing*
- Nuclear Research
 - *Nuclear Physics Research*
 - *Nuclear Chemistry Research*
 - *Nuclear Materials Research*

- Non-weapons Research
 - *Nuclear Energy Research*
 - *Nuclear Propulsion Research*
 - *Biomedical Research*

1.6 Integrity

To be eligible for the National Register a building or structure must possess not only historic significance within a recognized context and theme during an identified period but also integrity from that period.²¹ Integrity is the ability of a property to convey its significance. The National Register criteria recognize seven qualities or aspects that, in various combinations, define integrity in a building. To retain its historic integrity a property will possess the majority of the following aspects: location, design, setting, materials, workmanship, feeling, and association from its period of historical significance.

- **Location**—the place where a property was constructed or an event occurred
- **Design**—the combination of elements that create the form, plan, space, structure, and style of a property. Design reflects historic functions, technologies, and aesthetics
- **Setting**—the physical environment of a historic property
- **Materials**—the physical elements that were combined or deposited during a particular period of time and in a particular pattern or configuration to form a historic property
- **Workmanship**—the physical evidence of the crafts of a particular culture or

²¹ The following discussion on integrity is taken from U.S. Department of the Interior, *National Register Bulletin* 39, 46.

people during a given period of history or prehistory

- **Feeling**—a property's expression of the aesthetic or historic sense of a particular time period
- **Association**—the direct link between an important historic event or person and a historic property

Determining which combination of these aspects needs to be present for a building to have integrity depends on the particular criterion under which the building's historic significance was established.

1.6.1 Thresholds for Integrity under Criterion A or B

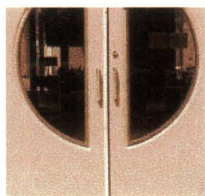
A property eligible for historic significance under Criterion A or B—association with a person or event—must possess some features of all seven aspects of integrity. However, integrity of design and workmanship is not as critical as the others. A good overall test of integrity under Criterion A or B is whether a historical contemporary from the period of its significance would recognize the building as it exists today.

1.6.2 Thresholds for Integrity under Criterion C

A property eligible for consideration under Criterion C—distinctive design or construction—must retain those physical features that reflect its time period and method of design and construction. The aspects of integrity most important for Criterion C are design, workmanship, and materials. Location and setting will also be important if the property's design is a reflection of the surrounding environment.

1.6.3 Thresholds for Integrity under Criterion D

A property eligible for consideration under Criterion D—information potential—must possess the aspects of location, design, materials, and workmanship from its period of significance. The aspects of setting and feeling will not be as important in assessing integrity under this criterion.



2. LOCAL CONTEXT

Local context refers to the specific history of a city, town, state, or region in relation to a potential historic structure, building, or district. In the case of LLNL, local context would include the history of the town of Livermore, the history of the state of California, and the history of the western United States.

Because LLNL is a national laboratory and most closely associated with the events of the Cold War, the local historical context plays a negligible role in assessing individual structures. Nevertheless, the following early history of Livermore is provided as background information and in the event that local trends, themes, or events are evidenced in the built environment of LLNL.

2.1 Early Livermore

Pre-historic evidence indicates that hunter-gatherers from the Hokan language group inhabited the Central Valley of California in the earliest days. Scholars have speculated that, between 3000 and 5000 B.C., people

of the Penutian language group usurped these hunter-gatherers and established a more specialized economy based on the rich natural resources of the area.²²

In the 1770s, when the Spanish first traveled through the Livermore-Amador Valley, the descendants of the Penutian people, the Costaños and the Yokut, inhabited the San Francisco Bay/Monterey Bay areas and the Central Valley.²³ *Constaños* was a native term that meant coast dweller. The Spanish used the term *Costanoan*.

2.2 Spanish Colonization

From 1769 to 1821, Spain worked to colonize and settle California.²⁴ Spanish colonization

²² U.S. DOE and University of California, *Final Environmental Impact Statement/Environmental Impact Report for Continued Operation, Including Near-Term Proposed Projects, of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore*, Vol. III, DOE/EIS-0157 (Livermore: Lawrence Livermore National Laboratory and Sandia National Laboratories, 1992), H-9.

²³ Ibid.

²⁴ The following information on Spanish colonization and the establishment of the missions is from James J. Rawls and Walton Bean, *California: An Interpretive History*, 7th ed. (New York: McGraw-Hill, 1998), 26-42.

efforts used three institutions: missions, pueblos, and presidios.

The primary institution of colonization was the mission. Missions, operated by Franciscan priests, provided religious instruction in Catholicism to California Native peoples and taught them how to raise crops and cattle in the Spanish manner. Spanish soldiers built presidios, or military outposts, near the missions to provide protection to the Franciscans and their converts. Spain provided free land and farming supplies to settlers willing to establish pueblos—small towns—to provision the presidios.

Between 1769 and 1782, Junípero Serra, a Franciscan priest, founded the first nine missions along the California coastline. From 1786 to 1798, Serra's successor, Fermín Francisco de Lasuén, continued that legacy, building an additional nine missions.

The Livermore region held little appeal for the Spanish. The nearby San José mission used the Livermore Valley to graze livestock, and travelers passed through using the route along the present-day Corral Hollow Road (near LLNL's Site 300), which was known as "El Camino Viejo." However, the Livermore area remained virtually uninhabited during the Spanish period except for small villages of Indians that worked the mission herds.²⁵

2.3 Mexican Period

In 1821, the Spanish colonies in America won their independence from Spain. As a result, California became a province of Mexico. In 1834, the Mexican government decreed the secularization of the missions.

In theory, secularization called for the replacement of the Franciscans with a secular clergy and the redistribution of mission land to the converted Indians, or neophytes. In practice the Mexican government sold much, if not all, of the land to wealthy Californios—second- and third-generation Spanish colonists, who became Mexican citizens.²⁶

Unlike Spain, Mexico welcomed foreign traders and settlers. After 1821, U.S. citizens began to establish trade relationships with California merchants. They also purchased large land grants (formerly mission land) from the Mexican government and began to settle in California in larger numbers. This influx of U.S. and other foreign immigrants eventually led to clashes with the Mexican government and growing sentiment in the United States for the annexation of California.

In the 1830s, shortly after Mexican independence, people began to settle in the Livermore area. In 1834, José María Amador bought a large land grant, the San Ramon, from the Mexican government and made his home there. In 1835, two brothers, Juan Pablo and Augustin Bernal, and their brothers-in-law, Antonio Sunol and Antonio Pico, purchased the Valle de San Jose land grant. That same year Robert Livermore and José Noriego acquired the Las Positas land grant, and José Pacheco acquired the Santa Rita land grant from Mexico. These four land grants comprised the majority of the land in what would be called the Livermore-Amador Valley.²⁷

²⁵ Merilyn Calhoun, *Early Days in the Livermore-Amador Valley* (Hayward, Calif.: Alameda County School Department, 1973), 19–20; and *Final Environmental Statement/Environmental Impact Report*, H-17.

²⁶ All information on California during the Mexican period is from Rawls and Bean, *California*, 54–64.

²⁷ Calhoun, *Early Days in the Livermore-Amador Valley*, 18–20; and G. B. Drummond, *William Mendenhall: The Story of the Founder of the Town of Livermore, California* (Livermore: Livermore Heritage Guild, 1996), 5.

The Livermore rancheros, as the owners of these Mexican land grants were called, raised cattle for a living. Ranchos often had 1,000 head of cattle or more. The rancheros used mission Indians as servants and cowhands. Cattle provided meat, hides, and tallow that Californios sold to the foreign merchants plying the waters of the Pacific coastline.

2.4 The Mexican-American War

In 1846, the United States declared war on Mexico as the result of increasing tensions between the two nations over territorial issues. At the end of the two-year conflict, the United States received huge tracts of Mexican land, including the future states of New Mexico, Arizona, Colorado, Nevada, Utah, Wyoming, and California.²⁸

After the Mexican-American War, settlers continued to arrive in the newly acquired U.S. territory. In 1848, thousands of people from all around the world joined the steady trickle of migrants to California when gold was discovered at Sutter's Mill in the northern part of the state. The Gold Rush, which began in earnest in 1849, transformed California, doubling and then tripling the population almost overnight. California became a state in 1850.²⁹

The path to the goldfields led through the Mission San José and the Livermore-Amador Valley. Many potential prospectors stopped to rest at the ranchos of Robert Livermore and José Amador. Some travelers decided to abandon the search for gold and instead settle in the Livermore-

Amador Valley, where they could make a living providing supplies and services to the miners passing through. Other early pioneers discovered the Livermore-Amador Valley to be a rich area for raising crops and livestock.³⁰

Many towns in the region date from this period. In 1852, Michael Murray and Jeremiah Fallon, two Irish immigrants on their way to the goldfields, abandoned their plans and purchased land from José Amador. Originally called Amador, the settlement was eventually renamed Dublin to reflect the Irish heritage of many of its early inhabitants.³¹ During the 1850s and 1860s, settlers established many other small towns in the Livermore-Amador Valley, including Pleasanton, Sunol, and Laddsville.³²

2.5 Mining

Although the Gold Rush bypassed the Livermore area, in 1855, some intrepid miners discovered coal in Corral Hollow, an area just fourteen miles southeast of Livermore. The first coal mine, the Pacific, began operation the following year. In 1862, miners discovered additional coal deposits in the Arroyo Seco Canyon just west of Corral Hollow. From 1862 to 1907, eight mining companies worked the region and produced over 8,500 tons of coal.³³

³⁰ Calhoun, *Early Days in the Livermore-Amador Valley*, 26–27; and Olive Townsend, *Livermore Long Ago* (Livermore: Livermore School District, 1961), 15–19.

³¹ Virginia Bennett, *Dublin Reflections and Bits of Valley History* (Dublin, Calif.: Dublin Friends of the Library, 1978); and "History of Dublin," website, www.ci.Dublin.ca.us.

³² Dorothy Davis, ed., *A Pictorial History of Pleasanton* (Pleasanton, Calif.: Pleasanton Bicentennial Heritage Committee, 1976), 6–8; and Calhoun, *Early Days in the Livermore-Amador Valley*, 31–32.

³³ For more detailed information on mining in the Livermore-Amador Valley, see Dan L. Mosier, *Harrisville and the Livermore Coal Mines* (San Leandro, Calif.: Mines Road Books, 1978).

²⁸ For more information on the Mexican War, see Rawls and Bean, *California*, 85–89.

²⁹ *Ibid.*, 91–98.

During the height of the coal boom, two company towns with thriving populations existed in the Livermore-Amador Valley. Harrisville was established in 1875, followed by Tesla in 1890. The mines of the Corral Hollow and Arroyo Seco produced a coal suitable for many industrial uses. The Livermore mines, like many mines of the era, were plagued by cycles of boom and bust. Tesla, the last of the region's mines, closed in 1911.³⁴ The Livermore coal mining districts are shown in figure 3.

2.6 The Town of Livermore

The arrival of the Central Pacific Railroad to the Livermore Valley in 1869 prompted William Mendenhall, a California rancher, to found the present-day town of Livermore.

Mendenhall arrived in California in 1845. In 1846, he participated in the Bear Flag Revolt,

a rebellion of American settlers pushing for U.S. annexation of California during the Mexican-American War. After the war, Mendenhall traveled throughout northern California and Oregon, trying his hand at mining and ranching. In 1862, he finally settled in the hills near Livermore and began raising livestock. He eventually purchased part of the old Juan Pablo Bernal land grant and a portion of the Rancho Santa Rita land grant. In 1866, Mendenhall helped build the first Livermore Valley schoolhouse.

In 1869, Mendenhall donated twenty acres of his land to establish a depot for the Central Pacific Railroad. The depot and the town of Livermore quickly emerged as a shipping port for the agricultural products of the Livermore-Amador Valley.³⁵

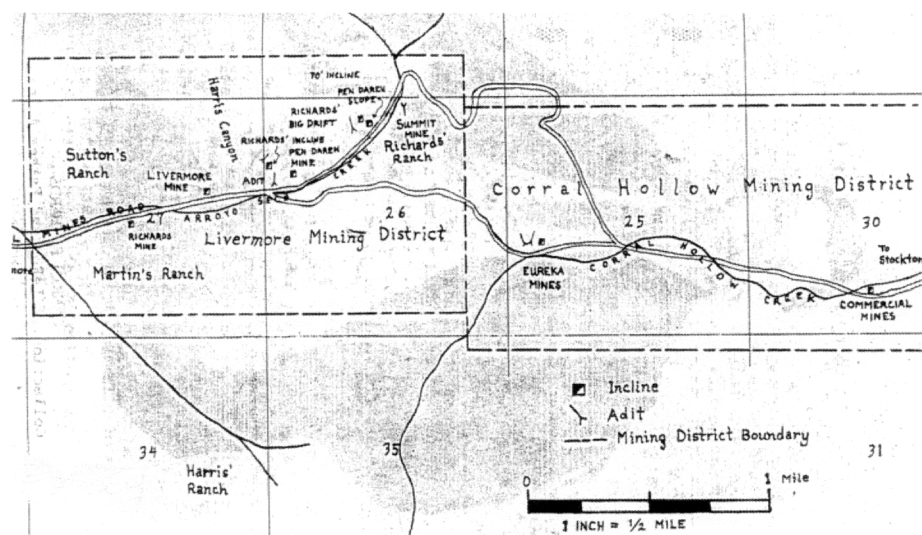


Figure 3. Livermore and Tesla coal mining districts, 19th century. Map used by permission of Mines Road Books.³⁶

³⁴ Dan L. Mosier and Earle E. Williams, *History of Tesla: A California Coal Mining Town* (Fremont, Calif.: Mines Road Books, 2002), 305

³⁵ Drummond, William M. Mendenhall, 1-7.

³⁶ Mosier, *Harrisville and the Livermore Coal Mines*, 9.

2.7 Agriculture

Cattle ranching continued to be the prime economic activity in the Livermore-Amador Valley even after California became a U.S. territory. The Gold Rush increased the demand for beef. New settlers to the region, like the *rancheros* before them, made their living raising cattle. Fallon and Murray, the Irish settlers of Dublin, introduced sheep herding to the region. Other early settlers began to raise horses for both riding and drafting.

In 1856, Robert Livermore's son Joseph planted the first commercial wheat crop. The next year other settlers followed suit; by the 1870s, wheat and other agricultural crops had surpassed cattle as the primary products of the Livermore-Amador Valley. The arrival of the railroad in 1869 further facilitated farming in the Livermore-Amador Valley. Many agricultural products—including fruit, vegetables, olives, nuts, hops, sugar beets, and dairy products—could be shipped to far-away markets. Farming remained a central occupation in the Livermore area until the 1950s.³⁷

2.7.1 Viticulture

Robert Livermore planted the first grape vines in the Livermore-Amador Valley as early as the 1840s. Nevertheless, viticulture did not take hold in the area until French settlers established the first commercial vineyards in the 1870s. In 1880, Charles Whetmore established the Cresta Blanca Winery. In 1883, two immigrants, Carl Wentz from Germany and James Concannon

from Ireland, came to the region and established what would become world-famous wineries. By 1885, over 4,000 acres of land in the Livermore-Amador Valley were planted in grapevines. Wine continues to be a predominant agricultural staple in the area to this day.³⁸

2.8 Industry

In the 1890s, an abundant supply of clay in the region began to attract the ceramic industry. Several towns developed around these brick, pottery, and tile works. One of the first company ceramic towns, aptly named Pottery, was established in 1892 in the region known as Corral Hollow, southwest of LLNL's Site 300. The success of Pottery enticed other ceramics businesses to open plants in Livermore.

In 1895, the Carnegie Brick and Pottery Company joined the fledgling ceramics industry in Corral Hollow. A small town (located on present-day Site 300) surrounded the brick works. The town, known as Carnegie, consisted of the homes for company supervisors, a schoolhouse, stores, and a water supply. Most of the workers at the Carnegie plant lived south of Corral Hollow Road in hotels and boardinghouses (outside LLNL property). The Carnegie plant operated forty-five kilns and supported a thriving community of approximately 3,500 people.³⁹ The Carnegie factory and surrounding buildings are shown in figure 4.

³⁷ Calhoun, *Early Days in the Livermore-Amador Valley*, 48–53.

³⁸ *Ibid.*, 50–51.

³⁹ William Self Associates, *Documentation and Assessment of the History of the Lawrence Livermore National Laboratory Livermore Facility*, 44.

2. LOCAL CONTEXT

In 1916, the Gladding McBean Pottery Company, a competing firm, bought and demolished the Carnegie Brick and Pottery Company. A year later, the buildings of the Carnegie community lay abandoned and ruined.⁴⁰

The residences of the Carnegie town that existed within the boundaries of what is now LLNL Site 300 no longer exist. It is thought that when the Gladding McBean Pottery Company demolished the Carnegie factory they may also have destroyed all the surrounding residences.⁴¹

Despite the demise of Carnegie, Livermore sustained continued modest industrial growth. For example, in 1914, the Coast Manufacturing & Supply Company moved its safety fuse works from Oakland, where it had been located since 1867, to Livermore in order to obtain larger facilities.⁴²

A 1927 Livermore Chamber of Commerce brochure boasted the Kaiser Paving Company, Livermore Cheese Company, W. S. Dickey Clay Manufacturing Company, Pacific Gas and Electric, and the Livermore Oil Company.

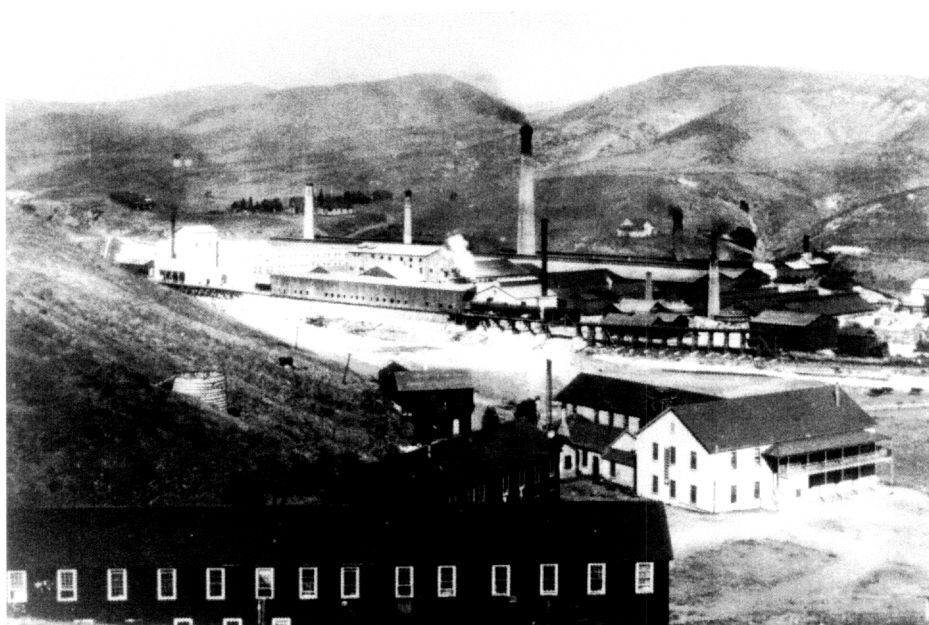


Figure 4. Carnegie Brick and Pottery Company brickworks, 1890s.⁴³

⁴⁰ Mosier and Williams, *History of Tesla*, 308.

⁴¹ A previous historical assessment of the Carnegie Town Site within the boundaries of LLNL Site 300 has determined that the archeological remnants of the buildings may be eligible, along with the larger Carnegie Brick and Pottery Company and surrounding community (outside of the boundaries of LLNL), for National Register status. For more information regarding this assessment, see William Self Associates, *Documentation and Assessment of the History of the Lawrence Livermore National Laboratory Livermore Facility*.

⁴² "Livermore California: Between the Sea and the San Joaquin," replica Chamber of Commerce brochure, circa 1927, Livermore Heritage Guild, Livermore, California.

⁴³ Carnegie factory, LLNL Archives.

2.9 LLNL Local Context

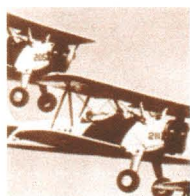
The land that LLNL is situated on has a long local history that includes early California Indian habitation, Spanish exploration and conquest, Mexican occupation, U.S. annexation and statehood, mining, agriculture, and early industry.

For a building, structure, or district to be of historic interest within the local context of either Livermore or California history, it must specifically reflect the areas and the time periods of local history discussed above.

For the most part, buildings and structures at LLNL were not built until WWII and after. The exception is the remnants of the Carnegie community that exist within the boundaries of LLNL's Site 300. An earlier historical assessment of this area suggested that this site may be eligible for the National Register under Criterion A, association with

an important event or pattern of events and/or Criterion D, a property that has yielded or has the potential to yield in the future important information about history or prehistory. The Carnegie community may be of interest within the regional context of the industrial boom in Corral Hollow between the years 1890 and 1912.

The earlier historical assessment of the remains of the Carnegie community that lie within the boundaries of LLNL also noted that any further assessment for National Register eligibility should be conducted with the California SHPO and also include those parts of the Carnegie community outside the LLNL property boundaries. Further assessment of the Carnegie community requires archaeological expertise and is, therefore, outside the scope of this project. DOE/NNSA and LLNL expect to do this work in the near future.



3. WWII CONTEXT

WWII embroiled the nations of Europe, Asia, and America in one of the bloodiest conflicts in history. The United States entered WWII on December 8, 1941—the day after Japanese bombers attacked the U.S. naval base at Pearl Harbor, Hawaii, destroying much of the Pacific fleet.

The United States committed ground troops, naval ships, and air units to both the Atlantic and Pacific theaters. LLNL was originally built as one of many U.S. NAS sites in support of the naval war effort.

Nevertheless, NAS Livermore's contribution to WWII was a limited one, consisting of training naval aviators and providing limited support, in the form of respite for naval carrier pilots, to the larger U.S. war effort.

Many of LLNL's original buildings date from WWII and are still in use as offices, storage facilities, or shops. These structures

will require an historical assessment. WWII buildings at LLNL will be deemed historically significant within the WWII context to the extent they still represent the specific WWII legacy mentioned above.

3.1 NAS Livermore

On January 23, 1942, less than two months after the attack at Pearl Harbor, the navy informed W. Gatzmer Wagoner, a rancher in Livermore, that it was appropriating 629.28 acres of his property for use as a U.S. Naval Reserve Air Corps Training Field.⁴⁴ The Wagoner land was located approximately three miles from the town of Livermore, with East Avenue as its southern boundary and Greenville Road as its eastern boundary. A picture of Wagoner field in use as the NAS Livermore airfield is depicted in figure 5.

Federal law permitted the Secretary of War to initiate condemnation proceedings

⁴⁴ This and subsequent information on NAS Livermore is from Wofford, "Livermore Naval Air Station History," 3.

and occupy private property in a national emergency. The U.S. Navy eventually negotiated and paid Wagoner \$75,260 for his land.

The navy appropriated an additional fifty acres of land south of East Avenue for a gunnery range and additional barracks from Louis Madsen, John and Dora Bargman, and Charles and Sue Nissen.⁴⁵ In addition to purchasing property, the navy also negotiated

the use of two 100-acre sites for additional landing fields from Wagoner and the Silva brothers who owned a neighboring ranch.

The Dinwiddie Construction Company broke ground for NAS Livermore on January 29, 1942. With the help of recruits from the Oakland Naval Reserve Air Base, the Dinwiddie Company completed construction in less than four months. NAS Livermore commenced operations in May 1942.

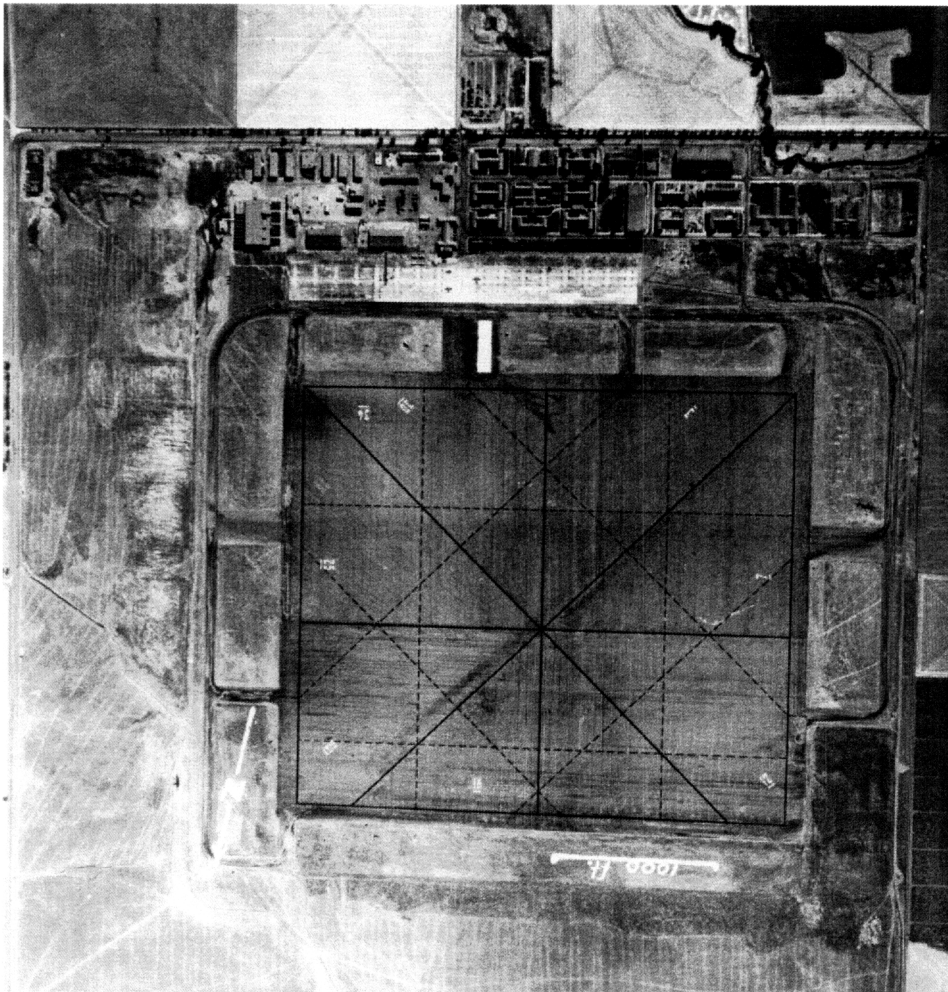


Figure 5. NAS Livermore airfield, 1943.⁴⁶

⁴⁵ The appropriation of the property owned by Louis Madsen, the Bargmans, and the Nissens was contested in court. The court ruled in favor of the U.S. Navy, and the plaintiffs were awarded \$4,325 as compensation for their land. Wofford, "Livermore Naval Air Station History," 7.

⁴⁶ WWII airfield at NAS Livermore, 1943, LLNL Archives.

Initial construction included three barracks, an administration building, a dispensary, bachelor officers quarters, a subsistence building, an auditorium, a recreation building, and an instruction center.

A second phase of construction added an operations and command building, a stores building, a garage and shop building, gas storage building, and a building for heat and water supply. Future plans allowed for an aircraft inspections hangar, three additional barracks, and an addition to the subsistence building. A comprehensive list of NAS Livermore buildings as they existed in 1949 is presented in figure 6.

NAS Livermore had two primary missions during WWII—training pilots and providing respite for operational units. During its first mission, from May 1942 until October 1944, NAS Livermore operated as a training base for naval aviators. As the need for trained pilots decreased toward the end of the war, naval training programs began to close. The training program at NAS Livermore closed in October of 1944. From October 1944 until the end of the war, NAS Livermore provided support and respite for operational units of the Twelfth Naval District. To a lesser extent during its second mission, NAS Livermore also operated as a testing base for navy equipment.

3.2 Naval Air Support for WWII

The U.S. Navy first successfully used air units in bombing campaigns during World War I (WWI).⁴⁷ Nevertheless, at the beginning

of WWII, the navy's air force was still in its infancy. The loss of naval air power in the attack at Pearl Harbor exacerbated the need for more aircraft carriers, airplanes, and trained pilots. When the United States entered WWII, the navy possessed only eight aircraft carriers; five patrol wings; two Marine aircraft wings; 5,233 aircraft; ten dirigibles; 5,900 officers; and 21,678 enlisted members. By war's end, these forces had grown to over 100 aircraft carriers; 40,900 aircraft; 168 airships; 60,095 pilots; and 370,760 support personnel.⁴⁸

To an unprecedented degree, naval air power figured prominently in the military strategies of both the Allies (the United States, Great Britain, France, and the Soviet Union) and the Axis (Germany, Italy, and Japan) powers, during WWII.

The battle for supremacy in the European theater involved the protection of merchant shipping and amphibious operations. In the Atlantic and the Mediterranean the Allies struggled to keep their shipping lanes open against constant attack from Axis submarines. The British and, increasingly, the U.S. navies used both land-based aircraft and airplanes launched from aircraft carriers to protect merchant vessels.⁴⁹

Aircraft carriers also provided air cover for amphibious landings in North Africa, Sicily, Salerno, and Normandy.⁵⁰

⁴⁷ For more information on naval aviators in WWI, see William Armstrong, "U.S. Naval Aviation Training, 1911–1922," in Naval Aviation News staff, eds., *Naval Aviation Training* (Washington, D.C.: GPO, 1985).

⁴⁸ Sandy Russell ed., *Naval Aviation 1911–1986: A Pictorial Study* (Washington, D.C.: GPO, 1986), 44.

⁴⁹ John M. Lindley, "Wings Over the Ocean: A History of Sea Aviation, Part Twelve," *Naval Aviation News* (July 1978).

⁵⁰ John M. Lindley, "Wings Over the Ocean: A History of Sea Aviation, Part Thirteen," *Naval Aviation News* (August 1978).

3. WWII CONTEXT

NAS 1949		LLNL 1984	
11	OPERATIONS		DEMOLISHED
12	CHECK BUILDING (1)		DEMOLISHED
13	ADMINISTRATION	415	SECURITY
14	POWER PLANT	401	STEAM PLANT
15	GARAGE	402	AUTOMOTIVE FLEET
16	BUS GARAGE	403	GARAGE
17	PUBLIC WORKS		DEMOLISHED
21	CHECK BUILDING (2)	412	BIOMEDICAL LAB
22	LINK TRAINERS		DEMOLISHED
23	FIREHOUSE		DEMOLISHED
25	PAINT AND ODOE SHOP	419	DECONTAMINATION
26	ASSEMBLY AND REPAIR BUILDING	511	CRAFT SHOPS
27	ENGINE TEST BUILDING	514	WASTE DISPOSAL
31	BARRACKS	315	TEAM RESEARCH - HUMAN RESOURCES
32	BARRACKS	314	ACCOUNTING
33	RECREATION BUILDING	310	HEALTH SERVICE & SOUTH PASS OFFICE
34	AUDITORIUM		BURNED DOWN AFTER 1944
35	SUBSTANCE BUILDING		DEMOLISHED
36	W O O ENLISTED WAVES QUARTERS	316	TEAM RESEARCH - CLASSIFIED MAIL
37	BARRACKS ENLISTED WAVES - EMPTY		DEMOLISHED - SANDIA PROPERTY
38	SCRUB BUILDING		DEMOLISHED
39	OPERATIONS (LINE SHELTER)		DEMOLISHED
41	BARRACKS		DEMOLISHED
42	BARRACKS		DEMOLISHED
43	INSTRUCTION BUILDING #1	319	COMP/ORG/CREDIT UNION/HUMAN RESOURCES
44	INSTRUCTION BUILDING #2	219	PAO/PHYSICS
45	SWIMMING POOL		SWIMMING POOL
46	CHIEF PETTY OFFICERS CLUB	213	PHYSICS
47	SCRUB BUILDING		DEMOLISHED
51	BARRACKS	217	BUDGET/DPS
52	BARRACKS	218	COMPUTATION
53	DRILL HALL	212	ACCELERATORS
54	J O O - EMPTY		DEMOLISHED
55	BARRACKS	216	COMPUTATION - DNA
61	DISPENSARY		DEMOLISHED
62	SENIOR OFFICERS QUARTERS		DEMOLISHED
63	WELL #1		CAPPED
64	WELL #2		CAPPED
65	GREENHOUSE		DEMOLISHED
222	SYNTHETIC TRAINING DEVICES		DEMOLISHED
241	SUPPLY AND STORES #1		DEMOLISHED
242	SUPPLY AND STORES #2		DEMOLISHED
243	SUPPLY AND STORES #3		DEMOLISHED
244	COLD STORAGE BUILDING	404	WAREHOUSE
245	SUPPLY AND STORES #4	405	WAREHOUSE
246	SUPPLY AND STORES #5	516	TEMP LAB & SHOP
247	SUPPLY AND STORES #6	517	WAREHOUSE
112	OPERATIONS ANNEX		DEMOLISHED
113	OPERATIONS ANNEX		DEMOLISHED
223	GUNNERY INSTRUCTION		DEMOLISHED
310	ORDNANCE		DEMOLISHED - SANDIA PROPERTY
311	AMMUNITION STORAGE		DEMOLISHED - SANDIA PROPERTY
312	RADIO TRANSMITTER		DEMOLISHED - SANDIA PROPERTY
4	MARRIED OFFICERS QUARTERS - NOT SHOWN		DEMOLISHED
6	MARRIED OFFICERS QUARTERS - NOT SHOWN		DEMOLISHED

Figure 6. NAS Livermore building list, 1949.⁵¹

⁵¹ Wofford, "Livermore Naval Air Station History," 67.

The war in the Pacific, even more than in the Atlantic, revolved around strategic control of the air and sea. The use of large land armies or land-based aircraft to attack Japan proved impossible because of its geographical location. Therefore, naval air power provided critical support in amphibious landings to take possession of islands for forward bases and in protecting merchant shipping by detecting and eliminating enemy submarines.⁵²

3.3 Naval Air Training

As early as 1935, President Roosevelt began a slow build-up of the military against the eventuality that the United States might enter the war. Several pieces of ensuing legislation enhanced the capabilities of the navy's air forces in readiness for a possible coming conflict. The 1935 Aviation Cadet Act created a pilot training program for college graduates. It also established the position of aviation cadet within the U.S. Navy and Marine Corps Reserves. In 1938, Congress sanctioned the manufacture of 3,000 new airplanes as part of a larger naval expansion.⁵³

After the attack on Pearl Harbor in 1941 the expansion of the naval air force started in earnest. Training pilots became a first priority. The numbers of students being trained jumped from 800 per month to 2,500.⁵⁴

Many universities provided preparatory training for pilots as part of the war effort. These programs emphasized physical fitness

training and military doctrine.⁵⁵ After three months at a preparatory school, potential cadets went on to Civil Aeronautics Authority War Training School (CAA-WTS) for another eight to twelve weeks and forty hours of flight training in light aircraft. By 1943, over ninety-two colleges participated in the CAA-WTS program. After six months of preliminary training, the recruit began official flight school.

Navy training consisted of four command phases: primary, intermediate, operational, and technical. The first three were varying levels of flight instruction and the last was an aircraft technical and maintenance program. All naval aviation cadets went through the first three commands—a total of nine months of flight training.

Naval aviation cadets spent eleven to fourteen weeks, and ninety to one hundred hours of flight time, at primary command, learning precision flight techniques in a Boeing N2S Stearman aircraft.⁵⁶ Primary command consisted of ten NASs located at Bunker Hill, Indiana; Dallas, Texas; Glenview Illinois; Grosse Ile, Michigan; Minneapolis, Minnesota; New Orleans, Louisiana (instructor's school); Norman, Oklahoma; Ottumwa, Iowa; St. Louis, Missouri; and Livermore, California.⁵⁷

After primary command, cadets spent fourteen to sixteen weeks and 160 flight hours in intermediate command, flying more powerful aircraft. Cadets also learned instrument flight and began specialization in

⁵² Ibid.

⁵³ Matt Portz, "Aviation Training and Expansion, Part 1," *Naval Aviation News* (July–August, 1990), 23–24.

⁵⁴ Ibid., 25.

⁵⁵ Ibid., 24.

⁵⁶ Matt Portz, "Aviation Training and Expansion, Part 2," *Naval Aviation News* (September–October, 1990).

⁵⁷ Ibid., 26.

carrier, multi-engine sea or land, or observation-type aircraft.⁵⁸ Intermediate command options included two Naval Air Training Centers (NATC) at Pensacola, Florida, and Corpus Christi, Texas, and the instrument instructor's school at NAS Atlanta, Georgia.⁵⁹

Finally, aviator cadets spent two months and 100 hours of training at operational command learning to fly combat aircraft equipped with weapons. Operational command included seventeen NASs along the Florida, Georgia, and Carolina coasts.⁶⁰

After completing three to nine months of preparatory and pre-flight school and nine months of flight training, a cadet finally received orders to report to a squadron.

3.4 NAS Livermore: Flight School

In May 1942, regular base operations commenced at the new naval air station in Livermore as part of NAS Oakland. On June 1, 1943, NAS Livermore officially separated from NAS Oakland and became a Primary Flight Training Center. Over 4,000 aviation cadets began their training at NAS Livermore during the years that it served as a primary training command, from June 1, 1943, to October 15, 1944.⁶¹

NAS Livermore usually required 225 officers and 1,700 enlisted personnel to run the base efficiently.⁶² Two hundred Women Appointed for Voluntary Emergency Service

(WAVES) also provided support. WAVES served on most training bases during WWII in non-combat and non-flying capacities.⁶³

Cadets at NAS Livermore endured a rigorous and regimented training. Ten-hour days, ten days in a row were a common work schedule. Cadets drilling in front of the Administration Building are depicted in figure 7. Cadets trained both on the ground and in the air.

Ground school included lectures and time logged in a Link Trainer, a flight simulation machine designed by Edwin A. Link in 1931.⁶⁴ The Link Trainer consisted of a cockpit mounted on a pedestal powered by a motor and bellows to simulate pitches, rolls, dives, and climbs. Initially, Link sold most of his trainers to amusement parks. But with the start of WWII, he sold 6,271 trainers to the U.S. Army and 1,045 to the U.S. Navy.

At NAS Livermore, WAVES trained aviator cadets on the Link Trainer. In addition to simulating flying, the Link Trainers at NAS Livermore also had static control, a device that could mimic storm conditions. Link Trainer operators at Livermore also set up the flying machines to simulate specific navy conditions, such as the rolling movement pilots would encounter on a carrier.⁶⁵

⁵⁸ Ibid., 24.

⁵⁹ Ibid., 26.

⁶⁰ Ibid.

⁶¹ Wofford, "Livermore Naval Air Station History," 35–37.

⁶² Matt Portz, "Memories of WWII Training" in Naval Aviation News staff, eds., *Naval Aviation Training* (Washington, D.C.: GPO, 1985).

⁶³ Portz, "Aviation Training and Expansion, Part 2," 26. For a more thorough history of the WAVES, see Karen Anderson, *Wartime Women: Sex Roles, Family Relations, and the Status of Women During WWII* (Westport, Conn.: Greenwood, 1981); Olga Gruhzt-Hoyt, *They Also Served: Women in WWII* (Secaucus, NJ: Carol Publishers, 1995); and Susan H. Hartmann, *The Home Front and Beyond: American Women in the 1940s* (New York: Twayne, 1995).

⁶⁴ Information on Link Trainers from the Maps Air Museum at the Akron-Canton Airport, www.mapsairmuseum.org; and the U.S. Air Force Museum, www.wpafb.af.mil/museum.

⁶⁵ Wofford, "Livermore Naval Air Station History," 35–36.

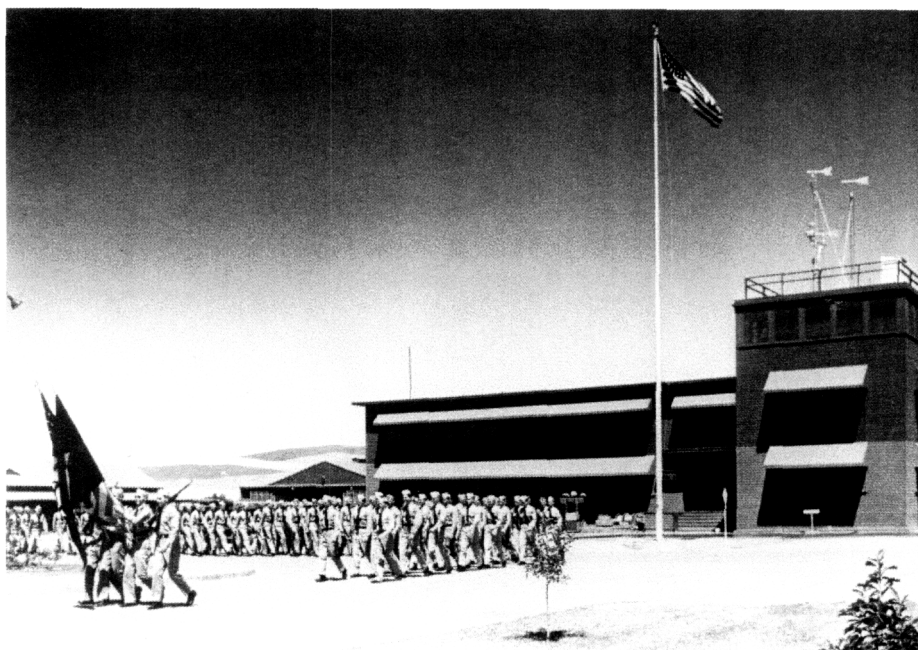


Figure 7. Naval air cadets drilling, NAS Livermore, 1943.⁶⁶

WAVES operating the Link Trainers in NAS Livermore Building 22 are depicted in figure 8. This building no longer exists.

Cadets spent their airtime hours learning how to fly a precise course and altitude. Cadets also practiced landings and takeoffs from the NAS runway and touch-and-go landings from “rectangular blacktop mats 3,000 by 2,700 feet square.”⁶⁷ Cadets also learned how to perform tight S-turn and slip landings within a 200-foot circle to ready those pilots destined for service on aircraft carriers.⁶⁸ Cadets flying in formation in Boeing N2S Stearmans are shown in figure 9.

After completing the requisite fourteen weeks of primary training, aviator cadets

graduated from NAS Livermore and went on to intermediate and operational training. NAS Livermore had one of the best production rates and safety records in the primary command, seeing 4,000 aviators through the first phase of training.⁶⁹

As the war began to wind down in 1944 so too did the need for large numbers of navy pilots. On November 15, 1944, the navy terminated the Primary Flight Training School at NAS Livermore and designated it a base for operational units from the Twelfth Naval District.

⁶⁶ Naval air cadets drilling at NAS Livermore, 1943, Box 025, LLNL Archives.

⁶⁷ Portz, “Memories of WWII Training,” 10.

⁶⁸ *Ibid.*, 10–12.

⁶⁹ Portz, “Memories of WWII Training,” 10.

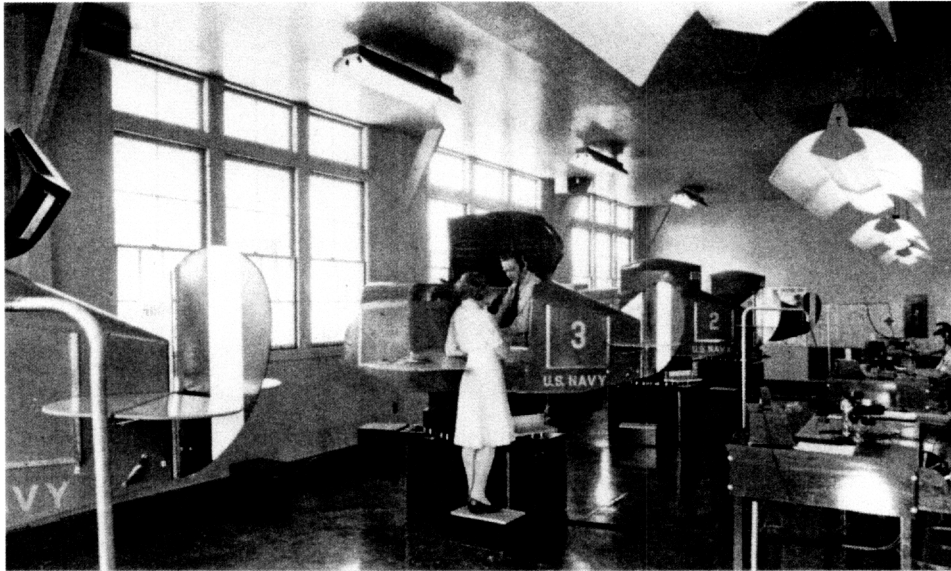


Figure 8. WAVES-enlisted personnel training naval officer on Link Trainer, NAS Livermore, 1943.⁷⁰



Figure 9. NAS Livermore, cadets flying formation, 1943.⁷¹

⁷⁰ Link Trainer at NAS Livermore, 1943, Box 843, LLNL Archives.

⁷¹ NAS Livermore cadets flying Boeing N2S Stearmans, Box 496, Folder 14137, LLNL Archives.

3.5 NAS Livermore: Operations and Testing

From November 15, 1944, until December 1, 1945, NAS Livermore provided operational support and respite for Pacific fleet carrier pilots.⁷²

During NAS Livermore's second mission as an operational base, new flight techniques and equipment were tested there. For example, one of the new navy flight procedures, the ground-controlled approach, was tested there. A pilot would fly blind-folded (with a co-pilot for safety) and land via the instructions of the tower operator.

The U.S. Navy also tested Jet-Assisted-Take-Off (JATO) bottles at NAS Livermore. A JATO bottle blasted a fighter plane 200 feet straight into the air in seconds from as little as a fifty-foot airstrip. NAS Livermore also had the honor of testing some of the first jet engines. The Navy built a hangar with a test pad, currently LLNL Building 514, specifically for this project.

As an operational base, NAS Livermore performed a standard support activity for the navy. Only the testing missions during this period are of historic interest. In particular, from November 15, 1944, to December 1, 1945, the testing of JATO bottles and jet engines that took place at NAS Livermore may qualify for the National Register under the WWII context and theme of NAS support of the U.S. war effort.

3.6 NAS Livermore: Naval Air Reserve Training Center

On December 1, 1945, NAS Livermore's mission changed again. NAS Livermore

became a training base again, but this time for the post-war U.S. Naval Air Reserve. A short six months later, the navy began preparations for the eventual closing and decommissioning of NAS Livermore. The station finally closed on December 31, 1946.

3.7 WWII Preservation Themes

The U.S. Navy commissioned and built NAS Livermore in January 1942, shortly after the attack on Pearl Harbor, as part of its military build-up to help prosecute the war in the Pacific. NAS Livermore operated from May 1942 until December 1946.

During this time period, NAS Livermore's primary contribution to the war effort involved the training of naval pilots and providing support and respite for carrier pilots. Buildings at NAS Livermore, now LLNL, will be considered historic within the WWII context to the extent that they reflect these specific WWII endeavors. Preservation themes for NAS Livermore/LLNL for WWII are the following:

- Naval pilot training
- NAS support of the U.S. war effort

3.7.1 Preservation Theme: Naval Pilot Training

NAS Livermore's primary role in WWII was to train naval pilots. From June 1, 1943 until October 15, 1944, NAS Livermore operated as a Primary Flight Training School for naval aviator cadets. From December 1, 1945 until December 31, 1946, NAS Livermore operated as a training school for the Naval Air Reserve Training Center and trained naval air reserve pilots.

⁷² Wofford, "Livermore Naval Air Station History," 37.

At the beginning of WWII, the U.S. Navy desperately needed trained pilots. Along with many other naval air stations in the United States, NAS Livermore provided trained naval aviators for active duty. In its role as a pilot training facility, NAS Livermore provided a necessary but routine military training function.

3.7.2 Preservation Theme: NAS Support of the U.S. War Effort

The other priority mission of NAS Livermore during WWII was to provide support to the U.S. war effort in the Pacific, primarily as a rest stop for operational units of the Twelfth Naval District. NAS Livermore also supported the U.S. war effort by testing naval aviation equipment and techniques.

From October 15, 1944, until December 1, 1945, NAS Livermore acted as an operational base for carrier pilot crews. Operational units would stay at Livermore to recuperate and rest before returning to active duty in the Pacific. NAS Livermore was one of many U.S. operational bases during WWII. In its role as an operational base, NAS Livermore provided a needed but routine military support function.

From October 15, 1944 until December 1, 1945, the navy also used NAS Livermore to test new flight techniques and equipment. The navy tested JATO bottles to enhance the speed and distance of navy fighter planes as they took off. NAS Livermore also hosted some of the first jet engine tests. These testing missions were not routine naval operations; they are of historic interest within the WWII context and the NAS Support of the U.S. War Effort theme.

3.7.3 Thresholds for Historic Interest

For an LLNL building to be considered historic within the WWII context it must meet one of the previously discussed NHPA criteria:

- **Criterion A**—association with a historic event
- **Criterion B**—association with a historic person
- **Criterion C**—exceptional design or construction
- **Criterion D**—potential to yield important information⁷³

Additionally, LLNL WWII structures must qualify within one of the established preservation themes of naval pilot training or NAS support of the U.S. war effort. The following guidelines further define the threshold for historic interest within the WWII context of naval pilot training and NAS support of the U.S. war effort:

- Has association with a historic moment or event in WWII naval pilot training or NAS support of the war effort. This might involve a significant improvement in training technique or equipment. It might also involve a historic naval battle or engagement in which NAS Livermore provided direct support (Criterion A)
- Has association with a person of historic importance to WWII. This person should be recognized by the historic profession and be the subject of a body of scholarly work. The building should also be the primary place where the historic person

⁷³ This is an abbreviated version of the NHPA criteria. For a full discussion of the NHPA criteria, see Section 1.3.3 of this report. See also U.S. Department of the Interior, *National Register Bulletin 15*, 2.

worked or made his/her contribution to WWII (Criterion B)

- Represents an exceptional WWII naval building type, style, or construction (Criterion C)
- Has potential to provide important historic information pertinent to WWII naval history that could not be obtained elsewhere. This criterion usually refers to archaeological sites and is the least relevant to WWII structures at LLNL (Criterion D)

3.8 WWII Buildings and Integrity

For an LLNL building to be eligible for the National Register under the above defined historic context, themes, and periods of significance, it must also possess integrity. Integrity is the ability of a building to reflect its historic context, theme, and period of significance.⁷⁴ In other words, the building must retain enough of its physical features to look and feel as it did during the period of its historic importance.

The following sections detail the kinds of WWII structures present at LLNL, their primary features, and thresholds for assessing their historic integrity.

3.8.1 WWII Building Types

Prior to WWII the navy had only four permanent training stations in the United States—Newport, Rhode Island; Norfolk, Virginia; Great Lakes, Illinois; and San Diego, California. In 1939, the Chief of the Navy Bureau of Yards and Docks received authority to plan and build additional facilities in preparation for the possibility

of U.S. entry into the war in Europe. Naval construction accelerated even faster after the attack on Pearl Harbor.⁷⁵

Naval construction before 1941 tended toward permanent buildings designed to reflect the high-style architecture of the period. For instance, permanent buildings at NAS Alameda, a new naval air station in the San Francisco area, reflected art deco design blended with military neo-classicism. After 1941, the navy primarily built temporary buildings and cantonments designed to last five to seven years.⁷⁶

Temporary buildings were characterized by wood-frame construction and wood shiplap siding. Where wood was scarce, the military substituted cement-asbestos panels. The pre-fabrication of building components such as ready-cut sections of wood and steel was implemented on a limited basis. More important for rapid construction were the elimination of the competitive bidding process, use of standardized building drawings, platform framing, and the use of stock items like doors and windows.⁷⁷

NAS Livermore was one of dozens of auxiliary airfields built during WWII to supplement the two main naval air stations at North Island near San Diego and at Alameda in the San Francisco Bay Area. NAS North Island and NAS Alameda, along with Marine Corps Air Station El Toro in

⁷⁴ For an expanded discussion of integrity, see Sections 1.6–1.6.3 of this report. See also U.S. Department of the Interior, *National Register Bulletin* 39, 46.

⁷⁵ John S. Garner, *WWII Temporary Military Buildings: A Brief History of the Architecture and Planning of Cantonments and Training Stations in the United States*, CRC-93/01 (Champaign, Ill: U.S. Army Construction Engineering Research Laboratories, 1993), 16–17.

⁷⁶ Stephen Mikesell, *California Historic Military Buildings and Structures Inventory, Volume II: The History and Resources of the Military in California 1769–1989* (Sacramento: U.S. Army Corps. of Engineers, 2002), 7-2–7-4.

⁷⁷ Garner, *WWII Temporary Military Buildings*, 14–18, 39.

Orange County, trained the vast majority of pilots who fought in the Pacific theater on naval air carriers.⁷⁸

The WWII buildings of NAS Livermore were typical of other navy temporary construction of the period. The Navy Bureau of Yards and Docks provided standardized military architectural plans to local architectural and engineering firms, which altered them to fit local building conditions. NAS Livermore buildings were based for the most part on WWI-era building designs. The barracks were from the B-1 series, introduced at Camp Lawrence in 1918.⁷⁹ Hangars, storerooms, and other special structures were also largely based on earlier WWI-era building designs. A notable exception to the standard WWI-era design was the innovative use of laminated freestanding wood arches in drill halls instead of hard-to-obtain steel. The New York architectural firm of Shreve, Lamb, and Harmon originally incorporated this design feature in its building drawings for the navy.

There are seven loose groupings of WWII building types still present at LLNL.⁸⁰ These buildings were all originally built as part of NAS Livermore in 1942. The seven building types are as follows:

- B-1 H-Type Barracks
- H-Plan Classroom
- WAVES Residence
- Drill Hall

- Warehouses
- Industrial
- Miscellaneous

Few of them appear to retain their external or internal integrity—that is, they no longer look as they did when NAS Livermore was in operation during WWII. Furthermore, NAS Livermore no longer exists as an intact group of buildings. Many WWII structures have been demolished and Cold War laboratories built in their place. The effect is that Cold War buildings exist in the midst of a former and much transformed naval air station. The assessment of the WWII buildings will address the issue of integrity in detail.

3.8.2 WWII Building Features

The following features characterize each of the seven LLNL WWII building types:

B-1 H-Type Navy Barracks

- Two-story structure
- Wood frame
- Drop siding
- Double-hung wooden sash windows
- H-shaped floor plan
- Sleeping quarters
- Common area

H-Plan Classroom

- Two-story structure
- Wood frame
- Drop siding
- Double-hung wooden sash windows
- Classrooms

⁷⁸ Mikesell, *California Historic Military Buildings and Structures Inventory*, 7-12-7-15.

⁷⁹ Garner, *WWII Temporary Military Buildings*, 48.

⁸⁰ The seven WWII building classifications are adapted from William Self Associates, *Documentation and Assessment of the History of the Lawrence Livermore National Laboratory Livermore Facility*, 33–35.

WAVES Residence

- Two-story structure
- Wood frame
- U-shaped floor plan
- Drop siding
- Double-hung wooden sash windows
- Sleeping quarters
- Common area

Drill Hall

- Rectangular structure
- Wood frame
- Glue-laminated arches
- No interior columns
- Large central space
- Double-hung wooden sash windows
- Drop siding
- Maple flooring

Warehouses

- One-story structure
- Flat roof
- Drop siding
- Capacity for storage
- Wood trusses

Industrial

- Concrete or wood frame
- Gabled, saw-toothed, or flat roof
- Composite or concrete roofing
- Drop siding
- Capacity for large equipment and/or repair activities
- Wood trusses

Miscellaneous

- One- or two-story structures
- Wood frame
- Drop siding
- Capacity for offices or storage

3.8.3 WWII Thresholds for Integrity

If a WWII building is judged historically significant under one or more of the four criteria, then, in addition to possessing the representative characteristics of a building of its type, it must also retain enough of its physical features to reflect the period of its historical importance.

The following characteristics form the thresholds for integrity for Criteria A, B, C, and D:

- The building must be in its original location.
- The building must not have more than fifty per cent of its original design and construction modified, including the increase or decrease of gross square footage.
- The building must retain the equipment used in historically interesting work.
- Equipment can be found historically significant whether or not it remains in its original location. If it has not been modified for continued use (i.e., it has been mothballed), this equipment should be at least eighty percent intact (i.e., returning it to its original state and operability would require negligible effort). If the equipment has been in use since the period of its historic significance, it will be considered to have integrity if it is still used for the basic purpose for which it was deemed historic and if the specific historically significant aspects of its design are intact.
- The building must reflect, look, and feel as it did during the time period when it was historically significant.
- The building must be the actual place where a historic event occurred or where a historic person worked during his or her productive life.

3. WWII CONTEXT



4. COLD WAR CONTEXT

The primary context for assessing buildings at LLNL is the Cold War. The AEC established LLNL in 1952 as a second nuclear weapons laboratory in direct response to Cold War concerns.

Because the majority of buildings at LLNL were either used or built during the period of the Cold War, this report focuses in some depth on this historic context and the themes it includes. The Cold War encompassed a variety of political, cultural, technological, and economic issues in U.S. history.⁸¹

Clearly, all facets of the Cold War do not apply to LLNL's built environment. The nuclear arms race is the primary aspect of the Cold War in which LLNL's role must be understood. In addition, LLNL contributed to related Cold War efforts, most notably, peaceful uses of nuclear energy and the space race. These efforts are more limited than the broader nuclear weapons work LLNL performed within the Cold War context, but they must be considered.

In this section, nuclear strategy and nuclear stockpile development will be outlined, as will the development of the nuclear weapons

⁸¹ The literature on the Cold War and the nuclear arms race is vast. In addition to works previously cited in footnote 20, the discussion in this section is taken largely from the following sources: Bernard Brodie, Michael D. Intriligator, and Roman Kolkowicz, eds., *National Security and International Stability* (Cambridge, Mass.: Oelgeschlager, Gunn & Hain, 1983); McGeorge Bundy, *Danger and Survival: Choices about the Bomb in the First Fifty Years* (New York: Random House, 1988); Ashton B. Carter, John Steinbruner, and Charles A. Zraket, eds., *Managing Nuclear Operations* (Washington, D.C.: Brookings Institution, 1987); John Lewis Gaddis, *Strategies of Containment: A Critical Appraisal of Postwar American National Security Policy* (New York: Oxford University Press, 1982); Gregg Herken, *The Winning Weapon: The Atomic Bomb in the Cold War 1945–1950* (New York: Alfred A. Knopf, 1980);

Richard G. Hewlett and Francis Duncan, *Atomic Shield, 1947–1952*, Vol. 2 of *A History of the United States Atomic Energy Commission* (University Park and London: The Pennsylvania State University Press, 1969); Richard G. Hewlett and Jack M. Holl, *Atoms for Peace and War, 1953–1961*, Vol. 3 of *A History of the United States Atomic Energy Commission* (Berkeley: University of California Press, 1989); David Holloway, *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939–1956* (New Haven and London: Yale University Press, 1994); Fred M. Kaplan, *The Wizards of Armageddon* (New York: Simon & Schuster, 1983); John Newhouse, *War and Peace in the Nuclear Age* (New York: Alfred A. Knopf, 1989); and Richard Rhodes, *Dark Sun: The Making of the Hydrogen Bomb* (New York: Simon & Schuster, 1995).

complex and LLNL's role within it. Section 6 will outline the preservation themes relevant to LLNL properties in the Cold War context, providing summary information relevant to the histories of the particular activities under consideration.

In examining nuclear strategy and the development of the nuclear stockpile, it is important to note that no simple causal relationship exists between the two. Each presidential administration developed a nuclear strategy or policy to accommodate potential nuclear conflicts with the Soviet Union and, later, China. The nuclear weapons complex developed weapons and technology within these larger policies and with the specific mission needs of particular branches of the armed forces in mind. However, the complex also explored weapon concepts and developed technologies that in turn affected policy options and political thinking about nuclear arms.

Distinct periods of Cold War policy are identifiable by presidential administration, although there is some overlap in each transition. The periods are defined as follows:

- Early efforts at international control (1945–1948)
- Truman's containment efforts and early stockpile growth (1949–1952)
- Eisenhower's New Look, with a dependence on Massive Retaliation (1953–1960)
- Kennedy's Flexible Response (1961–1964)
- Johnson's emphasis on deterrence with Assured Destruction (1965–1969)

- Nixon's détente and emphasis on a war-fighting capability, with first-strike as well as tactical weapons and increased conventional forces (1970–1980)
- Reagan's increases in war-fighting capability (1981–1988)
- End of the Cold War (1991)

Policy and weapons design/production proved integrally linked. For example, the complex produced a large number and variety of weapons in a relatively short time in response to administration and defense perceptions of a communist threat in the late 1940s. A decade later, when the stockpile was swollen with weapons produced under the policy of massive retaliation, President Kennedy's administration was able to revisit the matter and introduce a policy of flexible response precisely because there were so many weapons available, including tactical devices with lower yields.

4.1 Beginnings of the Cold War

The roots of the Cold War lie in the essential philosophical differences between the United States and the Soviet Union that were apparent beginning with the Bolshevik Revolution of 1917. The very different world outlooks of the enthusiastically capitalist nation with a growing trade capacity and the communist, anti-capitalist nation with a call to export its revolution lay at the base of ongoing suspicions. The United States did not recognize the new Soviet state until 1933, largely in an effort to convey moral disdain. In turn, the Soviet Union maintained a consistent paranoia about alleged Western states' ongoing efforts at internal subversion.

The basic differences did not disappear when the United States entered WWII on the

side of the Allies, who included the Soviet Union. The basic philosophical differences between the Soviet Union and the Western powers exacerbated the apprehension among all parties over each other's self-interested behaviors.⁸²

4.1.1 Yalta and Potsdam

On January 20, 1945, shortly after his election to a fourth term as U.S. President, Franklin Roosevelt met at Yalta with Soviet Premier Joseph Stalin and British Prime Minister Winston Churchill to discuss the post-war world. Tensions surfaced immediately over the fate of Poland. Subsequent events made clear Stalin's intentions to disregard his promises at Yalta.

In April 1945, Roosevelt died in office and Harry Truman became President of the United States. In July 1945, after the surrender of Germany, Truman met with Stalin and Churchill at Potsdam, a city outside Berlin, to continue post-war negotiations. Germany was divided into four zones to be occupied and managed by the four winning powers: the United States, the Soviet Union, Britain, and France. The Allies also agreed to prosecute German Nazi leaders and sanction Germany with reparations.

Tension still remained over Poland and Eastern Europe. Stalin ignored his promise to hold free elections in Poland and installed

a Soviet puppet government. Truman wanted to hold Stalin to his agreement, but he still needed the Soviets to agree to join the United States in the Pacific against Japan. This was the primary diplomatic aim for the United States at Potsdam.

In the midst of negotiations, Truman learned of the successful detonation of the first atomic bomb at Trinity in New Mexico. This hardened his resolve and changed his manner in dealing with Stalin. Truman no longer needed Stalin's help with Japan. The United States and the Soviet Union no longer held any common goals. Nuclear weapons remained inextricably linked to Cold War actions and policies throughout the succeeding decades.

4.1.2 Hiroshima and Nagasaki

On August 6, 1945, the United States dropped an atomic bomb on the Japanese city of Hiroshima. Two days later, it dropped another atomic bomb on the city of Nagasaki. Japan surrendered on August 14, 1945, ending the war in the Pacific.

The Manhattan Project was the U.S. program to develop atomic bombs during WWII. A large, secret, well-funded program located administratively under the Manhattan Engineer District, the project oversaw the design, production, manufacture, and delivery of two different nuclear weapons designs during the war.⁸³

⁸² For a more detailed account of the suspicion with which the United States regarded the Soviet Union, see Morris, *Iron Destinies, Lost Opportunities*, 3–22. For brief accounts of the beginnings of WWII in Europe and the relationship between Russia and Germany, see Mark C. Carnes and John A. Garraty, *The American Nation: A History of the United States*, 11th ed. (New York: Longman, 2003), 727–730; and Palmira Brummet et al., *Civilization Past and Present*, 9th ed. (New York: Longman, 2000), 904–931.

⁸³ For more detailed information on the Manhattan Engineer District, see Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon & Schuster, 1986); F. G. Gosling, *The Manhattan Project: Making the Bomb*, DOE/MA-0001 (Washington, D.C.: U.S. Department of Energy, 1999); and Leslie R. Groves, *Now It Can Be Told* (New York: Harper & Brothers, 1962).

During WWII, the United States deliberately kept all knowledge of the development of the atomic bomb from the Soviet Union. Nevertheless, a thriving Soviet espionage network gained considerable information on the project during and after the war.⁸⁴

The U.S. decision to withhold this information during the war coupled with the temptation to use the atomic bomb as a bargaining tool (or implied threat) in post-war negotiations with the Soviet Union, also furthered the discord between the two former allies.⁸⁵

4.1.3 Final Straws

The actual beginnings of the Cold War date to a series of events that occurred in a tense period in the spring of 1946.

On February 9, during his election speech, Stalin criticized the United States and Western Europe, drawing stark lines between Soviet communism and corrupt western capitalism. Three days later the Soviets announced they had established a communist government in North Korea.

Also in February 1946, the media announced the existence of a far-flung network of Soviet espionage and the Joint Chiefs of Staff issued a statement to the President that the Soviet Union posed a serious military threat to U.S. interests.

On February 22, the U.S. ambassador to the Soviet Union, George Kennan, sent an 8,000-

word telegram to the U.S. State Department confirming the military's fears. Kennan noted that the Soviet Union, due to a long-standing sense of insecurity, was bent on world domination and that it was necessary for the United States to contain it. Kennan argued that consistent diplomatic and political efforts needed to be made by the Western powers to contain the Soviet Union and that it would, eventually, lose its aggressive ambitions.

4.1.4 The Atomic Energy Commission

The U.S. Congress, the military, and civilian scientists and engineers struggled with the issue of military versus civilian control of atomic energy immediately after the war. The debate was heated and occasionally acrimonious. It resulted in the Atomic Energy Act of 1946, which left atomic energy in civilian hands but required close cooperation and interaction with the military. The debate over the custody of actual weapons continued throughout the Cold War period and persists today.

The Act created an Atomic Energy Commission (AEC) to oversee all elements of atomic energy technology in the United States. On January 1, 1947, all property and personnel of the Manhattan Engineer District were transferred to the AEC. However, to make sure the technology pursued would meet military needs, the AEC had a liaison committee of military officials, known as the Military Liaison Committee (MLC). This arrangement created what is referred to as "dual-agency responsibility" for the weapons and their uses: the AEC controlled atomic energy, and the AEC and the military were jointly responsible for nuclear weapons.

In addition, the Act established a General Advisory Committee (GAC) within the

⁸⁴ For more information on Russian knowledge of atomic science and WWII espionage, see Rhodes, *Dark Sun*.

⁸⁵ For a more thorough discussion of how the atomic bomb featured in post-war negotiations, see J. Samuel Walker, *Prompt and Utter Destruction: Truman and the Use of Atomic Bombs* (Chapel Hill: University of North Carolina Press, 1997).

AEC, made up of prominent scientists and engineers. The GAC provided technical advice to the AEC and helped evaluate research and development programs and proposals.

The Act also created an oversight body within Congress. The Joint Committee on Atomic Energy (JCAE) was composed of members of both the House and the Senate, with equal membership from each of the political parties. Chairmanship alternated between the House and the Senate. The JCAE served as a powerful and independent oversight entity for the AEC, to the occasional but heated resentment of other members of Congress.

In the optimism of the war's end, there were some hopes of sharing nuclear power with the international community or even to completely step away from the newly unleashed force. In the immediate post-war period, only the United States had atomic weapons, and it only had a handful. No new advances in design or production were apparent in the two years immediately following the war. The first post-war nuclear test, Operation Crossroads, took place in July 1946. The two test events—Able and Bravo—were meant to test the effects of a nuclear weapon against a naval fleet and not to prove out a new weapons design. Nevertheless, it was a potent and obvious reminder of the presence of the new weapon and its power. It also ended any hope among other nations that the new power would be shared or demilitarized.

The management of atomic energy and weapons featured in all post-war negotiations between former combatants and came to overshadow all post-war diplomacy. The

fact of sole U.S. possession of the new type of weapon influenced the actions of all players in international diplomacy.

The AEC inherited, nurtured, and expanded a set of national laboratories, that is, large, multiprogram laboratories engaged in a range of research programs. With regard to the Cold War, the weapons laboratories—LANL and, later, LLNL—are of obvious interest. However, the AEC's set of national laboratories, not all of which were called that originally, defined themselves as a cohesive set consisting of Argonne, Berkeley, Brookhaven, LANL, and Oak Ridge. LLNL was added when it was created, although it was part of Berkeley until 1971. Not all of the laboratories pursued research directly related to defense, but they are all part of one another's context. The Cold War research that LLNL pursued, for example, was not all centrally tied to nuclear weapons design. However, much of the non-weapons research retained a Cold War focus. This will become clearer later in this section.

4.2 Truman and Containment

In 1947, arguing that the United States needed to step in and assist the Greek government in fending off pro-Communist insurgents, President Truman insisted that "it must be the policy of the United States to support free peoples who are resisting attempted subjugation by armed minorities or by outside pressure."⁸⁶ This is the first statement of the commitment that came to be known as the Truman Doctrine. It would end up being combined with the policy of contain-

⁸⁶ As cited in multiple U.S. history textbooks, including Alan Brinkley, *American History: A Survey*, vol. II, *Since 1865*, 10th ed. (Boston: McGraw-Hill, 1999), 971; and Pauline Maier, Merritt Roe Smith, Alexander Keyssar, and Daniel J. Kevles, *Inventing America: A History of the United States*, vol. 2, *From 1865* (New York and London: W. W. Norton & Company, 2003), 863.

ment first articulated by Kennan. Together they formed the basic framework for U.S. attitudes and policies toward the Soviet Union for the next forty years.

Several crises in 1948 and 1949 served to accelerate the chilling of relations between the United States and the Soviet Union. The Soviet Union's attempt to blockade the city of Berlin in 1948 was the first major Cold War crisis. It had direct effects on American nuclear strategy. The tensions stemming from the crisis resulted in a revised production system that aimed to quadruple the U.S. nuclear stockpile. In addition, a review of U.S. military nuclear readiness during the Berlin crisis found a discouragingly low level of preparedness; strategic bombing and nuclear weapons proponent General Curtis LeMay was consequently put in charge of the Strategic Air Command.

Early in 1949, in response to the growing Soviet influence in Eastern Europe, the United States initiated formation of the North Atlantic Treaty Organization (NATO). NATO was a collective security alliance between the United States and most of the nations of Western Europe, and served as a guarantee of American military support, including the use of nuclear weapons, in the event of Soviet military expansion westward. In response, the Soviet Union and its Eastern European allies formed the Warsaw Pact shortly thereafter.

Also in 1949, the Soviets detonated their first atomic device. Although predicted by politicians, defense analysts, and scientists as a likely, perhaps even inevitable, eventuality, the timeline leading to the Soviet shot was not clearly understood, and it shook U.S. policymakers.

Late in 1949, Chinese Communists, led by Mao Zedong, succeeded in toppling the nationalist government in that country, establishing the Peoples' Republic of China. U.S. policy analysts had predicted the communist triumph in China, just as they had the Soviet acquisition of nuclear weapons. Nevertheless, the American public was unprepared for both events, let alone their rapid succession, and there were strident demands for a dramatic response. In January 1950, Truman authorized the AEC to pursue development of a thermonuclear weapon, referred to as the Super.

The Super was a fusion device designed to fuse nuclei of hydrogen and promising much larger yields than the existing fission weapons. The decision to pursue the Super was based on the convincing argument that it represented a significant advance beyond the fission weapons created by the Manhattan Project and therefore a leap beyond what the Soviets had just tested. As a decision to stay ahead of Soviet technical advances, Truman's authorization of the Super marks the moment of U.S. commitment to the arms race.

Simultaneous with the authorization for thermonuclear weapons design efforts was the creation of a new U.S. national defense policy. As articulated by the State Department under Dean Acheson in early 1950, the doctrine of containment was militarized. Known as NSC-68, the document containing this new policy statement essentially merged the doctrine of containment with the Truman Doctrine, arguing for a massive build-up of U.S. military power to stop, and even overthrow, the Soviet threat.

4.2.1 Creating the Nuclear Weapons Complex

To support and enable its Cold War policies, the United States established a large complex of weapons design, testing, production, and assembly facilities. The initial and greatest push to create the complex came in the 1948–1952 time frame, when the Cold War was accelerating. Facility construction and expansion continued throughout the 1950s as the initial stockpile of nuclear weapons expanded into a massive arsenal.

The complex is an unusual set of facilities, containing both advanced research and development capabilities (as represented by the national laboratories) and disparate, immense industrial capacity (as represented in the vast array of entities involved in manufacturing and production across the United States).

Building on the arrangements and sites created during WWII for the Manhattan Project and conventional ordnance production, the AEC established a large and varied set of facilities. Some of these—primarily those involved in manufacturing activities—were privately owned. Others, including the national laboratories and material production sites, were owned by the AEC and operated by contractor entities. These are known as GOCO facilities—government-owned, contractor-operated installations. LLNL is a GOCO facility.

The production and design facilities put in place quickly and at great cost during WWII remained intact after the war. However, the expansion in purpose—from single, hand-crafted weapons produced under war-time duress to a significant stockpile of weapons created by an ongoing, peacetime defense production system—drove the demand for

expanded facilities and production capabilities. Despite a post-war emphasis on returning the military to peacetime status, evolving Cold War policy drove the expansion of the nuclear weapons complex.

The essential outlines of the U.S. nuclear weapons complex were put in place in the early years of the Cold War. By 1949, the nuclear weapons complex was coming into focus, fed by early Cold War fears and budding nuclear policy. In the immediate post-war period, LANL expanded its plans and efforts to design and test new physics packages for new weapons designs. Its branch enterprise, now Sandia National Laboratories (SNL), was engaged in ordnance engineering activities aimed at turning the nuclear physics package into a deliverable weapons design.⁸⁷ Production facilities at Hanford and Oak Ridge were still supplying nuclear material, and explosive lenses were poured at the Naval Ordnance Test Station at Inyokern in California. The component production portion of the complex was growing, with a variety of parts produced at a former Pratt & Whitney airplane-engine plant in Kansas City, as well as at the Mound Laboratory in Miamisburg, Ohio, and the Picatinny Arsenal in New Jersey. The Rock Island Arsenal in Illinois supplied steel bomb casings. The Burlington Plant of Iowa also opened to begin taking over weapon assembly activities. In 1949, the first of a series of sites designed to store the burgeoning nuclear arsenal opened at the Killeen base in Fort Hood, Texas. Figure 10 lists the facilities in the nuclear weapons complex in 1949.

⁸⁷ Formed in July 1945 as Z-Division of Los Alamos, the ordnance engineering group moved to a site near Albuquerque New Mexico, to work more closely with the military and be near an airfield. In 1949, Sandia separated from Los Alamos. Like LANL and LLNL, Sandia has been through several name changes; it is now Sandia National Laboratories.

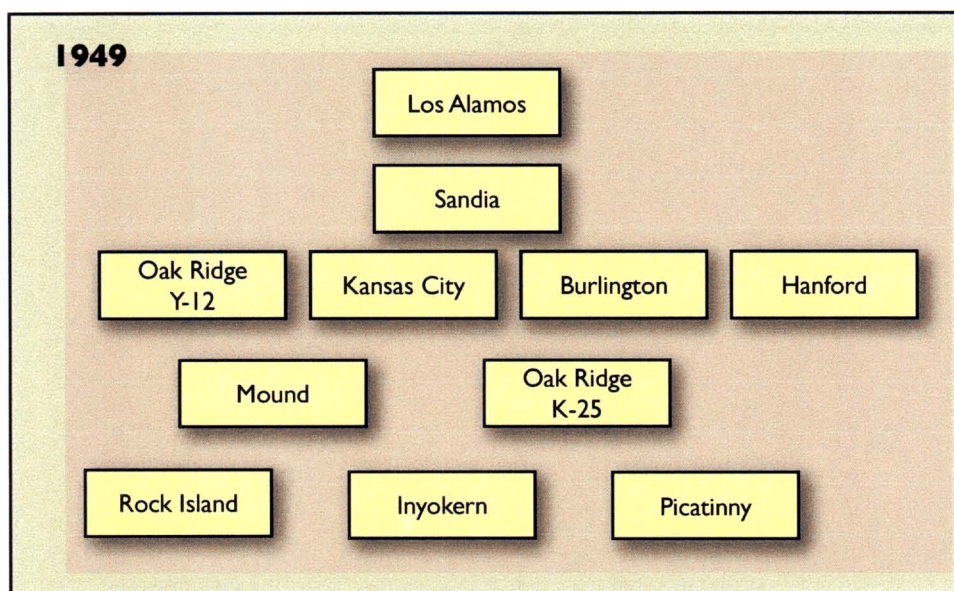


Figure 10. U.S. nuclear weapons complex, 1949.⁸⁸

4.2.2 Korean War

The largest and most important crisis in the early Cold War era was the outbreak of a hot war in Korea. After several years of diplomatic conflict over whether or how North and South Korea, partitioned by the Allies at the end of World War II, should be re-united, pro-Communist North Korea attempted to re-unite the country by force of arms in June 1950. It is now known that the North Korean government took this action without authorization or coordination from Moscow or Beijing, but at the time it appeared to be a clear example of communist expansion in Asia.

The Truman administration quickly committed the United States to containing this apparent case of Soviet expansion. Eventually, a United Nations (U.N.) force, comprised overwhelmingly of American

military personnel, would fight in Korea against both North Korean and Chinese forces.

The Korean War brought nuclear weapons to the forefront of Cold War policy. The policy of deterrence was fully articulated in the consideration of using nuclear weapons in Korea. This caused a further push for additional nuclear weapons and a further expansion of the complex.

In the spring of 1951, concerned with the tenuous military situation in Korea, President Truman authorized, for the first time in the AEC's history, the transfer of nuclear weapons to the U.S. Air Force for deployment to Asia.

Nuclear weapons were not used in Korea for several reasons. The most important was probably the conclusion that conventional

⁸⁸ This figure is adapted from Loeber, *Building the Bomb*, 85.

military means could be employed as successfully. In addition, the Truman administration was determined not to draw the Soviets directly into the war and was concerned that an ineffective use of nuclear weapons would undercut their deterrence value. This last proved critical numerous times in discussions of potential uses for nuclear weapons. However, the Truman administration continued preparations to use nuclear weapons in the future, if necessary.

The war in Korea also accelerated the push for tactical nuclear weapons, which were tested at the Nevada Test Site (NTS) in 1951. Tactical nuclear weapons had a smaller yield and could be used much like conventional artillery in limited engagements. The nuclear stockpile grew rapidly during the Korean War. By 1953, the U.S. arsenal contained over 1,100 weapons, up from approximately fifty just five years earlier.⁸⁹

4.3 Eisenhower and the New Look

Over the course of his two terms as President, Dwight Eisenhower re-shaped American nuclear policy. As Supreme NATO Commander in Europe from 1950 to 1951, Eisenhower paved the way for the forward deployment of American nuclear weapons in Europe. As President, he oversaw the growth of the nuclear stockpile to over 18,000 weapons by 1960. During Eisenhower's eight years in the White House, programs were undertaken to bring Intercontinental Ballistic Missiles (ICBMs) and Submarine Launched Ballistic Missiles (SLBMs) into the arsenal. ICBMs and SLBMs represented a significant advance in nuclear technology. Warheads mounted on ballistic

missiles now could be launched from considerable distances, by land or sea.

Most importantly, however, Eisenhower, concerned about the growing cost of a large, conventional military, became increasingly attracted to the nuclear option. The Eisenhower administration's "New Look" was a new military posture for the United States. The New Look was heavily dependent on the threat of massive retaliation with nuclear weapons in response to Soviet aggression. To add teeth to the language of deterrence, Eisenhower diversified the stockpile to include more tactical nuclear weapons, and also adopted the policy that, in the event of war, the United States would consider nuclear weapons available for use like any other munitions.

In the 1950s, the world witnessed a massive growth in both numbers and types of nuclear weapons at the disposal of the United States and the Soviet Union. NTS was established in 1950. By 1953, the nuclear weapons complex had expanded to several additional sites, including LLNL in California, and additional production facilities at Salt Wells in California, Portsmouth in Ohio, Paducah in Kentucky, and Savannah River in South Carolina. America's build-up in numbers of nuclear weapons was a deliberate part of the Eisenhower administration's New Look. While President Eisenhower himself pursued the possibility of nuclear disarmament, the nuclear weapons complex began work on at least forty new weapon programs between 1953 and 1961, some of which did not make it to the stockpile.

⁸⁹ "Declassification of Selected Nuclear Weapon Stockpile Information," *Sandia Classification Bulletin*, no. 94-8, November 1, 1994, 9.

The variety of weapons under development resulted from the introduction of new delivery systems—namely, missiles—and the new weapons design possibilities growing out of the research conducted at LANL and, eventually, LLNL.

Truman's authorization of the pursuit of a thermonuclear weapon resulted in promising early tests of the design. The Mike shot of Operation Ivy in 1952 was the first successful test of a large thermonuclear device. The Soviets were not far behind in this leg of the race, testing their own thermonuclear design in August 1953.

During the build-up in the nuclear arsenal, Eisenhower also developed and pursued an "Atoms for Peace" program. Announced in December 1953, Atoms for Peace was a program to explore non-weapons uses for nuclear energy and the power of fission. Although it never completely fulfilled Eisenhower's vision of shared energy for the world, the program did advance reactor technology and deliberately export it to other nations. The most significant result, from the point of view of an assessment of LLNL properties, was Project Plowshare, an effort to develop nuclear explosives for industrial purposes. Project Plowshare grew out of the Atoms for Peace perspective of pursuing peaceful uses; it was created and fostered at LLNL in the late 1950s.

4.3.1 Establishing LLNL

In 1942, the U.S. government acquired 629 acres of land east of the town of Livermore from rancher W. Gatzmer Wagoner and established a naval air station on the property. NAS Livermore served as a flight training facility for approximately 4,000 pilots during WWII. Late in 1944, training activities were

curtailed, and the facility was converted to a stopover base for pilots operating from aircraft carriers. The station was deactivated in 1946.

After the detonation of the first Soviet atomic device and the increased attention to weapons design and production, E. O. Lawrence, head of the University of California Radiation Laboratory (UCRL) at Berkeley, proposed a new accelerator to produce fissile material. The linear accelerator design he put forward would produce neutrons from deuterons; the neutrons could then be used to produce plutonium, uranium, and tritium. The Materials Testing Accelerator (MTA) would ensure sufficient material for expected increases in the nuclear stockpile. As with most large accelerator efforts, the proposal was to build a prototype first. The Mark I prototype Lawrence envisioned was too big to build at the Berkeley lab, so he selected a site in Livermore at the former NAS. Built by CR&D, the Mark I successfully fired its first beam in May 1952. Unfortunately for the project, by that time cheaper sources of uranium ore had been discovered in the United States and there was no need for the MTA.⁹⁰

In July 1952, the AEC agreed to create an additional design laboratory. The immediate purpose of the new facility was to pursue a thermonuclear weapons development program. Edward Teller had strongly and persistently argued the need for such a facility. Teller thought LANL was not proceeding quickly enough with a thermonuclear design, particularly in light of the

⁹⁰ Peter J. Westwick, *The National Labs: Science in an American System, 1947–1974* (Cambridge and London: Harvard University Press, 2003).

1949 Soviet atomic bomb test. Lawrence agreed with Teller and succeeded in convincing the AEC of the need for the new facility, as well as his ability to provide it at the site in Livermore.

LLNL was established as a branch of the UCRL in September 1952 at the MTA site on the former NAS Livermore. Just over 600 acres of former naval air station land were transferred to the AEC. The site was north of East Avenue (then County Road 1518), about three miles east of the center of Livermore and forty-eight miles east of San Francisco.

Herbert F. York was put in charge of the new laboratory. The initial activities planned for LLNL were diagnostic experiments during nuclear weapons tests. After Mike, the first large thermonuclear device, was detonated in November 1952 in a LANL test, LLNL began work on thermonuclear weapons designs.⁹¹

LLNL is somewhat unusual in the nuclear weapons complex in that its mission included non-weapons research from the beginning. York was deliberate and adamant about attracting and maintaining scientific talent at the Laboratory to encourage an atmosphere of high-quality achievement in research.

During the 1950s, in addition to pursuing thermonuclear designs, U.S. scientists faced the challenge of designing smaller and lighter warheads for missiles—a new delivery system. By the end of the decade, the goal was met. Of particular interest with regard to LLNL was the development

of the first nuclear weapons for the U.S. Navy. Polaris, the first Submarine-Launched Ballistic Missile (SLBM), was begun in 1957 and fielded with a warhead designed by LLNL.

Also in 1957, LLNL launched Project Plowshare at Teller's suggestion and the AEC's authorization. Part of the effort to develop peaceful uses for nuclear energy, Project Plowshare explored nuclear excavation and cratering, as well as coal gasification and natural gas stimulation in later years. The Laboratory remained central in Project Plowshare work until the project's last nuclear experiment in 1973.

1957 was a key year for LLNL. In addition to receiving the Polaris and Plowshare assignments, the Laboratory also received an assignment for the Air Force's Project Pluto. Pluto was a dedicated effort to develop nuclear ramjets to launch unmanned aircraft.

The latter years of Eisenhower's presidency and the first years of Kennedy's saw further transformations in U.S. nuclear policy. By the end of the 1950s, the policy of massive retaliation was beginning to look overly rigid and clumsy. The United States was not willing to engage in full-scale nuclear war over relatively small international crises like the periodic shelling of the islands of Quemoy and Matsu by the Peoples' Republic of China. In addition, the successful Soviet launch of Sputnik in 1957 led many Americans to believe that U.S. nuclear superiority was at risk.

Sputnik also added to U.S. Cold War concerns a blatant discussion of the need for scientific superiority over the Soviet Union to remain secure. The scientific community and

⁹¹ Herbert F. York, "Making Weapons, Talking Peace," *Physics Today* (April 1988): 44–45; and Westwick, *The National Labs*.

policy analysts already tended to compare progress in big science projects—e.g., accelerators and reactors—as part of the calculation of whether the Soviets were outpacing the U.S. The national laboratories compared their own technical capabilities, particularly in high-energy research and reactor work, to the Soviet efforts. With Sputnik, the brainpower behind U.S. military might was brought to the forefront in the public's mind and educational initiatives received widespread support in an effort to beat the Soviets.

In terms of specific interpretations of Sputnik's meaning within the nuclear arms race, the satellite illustrated the Soviet's success in rocket research. The leap from launching a satellite into space to launching a missile into space was not great in the imaginations of public and weapons designers alike.

The doctrine of massive retaliation was gradually yielding to the reality of mutual assured destruction, which essentially meant both sides had enough firepower to destroy one another completely should a nuclear war begin. This was the key thinking behind the idea of deterrence for most of the Cold War—that is, that both sides knew that initiating nuclear war would mean annihilation for both. Such annihilation was promised not only through the numbers of weapons, but also via the deployment options and variety of capabilities within each nation's stockpile. Thus, mutual assured destruction as a deterrent justified the pursuit of varieties of weapons as well as great numbers.

In the last years of his administration, Eisenhower hoped to end the Cold War and

the arms build-up through negotiation with the Soviet Union. He did succeed in negotiating a moratorium on nuclear testing between the United States and the Soviet Union. In place from 1958 through 1961, the hiatus in testing redirected some research efforts within the nuclear weapons complex, but did not deter nuclear weapons design efforts and build-up. LLNL continued to grow during this period, adding about 1,000 employees to its staff.⁹²

Eisenhower's final hopes for bringing an end to the Cold War in his presidency died when the U.S. U-2 surveillance aircraft carrying Francis Gary Powers was shot down by the Soviets in 1960.

4.4 Kennedy and Flexible Response

John Kennedy campaigned for the presidency on the pledge to close the supposed "missile gap" with the Soviet Union and willingly assumed the Cold Warrior mantle when he became President in 1961. He was undeterred when he discovered after becoming President that the United States actually enjoyed a large missile superiority over the Soviets.

Robert McNamara, U.S. Secretary of Defense under both Kennedy and Johnson, developed a new policy for the use of nuclear weapons. Known as "Flexible Response," the policy de-emphasized deterrence via massive retaliation and replaced it with a scaled plan of response in which the threat of nuclear weapons targeted at an enemy's population centers provided leverage for ending conflict. The policy embraced the notion of fighting and winning a limited nuclear war. Tactical

⁹² Bart Hacker, "A Short History of the Laboratory at Livermore," *Science and Technology Review* (September 1998), 16.

weapons were clearly emphasized, and the administration supported further stockpile growth.

Among the weapon options that entered the stockpile during Kennedy's presidency was the navy's Polaris missile, equipped with an LLNL-designed warhead. Also during this period, LLNL began working with the newly invented laser technology, applying its power to a variety of weapons and other research areas.

The most dangerous moment of the Cold War occurred during Kennedy's presidency. During the summer months of 1962, U.S. intelligence agencies observed and identified construction of nuclear missile sites in Cuba. Soviet-supplied equipment and technicians were creating the sites. Kennedy authorized a naval and air blockade around Cuba; Soviet ships stopped before arriving at the blockade. With the U.S. preparing to attack Cuba, Soviet Premier Nikita Khrushchev offered to remove the missile bases. Kennedy agreed not to invade Cuba and to remove U.S. missiles from Turkey. The next year, the two leaders finalized negotiations on the Limited Test Ban Treaty (LTBT), banning nuclear testing in the atmosphere, in the oceans, and in space.

In response to the military humiliation of the Cuban Missile Crisis, the Soviet Union embarked on a significant increase in its nuclear stockpile that would continue for the next two decades, providing justification for further U.S. increases in the 1980s.

4.5 Johnson and Assured Destruction

As President, Lyndon Johnson was much more concerned with issues of domestic

policy (e.g., civil rights, the Great Society, and the War on Poverty) than with foreign policy. In addition to contributing to the drift into the quagmire of Vietnam, this focus also resulted in shifts in nuclear strategy and policy. The increasing size of the Soviet arsenal resulted in (1) a gradual move back to the doctrine of assured destruction in the event of nuclear war, and (2) growing political pressure for arms control.

The war in Vietnam only reinforced these trends, and the 1960s began a series of nuclear arms control agreements between the United States and the Soviet Union. The first was the LTBT, concluded by Kennedy in 1963. In 1965, Johnson committed the United States to a Nuclear Non-Proliferation Treaty, which he signed in 1968 but which was not ratified until 1970.

Simultaneously, McNamara began to push to redefine U.S. policy again. Given the competition in the defense budget, and with his own experiences of the Berlin Crisis and the Cuban Missile Crisis in mind, McNamara articulated a change in the U.S. nuclear weapon policy under Johnson. He focused again on deterrence and, admitting the U.S. stockpile was already more than adequate, rebuffed proposals for additional weapon production. Johnson agreed, and the first reduction in the U.S. nuclear weapon program began.

With fewer weapon systems in design, some sites within the nuclear weapons complex were closed as early as 1964. By the end of the 1960s, growth in the size of the U.S. nuclear stockpile was clearly slowing. Even with the shift toward larger numbers of tactical weapons, the size of the arsenal, both in megatonnage and the

number of weapons, was on the decline by 1968. The consolidation of the complex continued, slowly, over the next three decades. The weapons design laboratories did not feel the contraction as early as the rest of the complex. LANL, already a mature institution, remained relatively stable in size throughout the 1960s, while LLNL continued to grow significantly during this period. They and the other national laboratories would begin to feel the effects of fewer weapon programs, growing criticism of U.S. scientific programs during the Vietnam War, and budget cuts in the face of post-1968 U.S. inflation in the 1960s. Figure 11 indicates the facilities in the nuclear weapons complex in 1968.

4.6 Nixon and Flexible Targeting

Richard Nixon's foreign policy triumphs with Moscow and Beijing resulted in a temporary thaw in Cold War relations known as *détente*. The most important consequences of *détente* for nuclear policy were the Anti-Ballistic Missile Treaty (1972) and the Strategic Arms Limitation Treaty (1972). By the early 1970s, treaties on these issues had become particularly important for both foreign and domestic policy. The development of anti-ballistic missiles had, by then, begun to threaten the stability of nuclear deterrence, and the development of Multiple, Independently Targetable Re-entry Vehicles (MIRVs), which permitted both sides to put many warheads on a single missile, threatened to cause an enormous acceleration of the arms race.

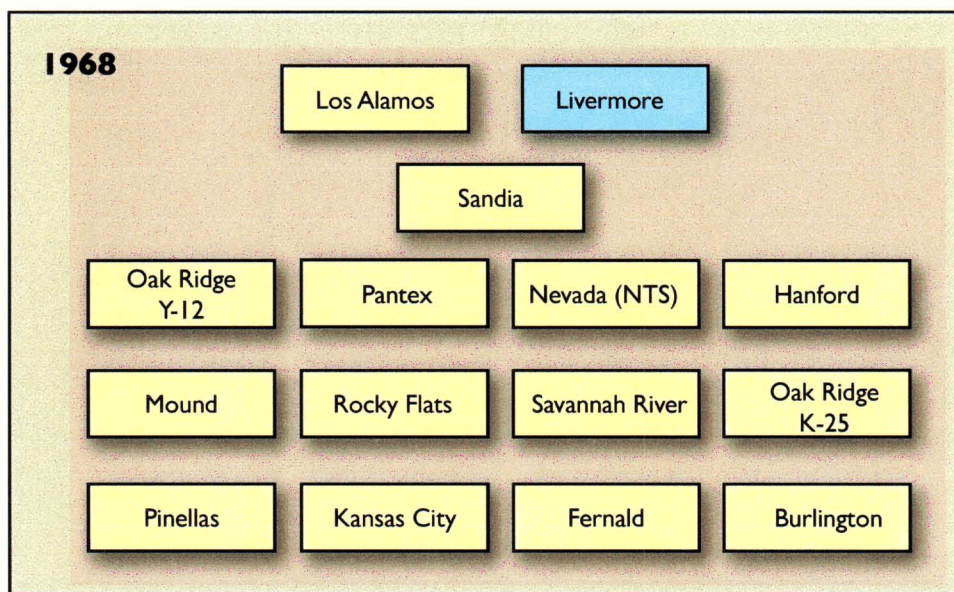


Figure 11. U.S. nuclear weapons complex, 1968.⁹³

⁹³ This figure is adapted from Loeber, *Building the Bombs*, 146.

MIRVs also offered possibilities to Cold War policymakers. If McNamara and Johnson saw MIRVs as a cheaper alternative to building additional weapon systems, Nixon's advisers saw them as another opportunity to pursue flexibility in war planning. The idea of the multiple warheads, aimed at different targets, was incorporated into a policy referred to as "Flexible Targeting," which was reminiscent of Kennedy's Flexible Response. Both emphasized controlled escalation during a war, introducing nuclear weapons as an option at various points in planning. MIRV technology appeared desirable, and stockpile numbers increased again.

LLNL's warhead design teams explored the possibilities and challenges offered by MIRV. The Laboratory's warheads for Minuteman II, Poseidon, and the second generation of Polaris were all MIRV designs.

Shortly after taking office, Nixon and his staff began an investigation of options for reorganization of the executive branch. One of the eventual results of this activity was the end of the AEC and JCAE, a significant transformation in the basic organization and outlook of the bureaucratic side of the nuclear weapons complex.

Over the next few years, several possible scenarios were explored for reconfiguring the different activities contained within the purview of the AEC, but the basic concern surrounded the fact that the AEC both promoted and regulated nuclear energy. The JCAE, a powerful and effective body within the Congress, had often been at odds with both the executive and other members of the legislative branch, as it was perceived to operate independently.

Finally, late in 1974, President Gerald Ford signed the Energy Reorganization Act, which separated the promotion and regulatory functions of the AEC. In January 1974, two new agencies replaced the AEC, which was abolished. The Nuclear Regulatory Commission (NRC) took over regulation of the nuclear energy industry. The Energy Research and Development Administration (ERDA) absorbed the rest of the AEC's functions, but was also charged to pursue non-nuclear energy options and to address environmental protection.

Shortages of natural gas and oil dominated the 1976 election campaigns of President Gerald Ford and Jimmy Carter. Carter implemented their mutual campaign promises of a centralized, comprehensive national energy policy by introducing legislation and signing the resulting bill to establish a cabinet-level department. DOE took over everything ERDA had operated, as well as the various power activities formerly included in the Department of the Interior, several power commissions, and other related energy functions from other agencies. DOE began operations on October 1, 1977. Also in 1977, the JCAE finally was abolished by amendment of the Atomic Energy Act.⁹⁴

During the mid-1970s, LLNL experienced a slow-down in growth as well as a redirection of some of its efforts into energy programs. In particular, the Laboratory pursued the large and expensive dream of fusion energy with its assignments in magnetic fusion research.

⁹⁴ Glenn T. Seaborg and Benjamin S. Loeb, *The Atomic Energy Commission under Nixon: Adjusting to Troubled Times* (New York: St. Martin's Press, 1993).

4.7 The Final Decade of the Cold War

In his single term as President, Jimmy Carter stressed the importance of international human rights. As for nuclear matters, his administration focused on securing further arms control agreements with the Soviet Union. These negotiations led to the signing of SALT II, a treaty that was shelved after the 1979 Soviet invasion of Afghanistan and never ratified by the U.S. Senate.

Ronald Reagan's reinvigoration of Cold War tension entailed a striking departure from earlier Cold War presidents: open discussion of how the United States could plan to fight, survive, and even win a nuclear war with the Soviet Union.

The hard-line language was accompanied by the largest peacetime military build-up in the nation's history. While most of the \$2 trillion defense program was aimed at non-nuclear weaponry, the budget included multiple new nuclear weapons systems, as well as the Strategic Defense Initiative (SDI). Serving the dual purpose of further intimidating Soviet leaders and quelling domestic pressure for a nuclear freeze, SDI proposed to build an anti-ballistic missile shield that would protect the entire nation against nuclear missile attack.

Popularly known as "Star Wars," SDI research focused on developing laser weapons and satellites to serve as a shield against incoming missiles. LLNL was a large recipient—the largest in California—of funding for SDI research. The Laboratory's work in laser research up to this point made it an obvious participant in the effort. LLNL

embarked on research to develop a free electron laser (FEL) and build a prototype of the laser weapon proposed to target enemy missiles via a large mirror in space off of which the laser's beam could be redirected. The Laboratory proposed building the prototype at Site 300, the test site it operates outside of Livermore, in Alameda and San Joaquin counties. Building it required more land than was available at Site 300 and a small land war ensued between local ranchers and DOE over acquiring additional property. SDI was cancelled in 1987 before the land was appropriated, and the issue was dropped.

4.8 Stand-Down

George H. W. Bush entered the White House in 1989 and oversaw the U.S. stand-down and demobilization from the Cold War.

The Soviet Union experienced radical reform under Mikhail Gorbachev in the late 1980s. The Communist regimes of Central Europe began to crumble as the citizenry took advantage of Gorbachev's reforms and their own demands for free elections to drive out hard-line leaders. In November 1989, East Germans forced the gates of the Berlin Wall open and began to tear it down.

In the summer of 1991, Bush and Gorbachev signed the Strategic Arms Reduction Treaty (START), agreeing to a 30–40% cut in strategic nuclear weapons. He then announced that the United States would unilaterally reduce its stockpile. He cancelled weapon programs in development. Congress later legislated a moratorium on nuclear testing.

Gorbachev withstood a coup in August 1991, but the Soviet Union itself dissolved in December. With the demise of the Soviet Union, the Cold War came to an end. The weapons laboratories underwent a period of transition as weapons design programs and testing options were cancelled. LLNL's efforts were redirected into large non-weapons programs such as inertial confinement fusion and the atomic vapor laser isotope separation effort.

In the end, the nuclear arms race portion of the Cold War is estimated to have cost the United States \$5.8 trillion. The Cold War's end brought a concern about and adjustment to the changing role of nuclear weapons in international diplomacy and events.



5. POST-COLD WAR CONTEXT

As the Cold War ended and nuclear testing ceased, LLNL's mission emphasis evolved, focusing more on nuclear science research interests, stockpile surveillance and maintenance, non-proliferation, and other scientific and technological aspects of national security.

In assessing the significance of LLNL, the Post-Cold War context poses difficulties. The Post-Cold War period, from 1991 to the present, is very recent history. The historical events of these recent years have barely begun to form into a coherent narrative. Only the most rudimentary suggestions may be formed for historical significance and preservation themes.

The U.S. decisions to halt all nuclear testing and the development of any new nuclear weapons in the foreseeable future mean that Nuclear Weapons Design and Nuclear

Weapons Testing have less importance in the Post-Cold War period as preservation themes. The divisions at LLNL that continue to do weapons research and development have shifted their focus to safety, maintenance, and modifications of the stockpile and away from the design and testing of new nuclear weapons.

However, Nuclear Research and Non-weapons Research appear to be of greater importance as preservation themes in the Post-Cold War context. In recent years, fusion, biomedical, environmental, and energy research have joined weapons research and development as primary missions at LLNL.

There do not appear to be any new themes introduced thus far into the Post-Cold War period. Therefore, the identifiable themes are as follows:

Nuclear Weapons Design

- Computing

Nuclear Weapons Testing

- High Explosives Testing

Nuclear Research

- Nuclear Physics Research
- Nuclear Chemistry Research
- Nuclear Materials Research

Non-weapons Research

- Nuclear Energy Research
- Nuclear Propulsion Research
- Biomedical Research

5.1 Criteria Consideration G

Most properties under fifty years of age are disqualified from National Register consideration automatically. However, Criteria Consideration G allows for National Register consideration of properties less than fifty years old if it can be demonstrated that they are of exceptional importance.

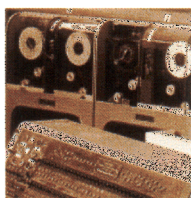
Although most buildings at LLNL are less than fifty years of age, they can be assessed under Criteria Consideration G. For example, themes within the Cold War context have thresholds establishing events of exceptional historic significance, as identified in section 6, below.

An LLNL facility may qualify for National Register consideration under the Post-Cold War context if it is associated with a

Post-Cold War event or a trend, person, or building style recognized to be of exceptional historic significance. At this juncture, a building built at LLNL since the Cold War's end would not be likely to meet such a threshold.

The themes most likely to produce properties of exceptional significance would be Nuclear Research and Non-Weapons Research. If, for instance, the ICF program at LLNL successfully achieves its goal of creating energy from fusion, then properties associated with that scientific achievement would need to be assessed. Likewise, the theme of Non-Weapons Research, and subtheme of Biomedical Research might also produce properties of exceptional significance if a breakthrough discovery in DNA should occur at LLNL.

Nuclear Weapons Design and Nuclear Weapons Testing are not likely to produce properties of significance in the Post-Cold War context. LLNL has not designed or tested new weapons since the late 1980s. However, should the U.S. resume design or testing of nuclear weapons and subsequently make new scientific breakthroughs in nuclear weapons technology, then buildings associated with these activities would also need to be assessed.



6. LLNL COLD WAR MISSIONS AND PRESERVATION THEMES

In 1952, the AEC established LLNL as a second nuclear weapons design facility. Herbert York, the first director of LLNL, articulated four missions for the new laboratory: designing thermonuclear weapons, providing diagnostic measurements for weapons tests for Los Alamos and Livermore, developing controlled thermonuclear reactions for power sources, and basic physics research.⁹⁵

As LLNL grew and the Cold War progressed, other missions were added. In the mid- and late-1950s, Rover and Pluto, programs to develop nuclear-propelled vehicles and missiles, and Project Plowshare, a nuclear engineering project, became major programs at the Laboratory. In the early 1960s, LLNL added a biomedical research program to its repertoire. In the 1970s and 1980s, energy research, stockpile safety, and stockpile

surveillance were added to the Laboratory's areas of research.

These missions form the basis for establishing the Cold War preservation themes for the assessment of structures and buildings at LLNL. The LLNL Cold War preservation themes and subthemes are:

Nuclear Weapons Design

- Weapons Design
- Computing

Nuclear Weapons Testing

- Nuclear Testing
- High Explosives Testing

Nuclear Research

- Nuclear Physics Research
- Nuclear Chemistry Research
- Nuclear Materials Research

Non-weapons Research

- Nuclear Energy Research
- Nuclear Propulsion Research
- Plowshare
- Biomedical Research

⁹⁵ University of California, Lawrence Livermore National Laboratory, *30 Years of Technical Excellence* (Livermore: Lawrence Livermore National Laboratory, 1982), 4; Herbert York, oral interview, 1981, LLNL Archives, 5–6; and York, "Making Weapons, Talking Peace," 44–45.

The following discussion of preservation themes is based on the historical activities of LLNL. Accordingly, the historical designations of LLNL research organizations are used. LLNL has undergone many re-organizations and research has occurred under many different organizations with many different titles over time. The following discussion does not represent the current organization of the Laboratory. Today, the smallest organizational unit is called a Group, then in ascending order, a Division, Department, Directorate or Program. However, in the past the Laboratory was organized much more informally and organizational titles did not adhere to present-day delineations or logic.

6.1 Theme: Nuclear Weapons Design

LLNL is one of only two laboratories responsible for designing the nuclear physics packages for weapons for the U.S. nuclear stockpile. The proposal to create the new laboratory and the AEC's support of it hinged largely on perceptions of stockpile needs and the thought that an additional facility to support and ultimately compete with LANL would improve the overall nuclear posture of the United States.

As a result, the Nuclear Weapons Design preservation theme clearly ties LLNL to the Cold War arms race. This theme is organized into two subthemes, Weapons Design and Computing, in order to fully delineate the type of work that nuclear weapons design entails and the potential for historically significant moments within it.

6.1.1 Subtheme: Weapons Design

In 1953, the AEC and the Department of Defense (DoD) reached an agreement that

detailed the process entailed in the design and production of nuclear weapons. The document listed six phases in the life of a weapon. A seventh phase was added in later years. The seven phases of the life cycle of a nuclear weapon are listed below.

Phase 1: Weapon Conception

- This phase involves the exchange of preliminary information that may lead to a feasibility study of a weapon program. This phase may involve studies done by LANL, LLNL, SNL, and/or the DoD, either independently or in cooperation with one another.

Phase 2: Feasibility

- In this phase, the AEC, DoD, and the contractor investigate the weapon concept and decide whether it can be applied and manufactured. If the weapon appears feasible, the AEC will issue a Phase 3 authorization for the development of the weapon.

Phase 3: Development

- During this phase, the weapon concept is given further design definition. A development program is launched based on the required military characteristics. Prototypes are produced and evaluated by both the AEC and the DoD.

Phase 4: Production Engineering

- In this phase, designs are translated into production terms. Tool-made samples are fabricated. Product specifications are released to the DoD.

Phase 5: Initial Production

- In this phase the first units are manufactured and delivered. Final evaluations are conducted and weapon models are approved for standardization.

Phase 6: Quantity Production/ Stockpile

- Weapons are produced in quantity and checked for quality as they enter the stockpile, and checked again during their stockpile life.

Phase 7: Retirement

- The weapon is removed from the stockpile and disassembled.⁹⁶

LLNL's primary mission during the Cold War was to design nuclear weapons. The weapons design process involved the first three phases of the weapon life cycle.

The primary responsibility for weapons design at LLNL fell to scientists in the Experimental Physics Division. Their interest lay in nuclear explosive technology and included designing nuclear experiments and devices, weapons for particular military applications, and nuclear explosives. Weapons design was largely theoretical in nature. This process proceeded through a complex series of thought experiments, which they described using the German word *gedanken*.⁹⁷

LLNL physicists first calculated by hand and used other "approximate analytical methods" to explore a new weapons

concept.⁹⁸ When the design began to take shape, its performance was calculated on high-speed computers. The computer then revealed any design flaws that required correction and recalculation. This stage of the design process could take anywhere from several months to a year. If the design continued to perform well on a theoretical basis, then a prototype device was constructed and tested to see if its actual physical performance met theoretical expectations.

The Experimental Physics Division pursued interesting nuclear technology independent of any specific weapons design assignment in order to advance the understanding of the properties and possibilities of the technology. The division also designed weapons to meet the military requirements of particular armed services as specified in the Phase 3 activities.

LLNL's initial attempts to design weapons ended in bitter disappointment. On March 31, 1953, six months after LLNL opened, Ruth, its first device, was tested at the Nevada Test Site (NTS). The explosion left the test tower partially intact—indicating that the test's yield was far below expectations. The test stand for the Ruth shot appears in figure 12. LLNL fired a second device, Ray, the next month. It too was considered a failure—a fizzle in weapons parlance.

Undaunted, LLNL physicists designed two more devices for the Castle test series in 1954, at the Pacific Proving Grounds (PPG). These shots also proved disappointing. LANL fired first during the Castle series. The LANL shot, Bravo, exceeded all

⁹⁶ The phases of the weapon life cycle are adapted from "An Agreement between the AEC and the DOD for the Development, Production, and Standardization of Atomic Weapons," 21 March 1953, AEC 485/24, Box 1264, Folder MRA9-1 Design and Development, Department of Energy, Headquarters, Historical Archives, Germantown, Maryland, 3-5 (hereafter cited as DOE Archives); and Leland Johnson, *Sandia National Laboratories: A History of Exceptional Service in the National Interest*, SAND97-1029 (Albuquerque: Sandia National Laboratories, 1997), 52-53.

⁹⁷ LLNL weapons design information is from University of California, *Status Report: Fiscal Year 1958* (Berkeley: University of California Lawrence Radiation Laboratory, 1958), 81-83; and University of California Lawrence Radiation Laboratory, *Status Report: Fiscal Year 1959* (Berkeley and Livermore: University of California Lawrence Radiation Laboratory, 1959), 17-18.

⁹⁸ *Status Report: Fiscal Year 1958*, 81.



Figure 12. Ruth test stand, first LLNL test shot, 1953.⁹⁹

expectations with a yield of fifteen megatons. LLNL scientists designed the Koon device. The shot fizzled. In disappointment, LLNL scientists canceled the second shot.

LLNL returned to its design efforts and soon began to produce successful test shots and earn weapons assignments. On March 1, 1955, LLNL fired its first successful thermonuclear test shot in the Teapot test series at NTS. That summer, the Laboratory received its first nuclear weapons development assignment. LLNL contracted to produce a small warhead,

designated the W27, for the Regulus II navy missile.¹⁰⁰

Other weapons assignments followed. In 1956, LLNL began the design and development of the W45 for the army's Little John and Terrier tactical missile systems, and the W48 for the 155-millimeter howitzer atomic projectile.¹⁰¹ In 1957, LLNL received what would become one of its most successful weapons assignments—the design of a small warhead to fit the Polaris,

⁹⁹ The Ruth Test Stand, Negative GLC-11, Box 145, Folder 10975, LLNL Archives.

¹⁰⁰ "Lawrence Livermore National Laboratory," unpublished history, n.d., 6.

¹⁰¹ *Serving the Nation for Fifty Years*.

a submarine-launched ballistic missile. LLNL received the Navy Certificate of Merit in 1961 for its design.¹⁰² The Polaris was a solid-propellant intermediate-range ballistic missile armed with the W47, a small high-yield warhead, which could be launched from a submerged submarine. This represented a significant strategic capability for the navy.

Since 1945, a total of sixty-nine different weapons have been placed in the nuclear stockpile. LLNL designed its first warhead, the W27, in 1958. Thereafter, of the total number of weapons deployed (forty-three), LLNL designed seventeen and LANL designed twenty-seven. Figure 13 lists the LLNL nuclear weapons deployed in the stockpile from 1945 to 1989.

This report does not review all of the individual nuclear weapons designs developed by LLNL. Instead, the discussion will focus on major breakthroughs in nuclear weaponry and how LLNL contributed to their development. These breakthroughs in weapon technology will be used to assess the historic significance of LLNL facilities involved in the design of nuclear weapons. However, the overall impact of LLNL nuclear weapons designs on the development of the U.S. nuclear stockpile also is significant; facilities and objects also will be evaluated regarding their contribution to all or a majority of the LLNL weapons designs.

Nuclear Bombs

LANL scientists designed the first atomic bombs—Fat Man and Little Boy. Fat Man, an implosion device, detonated a sphere of conventional HE that compressed a sphere

of nuclear material into a supercritical mass. The introduction of neutrons to the core initiated the nuclear fission chain reaction—and the resulting nuclear explosion. Little Boy, a gun-type device, accelerated two sub-critical pieces of nuclear material into each other within an elongated gun-shaped cylinder to create a supercritical mass, which then resulted in a nuclear explosion. Of these two methods, the implosion device used less nuclear material and was the more efficient. These early weapons each had a yield equivalent to approximately 20,000 tons of TNT.

Post-WWII improvements in weapons design included advances in HE, pit design, tampers, and initiators. LANL, as the only design laboratory at the time, made all the

WEAPON DESIGN	ENTERED STOCKPILE	DELIVERY SYSTEM (FOR WARHEADS)
B27	1958	
W27	1958	Regulus I, Rascal
W38	1961	Atlas E/F, Titan I
B41	1960	
W45	1962	Little John, Terrier, Bullpup, MADM
W47	1960	Polaris A1/2
W48	1963	155-mm Artillery
W55	1964	SUBROC
W56	1963	Minuteman II
W58	1964	Polaris A3
W62	1970	Minuteman III
W68	1970	Poseidon C3
W70	1974	Lance
W71	1975	Spartan
W79	1986	8-inch Artillery
B83	1983	
W84	1983	Ground-launched Cruise Missile
W87	1986	Peacekeeper

Figure 13. LLNL nuclear weapons, 1945–1989.

¹⁰² "Memorandum to Editors," press release, 3 March 1961, 31045, Box 213, Folder 2045, LLNL Archives.

early technological advances in nuclear bomb design.

Thermonuclear Weapons

The most significant technological breakthrough in nuclear weapons design in the post-WWII period was the development of the hydrogen or thermonuclear bomb. A thermonuclear bomb used an explosive fission reaction to create fusion—the joining of the isotopes of hydrogen with a heavier element like helium. The result was a greater yield than fission alone could produce. This kind of reaction was thought to occur naturally only in the stars and sun.¹⁰³

In 1942, LANL first pursued thermonuclear research as an alternative route to atomic weaponry. In 1944, Edward Teller, then at LANL, headed up a special group devoted entirely to research on the hydrogen bomb. By 1946, LANL scientists concluded that a hydrogen bomb, although theoretically feasible, still required too much work to be ready for wartime use. Research on the thermonuclear took a backseat to fission weapons design at LANL both during and after the war.¹⁰⁴

In 1949, the Soviet Union detonated its first nuclear weapon, reawakening interest in the development of the hydrogen bomb. In 1950, Truman tasked the AEC to develop a thermonuclear weapon. LANL renewed its efforts in thermonuclear research.

In 1951, Teller and Stanislaw Ulam, a LANL mathematician, came up with a break-

through in thermonuclear design—radiation implosion—the use of radiation from a fission explosion to create the fusion reaction. Despite this important advance in thermonuclear research, Teller became impatient with LANL director Norris Bradbury's support of the project and began to push for another AEC sponsor.

Teller approached E. O. Lawrence, director of the University of California Radiation Laboratory (UCRL), and together, in 1952, they persuaded the AEC to establish a second nuclear weapons design laboratory in Livermore, California.

In the meantime, LANL scientists continued their work on thermonuclear weapons. In 1952, they detonated the first successful full-scale thermonuclear device, the Mike shot, during Operation Ivy. The device used in Mike weighed approximately 65 tons. The task of inventing a deliverable thermonuclear weapon still remained.

In 1954, production began of LANL's B14, the first thermonuclear weapon in the U.S. stockpile.

In 1955, LLNL detonated its first successful thermonuclear device during the Teapot test series. Soon after, the Laboratory received the assignment to develop a thermonuclear weapon for the navy Regulus II missile.

LLNL's B27 and W27 began production in 1958. The B27 was one of the first small two-stage thermonuclear weapons. LLNL weapons physicists designed the B27 to be dropped or lofted from a navy bomber. Only a few navy aircraft had bomb bays big enough for the B27. It was retired in

¹⁰³ Loeber, *Building the Bomb*, 230; and Richard Rhodes, *Dark Sun*, 247.

¹⁰⁴ For an in-depth history of the development of thermonuclear weapons see Rhodes, *Dark Sun*.

1960. The W27 weighed 2,800 pounds and fit the navy Regulus II and the air force Rascal missiles. It remained in the stockpile until 1962.

Tactical Nuclear Weapons/Atomic Artillery

Early nuclear strategy relied on large, high-yield weapons delivered by the air force. However, the army and navy also wanted access to nuclear technology. In 1950, physicists at LLNL began designing tactical nuclear weapons or atomic artillery for the army.

Tactical nuclear weapons were short-range and smaller in size and yield than weapons used by the air force. They consisted of a nuclear artillery shell that could be loaded into a cannon or a warhead that could be launched from a tactical missile.¹⁰⁵ The advantage in atomic artillery was that it could be used much like conventional weaponry in limited engagements. The disadvantage was the close-range detonation of a nuclear device to those who deployed it.

LLNL designed the first nuclear artillery warhead, the W9, for the army's 280mm howitzer. Production began in 1952. The shell weighed 900 lbs. The cannon designed to deliver it weighed ninety-three tons with a gun carriage made of two separate tractor units, each with its own driving and steering equipment. The 280mm howitzer had a range of fourteen miles.

The air force and navy opposed the use of precious nuclear material on atomic artillery and opposed the W9 project. Their critique

was not unjustified—the W9 was very inefficient even for a gun-type weapon. Although LLNL went on to improve subsequent models, scientists found the work uninteresting and secondary to the development of large high-yield implosion devices. Nevertheless, Eisenhower's New Look emphasized reliance on a diversified nuclear arsenal with tactical as well as strategic weapons.

LLNL's interest in thermonuclear weapons with a smaller yield led to an interest in developing atomic artillery and tactical nuclear weapons for the army. In 1953, the army approached the AEC with a request for an even smaller warhead for their eight-inch howitzer. Shortly afterwards, Teller let the AEC know that LLNL had been doing some research in small fission weapons. Herb York, director of LLNL began to let key staff know that the Laboratory might soon become involved in the "small weapons business."¹⁰⁶

In 1955, the AEC officially made LLNL the lead laboratory for the development of atomic artillery. In 1957, LLNL received the assignment to develop a nuclear artillery shell for the army's 155mm howitzer. The W48 entered the stockpile in 1962. LLNL retained the responsibility for atomic artillery over the years. In 1981, LLNL designed the

¹⁰⁵ Loeber, *Building the Bombs*, 87–90.

¹⁰⁶ C. L. Blue to W. B. Reynolds, 8 June 1953, Ernest Orlando Lawrence Berkeley National Laboratory Declassified Records, 434–95, Box 4, File 19–10–364, Lawrence Berkeley National Laboratory Archives, 1 (hereafter cited as LBNL Archives).

W79, an eight-inch artillery shell, which replaced LANL's long-lived W33. The W33 went into the stockpile in 1956, shortly before LANL abdicated responsibility for atomic artillery to LLNL.

In addition to atomic artillery, LLNL also designed other tactical nuclear weapons for the army and navy. These tactical weapons were short-range, low-yield missiles and atomic munitions. In 1962, production began of LLNL's W45 warhead, which fit a variety of different delivery systems—the air force air-to-surface missile, Bullpup; the navy surface-to-air missile, Terrier; and the army surface-to-surface missile, Little John. The W45 was also adapted to fit the army Medium Atomic Demolition Munition. The W45 was designed to deliver different yields depending on the delivery system.

Intermediate-Range Ballistic Missiles (IRBM)/Inter-Continental Ballistic Missiles (ICBM)/Submarine-Launched Ballistic Missiles (SLBM)

IRBMs, ICBMs, and SLBMs were significant advances in nuclear delivery systems. Ballistic missiles—capable of leaving the earth's atmosphere and re-entering to reach a target—changed the stockpile almost as radically as the development of thermonuclear weapons. Thermonuclear warheads could be attached to ballistic missiles and launched by land or sea at considerable distances from a target.

An IRBM had a rocket-propelled vehicle with a range of 1500 to 3000 nautical miles. An ICBM was a rocket-propelled vehicle capable of delivering warheads between continents. An ICBM had a booster, re-entry vehicle, and penetration aids. An SLBM was a rocket-propelled vehicle launched from

a navy submarine. Warheads for IRBMs, ICBMs, and SLBMs needed to be extremely small and compact.

In 1954, the AEC successfully tested light-weight nuclear warheads during the Castle test series. In 1955, Eisenhower approved the development of four ballistic missiles: two air force ICBMs, the Atlas and Titan; and two IRBMs, one for the air force (Thor) and one for the army (Jupiter). Eisenhower placed top priority on the ballistic missile program.¹⁰⁷

In 1956, the AEC charged both LANL and LLNL with designing a warhead that could be used in all four of the proposed missiles. In 1959, the first Atlas ICBM was equipped with a LANL W49, and stationed at Vandenberg Air Force Base in California. In 1959, the Thor IRBM equipped with the LANL W49 also entered the stockpile.

Fewer than 100 ICBMs were deployed between 1959 and 1962. The LLNL-designed W38, a larger yield warhead for the Atlas ICBM, began entering the stockpile in 1961. In 1962, the Titan ICBMs were deployed, all equipped with the LLNL W38 warhead.

The second generation ICBMs, the Minuteman I and Minuteman II were deployed between 1962 and 1969. The majority of these missiles were equipped with the LLNL-developed W56 warhead.

The navy also insisted on a ballistic missile and plans were made to convert the Jupiter missile for submarine use.

¹⁰⁷ Ronald E. Powaski, *March to Armageddon: The United States and the Nuclear Arms Race, 1939 to the Present* (New York: Oxford University Press, 1987), 63.

In 1956, Teller attended a navy study group at Woods Hole, Massachusetts, and boldly promised that LLNL could deliver in three years a warhead small enough to be launched from a submarine. In 1957, the navy abandoned the Jupiter program and awarded LLNL the Polaris contract to develop a warhead for an SLBM.

LLNL physicists faced a real challenge. Jack Rosengren, a Polaris physicist, noted that existing warheads were “simply too large and heavy to be thrown any real distance” by current missile technology. Nevertheless, in 1958, the Experimental Physics Division made important breakthroughs on Polaris, which were confirmed during Operation Hardtack at Bikini just months before the nuclear testing moratorium began.¹⁰⁸

Despite the three-year moratorium, LLNL completed work on the W47 warhead for Polaris on schedule. In 1960, the Navy launched the U.S.S. George Washington, the first submarine equipped with the Polaris SLBM.¹⁰⁹ Figure 14 depicts the launch of the Polaris missile equipped with the W47.

The navy also proposed the development of a submarine-launched rocket (SUBROC) at the 1956 Nobska summer conference. A SUBROC posed many difficult technical challenges for weaponeers. The SUBROC would launch from a submerged submarine torpedo tube, rise to the ocean surface, fire its rocket, fly several miles, and submerge again to a pre-set depth and detonate its target. These were very sophisticated procedures for 1950s signal and sonar technology.

¹⁰⁸ Chet Fankhauser to F. C. Gilbert, text of proposed Polaris article, 29 August 1972, 31045, Box 213, Folder 2045, LLNL Archives, 2–4.

¹⁰⁹ “Nuclear Weapons Research,” *Newsline* (August–September 1977), 1–2.

In 1959, the navy formally requested the development of a warhead for the SUBROC rocket. In 1964, LLNL’s W55 warhead for the SUBROC began production.

Multiple Independently Targeted Re-entry Vehicle (MIRV)

In the 1970s, scientists developed MIRVs, the next breakthrough in nuclear technology with a significant impact on U. S. strategic nuclear capability. By placing multiple warheads on a single missile, MIRVs allowed each missile launched to hit several targets. This technology increased targeting flexibility and maximized the potential damage from each missile. MIRVs required much smaller warheads than any previous delivery system. The technology required for MIRV warheads “pushed the envelope of yield to weight ratio.”¹¹⁰ MIRVs also were the first ballistic missiles with radiation-hardened re-entry vehicles and components to protect the weapon from a nearby nuclear detonation—whether from another warhead or an anti-ballistic- missile weapon.

In 1964, LLNL introduced the first multiple re-entry vehicle technology, the W58 for the Polaris submarine. The W58 replaced the single W47 warhead with a cluster of warheads that dispersed like shotgun pellets.

In 1970, LLNL deployed the first MIRVed warheads—clusters that could actually be independently targeted. Between 1970 and 1975, new Minutemen III ballistic missiles entered the stockpile equipped with LLNL designed W62 warheads. Each W62 featured

¹¹⁰ *Serving the Nation for Fifty Years*, 45.

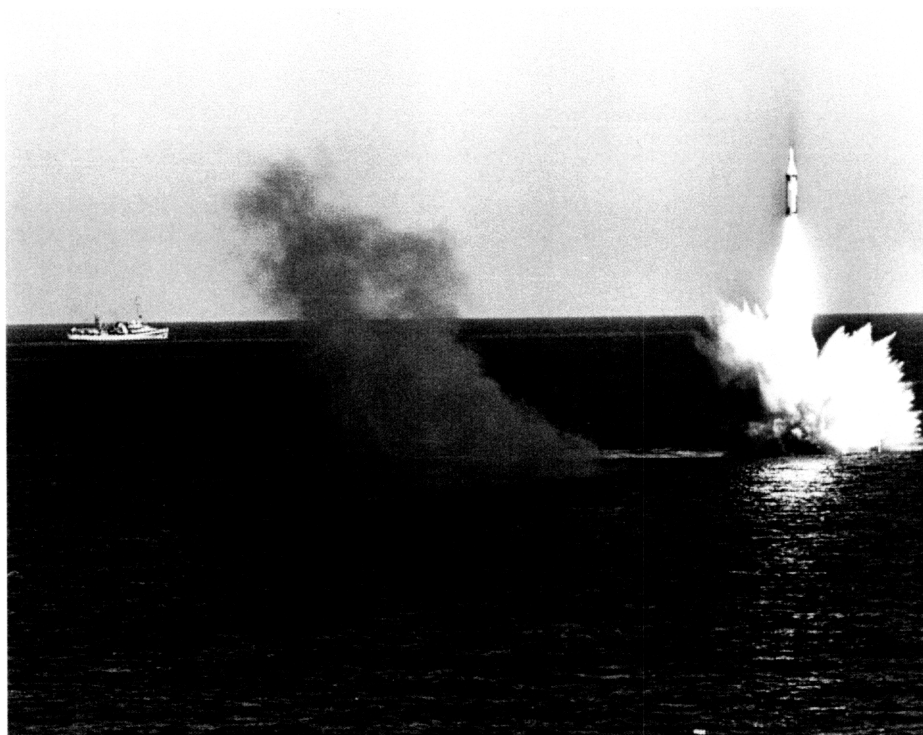


Figure 14. Polaris missile with LLNL-designed W-47 nuclear warhead, 1960.¹¹¹

three separate warheads, increasing the stockpile significantly. Between 1970 and 1975, the navy also MIRVed its submarine fleet, replacing all Polaris missiles with Poseidons. Each Poseidon missile carried the LLNL-designed W68 with anywhere from six to fourteen separate warheads.

In 1986, LLNL introduced the W87 for the MX Peacekeeper ICBM, one of the last MIRVed weapons to enter the stockpile. The W87 had several innovative features. It held ten to twelve warheads in a semi-tapered cone within the re-entry vehicle, could be fuzed for five different attack modes, and the primary used insensitive high explosive (IHE), an HE impervious to shock, heat, or explosions.¹¹²

¹¹¹ Polaris launch, Negative 1051516, Box 583, LLNL Archives.

Enhanced Neutron Radiation Warhead/Neutron Bomb

The neutron bomb was designed to kill enemy personnel with great quantities of neutrons but with negligible blast and heat effects to an area. Essentially, a neutron bomb would kill people and preserve buildings and equipment. This weapon's design reduced radiation and confined collateral damage to a smaller area than conventional nuclear weapons.¹¹³

In 1961, Teller first advocated the development of a neutron bomb. Although the Eisenhower administration rejected such research, LLNL continued to work on

¹¹² "Peacekeeper Warhead," *Energy and Technology Review* (July 1984), 33; "TATB Detonators," *Energy and Technology Review* (July 1985), 26–27; and "Defense Systems," *Energy and Technology Review* (July 1987), 12–13.

¹¹³ Loeber, *Building the Bombs*, 89.

enhanced neutron radiation warheads. In the mid-1960s, both LANL and LLNL began development of enhanced radiation warheads for the army Sprint, an anti-ballistic missile designed to knock Soviet ICBMs from the sky. In 1968, LLNL's W65 warhead was canceled in favor of the LANL-designed W66, which finally entered the stockpile in 1974.

LLNL developed two enhanced radiation warheads for the army—the W70 mod 3 for the Lance missile in 1973, and the W79 for the eight-inch artillery shell in 1981.

Of the seventeen weapons designed and introduced to the stockpile by LLNL, the W38, W47, W56, W62, W68, and W87 warheads represent either significant breakthroughs in nuclear weapons design or important strategic advancements in the U.S. stockpile. The bulk of the early ICBM missiles—the Atlas, Titan, Minuteman I, and Minuteman II—were armed with LLNL-designed warheads (the W38 and W56). The U.S. ICBM stockpile growth from 1959 to 1969 represented a significant increase in strategic capability and can be directly linked to Cold War policy in both the Kennedy and Johnson administrations. The W47 warhead used in the navy Polaris SLBM represented a brand new capability for the military—a fleet of ballistic missiles armed with nuclear warheads. The W62, W68, and W87 warheads on the Minuteman III, Poseidon, and MX Peacekeeper missiles, respectively, represent both technological breakthroughs and strategic advancements in the stockpile. MIRV weapons increased both precision in targeting and numbers of weapons in the stockpile.

Because LLNL was involved in the design of nuclear capabilities recognized by the military as strategically important within the larger context of Cold War policy, buildings where this work occurred may be eligible for National Register consideration.

However, until a design reached the testing phase, scientists performed the majority of the work in their minds, in conversation with their colleagues, and on paper, blackboards, and computers. Because nuclear weapons design work is primarily cognitive, it is not likely to be reflected in the buildings and structures at LLNL.

For an LLNL building to be considered historically interesting within the theme of nuclear weapons design, it must be associated with multiple weapons of strategic importance, or a major scientific breakthrough in nuclear weapons design must have occurred there. A scientific breakthrough or innovation in nuclear weapons design is defined as “the development of a new military technology that leads to significant changes...in the realm of strategy, in the organization of military forces, or in the distribution of resources among services.”¹¹⁴

In addition to its association with multiple weapons or breakthrough technology, the building must also possess integrity. That is, the building must clearly reflect the design work that occurred there during the period of historical significance.

¹¹⁴ This definition of innovation in weapons design is from Matthew Evangelista, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies* (Ithaca: Cornell University Press, 1988), 51.

6.1.2 Subtheme: Computing

Computing represents a distinct subtheme within the larger preservation theme of nuclear weapons design. LLNL has consistently maintained a cutting-edge computer capability to assist physicists in the design of nuclear weapons.

LLNL physicists computed the behavior and internal interactions of each new weapons design on large, high-speed, digital computers as much as possible. By using such computers, scientists reduced the number of field tests needed to confirm a weapon's feasibility. Computers reliably and efficiently calculated many different kinds of complex differential equations in field—such as neutronics, radiation, and hydrodynamics—that shed light on a weapon's design.¹¹⁵ Computers simulated “the processes and the physics of nuclear weapons.”¹¹⁶

As early as 1945, LANL scientists used one of the first computers ever developed, the Electronic Numerical Integrator and Computer (ENIAC), to perform the increasingly complex calculations needed to design a nuclear weapon.¹¹⁷ Herman Goldstein and a group of engineers from the University of Pennsylvania designed the ENIAC to run on vacuum tubes rather than gears. In 1948, LANL followed the ENIAC with a computer of its own, the MANIAC, designed by Nicholas Metropolis from the University of Chicago.¹¹⁸

LLNL purchased its first computer, the UNIVAC, in 1953, shortly after the site

opened.¹¹⁹ The UNIVAC was followed almost immediately by a string of ever faster and more complex computers. In 1954, LLNL purchased the IBM 701, a computer a dozen times faster than the UNIVAC. In 1956, an additional four computers joined the UNIVAC and the 701. When these six computers quickly became insufficient to meet the growing needs of LLNL physicists, the Computation Department began looking for a contractor that could build a really superior machine.¹²⁰ The Univac is pictured in figure 15.

In 1960, the Sperry Rand Company of Philadelphia delivered the Livermore Advanced Research Computer (LARC) to LLNL. LARC represented a significant advance in computing capability for LLNL. It was completely transistorized and ten times faster than all previous computers at the Laboratory.¹²¹ Figure 16 shows computer programmers at the LARC.

In 1961, LLNL purchased the IBM Stretch, a machine capable of performing 100 billion calculations a day—four times faster than LARC.¹²² LLNL purchased the second Stretch machine; the AEC purchased the original IBM Stretch for LANL earlier in the year.¹²³

¹¹⁸ The MANIAC was not an actual acronym, although words would be assigned to it over time. Rather, it was an amusing name created by the machine's inventors, Nicholas Metropolis and John von Neumann.

¹¹⁹ Remington Rand, “Contract No. AT(30-1)-1393 Purchase of Univac Fac-Tronic Computing System No. 4 and Operation, Testing, and Delivery Thereof,” 4 November 1952, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1952, Folder Project Whitney, Computers, Univac, General Correspondence, LBNL Archives.

¹²⁰ “20 Years in Livermore,” *Newsline* (September 1972), 8–10.

¹²¹ “20 Years in Livermore,” 9.

¹¹⁵ *Status Report: Fiscal Year 1958*, 117–121.

¹¹⁶ Ann Parker, “From Kilobytes to Petabytes in 50 Years,” *Science and Technology Review* (March 2002), 20.

¹¹⁷ Rhodes, *Dark Sun*, 249.

6. LLNL COLD WAR MISSIONS
AND PRESERVATION THEMES

Over the years, LLNL continued to upgrade its computers to keep pace with the rapid advance of computer technology. Beginning in 1963, Control Data Company (CDC) furnished the Laboratory with the latest in large computers for fifteen years. In 1976, LLNL moved into parallel computing when it acquired the CDC Star-100s, followed by the Cray 1. The Cray could simulate complex physical processes, such as the “intensity and path of a wave of pressure within a detonated explosive,” as either a three-dimensional image or an equation.

In the 1990s, the use of massive parallel machines, like the Meiko, paved the way for LLNL’s entry in 1996, into the Advanced Simulation and Computing Initiative (ASCI). ASCI is a joint LLNL, LANL, and SNL program to use parallel supercomputers to simulate the performance of nuclear weapons in the stockpile.¹²⁴

Most computers at LLNL are not of historic interest. Although LLNL worked closely with computer companies to establish



Figure 15. LLNL’s first computer, Univac, 1953.¹²⁵

¹²² “20 Years in Livermore,” 9; and Parker, “From Kilobytes to Petabytes in 50 Years,” 21.

¹²³ Arnold Lerner, IBM Data Division, to Walter Brummet, AEC Contracts Division, telegram, 1961, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1961, Folder Major Instruments, Computers, Stretch, LBNL Archives.

¹²⁴ Parker, “From Kilobytes to Petabytes in 50 Years,” 21–22.

¹²⁵ Univac Computer, Negative 3828, Box 077, Folder 10563, LLNL Archives.



Figure 16. Livermore Advanced Research Computer, 1960.¹²⁶

design specifications, companies like Rand, IBM, and CDC made the actual design and breakthroughs in computer technology. LLNL and LANL tended to drive the computer industry—companies designed ever more powerful computers to suit laboratory computing needs—but LLNL and LANL did not make or design the computers themselves. Therefore, most computers at LLNL will not be of historic interest.

The exception is the LARC, which was the largest and most powerful computer of its day. LARC was designed especially for LLNL and no other laboratory or facility had one. Therefore, any building associated with LARC will be considered eligible for National Register eligibility, under the subtheme of computing if LARC is still extant within it and intact. However, as the computer buildings at LLNL have been constantly upgraded, it is unlikely that LARC still remains in its original location,

and the building without its historically interesting equipment would not be of historic interest by itself. If LARC does exist at LLNL in any form, it should be assessed as an object of historic interest, regardless of its location.

6.2 Theme: Nuclear Weapons Testing

In large part, the AEC created LLNL as a second nuclear weapons laboratory to conduct diagnostic measurements of nuclear weapons in nuclear tests. Nuclear weapons testing involved conducting weapons tests, measuring the performance and effects of nuclear devices, and analyzing the data retrieved from test shots. Most of this testing was done as part of weapons development; however, a few U.S. nuclear tests were conducted to study weapon effects.

Initially, the AEC expected that LLNL would perform diagnostics for LANL. However, LLNL's mission also included weapon development, and the diagnostic work was primarily focused on its own tests. LLNL and LANL often compared and shared diagnostic test results.

¹²⁶ LARC, Negative C-2287, Box 077, Folder 10563, LLNL Archives.

When a weapons design reached the final phases of development it required testing at one of the testing grounds available to LLNL: the PPG, NTS, or Site 300. Site 300, an HE test facility fifteen miles east of LLNL, primarily provided pre-testing of devices without their nuclear components. Experimental devices exploded at one of these test sites yielded information critical to making a weapons design even more efficient.¹²⁷

6.2.1 Subtheme: Nuclear Weapons Testing

The Testing Division was largely responsible for conducting nuclear tests and measuring the performance of nuclear devices. However, other departments, e.g., the Radiochemistry Division, also performed analyses on experimental nuclear weapons.

A nuclear test shot at PPG or NTS involved several hundred employees and months of preparation. The Test Division would first put together the test assembly at LLNL, then break it down and reassemble it at PPG or NTS. Most test assemblies were large—as big as a railroad engine—and weighed as much as forty-five tons.¹²⁸

Test diagnostics recovered important aspects of nuclear design performance, including yield, cratering, fallout, and radiation. Test Division scientists and engineers used a variety of techniques to gather this information. For instance, bomb-fraction tracer sets attached to the device could determine the fission and fusion yield of a weapons design; nuclear emulsions and threshold detectors measured neutron yield and spectra; optical and electronic transmission and recording

methods recorded the time variations of prompt radiations; and streaking and framing cameras could capture images of the detonation at incredibly fast speeds—e.g., three-billionths of a second.¹²⁹

The evolution of diagnostic testing methods at LLNL featured the development of ever more precise optical, electronic, seismic, and X-ray recording equipment. In 1957, during the Whitney shot, LLNL test scientists first experimented with the optical transmission of data rather than with the extensive network of buried cables used previously. Rather than cables, field testers developed an elaborate optical telescope system that could be viewed from an underground bunker 1,000 feet away from ground zero.¹³⁰ In 1961, the Test Division designed new camera equipment with greater high-speed and time-dependent spectroscopy capabilities.¹³¹ More recent improvements in diagnostics include the development of a gas-sampling technique in 1979, the use of fiber-optic cable for data collection in 1982, and improvements in gamma ray spectroscopy in 1984.¹³²

Most nuclear testing occurred at PPG or NTS. LLNL conducted its first nuclear testing experiment during Operation Upshot-Knothole at NTS in the spring of

¹²⁷ LLNL history, unpublished manuscript, 1966–1967, LLNL Archives, 3; and *Status Report: Fiscal Year 1958*, 101.

¹²⁸ “Twenty Years in Livermore,” 26–31.

¹²⁹ George Barton, *Guide to Radiochemical Diagnostics* (U), UCRL-5191, SRD (Livermore: University of California Radiation Laboratory, 1958); W. Singlevich and E. M. Douthett, *Operation Buster and Jangle Radiochemical Analysis of Bomb Debris* (U), SRD (Oak Ridge, Tenn.: Technical Information Service AEC, 1952); and *Status Report: Fiscal Year 1958*, 101.

¹³⁰ “Twenty Years in Livermore,” 29.

¹³¹ *Status Report: Fiscal Years 1960 and 1961*, 91.

¹³² “Highlights of Laboratory Achievements During 1979,” *Energy and Technology Review* (August 1980), 19–21; “National Defense,” *Energy and Technology Review* (July 1982), 11; and “New Gamma-Ray Diagnostics,” *Energy and Technology Review* (July 1984), 11.

1953. The following year, LLNL fired its first test shot at PPG during the Castle test series. LLNL participated in all succeeding nuclear test events until the end of the nuclear testing program in 1992.

Specific nuclear tests may be of historic interest either because they are associated with a weapon system of particular significance, or because of technical breakthroughs that occurred during them. The buildings associated with nuclear tests include staging areas, test structures, and test buildings. The most likely buildings to be associated with historically significant nuclear tests would be those at PPG and NTS.

The assessment of structures at PPG and NTS is outside the scope of this project. It is unlikely that many buildings at LLNL will be of historic interest on the basis of association with an important nuclear test simply because no full-scale nuclear testing took place there. The exception would be a staging area or an assembly building where test devices were assembled or staged prior to their use at NTS or PPG in a historically significant nuclear test series. Such a building would also need to possess historic integrity. That is, it would have to clearly reflect nuclear staging or assembly activities and be clearly associated with an important nuclear test.

Buildings and structures at LLNL may also be of historic interest within the context of the Cold War and the theme of nuclear testing if they demonstrate a clear connection to the development of breakthrough nuclear testing diagnostic techniques or equipment. This breakthrough in technology must have significantly

altered or changed the way that the science of nuclear testing was conducted. Furthermore, the building must also have historic integrity. It must clearly reflect that breakthrough moment in nuclear testing diagnostics.

6.2.2 Subtheme: High Explosives Testing

Before LLNL field testers conducted a large-scale nuclear event at PPG or NTS, they pre-tested as many as ten to fifty devices at Site 300, an HE test facility fifteen miles from the main LLNL site.

HE is critical to the performance of nuclear weapons and a variety of components. It is key to achieving the critical mass necessary for detonation.¹³³

The devices tested at Site 300 ranged from “small simple hydrodynamic assemblies to full-scale devices less nuclear components.”¹³⁴ Diagnostic information gained from these tests included information about theoretical values, ballistic performances of HE components, transit times, and simultaneity. This information allowed weapons designers to establish ultimate design criteria.¹³⁵

In 1955, LLNL purchased 3,400 acres of ranch land from William J. Kelley, F. B. Kelley, and Bert Ranta to conduct these HE experiments.¹³⁶ As program needs expanded, LLNL purchased additional acreage over the years, bringing the total to 7,000 acres.

¹³³ “Inside Site 300,” *Newsline* (Fall 1981), 5.

¹³⁴ *Status Report: Fiscal Year 1958*, 176.

¹³⁵ *Ibid.*

The three main activities conducted at Site 300 were and are: hydrodynamic testing, HE processing, and environmental testing.

Most of the buildings at Site 300 were constructed between 1955 and 1960. In 1976, new developments in nuclear weapons design and testing necessitated the upgrade of Site 300 facilities.

Hydrodynamic Testing

Hydrodynamic testing involved the simulation of nuclear explosions at extremely high temperatures—so high that solids become liquid. Site 300 scientists then observed the flow of matter under these extreme conditions.¹³⁷ Ultimately, the purpose of these experiments was to observe the behavior of a nuclear device at the precise moment it exploded. The information gained allowed weapons designers to verify that their designs would work as expected.

Hydrodynamic testing occurred in the east and west firing areas at Site 300. The main firing facilities included five underground reinforced concrete bunkers with diagnostic equipment.¹³⁸

The diagnostic equipment used to capture images of an exploding device included electrical pins and raster oscilloscopes, linear

accelerators using flash X-ray, and high-speed framing and smear cameras.¹³⁹

In 1955, LLNL built the first three hydrodynamic testing buildings at Site 300. Bunker 801 recorded test explosions with high-speed cameras that viewed the event from a mirror system. Bunker 802 was equipped with pins or electrical contacts connected to electronic equipment. When a device was exploded in the bunker, the motion of the parts could be measured by recording the instant of contact between a pin and the portion of the device that hit it. Bunker 812 housed a linear accelerator (linac), the XR2, which could X-ray the inner motions of test assemblies during firing.¹⁴⁰

In 1960, two additional bunkers were added to the hydrodynamic test facilities at Site 300. Bunker 850 had additional pin and optics capabilities. Bunker 851 was built to house an even more powerful linac.¹⁴¹

Site 300 scientists increasingly refined their diagnostic techniques over the years so that they could see more and more of the internal workings of a device at the moment that the conventional explosives imploded the nuclear material. In 1951, the XR2 machine provided a primitive X-ray capability for Site 300. In 1960, a high-energy linac replaced the XR2 machine. It

¹³⁶ "Proposed Weapons Research Remote Site," Site 300 Memorandum, 18 October 1954, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1960, Folder Reactors, Plant, Livermore Site 300, LBNL Archives; and "Preliminary Proposal for Site 300," 1 July 1953, Ernest Orlando Berkeley National Laboratory Declassified Records, 43-95, Box 4, File 19-10-364, LBNL Archives.

¹³⁷ *Status Report: Fiscal Year 1958*, 81.

¹³⁸ "Site 300 Organization and Activities," unpublished report, 28 July 1980, Site 300 Manager's Administrative Files.

¹³⁹ *Status Report: Fiscal Year 1959*, 55; *Status Report: Fiscal Year 1960 and 1961*, 11-12; and University of California Lawrence Radiation Laboratory, *Status Report: Fiscal Year 1962* (Berkeley: University of California Lawrence Radiation Laboratory, 1962), 55.

¹⁴⁰ *Status Report: Fiscal Year 1958*, 176.

¹⁴¹ *Ibid.*, 176-177; and R. Mullins to J. Carothers, "Site 300 Yearly Summary," memo, 5 December 1960, Site 300 Manager's Administrative Files.

could produce even greater X-ray flashes to image mock nuclear weapon primaries as they imploded.¹⁴² In 1982, Site 300 installed an even more powerful linac in the Flash X-Ray (FXR) Radiography facility, an up-to-date hydrodynamic testing facility. The evolution of Site 300's X-ray capabilities are depicted in figures 17, 18, and 19.

The FXR accelerator could photograph mock nuclear weapons components as conventional HE triggered a simulated nuclear explosion. The FXR made it possible to conduct fewer actual nuclear tests.¹⁴³ Bunker 801, the first hydrodynamic facility built at Site 300, housed the new FXR Radiography Facility. Constantly upgraded since 1982, the FXR Radiography Facility is currently used to assist in stockpile stewardship.¹⁴⁴

High Explosive Processing

Site 300 scientists also processed and fabricated their own HE components for test devices.

Prior to 1955, LLNL weapons designers used facilities belonging to outside vendors to provide explosives and hydrodynamic analysis. However, with the acquisition of land for hydrodynamic facilities, LLNL also planned an HE processing area to produce "a prototype HE of any device envisioned by the ... [LLNL] program."¹⁴⁵

HE processing involved mixing and blending molding powders and melting, casting, and pressing them into shapes. The fabrication process involved machining and assembly of the processed shapes.

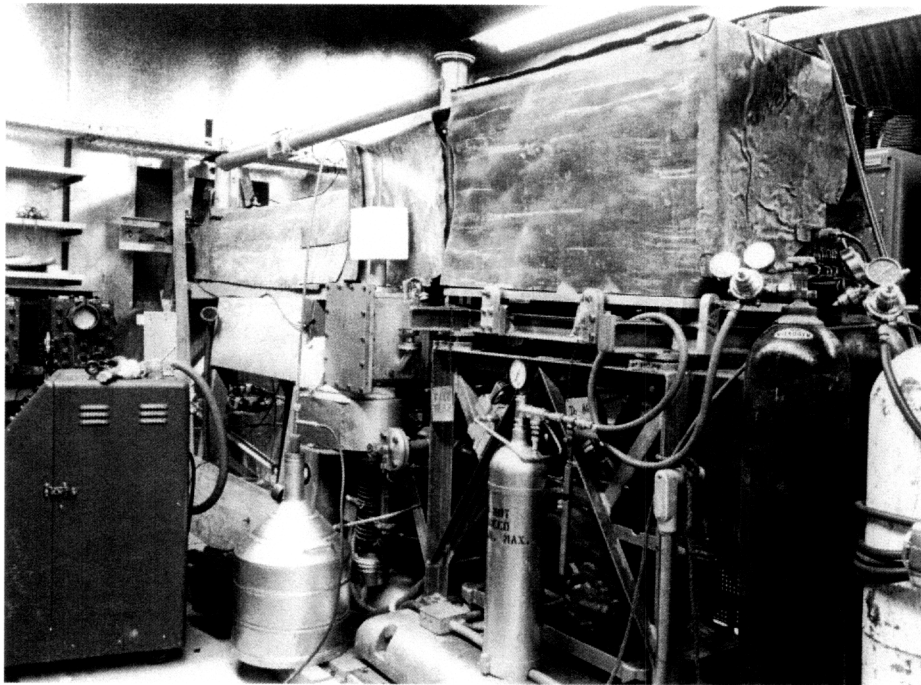


Figure 17. XR2 machine, Site 300, bunker 812, 1955.¹⁴⁶

¹⁴² *Serving the Nation for Fifty Years*, 23.

¹⁴³ *Serving the Nation for Fifty Years*, 23; and John Miller, "Costly X-Ray Machine to Aid Atom Experts," *The Oakland Tribune*, 25 October 1979, C-11.

¹⁴⁴ *Serving the Nation for Fifty Years*, 77.

¹⁴⁵ A. J. Hulse, "Site 300 Facilities," memo, 1957, Site 300 Manager's Administrative Files.

¹⁴⁶ XR-2 machine at Site 300, Negative GTB 553-4587, Box 003, LLNL Archives.

6. LLNL COLD WAR MISSIONS
AND PRESERVATION THEMES

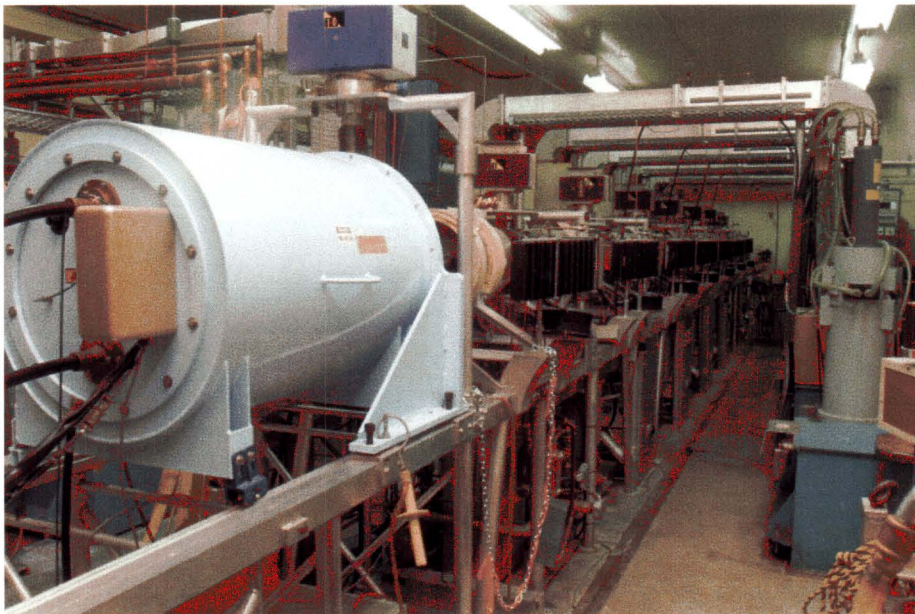


Figure 18. Building 851A, Site 300, linac, 1960.¹⁴⁷

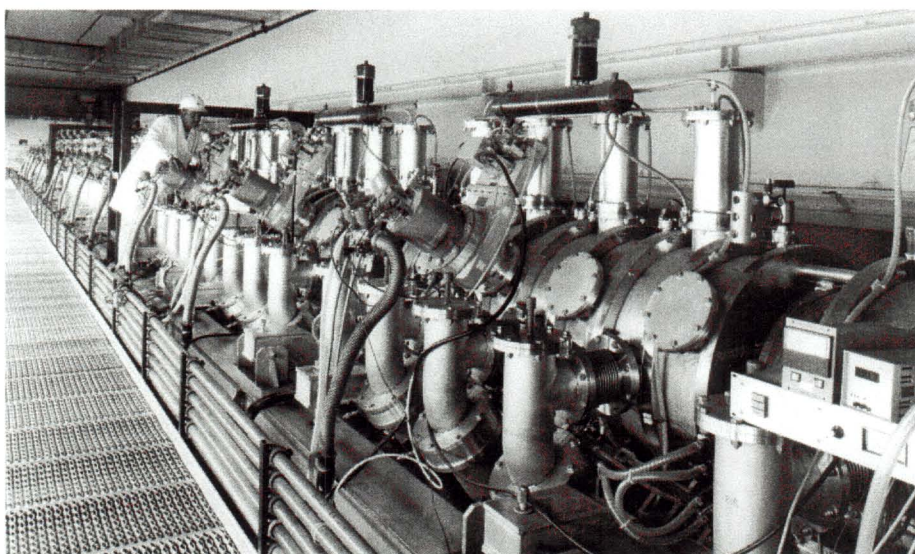


Figure 19. FXR accelerator, Building 801, Site 300, 1982.¹⁴⁸

¹⁴⁷ Building 851A linac, LLNL photographer, 2003.

¹⁴⁸ Flash X-ray linac at Site 300, Box 386, LLNL Archives.

Another integral part of developing HE for test devices was the development of new materials and processing technology. The Chemistry Department had responsibility for materials research at Site 300, and the Chemical Engineering and the Mechanical Engineering Departments conducted research into processing technology. HE process development included isostatic pressing, elastomer-container development, adhesives development, mix-and-blend technologies development, and tooling development.¹⁴⁹ HE processing also involved the analysis and storage of the finished product.

In 1955, LLNL built its first HE processing facilities, the Trim and Assembly Building, and the HE Machining Building. In 1959, an HE Press Building, HE Blending and Mixing Building, Radiography Laboratory, Chemistry Laboratory, and an HE Assembly Building were added.¹⁵⁰ In 1959, a larger HE Press complex of buildings was added to accommodate the preparation and isostatic pressing of bulk explosives and inert compounds.¹⁵¹ A steam plant, waste treatment facility, and storage buildings were added in the 1960s. HE processing, like machining and pressing were conducted with remote equipment. The control room of Building 807, HE Machining, is shown in figure 20.

In 1976, LLNL researchers made a design breakthrough on the IHE triamino-trinitrobenzene (TATB), which led to

its widespread use in nuclear weapons. TATB is highly insensitive to external shocks caused by explosion, fire, or crash. The W87, designed by LLNL, was the first nuclear weapon to employ TATB in both the detonator and main explosive charge. IHE significantly improved nuclear weapons safety. In the 1990s, LLNL chemists determined a process for the inexpensive manufacture of TATB.¹⁵²

Environmental Testing

HE testing at Site 300 also maintained a small capability in environmental testing. These tests determined the behavior of assemblies under different kinds of environmental conditions. Static tests exposed assemblies to varying temperatures, pressures, and humidities. Dynamic tests subjected assemblies to shaking, dropping, acceleration, and deceleration.

Environmental test equipment included drop towers, shake tables, and underground assembly and firing facilities.

The Environmental Testing Area at Site 300 was built primarily between 1958 and 1962. In the 1980s, LLNL upgraded its environmental testing capabilities to accommodate increasing sophistication in weapons design.

The Thermo/Mechanical Test Complex was one of the first environmental testing facilities built at Site 300. Building 830 provided facilities for long-term accelerated aging and compatibility tests. Building 832 conducted mechanical testing in tension, compression, thermal expansion, and creep. Building 833 expanded the mechanical and thermal testing

¹⁴⁹ *Status Report: Fiscal Year 1958*, 177.

¹⁵⁰ A. J. Hulse, "Site 300 Facilities," 4.

¹⁵¹ Lawrence Livermore National Laboratory, *Site-Wide Remedial Investigation*, UCRL-AR-108131 (Livermore: Lawrence Livermore National Laboratory, 1994), 13–4–53.

¹⁵² *Serving the Nation for Fifty Years*, 56–57.

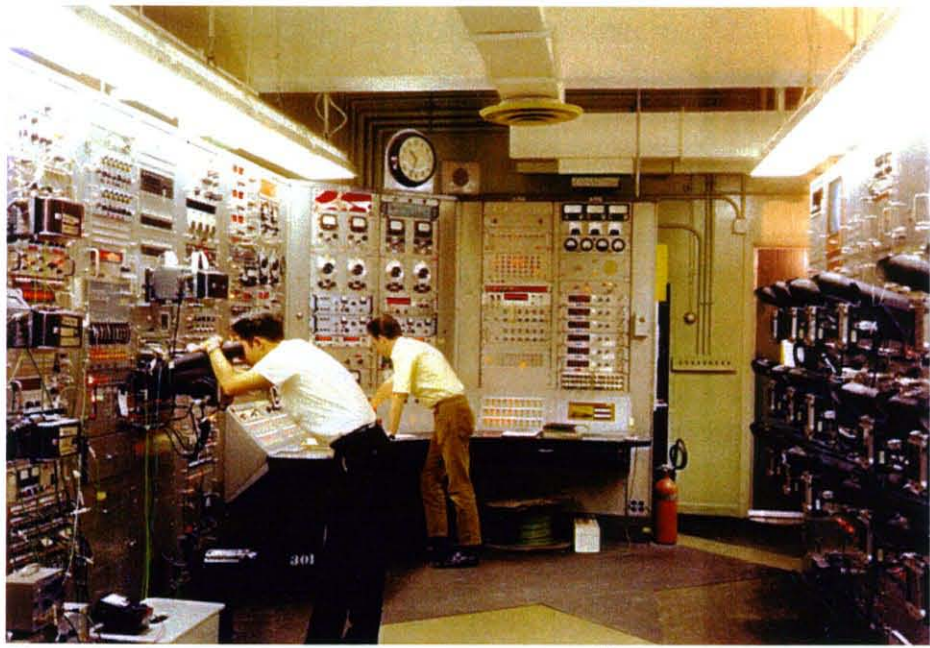


Figure 20. Building 807, HE machining control room, 1960s.¹⁵³

capability for HE. Building 834 provided nineteen thermal chambers in six test cells, including a combined temperature and humidity chamber.¹⁵⁴

In 1960, LLNL added the Dynamic Test Complex to its environmental test capabilities. The Dynamic Test Complex consisted of two areas separated by a one kilometer. Building 854 provided shock, vibration, acceleration, and deceleration machines for components and devices containing HE and hazardous materials. The control room for the Dynamic Test Complex is shown in figure 21. Building 858 was a thirty-meter drop tower for guided free-fall impact testing. Components tested could contain HE or inert materials.¹⁵⁵

Between 1960 and 1962, Building 855, the Disassembly Complex, was added to the environmental test area for the examination of damaged components and devices in environmental or dynamic testing. The Disassembly Complex provided remote control features to protect workers against the possible detonation of damaged HE components.¹⁵⁶

In 1970, Building 836, the Multiple-Actuator Hydraulic Shaker Facility was built. This provided a high-force, high-amplitude, low-frequency shock and vibration test capability for the environmental test area of Site 300.¹⁵⁷

In 1978, LLNL developed a plan to re-vamp Site 300 environmental facilities. Improvements in weapons design had exceeded the

¹⁵³ Building 807 remote control machining room, 1960s, LLNL Archives.

¹⁵⁴ K. W. Volkman, D. K. Fisher, and J. G. Katz, *Environmental Test Facilities and Testing at Lawrence Livermore Laboratory*, UCRL-80837 (Livermore: Lawrence Livermore Laboratory, 1978), 6–8.

¹⁵⁵ *Ibid.*, 8–12.

¹⁵⁶ “Site 300 Organization and Activities,” unpublished report, 28 July 1980, Site 300 Manager’s Administrative Files, 3.

¹⁵⁷ Volkman et al., *Environmental Test Facilities and Testing at Lawrence Livermore Laboratory*, 2–5.

environmental test capabilities at Site 300. The plan proposed ten new or renovated facilities that would include the following improvements: new computer systems, X-ray film processor, thermal chambers, hydraulic actuator slip table, twenty-four-inch pneumatic actuator, mobile data acquisition van, signal conditioning system, and air-handling and filter hoods for machine tools.¹⁵⁸ In 1979, a modified plan requested five of the upgraded facilities.

In 1983, LLNL dedicated two new environmental test facilities at Site 300—the Thermal Test Facility and the Hydraulic Shaker Facility. The Thermal Test facility had solar ovens capable of reaching temperatures of 230 degrees Fahrenheit. One of the ovens could hold assemblies the size of a three-quarter ton truck. The Hydraulic Shaker

Facility replaced a twenty-five year old system. It housed a new indoor shaker table which could vibrate a weapons test assembly 5 to 20,000 times a second with up to 40,000 pounds of force.¹⁵⁹

The HE testing of weapons components and test assemblies at Site 300 allowed scientists to preview and alter weapons designs without the expense of full-scale nuclear testing at NTS or PPG. Most HE testing at Site 300 was a support function for the nuclear weapons program. However, hydrodynamic testing and HE processing led to breakthroughs in nuclear weapons design—like the IHE safety features incorporated in the W87. Therefore, the hydrodynamic and HE process areas at Site 300 require a historical assessment.



Figure 21. Dynamic Test Complex, Building 854, control room, 1960.¹⁶⁰

¹⁵⁸ David F. Hillyer, *Weaponization Facilities Project*, UCRL-89141 (Livermore: Lawrence Livermore National Laboratory, 1983), 4–5.

¹⁵⁹ Mike Ciruolo, “Nuclear Test Facility Dedicated,” *The Daily Californian*, 24 March 1983.

¹⁶⁰ Building 854, control room, 1960, LLNL Archives

Environmental testing, in contrast, was a more routine type of testing within the nuclear weapons complex designed to determine how weapons survived in the stockpile and in the harsh environments of their use. Environmental testing produced more incremental knowledge about performance at a later stage in the weapons design process. Therefore, the environmental test facilities at LLNL's Site 300 are not of historic interest.

To be considered of historic interest within the subtheme of high explosives testing, a building must be associated with a major scientific discovery that advanced the science of nuclear weapons design or nuclear testing. A building may also be of historic interest within this subtheme if it is clearly associated with the development of a breakthrough technology in hydrodynamic testing or HE processing. Alternatively, due to the importance of HE processing and hydrodynamic testing to the LLNL weapons design program, a building or set of buildings that is illustrative of this practice over time may also be eligible to the National Register.

Whatever its associations, however, a building must still possess integrity to be considered eligible to the National Register. It must be intact and still reflect the historic technological breakthrough, weapon system, or development in technique or equipment.

6.3 Theme: Nuclear Research

Herbert York, the first director of LLNL, included basic research as one of the original missions of the Laboratory. York thought it would benefit the overall climate and standard of technical excellence of the new laboratory to provide work opportunities

for young scientists and engineers interested in doing advanced research in science and technology but who might not be "keen on weapons."¹⁶¹ Since those early years, LLNL has continued its basic research programs in physics, chemistry, and materials research. In turn, these research areas have contributed to and shaped the field of nuclear science.

The theme of nuclear research at LLNL pertains to both weapons and non-weapons knowledge and practical applications in the field of nuclear science

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6.3.1 Subtheme: Nuclear Physics Research

Nuclear physics research at LLNL evolved and changed over the years. Initially focused on weapons-related research problems, nuclear physics research expanded to include more academically oriented projects. In the 1950s, research in nuclear physics occurred in several different groups or divisions. These original groups were the Theoretical Physics Division, the Computation Division, the Nuclear Physics Group, and the Neutronics Division.¹⁶²

In 1962, LLNL director John Foster acknowledged the importance of basic physics research to the Laboratory's applied programs in weapons, fusion research, and reactors. He consolidated all groups doing basic physics research under a newly

¹⁶¹ *30 Years of Technical Excellence*, 4–5.

¹⁶² *Status Report: Fiscal Year 1958*, 35–46.

formed Physics Department and called for stronger ties between basic physics research and LLNL's applied programs.¹⁶³ The newly formed Physics Department incorporated the original four divisions—Neutronics, Nuclear Physics, Theoretical Physics, and Computation—under one department.¹⁶⁴

Subsequent reorganizations in LLNL's organizational structure resulted in name changes for these divisions. Sometimes divisions were consolidated or new ones added to reflect expanding research programs within divisions.

In the 1960s, divisions in lasers, atmospheric research, equation of state, hydrodynamics, and astrophysics became research areas in their own right.¹⁶⁵

This report does not detail every nuclear physics project that LLNL was engaged in; instead it outlines the basic research objectives in the nuclear physics program. The following descriptions of LLNL nuclear physics research objectives are aids in establishing thresholds of historic interest within the context of the Cold War, the theme of nuclear research, and the subtheme of nuclear physics research.

This report will define the original four physics divisions, discussing new divisions within the division in which they originated.

The Laser Division will be discussed separately, as it becomes a major programmatic mission in the 1970s.

Theoretical Physics

In the 1950s, physicists in the Theoretical Division devoted most of their time to supporting the weapons program. As described in section 6.1.2, above, physicists first worked out weapons designs on paper or computers as mathematical equations.¹⁶⁶

In addition to warhead design, theoretical physicists also supported weapons research by working complex differential equations on problems related to neutronics, hydrodynamics, and radiation. Neutronics focused on fission reactions, hydrodynamics explored the actual explosion of a nuclear device, and radiation focused on the waste products of a nuclear explosion.

Theoretical physicists used computers to explore the nature of particle physics and the phenomena of nuclear scattering.¹⁶⁷ Research on nuclear scattering revealed important information on the nucleus and led to the increased understanding of the reactions that took place in fission and fusion devices.¹⁶⁸

Physicists in the Theoretical Division also supported the research of other programs. They provided much of the preliminary

¹⁶³ John Foster to W. Reynolds, memorandum, 25 May 1962, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1962, Folder Administration and General Service Department, LBNL Archives.

¹⁶⁴ D. M. Wilkes, press release, 18 June 1962, Administrative Memorandum, LLNL Archives; and "Merkle Named Boss of New Department for Physics Research," *The Magnet* (June 1962), 1.

¹⁶⁵ *30 Years of Technical Excellence*, 63.

¹⁶⁶ *Status Report: Fiscal Year 1958*, 35–46.

¹⁶⁷ *Ibid.*

¹⁶⁸ "We Explore the Atom," *The Magnet* (November 1957), 5.

work and calculations for projects in controlled thermonuclear fusion, nuclear power, and nuclear propulsion.¹⁶⁹

In 1961, physicists J. Anderson and C. Wong demonstrated the relationship between proton and neutron in medium-weight nuclei.¹⁷⁰

Theoretical physicists continued throughout the 1960s to pursue research questions in elementary particle discovery, nuclear physics, and atomic physics. Experimental research explored the nucleon-nucleon problem, electron and positron collisions with atomic hydrogen, and the existence of the B meson.¹⁷¹

In 1977, the President's Science Advisory Committee (SAC) recognized LLNL's work in two areas of nuclear physics as having made important contributions to science. SAC noted that LLNL physicists discovered "the importance of using positron beams to initiate photonuclear processes."¹⁷² They also noted LLNL's discovery of "fundamental...regularities in nuclear energy level structure." This work on analog states led to later insights about nuclear structure.

In the 1970s and 1980s, T-Division, a combined Theoretical Physics and Computation

Division, continued to support the weapons program and fusion research. In addition, the group supported LLNL's new efforts in laser fusion.¹⁷³

In 1963, a separate Atmospheric Research group emerged from the Theoretical Physics Division, eventually becoming today's Atmospheric and Geophysical Sciences Division. Atmospheric research at LLNL stemmed from attempts to model fallout from nuclear weapons testing with computers in the late 1950s and 1960s.

In the 1970s, LLNL atmospheric researchers began to model accidental releases of radiation. This led to the development of the Atmospheric Release Advisory Capability (ARAC), an emergency response function serving the government. In 1979, ARAC opened ahead of schedule to respond to the Three Mile Island nuclear power plant accident. LLNL has also been involved in research on global warming and its causes. In 1989, LLNL established the Program for Climate Model Diagnosis and Intercomparison (PCMDI) to assist in the evaluation of the many different global climate models in existence worldwide.¹⁷⁴

Computation

In the 1950s, the Computation Division provided mathematical support for the Weapons Division and the Theoretical

¹⁶⁹ Ibid.

¹⁷⁰ "Twenty Years in Livermore," 15.

¹⁷¹ University of California Lawrence Radiation Laboratory, *Status Report: Fiscal Year 1963* (Berkeley: University of California Lawrence Radiation Laboratory, 1963), 9–10.

¹⁷² University of California (System). *Report of the Committee to Examine the University's Relationship with the Los Alamos and Livermore Laboratories. Report on the Scientific Advisory Committee on the Lawrence Livermore Laboratory and Los Alamos Scientific Laboratory* (Berkeley, Calif.: The Committee, 1978), 9.

¹⁷³ Lawrence Livermore Laboratory, *Directors Program Review Physics Department: Summary Information* (Livermore: Lawrence Livermore Laboratory, 1978).

¹⁷⁴ "Energy and Environment: Understanding Our World," *Science and Technology Review* (October 2002), 18–20.

Division. Computational physicists primarily designed numerical codes that would simulate the physical problems involved in nuclear weapons design and testing.

Like the theoretical physicists, computation physicists also supported work in fusion research and reactors.

Non-weapons-related physics research that made use of computers included programs that could predict atmospheric flow patterns and plot the life-cycle of stars.¹⁷⁵

Called upon by a variety of groups within the Laboratory to provide computational support, the division addressed a succession of disparate problems. In the 1960s, some of the most significant and interesting projects included: thermodynamic properties of matter, a more satisfactory model of the sun, theoretical studies of melting, theoretical studies of freezing, weather prediction, and modeling time-dependent, wind-driven ocean currents.¹⁷⁶ The 1964 computation of the first accurate orbit of Mars is an example of the type of detailed results these efforts generated.¹⁷⁷

In 1975, Computation became involved in a project sponsored by the Department of Transportation. The Climatic Impact Assessment Program (CIAP) was a comprehensive program to study the impact of

transportation systems on climate and atmosphere. In 1977, the President's SAC reported that computational physics research at LLNL had been influential in industry development of new computational abilities. The SAC highlighted LLNL's participation in CIAP and, in particular, the development of a pollution model of the stratosphere.¹⁷⁸

In the 1980s, computation physicists at LLNL continued to support the weapons program, fusion research, and basic physics research. They developed computer-generated models of nuclear ion scattering, electron-ion collision cross-sections, nuclear shapes, combustion chemistry, vibrating molecules, interacting periodic systems, different states of matter, and the birth of the galaxy.¹⁷⁹

In 1982, LLNL developed dynamics in three dimensions (DYNA3D), a computer code that simulated the environmental testing of the B83. Private industry soon began using DYNA3D to test everything from cars to commercial airplanes. Industrial users included General Motors, Daimler-Chrysler, Alcoa, General Electric, Lockheed Missiles and Space, General Dynamics, Boeing Commercial Airplane Group, Adolph Coors Co., Rockwell International, and FMC Corp.

Computation research remains integral to the mission at LLNL today. In 2002, the

¹⁷⁵ *Status Report: Fiscal Year 1958*, 117–119; and *Status Report: Fiscal Year 1959*, 35–39.

¹⁷⁶ University of California Lawrence Radiation Laboratory, *Status Report: Fiscal Year 1965* (Berkeley: University of California Lawrence Radiation Laboratory, 1965), 10–19.

¹⁷⁷ "Twenty Years in Livermore," 17.

¹⁷⁸ Lawrence Livermore Laboratory, *Theoretical Physics Division Annual Report: 1975*, UCRL-500035–75 (Livermore: Lawrence Livermore Laboratory, 1975), 81; and *Report of the Committee to Examine the University's Relationship with the Los Alamos and Livermore Laboratories*, 9–10.

¹⁷⁹ University of California Lawrence Livermore National Laboratory, *30 Years of Technical Excellence: T-Division* (Livermore: Lawrence Livermore Laboratory, 1982), 2.

latest LLNL super computer, the ASCI White, modeled the first full-system three-dimensional simulation of a nuclear weapons detonation.¹⁸⁰

Astrophysical research was another area to emerge in the 1960s within the Physics Group. LLNL's computer capabilities enabled it to do increasingly sophisticated astrophysical research. In the 1960s, LLNL astrophysicists discovered the basic mechanism of supernova explosions. They also calculated the collapse involved in the creation of a black hole. In the 1970s, LLNL astrophysicists developed the first stellar evolution models and predicted the existence of quark stars. In the 1980s, LLNL formulated an equation of state and opacity code, which subsequently became the model in stellar physics. In the 1990s, LLNL astrophysicists joined the Massive Compact Halo Objects (MACHO) project, a joint collaboration with many universities to search for dark matter.¹⁸¹

The history of LLNL's broader computing capability is outlined above in Section 7.1.1, "Subtheme: Computing."

Neutronics

The Neutronics Division at LLNL performed experiments in neutron physics to support the nuclear weapons program and to advance the science of nuclear physics. The four main areas of work in the Neutronics

Division were operation of research reactors, reactor neutron-physics research, critical assembly studies for the weapons and nuclear propulsion programs, and general nuclear safety.¹⁸²

The Neutronics Division operated research reactors for the physics, chemistry, and biochemistry programs at LLNL and LBNL. The research reactors at LLNL included the Water-Boiling Neutron Source Reactor (WBNS), Livermore Pool-Type Reactor (LPTR), and later the Fran, Kukla, and Super-Kukla nuclear burst machines.

The very first reactor at LLNL was the WBNS inherited from CR&D. In 1953, CR&D built the WBNS, a small thermal reactor, to produce neutrons for exponential studies. Exponential studies explored the "neutron spectra and distribution in fast breeder reactor cores of various composition." These studies produced information on plutonium metal systems.¹⁸³

The water-boiler type reactor was primarily intended for student training programs or for very limited research programs. In 1944, LANL built the first water-boiler reactor. LANL's Low Power Reactor (LOPO) was dismantled and rebuilt several times from 1944 to 1950. In 1952, Atomics International, a division of North American Aviation built a water boiler reactor for the AEC.

¹⁸⁰ *Serving the Nation for Fifty Years*, 111.

¹⁸¹ *Theoretical Physics Division Annual Report: 1975*, 66.

¹⁸² *Status Report: Fiscal Year 1958*, 129–131; *Status Report: Fiscal Year 1959*, 43–45; and *Status Report: Fiscal Year 1960–1961*, 12–14.

¹⁸³ *Livermore Research Laboratory, Hazards Attendant to Operation of Water Boiler Neutron Source With Exponential Studies*, LWS-29066 (Livermore: Livermore Research Laboratory, 1953), 5–6.

Atomic International then built the WBNS for CR&D. The WBNS was a 100-watt water-boiler style reactor similar to those in operation at North American Aviation and LANL. The WBNS consisted of "a central core tank filled with fuel solution, surrounded by a graphite moderator, and equipped with the instrumentation and controls necessary for operation and safety."¹⁸⁴

In 1954, shortly after acquiring all CR&D facilities and equipment, LLNL proposed building a more flexible research reactor. The proposal called for a high thermal neutron flux swimming pool type reactor. The Chemistry Group of LLNL required a more powerful reactor to conduct radiochemical analysis of nuclear test samples for the weapons program. Without a larger reactor, scientists at LLNL would be dependent on LANL or the Applied Radiation Corporation (ARCO) to process test samples.¹⁸⁵

The swimming pool type reactor, or Livermore Pool Type Reactor (LPTR), was a "one megawatt solid fuel, light water moderated and cooled reactor."¹⁸⁶

The reactor core resided in a tank approximately six feet in diameter and three-eighths of an inch thick surrounded by biological shielding. The fuel elements of the reactor core were modeled after those in the

Materials Test Reactor (MTR) located at the National Reactor Testing Station in Idaho.¹⁸⁷

The design of a swimming pool type reactor was considered superior to a water boiler because it overcame the problems with escaping gases or loose fission products experienced by water-boiler reactors. In the event of an accidental explosion, the water surrounding the swimming pool type reactor would contain radiation.¹⁸⁸

In 1955, the Foster Wheeler Corporation began construction on the LPTR. Although primarily constructed for use in the weapons program, the LPTR also incorporated features that made it useful for research in many other programs, including physics and biomedicine. The LPTR is depicted in figure 22.

The LPTR was completed and first operated in 1958.¹⁸⁹ It was the largest research reactor on the West Coast at the time. After 1959, the WBNS was primarily used only a few hours a week for graduate seminars in nuclear engineering.¹⁹⁰ A workhorse for the weapons program and other research at LLNL, the LPTR ran for over twenty years. It was finally decommissioned in 1980.¹⁹¹

The reactor neutron-research program of the LPTR had three general experimental programs: precision gamma studies, solid-state

¹⁸⁴ Livermore Research Laboratory, *Hazards Attendant to Operation of Water Boiler Neutron Source*, 5.

¹⁸⁵ Arthur T. Biehl to Herbert York, memorandum, 23 April 1953, "Proposed UCRL, Livermore Research Reactor," Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1953, Folder Project Whitney, Reactors, LBNL Archives.

¹⁸⁶ Robert Detterman, *Safeguard Report Livermore Pool Type Reactor* (New York, NY: Foster Wheeler Corporation, 1956), 16.

¹⁸⁷ Ibid.

¹⁸⁸ Ibid.

¹⁸⁹ Albert Kirschbaum, memorandum, "Open House," 2 May 1958, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1958, Folder Major Instruments, Livermore Pool Type Reactor, LBNL Archives.

¹⁹⁰ *Status Report: Fiscal Year 1959*, 45.

¹⁹¹ *Serving the Nation for Fifty Years*, 11.



Figure 22. Building 280, Livermore Pool Type Reactor, 1958.¹⁹²

studies with neutron diffraction spectrometers and radiation damage experiments, and precision measurements of neutron interactions with matter.¹⁹³

Expertise gained in reactor operation and research led to the prompt-burst neutron reactors—Kukla, Fran, and Super Kukla—used to conduct contained fission reactions. The Kukla was first developed in 1961. The

Fran and Super Kukla were installed at NTS in 1963 and 1964 respectively.

In 1961, Kukla, the first critical neutron-burst facility at LLNL, was constructed and installed in one of the vaults used for critical experiments. Physicists used Kukla to investigate neutron-burst initiation and radiation damage.¹⁹⁴

In 1963, the Neutronics Division built another neutron-burst machine, Fran, and installed it at NTS. In 1964, they designed an even larger

¹⁹² LPTR, Negative GLB-585-12421, Box 495, Folder 14136, LLNL Archives.

¹⁹³ *Status Report: Fiscal Year 1958*, 129.; and *Status Report: Fiscal Year 1963*, 14.

¹⁹⁴ *Status Report: Fiscal Year 1960-1961*, 12–14; and *Status Report: Fiscal Year 1962*, 7.

machine, Super Kukla, for NTS. The Super Kukla machine consisted of an assembly of fissionable material that could be remotely manipulated to produce short neutron bursts.¹⁹⁵

From 1955 to 1968, LLNL also participated in AEC reactor research for various nuclear propulsion projects. By 1963, Livermore was approaching Argonne in its level of reactor work. A more detailed analysis of LLNL's nuclear propulsion work is provided below in section 6.4.2 "Subtheme: Nuclear Propulsion Program."

The Kukla, Fran, and Super Kukla prompt neutron burst reactors were part of the Neutronic Division's critical assembly studies, which measured the amount of fissionable material necessary for a chain reaction to occur in a device or assembly.¹⁹⁶

Assemblies for weapons systems were tested on fast neutron systems. Enriched uranium assemblies also provided data on "critical mass, flux and power distributions, the effects of structural materials and voids, and the effectiveness of control and safety rod designs" for the nuclear propulsion program.¹⁹⁷

In 1964, with the demise of the nuclear propulsion program, the weapons program subsumed critical assembly studies.

The Nuclear Safety group reviewed and designed facilities for the fabrication of fuel elements. It also established safety

guidelines for storing and handling fissionable materials.¹⁹⁸

Experimental Nuclear Physics

The Experimental Nuclear Physics group conducted basic and applied research in medium-energy nuclear physics. In the 1950s, the two major instruments it initially used for this work were the 0.5-MeV Cockcroft-Walton accelerator and the 90-inch cyclotron. The Cockcroft-Walton was used as an intense source of 14-MeV neutrons and the cyclotron was a flexible source of protons, deuterons, alpha particles, and monoenergetic neutrons.¹⁹⁹ The Cockcroft-Walton accelerator and the 90-inch cyclotron primarily provided nuclear research for the weapons program. Figures 23 and 24 depict the first LLNL accelerators for the weapons program.

In 1962, the Experimental Nuclear Physics group added atomic physics and nuclear instrumentation to its research agenda. Atomic physics applied experimental methods learned in nuclear physics to other questions, such as, atomic cross sections. Nuclear instrumentation involved adapting nuclear equipment for use in space physics and satellite instrumentation.²⁰⁰

An outgrowth of the Experimental Nuclear Physics group's research was accelerator development. Accelerators at LLNL had a research life of approximately five years. Therefore, LLNL physicists constantly designed and replaced accelerators with new up-to-date models.²⁰¹

¹⁹⁵ *Status Report: Fiscal Year 1963*, 14; and "Twenty Years in Livermore," 17.

¹⁹⁶ *Status Report: Fiscal Year 1958*, 129.

¹⁹⁷ *Status Report: Fiscal Year 1959*, 43.

¹⁹⁸ *Status Report: Fiscal Year 1960–1961*, 12–14.

¹⁹⁹ *Status Report: Fiscal Year 1958*, 125.

²⁰⁰ *Status Report: Fiscal Year 1962*, 9–10.

²⁰¹ *Status Report: Fiscal Year 1963*, 13.

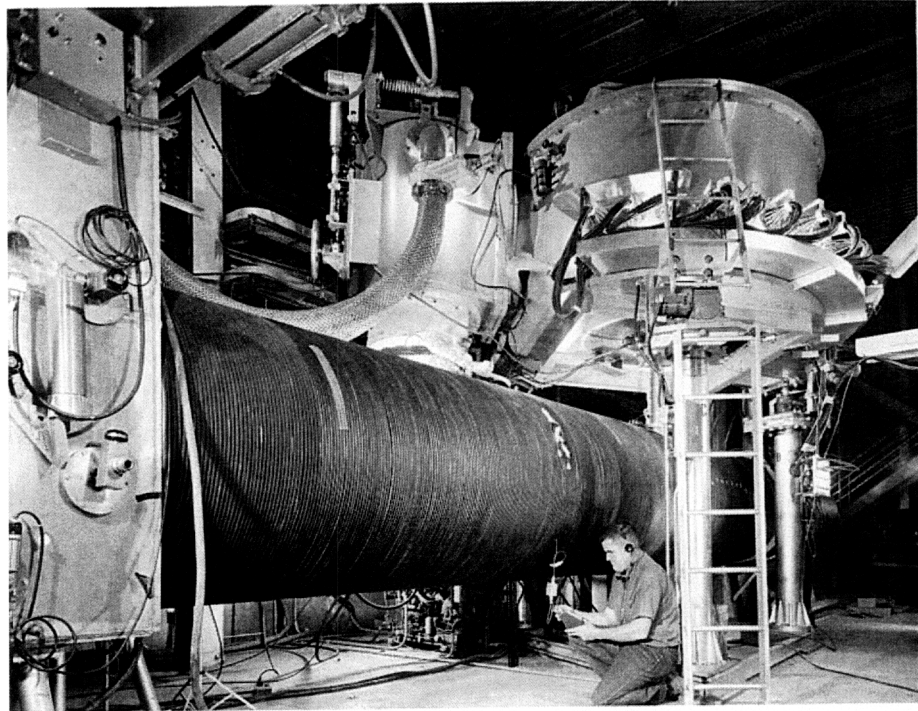


Figure 23. Cockcroft-Walton accelerator, Building 212.²⁰²

In 1950, CR&D built the Mark I, the very first accelerator, located in Building 431, at the LLNL site. The Mark I was a prototype machine for the Material Test Accelerator (MTA) project, an AEC-sponsored program to develop fissionable material—uranium, plutonium, and tritium—in a linear accelerator. In 1953, with the discovery of uranium deposits in the western United States, the MTA project waned in importance. CR&D began dismantling the Mark I in 1953 and the AEC canceled its contract in 1954.

In 1954, CR&D transferred all its facilities and equipment to LLNL. Both CR&D and LLNL established offices and laboratories at the former NAS Livermore. Among the

equipment LLNL received was the A-48 accelerator, also part of the MTA project. Physicists used the A-48 accelerator until 1958 for spectrometer exposures of the rare earth elements.²⁰³

When it first opened, LLNL operated, the Cockcroft-Walton accelerator and the 90-inch cyclotron, both located in Building 212, the former WWII drill hall. The Experimental Nuclear Physics group used these machines for testing theoretical predictions, weapons design, calibration of equipment used in nuclear test diagnostics, and for basic nuclear physics research.²⁰⁴ In 1964, the Physics Department replaced the Cockcroft-Walton accelerator with a new

²⁰² Cockcroft-Walton accelerator, Negative 3-1, LLNL Archives.

²⁰³ *Status Report: Fiscal Year 1958*, 75–77.

²⁰⁴ *Ibid.*, 126.

6. LLNL COLD WAR MISSIONS
AND PRESERVATION THEMES

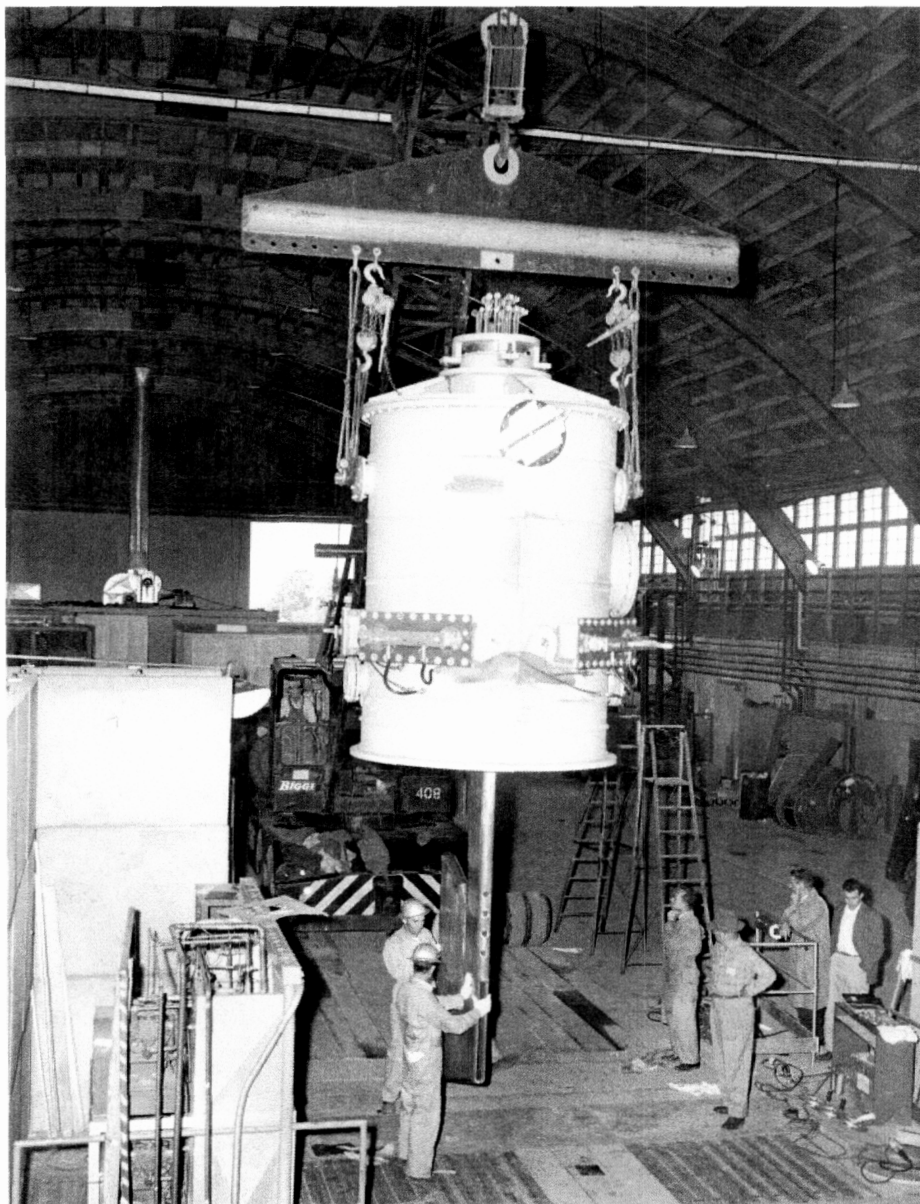


Figure 24. 90-inch cyclotron, Building 212.²⁰⁵

model.²⁰⁶ The 90-inch cyclotron operated for sixteen years. In 1968, it was dismantled and remodeled into a fifteen MeV cyclotron with a Van De Graff generator.²⁰⁷

²⁰⁵ 90-inch cyclotron, 1952, LLNL Archives.

²⁰⁶ W. J. Johnston to P. M. Goodbread, letter, 30 January 1964, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1964, LBNL Archives.

²⁰⁷ R. P. Connell to P. M. Goodbread, letter, 22 July 1968, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1968, LBNL Archives.

In 1957, LLNL built a new facility, Building 194, to house a 16-MeV linear accelerator (linac) built by ARCO.²⁰⁸ From 1960 to 1967, scientists conducted pioneering research on the linac, using monoenergetic photons to study the electromagnetic field. In 1969, a new 100-MeV electron-positron linear accelerator replaced the original linac. The

²⁰⁸ "Building 194, Increment 2—High-Flux Building," *The Magnet* (May 1959), 7.

new electron-positron linac was used for experiments in neutron physics, studies of electromagnetic interactions, and applied reactor technology.²⁰⁹

In 1960, Site 300 installed a linear accelerator in the hydrodynamic test area to study weapon initiators as they imploded. In 1982, Site 300 upgraded its hydrodynamic capabilities and installed the flash X-ray machine. The flash X-Ray takes highly detailed photographs of the insides of stockpiled weapons.²¹⁰

In 1964, Nicolas Christofilos, a physicist in the magnetic fusion research program, successfully tested a new linear induction magnetic accelerator, Astron, which he designed to heat plasma.²¹¹ Astron was located in Building 431. Ultimately, the magnetic fusion research program abandoned Astron as a viable approach to achieving power from fusion. However, the induction linac, which Christofilos invented, led to a series of ever more powerful induction linacs at LLNL that proved important in flash radiography and stockpile assessment.

In 1979, building on Christofilos's induction linac technology, LLNL built the Experimental Test Accelerator (ETA), located in Building 431. The ETA was a prototype accelerator designed as a directed energy weapon.²¹² In 1983, LLNL built a

larger and more energetic accelerator, the Advanced Test Accelerator (ATA) at Site 300. The beam of the ATA was used as a driver for a free electron laser (FEL). In 1987, LLNL installed a new induction linear accelerator, the ETA II, to conduct further FEL studies and to power a free-electron laser to heat plasma in the Microwave Tokamak Experiment (MTX).²¹³ ETA II was located in Building 431. In 1992, the ETA II was dismantled. In 1997, scientists re-furbished the ETA II for use in advanced radiographic experiments for stockpile stewardship.²¹⁴

With the exception of Astron, most LLNL accelerator research and development furthered the nuclear weapons program. The large majority of accelerator research in the United States over the last fifty years has been focused on high-energy physics—the study of matter and its properties. The largest centers of high-energy physics accelerator research are Brookhaven National Laboratory, the Stanford Linear Accelerator (SLAC) Facility, and Fermi National Accelerator Laboratory.²¹⁵

In 1952, Brookhaven built the Cosmotron, one of the first particle accelerators. In 1955, LBNL followed with the Bevatron, a more powerful accelerator. Stanford built a series

²⁰⁹ "‘Electron-Positron’ Linac to be Built at Livermore Lab," *The Magnet* (July 1967), 1, 6.

²¹⁰ *Serving the Nation for Fifty Years*.

²¹¹ "The Astron Facility is Ready to Face its Crucial Test," *The Magnet* (July 1964), 3.

²¹² Lawrence Livermore Laboratory, *Experimental Test Accelerator (ETA): Generation of High-Intensity Electron Beams*, Technical Summary (Livermore: Lawrence Livermore Laboratory, 1981).

²¹³ "New Linear Induction Accelerator," *Energy and Technology Review* (July 1987), 58–59; and "Microwave Tokamak Experiment," *Energy and Technology Review* (July 1987), 48–49.

²¹⁴ J. T. Weir, G. J. Caporaso, J. C. Clark, H. C. Kirbie, Y.-J. Chen, S. M. Lund, G. A. Westenskow, and A. C. Paul, *ETA II Experiments for Determining Advanced Radiographic Capabilities of Induction Linacs*, UCRL-JC-126072 (Livermore: Lawrence Livermore National Laboratory, 1997), 1.

²¹⁵ U.S. Department of Energy, *The Ultimate Structure of Matter: The U.S. High Energy Physics Program from the 1950s through the 1980s*, DOE/ER-0412 (Springfield, VA: National Technical Information Service, U.S. Department of Commerce, 1989), 1.

of accelerators in the 1950s culminating with the Mark III.²¹⁶ In 1961, Brookhaven built the Alternating Gradient Synchrotron (AGS), the first accelerator with strong focusing.²¹⁷ In 1966, Stanford built SLAC, a new generation of particle accelerators based on microwave technology.²¹⁸ In 1972, the Fermi National Accelerator Laboratory built a four-mile-long proton synchrotron—one of the largest particle accelerators in the world at the time.

The particle accelerators mentioned above have enabled most of the important scientific discoveries regarding high-energy physics and the nature of matter. Likewise, most technological advances in accelerator technology have occurred at Brookhaven National Laboratory, SLAC, or Fermi National Accelerator Laboratory.

Nevertheless, LLNL has contributed several important breakthroughs in accelerator technology with special applications to weapons development. Notable LLNL breakthroughs in accelerator research and development include: the invention of the induction linear accelerator, Astron (1964); the use of the positron beam to create the photonuclear process, 100-MeV electron-positron linear accelerator (1969); and the development of an accelerator as a directed weapon, ATA (1983).

Lasers

In 1962, shortly after lasers (devices that could produce short pulses of intense light) were invented, LLNL physicists began

exploring the possible energy and defense applications of this new technology. LLNL director, John Foster, appointed Ray Kidder to head Q Division, a new group dedicated to the study of lasers. Kidder wrote to the AEC describing the objectives of Q Division. “The principal objective of the laser research program is to ignite and burn a small amount of DT (deuterium-tritium) under controlled and reproducible laboratory conditions.”²¹⁹ Q Division hoped to use lasers to create a thermonuclear reaction that could be studied in a controlled environment. Early research efforts focused on the development of a high-powered pulsed laser oscillator.²²⁰ Early laser work at LLNL is depicted in figure 25.

In 1966, Q Division constructed a laser that would be the forerunner of the giant lasers of the 1970s and 1980s. Other firsts in laser research achieved by Q Division in the 1960s included: development of a computer program that calculated laser implosions, production of a multi-beam laser irradiation system, invention of a CO₂ laser, discovery of a special X-ray from laser-produced plasmas, and work on ultra-short laser pulses.²²¹

By 1969, the laser research effort at LLNL had become fragmented as other divisions entered the field. The weapons program hoped to use lasers to carry information, “relaying data from ground zero of a nuclear test shot.”²²² The Electronics Engineering Department also had a laser

²¹⁶ Ibid., 5.

²¹⁷ Ibid., 8.

²¹⁸ Ibid., 19.

²¹⁹ “Mastery of Fusion Starts with Toy,” *Newsline* (November 1973), 5.

²²⁰ *Status Report: Fiscal Year 1963*, 15; and *30 Years of Technical Excellence*, 37.

²²¹ “Mastery of Fusion Starts With Toy,” 5.

²²² “Versatile Lasers Shed Light on Plasma Studies,” *The Magnet* (March 1966), 2.



Figure 25. Early Q-Division laser research.²²³

program directed toward adapting the laser for use in the communications field. LLNL director Michael May asked physicist Carl Haussmann to reorganize and streamline the laser research program.

Haussmann focused LLNL laser research into two primary areas—laser fusion and the separation of isotopes.²²⁴

In 1971, LLNL physicists began experimenting with the possibility of using lasers to cause fusion reactions, a process known as Inertial Confinement Fusion (ICF). The ICF program goals were twofold: to produce thermonuclear micro-explosions for weapons studies and to develop civilian power applications. ICF research selected the neodymium-doped glass laser for its fusion experiments.²²⁵

Beginning in 1974, LLNL designed Janus, its first laser for ICF experiments. Janus is shown in figure 26. Janus was the first in a series of lasers, each more powerful than the last, that culminated in the National Ignition Facility (NIF), on which construction began in 1999 and is slated for completion in 2008. The LLNL series of lasers included Janus (1974), Cyclops (1975), Argus (1976), Shiva (1977), Novette (1982), and Nova (1985).²²⁶ Nova and the Nova Laser Fusion Facility are depicted in figures 27 and 28.

ICF research produced some important milestones. In 1974, the Janus laser produced the first ICF direct-drive implosions and fusion neutrons. In 1975, the Cyclops laser produced the first ICF radiation driven implosions fusion neutrons. In 1977, the Shiva laser

²²³ Early Q-Division laser research, Box 089, Folder 10603, LLNL Archives.

²²⁴ Arnie Heller, Katie Walter, and Gloria Wilt, "Leading the Best and the Brightest," *Science and Technology Review* (January/February 1999), 6–7.

²²⁵ *Ibid.*, 38.

²²⁶ "Laser Fusion: What Is It?" October 1982, slide presentation, Box 527, Folder F6071, LLNL Archives, 13.

demonstrated the 100 times liquid density compression of DT fuel. The twenty-beam Shiva laser was the most powerful laser in the world at the time. In the 1980s the Argus laser demonstrated improved coupling—a necessary requirement for the success of the Nova target physics program. The Novette and Nova laser experiments of the 1980s demonstrated characteristics necessary for ICF ignition.²²⁷ The Nova laser was ten times more powerful than the Shiva laser.

In 1973, LLNL physicists also developed the Laser Isotope Separation (LIS) program, a project that endeavored to use lasers to enrich uranium fuel for the nuclear industry.

LIS technology was proposed to replace the gaseous diffusion process used to separate uranium isotopes to produce enriched uranium for reactor fuel. LIS technology was thought to be more cost effective and environmentally friendly than gaseous diffusion. LLNL researchers first pursued “the atomic vapor method—using a dye laser pumped by a copper vapor laser to selectively excite, photoionize, and separate isotopes of choice.”²²⁸ The LIS process initially developed was the Atomic Vapor Laser Isotope Separation (AVLIS). In later years, a more efficient solid-state laser replaced the vapor laser.

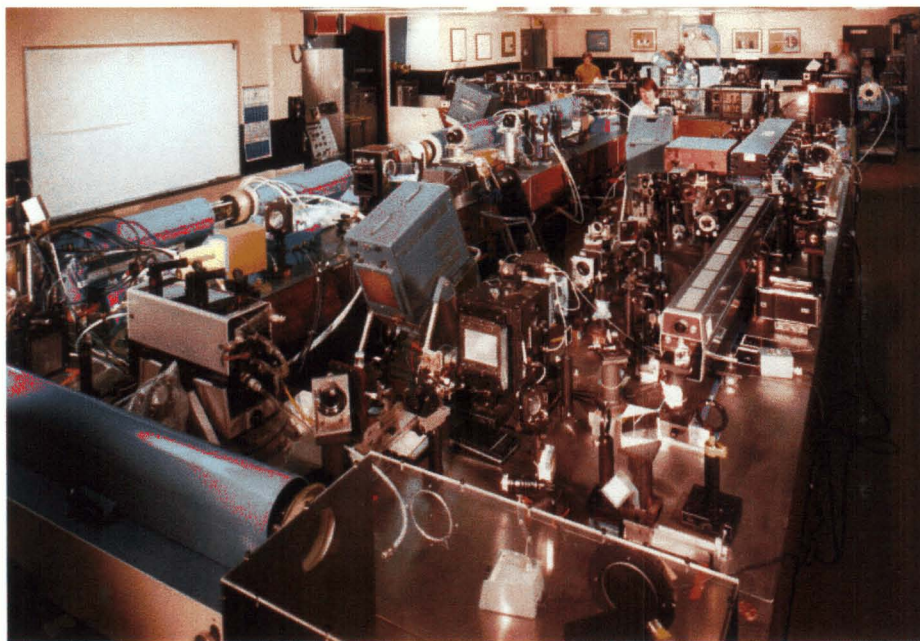


Figure 26. Janus laser, 1974.²²⁹

²²⁷ Lawrence Livermore National Laboratory, *Physics and Advanced Technologies: 2001 Annual Report*, UCRL-ID-1480881 (Livermore: Lawrence Livermore National Laboratory, 2001), 65.

²²⁸ Heller et al., “Leading the Best and the Brightest,” 8.

²²⁹ Janus laser, 1974, LLNL Archives.

6. LLNL COLD WAR MISSIONS
AND PRESERVATION THEMES

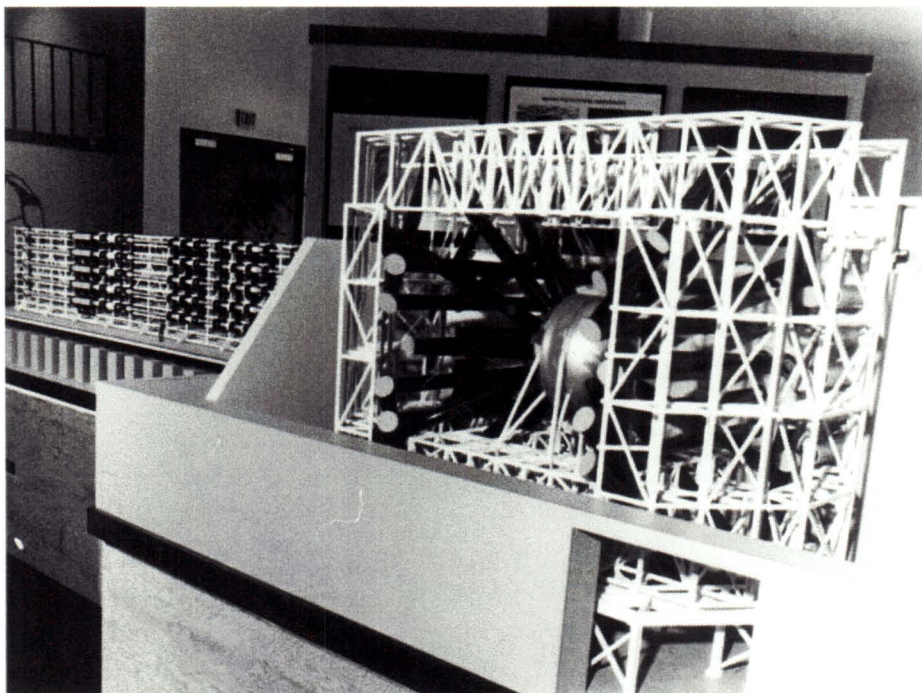


Figure 27. Scale model of Nova laser, 1985.²³⁰

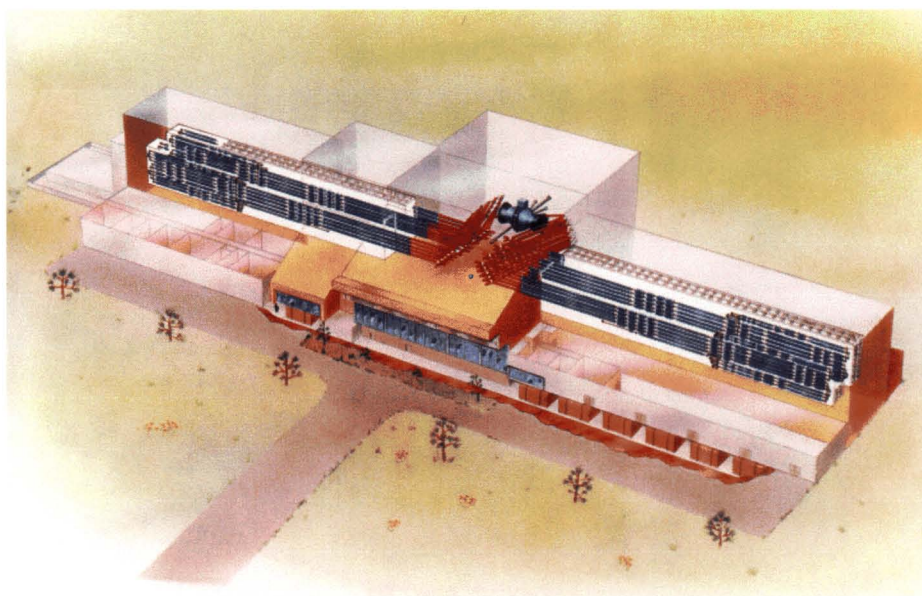


Figure 28. Artist's rendition, Nova Laser Fusion Facility, Building 391.²³¹

²³⁰ Nova laser model, 1985, LLNL Archives.

²³¹ Nova Laser Fusion Facility, artist's drawing, LLNL Archives.

In 1974, scientists succeeded in enriching a small quantity of uranium during the Morehouse experiment. Since then, the LIS has progressed through successive generations of separators. These separators included Regulis (1980), the Mars Facility (1984), and the Laser Demonstration Facility (1997).²³²

In 1992, Congress created the United States Enrichment Corporation (USEC) to make LIS technology available to private industry. In 1997, LLNL completed construction on a pilot enrichment plant, the Laser Demonstration Facility. However, changing demand for uranium led Congress to suspend USEC in 1999.²³³

Laser research in the United States virtually exploded in the 1960s. By far the largest research and development effort lay in industry. Industry applied laser technology to a wide variety of research and development projects. For instance, Bell Laboratories pursued lasers as the next step in optical communication.²³⁴ Other laser applications included medical therapies and computer components.

The military also pursued laser research for a variety of defense applications. The Air Force investigated lasers for space communication, lasers that could track space objects, and lasers powered by the sun. The Army studied lasers beams for guided missiles and beam weapons.²³⁵

LLNL embarked on laser research in the formative years of the field. LLNL pioneered research in the area of laser fusion. In the early 1970s, world demand for alternative sources of natural energy led Congress to dramatically increase funding for laser fusion research. In 1972, LLNL's laser fusion program expanded fourfold.²³⁶ In 1977, The President's SAC recognized LLNL's laser fusion research as both important and promising. SAC members saw LLNL's glass laser as a better approach to laser fusion than LANL's gas laser.²³⁷ In 1985, the Nova laser system confirmed the SAC assessment. Although the promise of laser fusion has yet to be realized, LLNL pioneered in this field and made several significant advances in laser fusion technology including the development of the first ICF laser, Janus; the development of Shiva, the most powerful ICF laser in the world; and the demonstration of the feasibility of fusion ignition, Nova.

The scientific community began research on laser isotope separation as early as 1963. In 1971, AVCO Everett Research Laboratories (AERL) demonstrated the first laboratory-scale uranium enrichment using a laser. In 1976, AERL subsequently developed an industrial scale separation process in partnership with Exxon. In 1973, LLNL also began research on uranium isotope separation using a laser. In 1980, Exxon terminated its project with AERL to build a pilot plant. In 1985, DOE selected Livermore as the

²³² Benjamin B. Snively to James I. Davis, "Isotope Separation Program Overview," 7 November 1974, Laser Program Annual Report, John L. Emmett Papers, 1973–1975, Box 419, Folder 4017, LLNL Archives; *30 Years of Technical Excellence*, 39; and *Serving the Nation for Fifty Years*.

²³³ *Serving the Nation for Fifty Years*, 51.

²³⁴ Joan Lisa Bromberg, *The Laser in America, 1950–1970* (Cambridge, Mass: MIT Press, 1991), 98–99.

²³⁵ *Ibid.*, 103.

²³⁶ *Ibid.*, 214–218.

²³⁷ *Report of the Committee to Examine the University's Relationship with the Los Alamos and Livermore Laboratories*, 14–17.

dominant leader in laser uranium isotope separation technology.²³⁸ Nevertheless, in 1999, Congress cancelled its support of laser isotope separation research—effectively terminating plans for the transfer of this technology to industry.

Although LLNL contributed to the advancement of LIS technology from 1973 to 1999, it did not pioneer research in this field. In addition, LIS technology was never successfully transferred to industry or used in the making of reactor fuel. At this time, it does not appear that LIS technology at LLNL is of historic interest and the properties associated with this research would not be historically significant for this activity. However, if LIS technology is ever successfully applied by industry, LLNL's LIS buildings will require consideration for their contributions.

Most physics research, like weapons design, is an activity hard to discern in the built environment. Physicists conducted theoretical and computational physics research in standard office buildings and with little visible equipment. Computers that calculated physics research were updated frequently and no longer exist in the buildings that originally housed them. Nevertheless, the following scientific discoveries, technology, and equipment are of historic interest within the context of the Cold War, theme of Nuclear Research, and subtheme of Nuclear Physics—the LPTR, Kukla, 100-MeV Electron-Positron Accelerator, Astron, ATA, Janus, Shiva, and Nova.

If a building is clearly associated with one

of the above discovery moments, technological breakthroughs, or equipment then it may qualify for National Register consideration.

The building also must have integrity. It must clearly reflect the historically significant discovery moment or technological breakthrough.

6.3.2 Subtheme: Nuclear Chemistry Research

In the 1950s, the Chemistry Division at LLNL was composed of three departments—Radiochemistry, General Chemistry, and Chemical Engineering. Like the Physics Department, the Chemistry Division also went through many organizational and name changes throughout the years. In 1959, the Chemical Engineering section changed its name to Process and Materials Development.²³⁹ By 1982, the entire Chemistry Division had changed its name to Chemistry and Materials Science.²⁴⁰ However, the work that the Chemistry Division performed remained essentially the same over the years.

Most of the chemists at LLNL supported the weapons program in various capacities. However, many also worked at least part time on pure research problems in nuclear chemistry that did not necessarily relate directly to research issues in nuclear weapons design or testing.

Radiochemistry

Most radiochemists provided support for the nuclear testing program by analyzing test samples to determine the efficiency of weapons designs. However, scientists in the

²³⁸ Bromberg, *The Laser in America*, 241–243.

²³⁹ "Livermore Chemistry Designates Section Names," *The Magnet* (August 1959), 7.

²⁴⁰ *30 Years of Technical Excellence*, 84.

Radiochemistry group also conducted basic research in nuclear chemistry.

In the 1950s, research projects included the study of the fission process, observation of the chemical exchange reactions in isotopic tracers, and the search for new isotopes.²⁴¹

In 1961, the Radiochemistry Section measured the neutron-capture cross sections of uranium, thorium, hafnium, and gold during the Project Plowshare Gnome nuclear test in Carlsbad, New Mexico. This was one of the most ambitious nuclear reaction cross-section measurements undertaken at the time.²⁴²

In 1967, Building 151, the Radiochemistry Laboratory was built as a state-of-the-art facility. Figure 29 depicts AEC officials touring the new facility.

In 1971, LLNL radiochemists Ron Loughheed and Ken Hulet along with physicists Jerry Wesolowski and Walter John discovered a new type of fission—symmetric fission—in a sample of fermium 257 and fermium 258, obtained from an underground nuclear test. All other spontaneous fission occurs asymmetrically. LLNL scientists thought that symmetrical fission might be the clue that finally unraveled the theory of fission.²⁴³



Figure 29. AEC officials tour Building 151, Radiochemistry Laboratory, 1967.²⁴⁴

²⁴¹ *Status Report: Fiscal Year 1958*, 112.

²⁴² *Status Report: Fiscal Year 1962*, 25–26.

²⁴³ “This is the First Time Symmetric Fission of Fermium-257 has been Observed,” *Newsline* (January 1971), 1–2; and “20 Years in Livermore,” 17.

²⁴⁴ Gas laboratory in Building 151, 1967, LLNL Archives.

In 1974, radiochemists Loughheed and Hulet participated in a joint LBNL/LLNL team of scientists that discovered Element 106, since named seaborgium.²⁴⁵ In 1978, LLNL radiochemists discovered a new isotope, mendelevium-259, by watching the decay of nobelium-259.²⁴⁶

General Chemistry

The General Chemistry group focused on research that furthered general knowledge in the field of nuclear chemistry and had direct application to the weapons program.

The primary sections in the General Chemistry group were Explosives Chemistry, Plutonium Metallurgy, Physical Chemistry, Theoretical Chemistry, and High-Temperature Chemistry.

In the 1950s, their work featured theoretical studies in quantum and statistical mechanics; high-temperature chemistry; chemistry of explosives; physical chemistry of metals; studies on hydrides; ceramics; X-ray diffraction; electron-spin and nuclear magnetic resonance; emission, infrared, and Raman spectroscopy; electron microscopy; inorganic and organic syntheses of new compounds; ionic, micro, and gas analyses; solid-state chemistry; electrochemistry; low-temperature calorimetry; physical chemistry of intermetallics; irreversible thermodynamics; and chemical thermodynamics.²⁴⁷

In 1955, LLNL proposed the addition of a Plutonium Facility, to advance “fundamental metallurgical information on Plutonium.”²⁴⁸ At the time, only a few chemists at LANL, Hanford, and Argonne worked in the field, and the focus was mainly on reactors. In 1960, LLNL’s facility opened and work began on alloying, impurities, tensile strength, chemical compounds, corrosion inhibition, and fabrication techniques.²⁴⁹

In 1962, chemists in the Explosives Chemistry group began work on safety or sensitivity in explosives. In 1976, this work culminated in a design breakthrough in the IHE triamino-trinitrobenzene (TATB), which led to its widespread use in nuclear weapons.

In 1965, the Physical Chemistry group studied the heat formation of the rare gas compound XeO₄, observed the first atomic emission spectrum of berkelium, and developed a new X-ray pole figure to measure the microcrystallites that compose the surface of metals.

In 1978, the General Chemistry Division developed two computer-based gamma ray spectrometer systems for the DOE safeguards program.²⁵⁰ In 1988, the division installed an even more powerful spectrometer as part of a two-year experiment to measure the mass of neutrinos—the subatomic particles that make up the mass of the universe.²⁵¹

²⁴⁵ Ronald J. Dupzyk, Charles M. Henderson, William Buckley, Gordon L. Struble, Robert G. Lanier, and Lloyd G. Mann, *Production of Radioactive Targets for Use in High-Resolution, Charged-Particle Reaction Spectroscopy*, UCRL 79837 (Livermore: University of California Lawrence Livermore Laboratory, 1977).

²⁴⁶ “LLL Achievements During 1978,” *Energy and Technology Review* (July 1979), 19–20.

²⁴⁷ *Ibid.*, 113; and *Status Report: Fiscal Year 1959*, 31.

²⁴⁸ Wallace B. Reynolds to H. A. Fidler, letter, 10 September 1955, Ernest Orlando Lawrence Berkeley National Laboratory Declassified Records, 434–95, Box 4, File 19–10–364, Livermore Metallurgical Laboratory, LBNL Archives.

²⁴⁹ *Ibid.*; and *Status Report: Fiscal Year 1960–1961*, 28.

²⁵⁰ “LLL Achievements During 1978,” 19–20.

²⁵¹ “Neutrino Mass Experiment Unveiled,” *Newsline* (June 1988), 3.

Chemical Engineering

Chemical Engineering, subsequently called Materials Science, was engaged in the development of plastics, metals, and ceramics used in both weapons applications and energy research.²⁵² Materials Science will be explored as a separate subtheme of Nuclear Materials Research within Nuclear Research in section 6.3.3 below.

For the most part, the Nuclear Chemistry Division acted as support for large programs like Weapons or worked on smaller research projects that added to the fundamental knowledge of nuclear processes and materials. It provided “pools of well-trained professionals capable of lending their expertise to the new and constantly changing technical problems faced in the major research programs.”²⁵³ Most nuclear research was of an incremental nature and did not represent either momentous scientific breakthroughs in nuclear science or in weapons development.

Nevertheless, the following achievements in nuclear chemistry research are of historic interest: the discovery of the element seaborgium in 1974, the design breakthrough in TATB that led to the enhanced safety of nuclear weapons, and the discovery of the isotope mendelevium in 1979. Furthermore, the Plutonium Research Facility is also of historical interest because of its direct importance to nuclear weapons design and its role within the nuclear weapons complex in

plutonium metallurgic research for weapons applications.

To qualify for National Register consideration within the context of the Cold War, theme of nuclear research, and subtheme of nuclear chemistry, a building needs to be associated with the achievements described above. The association with a discovery moment in the field of nuclear chemistry that is recognized to be of major historic interest to the international scientific community (e.g., the discovery of seaborgium or mendelevium) or the connection with a breakthrough in nuclear chemistry that led to a major improvement in weapons design (e.g., the discovery of TATB and the Plutonium Research Facility) make a building historically interesting.

In addition, the building must also retain historic integrity. It must clearly reflect the discovery moment in nuclear chemistry or technological breakthrough in weapons design.

6.3.3 Subtheme: Nuclear Materials Research

Closely tied to nuclear chemistry research is the subtheme of nuclear materials research. The province of the Chemical Engineering Division, materials research involved the development of materials, plastics, ceramics, and metals that could be used in the design of nuclear weapons.²⁵⁴

A retired materials specialist summarized the problem driving LLNL’s materials

²⁵² *Status Report: Fiscal Year 1958*, 113.

²⁵³ “Support Projects,” *Energy and Technology Review* (July 1981), 35.

²⁵⁴ *Status Report: Fiscal Year 1958*, 112–113.

research. "Nuclear weapons are made out of the world's worst combination of materials, organics, and metals."²⁵⁵ Scientists developed ways to stabilize the highly volatile combination of materials that made up a weapon and might possibly emit radiation, corrode, or create dangerous gases or chemicals.

Beyond weapons, materials research also provided support to other LLNL programs, including Project Pluto, Magnetic Fusion Research, and Project Plowshare.

Some of the notable projects undertaken in materials research included the development of ceramic fuel elements for reactor research; the selection, forming, welding, and brazing of materials such as beryllium, uranium, and thorium; development of thermoplastics, thermosetting resins, laminates, foams, and elastomers for weapons; and the study of radioactive gases, solids, and liquids.²⁵⁶

In the 1950s, Materials Science developed an economical and simple method for making parabolic mirrors.²⁵⁷ This group also studied beryllium intermetallics, practiced brazing beryllium into special shapes, developed plastics with filler materials, and prepared ceramic bodies of beryllium oxide and uranium-fueled beryllium oxide for Project Pluto.²⁵⁸

In the 1960s, Materials Science solved several difficult welding and brazing problems for the weapons program, including "a metal-

inert gas and tungsten-inert gas welding of uranium to thorium and diffusion bonding of beryllium."²⁵⁹ They also developed an injection-molding technique to shape complex plastic components. Research in ceramics focused on the fabrication of uranium-fueled beryllia reactor fuel elements for Project Pluto.²⁶⁰ Materials Science also conducted basic nuclear chemistry research, such as, the development of techniques to separate and purify heavy elements released in underground nuclear tests.²⁶¹

In the 1970s and 1980s, Materials Science projects included producing and characterizing metallic glasses, investigating the structure of Kevlar fibers for use in structural components, and researching the gasless combustion of condensed solids to synthesize refractory materials.²⁶²

Materials Science primarily studied the characteristics and determined the best methods for working with metals, ceramics, and plastics involved in the design and fabrication of nuclear weapons, reactor components, and other materials used in various research projects. For the most part, Materials Science provided support to the weapons program and other large research projects at LLNL. However, the ceramic fuel elements developed from 1957 to 1964 for the Project Pluto reactor are of historic interest.

²⁵⁵ *30 Years of Technical Excellence*, 84.

²⁵⁶ *Status Report: Fiscal Year 1962*, 29.

²⁵⁷ *Status Report: Fiscal Year 1958*, 113.

²⁵⁸ *Status Report: Fiscal Year 1959*, 32.

²⁵⁹ *Status Report: Fiscal Year 1962*, 24.

²⁶⁰ *Status Report: Fiscal Year 1963*, 22.

²⁶¹ *Status Report: Fiscal Year 1965*, 27–28.

²⁶² "Achievements and Developments at LLL During 1977–1978," *Energy and Technology Review* (1978), 14; "Support Projects," 35; and "Engineering and Science," *Energy and Technology Review* (July 1983), 47–48.

The technical challenge LLNL faced in Project Pluto was to develop fuel elements with efficient neutron properties and the ability to withstand extreme temperature and moisture. LLNL successfully pioneered unique ceramic fuel elements—out of a homogenous mixture of highly enriched uranium dioxide and beryllium oxide.²⁶³

In 1959, LLNL developed a pilot plant for the fabrication of beryllia fuel elements in Building 167, which no longer exists. However, other buildings associated with fuel element research for Project Pluto are still in active use at LLNL.

To be considered of historic interest under the theme of Nuclear Research, and sub-theme of Materials Research, a building must be associated with a major technological breakthrough in materials development that led directly to the design of a historically important weapons system or reactor component. In addition, the building must also maintain its integrity. That is, it must reflect the major technological breakthrough in materials research and/or development at the time it occurred.

6.4 Theme: Non-Weapons Research

Non-weapons-related research has always been an important aspect of the work at LLNL. As noted previously, Herbert York insisted on pursuing some projects not directly tied to weapons work in order to attract as many talented scientists as possible.

²⁶³ University of California Ernest O. Lawrence Radiation Laboratory, *Interim Status Report: Fiscal Year 1964* (Berkeley and Livermore: Ernest O. Lawrence Radiation Laboratory, 1964), vii.

In 1952, York defined non-weapons research as one of four original missions of the Laboratory. Project Sherwood, the development of controlled thermonuclear reactions for power, became a primary area of research and programmatic commitment for LLNL for years to come.

In 1955, Project Rover, a program to develop nuclear-powered space vehicles, was awarded to LLNL. In 1957, Project Pluto, a similar program aimed at developing a nuclear reactor to power low-altitude missiles, followed this project. By 1966, a space power program was firmly established at the Laboratory.

In 1957, LLNL also embarked on a program of research intended to convert nuclear devices for industrial use. For nearly twenty years, Project Plowshare explored a variety of practical applications for nuclear explosives.

In 1963, LLNL initiated a biomedical research program to study the long-term effects of radiation in human and animal populations. This research has continued at LLNL, leading most recently to the Laboratory's participation in the Human Genome Project.

Although York established non-weapons research at LLNL as separate from the nuclear weapons program, it is largely interwoven with weapons research. Undoubtedly, some of the subthemes of non-weapons research are peripheral stories within the larger context of the Cold War. For instance, important discoveries in biomedicine, although involved with nuclear

weapons testing, did not significantly influence Cold War policy or the development of the nuclear stockpile. However, many of the non-weapons-related research programs at LLNL spun off from weapons research or resulted in knowledge that directly benefited the weapons programs.

A building may be eligible for National Register consideration under the theme of non-weapons research if it is clearly associated with a technological breakthrough or scientific discovery that directly influenced the Cold War. A building may also be eligible under this theme if it led to a breakthrough in weapons development or nuclear research, even if the original work had not been part of weapons research.

6.4.1 Subtheme: Nuclear Energy Research

The main thrust of LLNL's energy research stems from Project Sherwood, a program to develop controlled thermonuclear fusion for power. York included this as one of the Laboratory's original missions. As early as the 1950s, scientists worried about the inevitable exhaustion of the world's supply of fossil fuel. One avenue scientists pursued was to replace costly sources of energy with fusion, which would rely on one of the world's cheapest elements—deuterium, a heavy hydrogen found in abundance in the ocean.²⁶⁴

In 1951, the AEC established Project Sherwood, a multifaceted research effort. In addition to LLNL, LBNL, LANL, Oak

Ridge National Laboratory (ORNL), the Naval Research Laboratory (NRL), New York University, Massachusetts Institute of Technology, and Princeton University all participated in the search for controlled nuclear fusion.²⁶⁵

The basic requirements needed to sustain controlled thermonuclear fusion are fourfold:

- To heat a small amount of fusion fuel until it combusts—at hundreds of millions of degrees
- To confine the super-heated fuel in a chamber (without touching the walls) long enough for the fusion energy released to exceed its combustion temperature
- To convert the energy released into electricity or heat
- To replace the combusted fuel and remove the waste product.²⁶⁶

To meet these requirements, AEC scientists tried to develop a special magnetic field produced by the magnetic coils that surround a fusion combustion chamber. The magnetic field prevented the super-heated fuel, or plasma, from contacting the chamber. Several promising concepts were pursued, including the pinch, the stellerator, and the magnetic mirror.²⁶⁷

The pinch concept attempted to create the magnetic field from the internal currents of

²⁶⁴ 30 Years of Technical Excellence, 32.

²⁶⁵ Amasa S. Bishop, *Project Sherwood: The U.S. Program in Controlled Fusion* (Reading, Mass: Addison-Wesley Publishing Inc., 1958).

²⁶⁶ 30 Years of Technical Excellence, 32.

²⁶⁷ Ibid.

the plasma. LLNL, LBNL, and LANL all had pinch programs.²⁶⁸

The stellerator concept confined plasma in an endless tube and employed an external magnetic field along the tube's axis. Princeton primarily pioneered this effort.²⁶⁹

The magnetic mirror concept confined plasma in a straight tube with an external axis magnetic field. Mirrors were used to prevent the loss of particles from the ends of the tube. LLNL pioneered this method, although LANL, ORNL, and the NRL also eventually pursued this type of fusion research.²⁷⁰

LLNL's early controlled fusion research experimented with several ways to confine plasma. A method using "radiation pressure from intense microwave fields" was abandoned as technically unfeasible after only a few trials.²⁷¹ The pinch and the magnetic mirror concepts proved more promising, and LLNL physicists designed a series of fusion research devices to solve the plasma problem. These devices included the Cucumber I, Table Top, Toy Top, Toy Top II, Levitron, Astron, Felix, Adiabatic Low-Energy Injection and Capture Experiment (ALICE), Baseball I, Baseball II, 2X, 2XII, 2XIIB, Tandem Mirror Experiment (TMX), Mirror Fusion Test Facility (MFTF), and the Mirror Fusion Test Facility Modification B (MFTF-B).²⁷² Several of these machines represent breakthroughs in fusion research.

LLNL scientists pioneered the magnetic mirror approach to the problem of heating and containing plasma long enough for fusion to occur. In 1952, they constructed the first magnetic mirror machine, Cucumber I, to demonstrate the feasibility of the magnetic mirror concept. The Cucumber I experiment is considered to be one of the first breakthroughs in fusion research.²⁷³

In 1960, the Toy Top machine succeeded in both heating and containing plasma in a mirror system. The Toy Top model was then chosen for further development.²⁷⁴ Toy Top is depicted in figure 30.

In 1957, Nicolas Christofilos began work on Astron, a revolutionary magnetic mirror device that employed "a cylindrical sheet of high-energy electrons" to confine and super-heat the plasma.²⁷⁵ Work on Astron ended with Christofilos's death in 1972. Astron never met its technical goals for the creation of a fusion reaction. Nevertheless, Astron research laid the groundwork for many current accelerator research applications. Astron is pictured in figure 31. Christofilos' Astron accelerator research was a breakthrough in induction linear accelerator technology leading to the Experimental Test Accelerator (ETA), the Advanced Test Accelerator (ATA), and the ETA II.²⁷⁶

²⁶⁸ Bishop, *Project Sherwood*.

²⁶⁹ Ibid.

²⁷⁰ Ibid.

²⁷¹ 30 Years of Technical Excellence, 35.

²⁷² Ibid.; *Status Report: Fiscal Year 1963*, 55–56.

²⁷³ Richard Post, telephone interview with Michael Anne Sullivan, 3 April 2003; and Edwin Hooper, telephone interview with Michael Anne Sullivan, 3 April 2003.

²⁷⁴ "Sherwood Program Development," R. F. Post Collection, Box 260, Folder 2628, LLNL Archives, 1.

²⁷⁵ *Status Report: Fiscal Year 1958*, 142.

²⁷⁶ 30 Years of Technical Excellence, 35.

6. LLNL COLD WAR MISSIONS
AND PRESERVATION THEMES

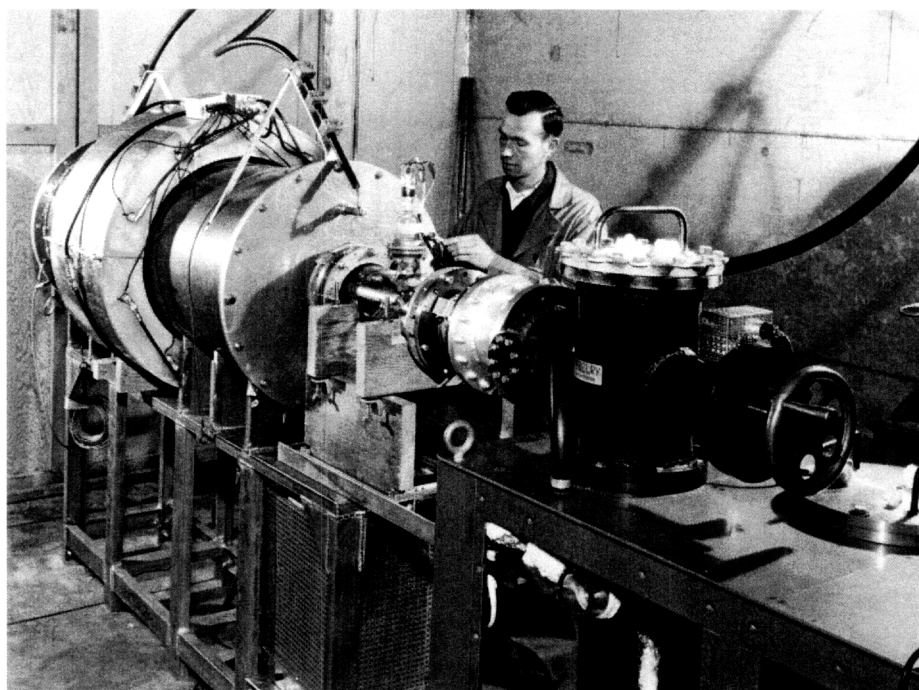


Figure 30. Toy Top, magnetic mirror machine, 1961.²⁷⁷

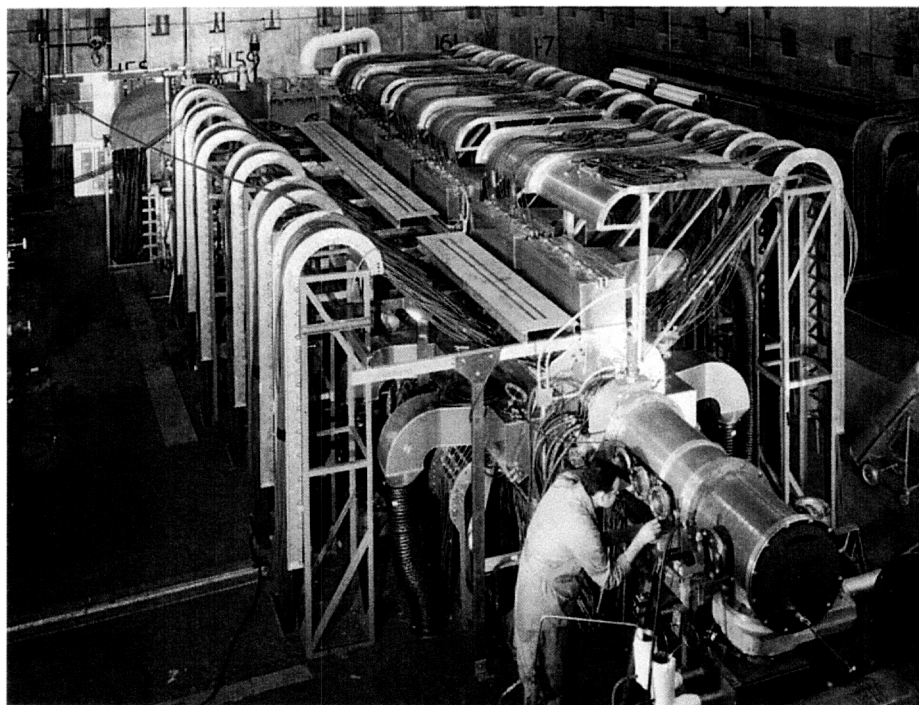


Figure 31. Astron, induction linear accelerator, Building 431, 1963.²⁷⁸

²⁷⁷ Toy Top, 1961, Box 21, Folder 10111, LLNL Archives.

²⁷⁸ Astron accelerator, 1963, LLNL Archives.

In 1968, the 2X machine, the lineal descendent of the Toy Top, made the next significant breakthrough in fusion research. The 2X overcame plasma instabilities by “evaporatively coating the vacuum chamber walls with a thin, clean, titanium metal surface that removed impurity atoms by surface absorption.”²⁷⁹ The 2X is depicted in figure 32.

In 1975, the 2XIIB machine finally succeeded in confining and heating plasma to the required temperature, density, and duration necessary for fusion to occur.²⁸⁰ The 2XIIB accomplished this through the addition of cold plasma toward the ends of the device.²⁸¹

In 1977, the success with the 2XIIB led to the TMX. In 1980, the TMX succeeded in creating a thermal barrier at the ends of the machine by heating electrons to retain the plasma—a major breakthrough in magnetic mirror technology.²⁸² The TMX is shown in figure 33.

The breakthrough in the TMX led to two more fusion experiments, the MFTF in 1980, and the MFTF-B in 1985. The magnets for the MFTF and the MFTF-B were the largest super-conducting systems ever built. The yin-yang magnets of the MFTF-B are depicted in figure 34. In 1986, DOE cancelled the MFTF-B program due to budget restrictions.²⁸³ With the cancellation of the MFTF-B,

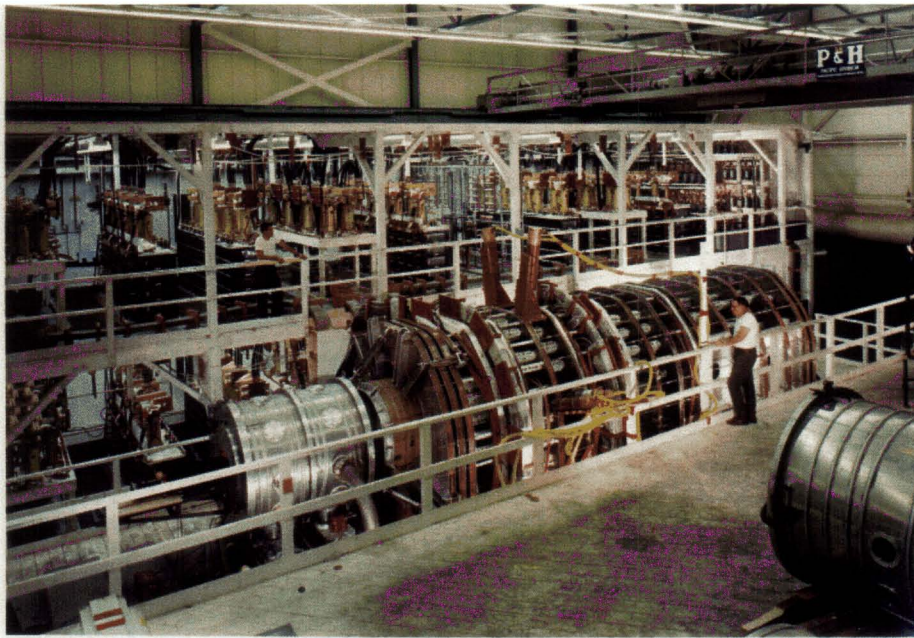


Figure 32. 2X, magnetic mirror machine, Building 435, 1964.²⁸⁴

²⁷⁹ Richard Post, “LLL Magnetic Fusion Research: The First 25 Years,” *Energy and Technology Review* (May 1978), 7; and “A New Stability for ‘Bottled’ Plasmas,” *The Magnet* (May 1968), 5.

²⁸⁰ *30 Years of Technical Excellence*, 34.

²⁸¹ Post, phone interview, 3 April 2003; and Hooper, phone interview, 3 April 2003.

²⁸² *Ibid.*

²⁸³ *30 Years of Technical Excellence*, 34; and *Serving the Nation for Fifty Years*.

²⁸⁴ 2X machine, Building 435, 1964, LLNL Archives.

6. LLNL COLD WAR MISSIONS
AND PRESERVATION THEMES

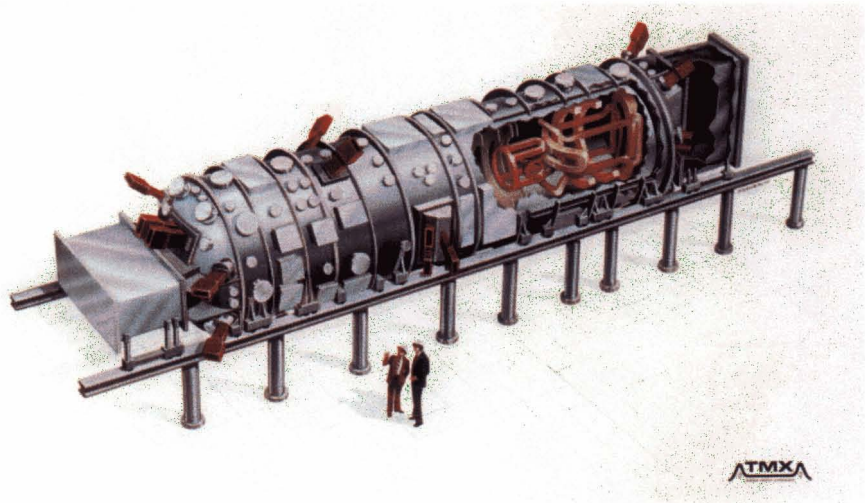


Figure 33. Artist's conception, TMX, 1980.²⁸⁵



Figure 34. MFTF-B, yin-yang magnets, 1985.²⁸⁶

²⁸⁵ TMX drawing, 1980, LLNL Archives.

²⁸⁶ MFTF-B yin-yang magnets, 1985, LLNL Archives.

DOE decided to pursue other fusion research avenues. MFTF-B was the last of the magnetic fusion projects at LLNL.

In 1987, after DOE mothballed the MFTF-B, LLNL redirected its Magnetic Fusion Energy program toward the tokamak concept.²⁸⁷ Originally pioneered by the USSR, the tokamak confined plasma in a toroidal-shaped reactor by the use of external coils.

In 1987, LLNL purchased the Alcator-C tokamak from the Massachusetts Institute of Technology. The Alcator-C tokamak was part of the MTX. The MTX used microwaves generated by a free-electron laser in the ETA II to heat the plasma in the Alcator-C tokamak to produce thermonuclear fusion.²⁸⁸ In 1992, the MTX scientists completed the tokamak plasma heating experiments, and the machine was dismantled.

Although the international physics community believed that the tokamak concept was still the most viable road to fusion, LLNL began to revisit an older fusion technology, called the spheromak, explored by LANL a decade earlier. The spheromak concept relies on a much smaller reactor with only a few external coils. The magnetic field is created internally through the movements of the plasma itself. Spheromak reactors are considered to be simpler in design and less costly to develop and maintain. In 1999, LLNL dedicated the Spheromak Physics Experiment (SSPX), which is currently still in operation.²⁸⁹

²⁸⁷ "Magnetic Fusion Energy," *Energy and Technology Review* (July 1987), 46–47.

²⁸⁸ "Microwave Tokamak Experiment," 48.

²⁸⁹ Arnie Heller, "Experiment Mimics Nature's Way with Plasmas," *Science and Technology Review* (December 1999), 18–19.

In the 1970s, LLNL established another fusion research program, which used a completely different route to the production of fusion. The Laser Fusion Program grew out of LLNL's early experiments with the new technology of lasers. This project explored the heating and combustion aspects of controlled fusion from a different angle than the magnetic mirror approach. The Laser Fusion Program tried to use high-powered lasers to super-heat fusion fuel and achieve combustion, a process known as Inertial Confinement Fusion (ICF). In 1974, LLNL completed Janus, the first in long series of lasers developed for ICF experiments that culminated in the National Ignition Facility (NIF).²⁹⁰

The lineage and accomplishments of LLNL's laser research place it more appropriately within the discussion of nuclear physics in section 6.3.1 "Subtheme: Nuclear Physics Research," and a fuller analysis is contained there.

Although fusion research was the major thrust of energy research at LLNL, other research programs have also addressed the problem of scarce natural resources. The Arab oil embargo of 1973–1974 lent a temporary impetus to LLNL's Energy and Resource Programs.

In 1975, research proceeded on two promising energy technologies—underground coal gasification and oil recovery from shale—that stemmed from another non-weapons related program, Project Plowshare. Project Plowshare will be more fully explored in section 6.4.3, "Subtheme: Plowshare."

²⁹⁰ *30 Years of Technical Excellence*, 37–40; and *Serving the Nation for Fifty Years*.

Coal gasification produced gas from thick coal beds without mining. To accomplish this goal several holes connected by a channel were drilled in a coal seam. Then the coal in the bottom of these wells was ignited. The ignition of the coal created gas, which escaped through the channel to production wells and then on to the surface. This technology had few environmental impacts.

Oil shale recovery from shale crushes the shale, then heats it to 450° C, forming shale oil, a petroleum-like product. LLNL primarily modeled this technology mathematically.

Some of the other projects explored included solar, geothermal, advanced battery research, and nuclear waste disposal. With the end of the Cold War and the decline in weapons research LLNL has again turned to energy research problems.²⁹¹

Of these LLNL energy research programs, thermonuclear fusion programs are of historic interest. LLNL pioneered the magnetic mirror approach to fusion. The following experiments are considered breakthroughs in this technology: Cucumber (1954), Toy Top (1960), 2XII (1968), 2XIIB (1975), and the TMX (1980).

For a building to qualify for National Register consideration within the context of the Cold War, theme of Non-Weapons Research, and subtheme of Energy Research, it must be clearly associated with a technological breakthrough in nuclear energy research of recognized importance. That is, the building must have housed and in

its construction and/or equipment reflect one or more of the specific breakthrough technologies noted above. The experimental machines identified above are themselves also historically significant as they are physical embodiments of the technological achievements.

In addition, the building or equipment must maintain its historical integrity. It must possess the equipment used in the energy breakthrough or otherwise still clearly reflect the breakthrough in energy research during the time that the breakthrough occurred.

6.4.2 Subtheme: Nuclear Propulsion Program

LLNL's nuclear propulsion program is part of the larger story of the U.S. Space Program. At first glance it does not seem to be directly related to LLNL's core mission—designing nuclear weapons. However, the U.S. Space Program also falls within the context of the Cold War. The U.S. regarded its space program and the race for mastery of space travel and exploration as an indicator of its scientific and technological superiority over the Soviet Union. In addition to space travel, the nuclear propulsion programs at LLNL also had clear ties to nuclear weapons strategy and stockpile development. Because LLNL's core mission and efforts in nuclear propulsion are more directly related to the nuclear weapons aspects of the Cold War, it is in this context that this work must be evaluated.

In 1955, LLNL instituted a nuclear propulsion program. The goal of this project was to develop nuclear reactors to power space vehicles or missiles. Nuclear propulsion research at LLNL lasted from

²⁹¹ 30 Years of Technical Excellence, 47.

1955 to 1968. The three main research efforts were Project Rover, a program to develop power for space travel; Project Pluto, a program to develop reactors to power low-altitude missiles; and the Space Reactor program, a project to develop nuclear generators for space vehicles. Although a relatively short-lived program, nuclear propulsion research added to LLNL's expertise in reactor design and led to other projects, including the Super Kukla, a prompt-burst neutron-pulse reactor designed to diagnose reliability in weapons in the stockpile.

Project Rover

In 1955, LLNL began work on the Nuclear Rocket Propulsion program, code-named Rover.²⁹² Scientists posited that nuclear energy would be superior to chemical fuel for the long-range propulsion of vehicles through the atmosphere and space.²⁹³

Initially, both LLNL and LANL developed reactor concepts for the Rover program. LLNL approached the problem by proposing a "10,000 megawatt single stage, graphite heat-exchanger rocket."²⁹⁴ The rocket would use LH₂ as a propellant in tanks that would fall away once they powered the vehicle into space. LANL proposed an "air-breathing ramjet carrying a nuclear rocket in its innards."²⁹⁵ The ramjet

would carry the rocket to a specific altitude and then drop off. The AEC funded both laboratories to pursue Rover research and development.

LLNL researchers bypassed the prototype stage and proposed building a small reactor. The Rover reactor would be fifty-two inches high with a six-inch beryllium reflector and a graphite core. In 1956, they began with a series of blowpipe tests—heating a graphite tube electrically to simulate one of the passages of the reactor core.²⁹⁶ The reactor was to follow the next year. In addition, LLNL also built a critical assembly called Puppy.²⁹⁷ In early 1957, the AEC decided to scale back the Rover research effort and assigned the project to LANL. LLNL's involvement in Project Rover lasted from 1955 to 1957, when LANL assumed full responsibility for the project.

Project Pluto

In 1957, LLNL's nuclear propulsion efforts shifted to Project Pluto, a program to design a low-flying nuclear reactor—a ramjet engine—to power a supersonic cruise missile. The Pluto reactor used air as a reactor coolant, whereas Rover had relied on hydrogen. This required that the Rover facilities be modified for Pluto research. During the first six months of the new project LLNL re-equipped its materials laboratory and built glove box facilities.

²⁹² James D. Fahey to Plant Engineering, memo, 3 August 1956, Box 476, Folder 4739, Rover Budget Review 1955–1956, LLNL Archives.

²⁹³ "Background Information on Los Alamos and Livermore Nuclear Propulsion Projects, and the Static Test Areas Being Developed at the Commission's Nevada Test Site," report, 27 September 1958, Bart Hacker's Records, Box 324, Folder 21286, LLNL Archives.

²⁹⁴ James A. Dewar, unpublished manuscript, 30 June 1995, Box 559, Folder 95690, LLNL Archives, 27.

²⁹⁵ Ibid.

²⁹⁶ Hayden Gordon and T. C. Merkle, *Nuclear Rocket Symposium*, 12 and 13 June 1956, University of California, Radiation Laboratory, Livermore Site, Bart Hacker's Records, Box 324, Folder 21286, LLNL Archives, 21–22.

²⁹⁷ E. C. Shute to W. B. Reynolds, letter, 18 October 1956, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1956, File Rover Program, Correspondence, LBNL Archives.

The primary technical challenge facing LLNL scientists in Project Pluto was the development of fuel elements with efficient neutron properties capable of withstanding extreme temperatures and moisture.²⁹⁸

LLNL met this technical challenge; researchers developed ceramic fuel elements out of a homogenous mixture of highly enriched uranium dioxide and beryllium.²⁹⁹ Because no expertise existed at the time in the manufacture of these specialized fuel elements, a pilot plant for the fabrication of beryllia fuel elements was established on site. LLNL also developed a simulated flying environment at NTS to test its ramjet engines, the Tory II-A and the Tory II-C.

In 1961, the Tory II-A demonstrated the technical feasibility of a reactor-powered ramjet engine.³⁰⁰ In 1964, shortly after the successful testing of the Tory II-C, a full-scale reactor, the AEC cancelled Project Pluto because no firm military commitment materialized to pursue this technology.³⁰¹ Figure 35 depicts the Tory II-A and Tory II-C reactors.

Space Reactor Program

In 1966, LLNL once again returned to space power research. This time the goal was to develop a reactor that could produce between one and ten mega-watts of electrical power for space vehicle generators. The proposed space reactor also needed to

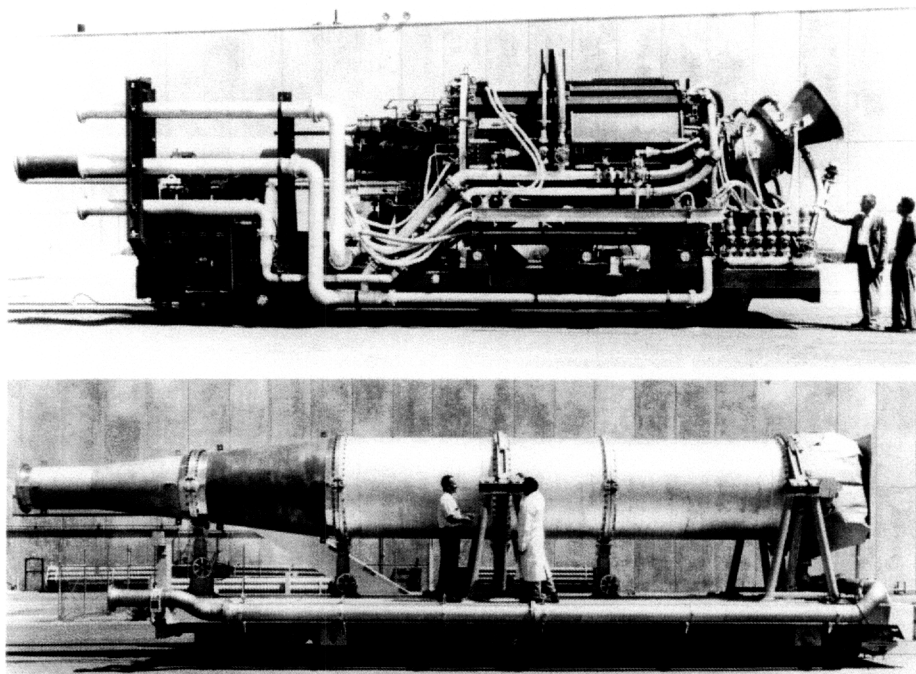


Figure 35. Tory II-A (top) and Tory II-C (bottom), ramjet engines for Project Pluto, 1961 and 1964.³⁰²

²⁹⁸ News Release, May 1964, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1964, Folder Pluto Program, LBNL Archives.

²⁹⁹ Ibid.

³⁰⁰ Ibid

³⁰¹ Press Release, 1 July 1964, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1964, Folder Pluto Program, LBNL Archives.

³⁰² Tory II-A and Tory II-C ramjet engines, 1961 and 1964, Box 570, Folder 10986, LLNL Archives.

work for 10,000 hours and be of the lowest possible weight. The reactor would be used for cosmological probes, manned planetary landings, and manned space stations.³⁰³

The Space Reactor program was a follow up to the SNAP-50/SPUR project, a project to develop reactors that could produce up to one megawatt of power. The AEC transferred the project from Pratt & Whitney Aircraft to LLNL following a budget reduction by Congress and a reorganization of the program. The AEC changed the program's emphasis from reactor construction and testing to basic reactor research.³⁰⁴

The Space Reactor program at LLNL planned experiments that would eventually lead to the development of a small liquid-metal-cooled reactor. Studies involved the development of unique metals that could withstand extremes in temperature yet still demonstrate chemical compatibility. LLNL space power scientists experimented with tungsten, uranium nitride fuel, and alkali-metal heat transport fluids.³⁰⁵

The AEC cancelled this program in 1968 before it was completed.

LLNL's research into nuclear propulsion and space power added to the Laboratory's growing expertise in reactor design and research. This expertise led to other applications in stockpile maintenance and diagnostics.

³⁰³ "New Livermore 'Space Reactor' Program," *The Magnet* (January 1966), 1.

³⁰⁴ Ibid.

³⁰⁵ LLNL history, unpublished manuscript, 1966–1967, 25; and "20 years in Livermore," 16–17.

For the most part, nuclear propulsion and space power programs at LLNL were too brief and inconclusive to have made any clear technological breakthroughs. However, Project Pluto does meet the threshold for historic interest. LLNL successfully designed, developed, and tested a reactor that could power a ramjet engine. It also designed and developed unique uranium and beryllium-enriched fuel elements.

A building may qualify for National Register consideration within the context of the Cold War, theme of non-weapons research, and subtheme of nuclear propulsion if it demonstrates a clear association with technological breakthroughs or scientific discoveries associated with Project Pluto. That is, the building must have housed and in its construction and/or equipment reflect one or more of the specific breakthroughs identified for Project Pluto. Likewise, equipment or objects that contained or are manifestations of technological or scientific breakthroughs in nuclear propulsion qualify for National Register consideration.

Additionally, the building, equipment, or object must also possess integrity. It must clearly still reflect the scientific discovery moment or the technological breakthrough during the period of its historic significance. That is, a contemporary from the period of significance would be able to recognize the building, equipment, or object as having housed or represented the discovery moment or technological breakthrough. Equipment or objects, if at least 80 percent intact, maintain integrity regardless of whether or not they are in their original location, unless their operation was integrally connected to the building location (that is, they could not operate unless in a specific location).

6.4.3 Subtheme: Plowshare

Even before the first atomic test at Trinity in New Mexico, scientists touted the future benefits of this awesome new power. Both scientists and social commentators predicted such wonders of modern science as nuclear-powered submarines and planes, atomic sources of energy to heat and light homes, and nuclear explosives that could move mountains or dig canals. Suggestions ranged from practical solutions for industry to fantastic creations from the realm of science fiction.³⁰⁶

In 1945, shortly after the United States dropped atomic weapons on Hiroshima and Nagasaki, the potential positive uses of atomic power received renewed attention in the media and within the scientific community. Many of the proposed beneficial byproducts of atomic energy received government sanction and funding. In 1946, the air force and the navy initiated research projects in nuclear-powered airplanes and ships, respectively.³⁰⁷ In 1947, the AEC established policies for nuclear research in medicine, biology, and power.³⁰⁸ In the early 1950s, several scientists and engineers, working independently at various AEC laboratories, began to explore the possibility of using nuclear devices for industrial applications.

In 1957, Edward Teller and Herbert York held a symposium at LLNL to discuss the feasibility of adapting nuclear weapons for industrial use. The following year, the

AEC assigned LLNL the lead in Project Plowshare, a multi-laboratory program to develop nuclear explosives for industrial projects such as nuclear engineering and mining. Dual benefits were imagined for the research, as Project Plowshare included proposals for using nuclear devices to gain important information about cratering, blast, radiation, and seismology that would be useful for the weapons program.³⁰⁹

Between 1958 and 1975, the AEC conducted thirty-five Project Plowshare nuclear tests, as well as numerous HE experiments simulating nuclear excavation.

The initial thrust of Project Plowshare research was the development of nuclear explosives for excavation purposes—earth moving and canal construction. In 1958, LLNL planned Project Chariot, an experiment to excavate a deep-water harbor at Cape Thompson, Alaska, with nuclear devices. Project Chariot was to be the initial project in a much larger program that would eventually lead to the excavation of a sea-level canal across the Isthmus of Panama. Neither Project Chariot nor a new Panama Canal was ever realized, although many preliminary nuclear tests to simulate excavation techniques were carried out.

On December 10, 1961, LLNL conducted the first of the Project Plowshare nuclear tests. The Gnome test detonated a three-kiloton device 1,200 feet below ground near Carlsbad, New Mexico. The goal of the test

³⁰⁶ Paul Boyer, *By the Bomb's Early Light: American Thought and Culture at the Dawn of the Atomic Age* (Chapel Hill: University of North Carolina Press, 1985).

³⁰⁷ Hewlett and Duncan, *Atomic Shield*.

³⁰⁸ Ibid.

³⁰⁹ For information on Project Plowshare and its beginnings, see Dan O'Neil, *The Firecracker Boys* (New York: St. Martin's Press, 1994), 9–30; Harlan Zodtner, ed., *Industrial Uses of Nuclear Explosives, Plowshare*, UCRL-5252 (Livermore: University of California Radiation Laboratory, 1958); and Edward Teller, Wilson K. Talley, Gary H. Higgins, and Gerald W. Johnson, *The Constructive Uses of Nuclear Explosives* (New York: McGraw-Hill Book Company, 1968).

was to produce nuclear energy for research purposes. Project Sedan followed Gnome, on July 6, 1962, at NTS. Project Sedan, the largest of the Project Plowshare experiments, a 100-kiloton cratering experiment, displaced twelve million tons of rock and left a crater 320 feet deep and 1,280 feet in diameter.³¹⁰ The crater of the Sedan shot is shown in figure 36.

In 1968, the focus of the Project Plowshare experiments shifted to the possibilities of nuclear mining. Many kinds of mining applications were explored, including gas well stimulation, the creation of underground gas storage facilities, oil recovery from shale, and leaching of copper ore. LLNL developed preliminary feasibility studies and proposals on all of these mining



Figure 36. Sedan crater, largest Project Plowshare test shot, 320-feet deep, 1,280-foot diameter, 1961.³¹¹

³¹⁰ Carl R. Gerber, Richard Hamburger, and E. W. Seabrook Hull, *Plowshare* (Oak Ridge: Atomic Energy Commission, Division of Technical Information, 1968); and LLNL history, unpublished manuscript, 1966–1967, 7.

³¹¹ Digital image courtesy of Sandia National Laboratories, CQuest Image No. 1965, 1961.

applications. However, LLNL only tested the nuclear devices for gas well stimulation. Project Gasbuggy (1967), Project Rulison (1969), and Project Rio Blanco (1973) were joint AEC- and industry-sponsored nuclear tests designed to stimulate the production of natural gas. Although all three tests succeeded in terms of technical achievement, the cost of using nuclear devices for mining proved to be prohibitive. The AEC cancelled Project Plowshare in 1975 due to budgetary and environmental concerns.³¹²

However, the expertise that LLNL gained in mining applications of nuclear devices led to more collaboration with industry to enhance energy production. LLNL pursued techniques for converting coal beds to gas without mining and recovering oil from shale. These types of industry/laboratory collaborations began in 1974 and ran through 1988. They are described in more detail above in section 6.4.1 "Subtheme: Nuclear Energy Research."³¹³

Project Plowshare testing occurred at NTS or at other off-site locations within the United States. LLNL conducted its first Project Plowshare test, Project Gnome, in 1961 in Carlsbad, New Mexico. Thirty-four other test shots were fired before the program ended in 1975.

Specific Project Plowshare nuclear tests may be of historic interest either because they represented technological breakthroughs in nuclear engineering or mining methods, or because they were associated with a significant technological breakthrough in nuclear testing in general. For example, the 1962

Sedan shot demonstrated the feasibility of using nuclear devices for excavation and resulted in the world's largest crater.

The kinds of buildings associated with an actual Project Plowshare nuclear test would include staging areas, test structures, and test buildings. The most likely buildings to be associated with historically significant Project Plowshare tests would be those at NTS.

The assessment of structures at NTS is outside the scope of this project. It is unlikely that buildings at LLNL will be of historic interest on the basis of association with an important Project Plowshare nuclear test. The exception would be a staging area or an assembly building where test devices were assembled or staged prior to their use at NTS or other nuclear test sites in a historically significant Project Plowshare nuclear test series. Such a building would also need to possess historic integrity. That is, it would have to clearly reflect nuclear staging or assembly activities and be clearly associated with an important Project Plowshare nuclear test.

6.4.4 Subtheme: Biomedical Research

In 1947, the newly established AEC created an Advisory Committee on Biology and Medicine to oversee and support research in radiation biology and health physics at all AEC laboratories. Areas of research included studies to determine the effects of radiation on living matter, radioisotope distribution programs, and projects to establish safety procedures for working with fissionable materials. The AEC consistently

³¹² Gerber et al., 9–12.

³¹³ Ibid.

promoted biomedical research. This research effort was expanded in 1974, when the AEC was reorganized into the Energy Research and Development Administration (ERDA), to include environmental and energy research as well. DOE has continued this research program.³¹⁴

In 1963, LLNL initiated a Biomedical Research Program to study the effects of radiation on humans and other living things. Dr. John Gofman, a noted medical researcher at UCRL, Berkeley, was recruited to head the new department.³¹⁵ Gofman initially focused on the study of internal emitters, radioactive particles taken into the body. Many AEC laboratories and university medical programs participated in the internal emitter studies. This program used animals to study the effects of inhaled and ingested radiation from fallout associated with weapons tests or nuclear power generation.³¹⁶

In the 1970s, the focus of the Biomedical Research Program shifted to the biological measurement of radiation doses received by a person subjected to radiation. Work in this area increasingly focused on DNA, investigating how it was damaged and how it repaired itself. LLNL developed several key tests and technologies to detect cell damage. The two different types of equipment developed to analyze cells included a flow

cytometer, which identified and sorted cells, and an image-analysis system, which made computer images of the cells seen through microscopes.³¹⁷

In 1987, technological breakthroughs in cell analysis at LLNL and LANL led to the DOE decision to launch the Human Genome Initiative, which eventually evolved into the Human Genome Project.

The Biomedical Research Program at LLNL evolved to include environmental research as well. Environmental research initially focused on how radiation from fallout affected air, land, sea, and fresh water. In the 1970s, the focus of the program expanded to include the assessment of damage that other energy technologies might cause the environment. Some of the projects that the Environmental Sciences Division undertook included long-term assessments of radioactive fallout from weapons tests in the Marshall Islands; the study of smog damage in Southern California; ecological impact studies of nuclear reactors in Eureka and Morro Bay, California; and an environmental study of the impact of geothermal development in California's Imperial Valley.³¹⁸

Biomedical research is included as a preservation subtheme within the Cold War context because of its close association with weapons testing. The biomedical program at LLNL originated due to concerns with radioactive fallout from nuclear testing and potential radioactive fallout from future Project Plowshare technologies.

³¹⁴ For more information on the AEC and biomedical research, see Douglas Vaughan, ed., *A Vital Legacy: Biological and Environmental Research in the Atomic Age* (Berkeley: Ernest Orlando Lawrence Berkeley National Laboratory, 1997).

³¹⁵ "Biomed Group Established at Livermore," *The Magnet* (June 1963), 1, 5.

³¹⁶ LLNL history, unpublished manuscript, 1967–1968, 22; and Vaughan, ed., *A Vital Legacy*, 11. In the 1970s the Environmental Sciences Division was within the overall Biomedical Research Program.

³¹⁷ *30 Years of Technical Excellence*, 44–45.

³¹⁸ *30 Years of Technical Excellence*, 44–45; "LLL Biomedical and Environmental Research: Program Overview," *Energy and Technology Review* (May 1976), 13–15; and "Imperial Valley Environmental Project," *Energy and Technology Review* (May 1976), 21–25.

Nevertheless, biomedical research was a ubiquitous Cold War activity within both the nuclear weapons complex and the medical community. Much of the research conducted at LLNL was similar to biomedical research at other AEC facilities. In fact, the 1977 President's SAC committee identified biomedical research at both LLNL and LANL as overly preoccupied with sophisticated instrumentation and engaged in "more or less routine health physics and environmental studies."³¹⁹ In addition, the types of buildings most likely associated with biomedical research at LLNL are generic medical laboratories and animal facilities.

Although biomedical and environmental research at LLNL was largely routine, the cytometer and the image-analysis system developed in the 1970s are of historic interest. A building may qualify for National Register consideration within the context of the Cold War theme of non-weapons research, and subtheme of biomedical research if it is associated with the equipment mentioned above or scientific breakthroughs or discovery moments in biomedical research made on them. Likewise, the equipment itself, regardless of its location would also be of historic interest. A building must also retain its historic integrity. It must reflect the breakthrough, technique, technology or discovery moment in biomedical research at the time of its historic significance. The original cytometers and image systems must also retain obvious integrity and be preserved intact. If still in use, they must retain the primary purpose for which they were designed. However,

biomedical research laboratories at LLNL, like computer facilities, have been constantly maintained and upgraded over the years. It is unlikely that historic biomedical equipment is extant and intact.

6.5 Thresholds for Cold War Preservation Themes

For a building or object at LLNL to qualify for National Register consideration within the context of the Cold War, it must fall within one of the themes and subthemes discussed above. It is possible for a building to qualify under more than one of the themes and subthemes. The Cold War preservation themes and subthemes for LLNL are summarized below.

Nuclear Weapons Design

- Weapons Design
- Computing

Nuclear Weapons Testing

- Nuclear Testing
- High Explosives Testing

Nuclear Research

- Nuclear Physics Research
- Nuclear Chemistry Research
- Nuclear Materials Research

Non-weapons Research

- Nuclear Energy Research
- Nuclear Propulsion Research
- Plowshare
- Biomedical Research

The preservation themes outlined above detail the specific ways in which LLNL contributed to the Cold War. These themes form the basis for assessing whether a building at LLNL might be found historic within the

³¹⁹ *Report of the Committee to Examine the University's Relationship with the Los Alamos and Livermore Laboratories*, 11-12.

context of the Cold War. Within the description of each theme or subtheme are also the general thresholds for historic interest within that particular theme or subtheme. The discussion below defines appropriate thresholds for determining the historic significance of LLNL buildings and objects within each of the four criteria for eligibility for the National Register.

6.5.1 Criterion A

For a building or object to be considered historic under Criterion A, it must be associated with an event or a pattern of events considered historically important within a defined historic context and theme.³²⁰ The Cold War is the series of events with which LLNL buildings must be associated to be significant under Criterion A.

As defined above, LLNL's links to the Cold War are found within the scientific discovery moments or the technological breakthroughs in the preservation themes.

Initial scientific discovery moments or breakthroughs are generally recognized as historic. However, after the initial discovery or breakthrough similar types of scientific research become routine.

For a scientific activity conducted at LLNL to be considered of importance, it must be more than a routine research activity. In addition, the building, equipment, or object must clearly reflect the historic breakthrough or the scientific discovery moment. That is, there must be something visible in the property that clearly illustrates or represents the historic breakthrough or the

discovery moment. For instance, a building might possess the equipment on which the significant breakthrough research occurred. Or the building might reflect the process or scientific discovery for which it was built. An object would be considered important if it was used for or provided direct research support for the technological breakthrough or scientific discovery. It would also be considered important if it was the direct and immediate product of the historic scientific discovery or event.

The exception to the individual breakthrough or discovery moment in LLNL's Cold War contributions is the overall impact of the Laboratory's research and development efforts on the U.S. nuclear weapons stockpile. The creation and growth of the nuclear stockpile clearly were of exceptional significance in U.S. history. A building or object that housed and reflects nuclear weapons design work, research directly related to weapons design, or weapons design testing and production may be eligible under Criterion A if it is associated with a particular weapons design identified earlier and/or is associated with at least half of the LLNL nuclear weapons designs placed in the U.S. stockpile.

6.5.2 Criterion B

For a building or object to be considered historic under Criterion B it must be associated with a person whose contributions to history are considered important within a defined context and theme. These contributions must also be well documented. For buildings or objects at LLNL to be considered historic under this

³²⁰ *National Register Bulletin 15, 12.*

criterion, they must be clearly associated in a primary manner with a person considered historic within the context of the Cold War in one of the established preservation themes: nuclear weapons design, nuclear weapons testing, nuclear research, or non-weapons research.³²¹

The threshold used to establish the historic importance of an individual is the recognition of that person by historians through a body of work in the form of papers, articles, and books. The historic person also must be associated with a particular building or object during the productive time period of his/her life, or during the time he/she made a significant discovery or breakthrough in nuclear weapons design, nuclear weapons testing, nuclear research, or non-weapons research.

6.5.3 Criterion C

For a building or object to be considered historic under Criterion C, it must represent a distinctive method of design or construction within an established historical period. It may also be eligible if it represents the work of a master or possesses high artistic value. A resource also may be eligible under Criterion C if it represents an identifiable entity whose components may lack individual distinction. This last requirement applies to groups of buildings or structures that may be classified as a district.³²²

For buildings at LLNL to qualify under this criterion, they must represent a distinctive type of building or architectural style, have all the common features of a building of this type, and be an important example

of this type of building design or construction. If the building design or construction materials represent a major breakthrough or innovation in this particular kind of facility, it will be considered of historic importance. However, if it merely represents a typical kind of construction or design for this type of facility, it will not be found historically significant. Nor does uniqueness or one-of-a-kind construction automatically qualify as exceptional. Objects will be found to be of historic interest under this criterion if they represent significant design features or breakthrough technologies inherent to that type of object.

LLNL buildings will meet the aesthetic aspect of Criterion C if they were designed or built by a noted architect or engineer and are a superior example of his/her work. Alternatively, the building will be eligible if it expresses high artistic values and possesses superior aesthetic qualities. Objects will meet the aesthetic aspect of Criterion C if they were designed or built by notable engineering firms in their field.

LLNL buildings will also be found to be historic under Criterion C, even if they do not possess individual distinction, if they are part of a district that is eligible for the National Register. Thus, they would be of historic interest if they are part of a group of laboratories that did similar work or were part of a project determined to be of historic importance in the context of the Cold War. They must be clearly associated with the other structures in the district and clearly contribute to the understanding of the district as a whole.

³²¹ Ibid., 14.

³²² Ibid., 17.

It is not likely that any LLNL buildings will be found eligible for the National Register under Criterion C.

6.5.4 Criterion D

For a building or object to be considered historic under Criterion D, it must yield, or be likely to yield in the future, information important to history or prehistory. This criterion most commonly applies to archeological sites rather than historic properties. In the case of buildings or equipment at LLNL, they will be eligible under this criterion only if there is important information about nuclear design, nuclear testing, nuclear research, or non-weapons research within the context of the Cold War that can be gleaned only from the building itself. In the case of the relatively young structures at this active facility, this is a very difficult criterion to meet due to the vast amount of information—written and oral—that is usually available. It is unlikely that LLNL will have properties that qualify as historic under Criterion D.³²³

6.5.5 Criteria Consideration G

Buildings and objects under fifty years of age are generally not considered eligible for the National Register.

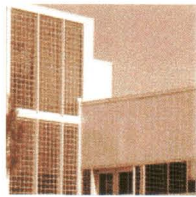
However, under Criteria Consideration G, properties and objects under fifty years of age can be considered eligible to the National Register if it can be demonstrated

that they are of exceptional significance. Thus, although the majority of structures and objects at LLNL would normally be excluded from eligibility to the National Register because they are under fifty years of age, they may be found eligible if they demonstrate exceptional historical significance.

The Cold War has been recognized as a period of exceptional significance within U.S. and world history. The thresholds established within each of the Cold War themes or subthemes above were defined narrowly to represent only the exceptional contributions LLNL made to U.S. Cold War history. Therefore, if the activities that took place in an LLNL building are found to meet the threshold for historic significance within one of the established Cold War preservation themes, that building will meet the requirements for exceptional significance. Similarly, objects that meet the threshold for historic significance within one of the established Cold War preservation themes will also meet the requirements for exceptional significance.

If a building or object appears to be historic based on the thresholds for any of the criteria outlined above, and it is of historic interest within one of the established LLNL Cold War preservation themes, it will be considered to meet the eligibility requirements.

³²³ Ibid., 21.



7. FACILITIES

L LNL main site facilities are located on DOE-owned land in the eastern portion of the Livermore Valley, forty-eight miles east of San Francisco in Alameda County, California. The main site is situated on 821 acres and includes approximately 500 buildings and structures totaling six million gross square feet. LLNL also maintains a 7,000-acre HE test area designated Site 300, which is located fifteen miles southeast of Livermore, in Alameda and San Joaquin counties. Site 300 includes approximately 200 buildings and structures totaling 400,000 gross square feet.³²⁴

The Laboratory's main site is bounded on the east by agricultural land used primarily for grazing and vineyards. To the north, the land is used by light and heavy industry, including electronics, optics, and trucking companies. Land to the west is primarily residential and has seen a rapid growth in

land sales, subdivisions, and annexations in recent years. LLNL is bounded on the south by SNL's California site. The two laboratories share several facilities, including a cafeteria, parking lots, utilities, and a fire department.³²⁵

LLNL classes its buildings into three categories—permanent, interim, and temporary. Permanent structures have long-term utility potential (usually fifty years) and are primarily constructed of steel, concrete, or masonry. A few permanent buildings have been made from wood. Interim buildings are modular prefabricated structures. They often have removable undercarriages and rest on sleeper systems, which provide foundational stability. Many also have plumbing, flexible interiors, finished exteriors, and landscaping. Interim buildings are considered short-term in life although of a longer duration than

³²⁴ McGuff, "Lawrence Livermore National Laboratory World War II and Later Historic Context and National Register Assessment: Scope of Work," 1.

³²⁵ Lawrence Livermore National Laboratory, *LLNL Site Development and Facility Utilization Plan* (Livermore: Lawrence Livermore National Laboratory, 1987), 1–1.

temporary due to their semipermanent features. Temporary buildings include all trailers and WWII structures. Temporary structures are intended for use while more permanent facilities are under construction. Because they are intended for brief habitation many do not have plumbing or toilet facilities. However, due to a constant space shortage, the WWII structures and trailers have been in use for more than fifty years and thirty years, respectively.³²⁶

Of the 500 LLNL buildings at the main site, approximately 250 are either interim or temporary. Of the 200 buildings at Site 300, only about twenty-five are interim or temporary. As most temporary or interim buildings were and are used primarily for office space, they will fall outside the established preservation themes and are unlikely to be of historic interest. The exception may prove to be the WWII structures. These are assessed because of their age and possible historic interest to the state of California.

Most of the facilities at LLNL fall within the design category of Industrial Vernacular and do not represent high-style architecture. Most buildings are unadorned and functional. There are a few buildings that display aspects of high-style architecture. LLNL also retains some original navy buildings from the WWII era. These represent standard designs for military construction of the period. Despite these few exceptions, LLNL mainly reflects its time and function—an active research and development laboratory originating in the decade of the 1950s.

LLNL is part of the DOE—formerly AEC and ERDA—nuclear weapons complex. However, there is no functional master design plan or construction guideline for the complex as a whole. Each facility developed buildings and structures suited to its respective mission. Most sites do rely on the Industrial Vernacular design. Form follows function at most sites, although function tends to differ between sites and local building materials and styles give them each a unique character.

7.1 Construction Patterns

The oldest facilities at LLNL date to WWII. The U.S. Navy purchased a portion of the Wagoner Ranch and built a naval air training station. First, they paved a square near the center of the site for a runway with several taxiways and a parking apron just to the south. Then, on the southern perimeter of the property, the navy built a drill hall, barracks, classrooms, and storage facilities along a north-south/east-west grid.³²⁷ After WWII, the navy brought operations at the site to a close. It ceased to be a naval air station in November 1945.

In 1950, the AEC took over NAS Livermore and CR&D began constructing a Materials Test Accelerator (MTA), under the direction of E. O. Lawrence of UCRL, for the production of nuclear materials such as plutonium and tritium. In 1951, UCRL also used the site for nuclear test diagnostics for LANL. In 1952, the AEC formally established LLNL as a second nuclear weapons design laboratory. LLNL operated as the Livermore branch of UCRL until 1971 when

³²⁶ *Ibid.*, 2–11, 2–12.

³²⁷ *Ibid.*, 1–4.

it became a separate entity.³²⁸ In 1955, LLNL acquired additional land for Site 300, an explosives test area southeast of the main site.

Originally, LLNL used the navy buildings for its offices and laboratories. Gradually, LLNL expanded, building additional facilities to the north and east in unoccupied areas. The first additions to the site included a cafeteria, storehouse, warehouses, chemistry laboratory, physics laboratory, fabrication and assembly facility, shop, and several special-purpose research laboratories.³²⁹

The WWII structures of NAS Livermore provided primarily office and storage space but few adequate laboratory facilities. Therefore, during the 1950s and 1960s, LLNL concentrated on building laboratories for both light and heavy research.

The number of light laboratories—those with smaller equipment and apparatus—quadrupled during this period. Heavy laboratories—those with high bays and radioactive shielding—doubled. The majority of the buildings built during these early decades were permanent structures designed to house the Laboratory's primary programs—weapons design and magnetic fusion research. Construction of the 1950s and 1960s stressed utilitarian features. Buildings were usually concrete structures with multiple laboratories or large corrugated metal structures that could house big equipment. Examples of typical kinds of 1950s and 1960s construction are Building 141, the Storage and Handling Facility; Building 243, the Pluto Assembly Building; Building 435, the Project Sherwood Laboratory; and Building 151, the Radiochemistry Laboratory, illustrated in figures 37, 38, 39, and 40.

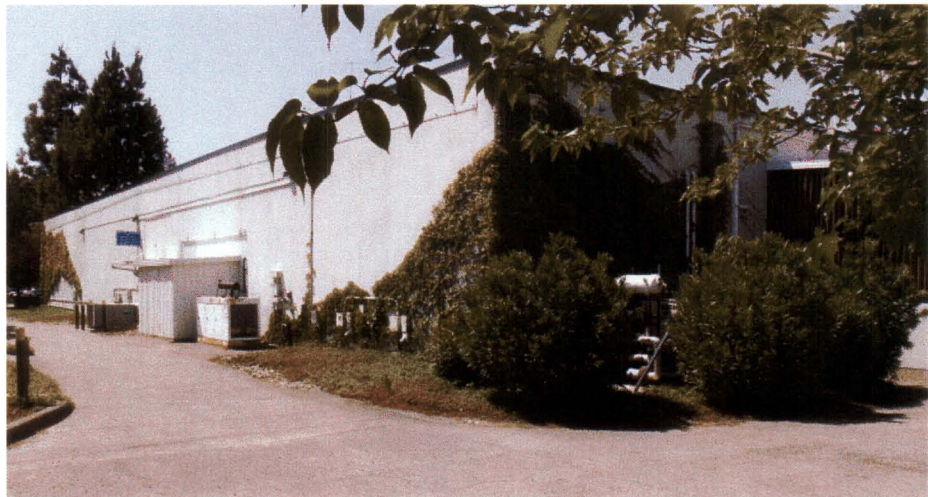


Figure 37. Building 141, Storage and Handling Facility, built 1954.³³⁰

³²⁸ Ibid.

³²⁹ University of California Radiation Laboratory, *Long Range Development Plan* (Berkeley: University of California Radiation Laboratory, 1957), 53; and Lawrence Livermore Laboratory, *Land Use* (Livermore: Lawrence Livermore Laboratory, 1972), 3.

³³⁰ Building 141, exterior, LLNL photographer, 2003.

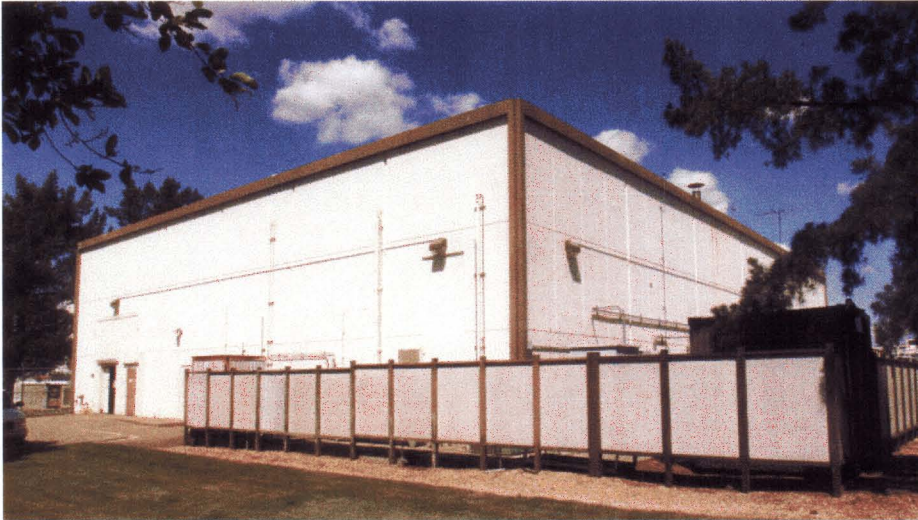


Figure 38. Building 243, Pluto Assembly Building, built 1959.³³¹

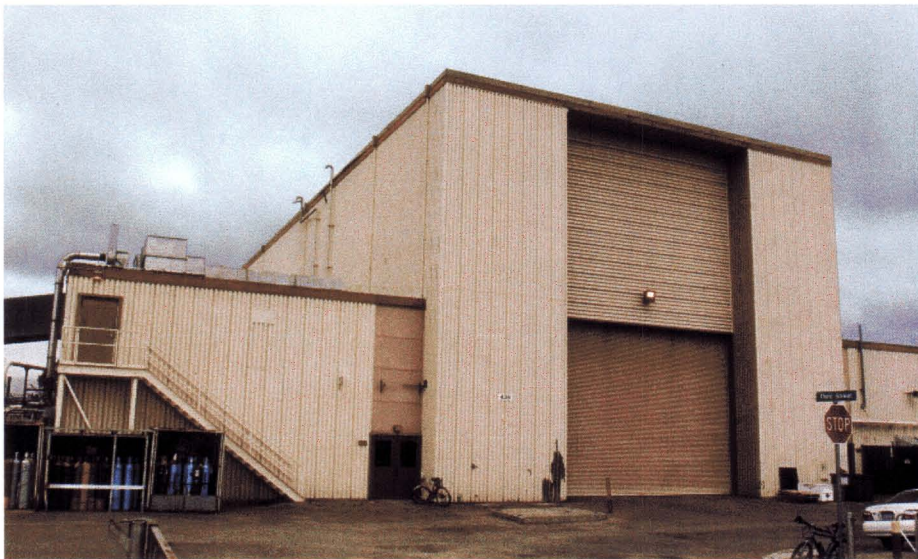


Figure 39. Building 435, Project Sherwood Laboratory, built 1960.³³²

In contrast to laboratory construction during this time period, new office facilities barely doubled in number. Many offices continued to be housed in the WWII barracks and classrooms. From 1950 to 1960, some additional new office buildings, both large and small, were built to supplement the WWII structures. In the 1960s, to further

accommodate the growing work force, the Laboratory began using trailers for additional office space. Examples of the different kinds of offices built during the 1950s and 1960s are shown in figures 41, 42, and 43: Building 131, Engineering offices; Trailer 2425, Chemistry offices; and Building 311, Personnel and Plant Engineering offices.

³³¹ Building 243, exterior, LLNL photographer, 2003.

³³² Building 435, exterior, LLNL photographer, 2003.



Figure 40. Building 151, Radiochemistry Laboratory, built 1968.³³³



Figure 41. Building 131, Engineering offices, built 1959.³³⁴

Two factors influenced the physical layout of the Laboratory during these early decades. E. O. Lawrence organized the Laboratory according to the matrix system—programs and their technical support personnel were to be housed together. When a program required additional facilities, new buildings were built as closely as possible to

the existing facilities.³³⁵ The other factor that influenced the look of LLNL was the grid street pattern that the Laboratory inherited from the navy. New facilities were built in blocks along this grid system according to programmatic requirements.³³⁶ These factors led to groupings of programmatically related buildings laid out in a military-like grid.

³³³ Building 151, exterior, LLNL photographer Marcia Johnson, 2003.

³³⁴ Building 131, exterior, LLNL photographer Marcia Johnson, 2003.

³³⁵ *LLNL Site Development and Facility Utilization Plan*, 1987, 2–2.

³³⁶ *Ibid.*, 1–5.



Figure 42. Trailer 2425, Chemistry offices, 1963.³³⁷



Figure 43. Building 311, Personnel and Plant Engineering offices, 1966.³³⁸

However, by the 1960s, these factors also led to several problems, including overcrowding in the southwest quadrant of the site, underuse of the northeast quadrant of the site, orphaned buildings situated far away from their relevant programs, and congested Laboratory streets. In 1968, LLNL hired the landscape architectural firm of Royston, Hanamoto, Beck, and Abbey to prepare a

long-range development master plan that would solve some of these deficiencies.³³⁹

The Royston Plan proposed a two-loop road system, with a rotary to replace the old grid pattern of streets. The inner-loop road system would curve around a central hub zoned for general support functions, such as business offices, libraries, plant engineering, and technical information services. The outer loop road acted as a service area to

³³⁷ Building 2425, exterior, LLNL photographer Marcia Johnson, 2003.

³³⁸ Building 311, exterior, LLNL photographer Marcia Johnson, 2003.

³³⁹ LLNL Site Development and Facility Utilization Plan, 1987, 2-2; and *Serving the Nation for Fifty Years*.

access the large laboratories. The new loop-road system eliminated much of the traffic congestion. The Royston Plan also allotted generous parcels of land for each program area to accommodate possible future development. The loop-road system and program areas are depicted in figures 44 and 45. The Royston Plan also suggested a liberal use of landscaping with bicycle paths and walkways to improve the aesthetic quality and overall working environment of the Laboratory.³⁴⁰

In the decade of the 1970s, facility development dropped off considerably.³⁴¹ In comparison to construction during the

previous decades, LLNL built few permanent structures. The largest construction projects in the 1970s were Building 381, the Laser Fusion Office, and Building 391, the Nova High-Energy Laser Building, both large-scale facilities designed for the Laser Program. The rest of the permanent structures were small-sized laboratories and storage structures.³⁴²

However, by the 1970s, a shortage of space for offices and support services had become critical. To accommodate this need, LLNL added a sizeable number of trailers and modular structures as temporary and interim solutions.³⁴³



Figure 44. Royston Plan 1968, artist's drawing, loop-road system.³⁴⁴

³⁴⁰ Ibid.; and Royston, Hanamoto, Beck, and Abbey Landscape Architects, *University of California Lawrence Radiation Laboratory Long Range Development Master Plan*, 1968, Box 148A, Folder 1405, LLNL Archives, 1–6.

³⁴¹ *LLNL Site Development and Facility Utilization Plan*, 1987, 2–11.

³⁴² "Site Map," PLC97-999-996EM, Plant Engineering Library, LLNL (Hereafter cited as PEL); and Real Property Data Summary, Lawrence Livermore National Laboratory, 2002.

³⁴³ *LLNL Site Development and Facility Utilization Plan*, 1987, 2–11.

³⁴⁴ Royston Plan 1968, loop-road system, LLNL Archives.

Construction in the 1970s reflected the influence of the Royston Plan. What permanent construction there was adhered to the guidelines suggested for flexible programming areas. Buildings built in this period also displayed more concern for

aesthetic appeal. Typical structures built in the 1970s are shown in figures 46, 47, and 48: Building 3724, ICF offices; Building 391, Nova Laser Facility; and Building 4675, Cafeteria.



Figure 45. Royston Plan 1968, program areas.³⁴⁵

³⁴⁵ Royston, Hanamoto, Beck, and Abbey Landscape Architects, *University of California Lawrence Radiation Laboratory Long Range Development Master Plan*, 1-6.



Figure 46. Building 3724, ICF offices, built 1975.³⁴⁶



Figure 47. Building 391, Nova Laser Facility, built 1978.³⁴⁷



Figure 48. Building 4675, Cafeteria, built 1979.³⁴⁸

³⁴⁶ Building 3724, ICF offices, exterior, LLNL photographer Marcia Johnson, 2003.

³⁴⁷ Building 391, Nova Laser Facility, exterior, Todd Coble, 2003.

³⁴⁸ Building 4675, Cafeteria, exterior, LLNL photographer, 2003.

During the 1980s, facilities development resumed earlier levels of construction. LLNL significantly increased its construction of permanent facilities. Permanent structures included light and heavy laboratories, storage facilities, and, to a lesser extent, offices. Construction also continued on interim and temporary structures for office

space and support services.³⁴⁹ Construction during this decade also continued to conform to the Royston Plan. Typical kinds of construction projects are depicted in figures 49 and 50: Building 482, DOE offices; and Building 197, Physics laboratory.



Figure 49. Building 482, DOE offices, built 1983.³⁵⁰



Figure 50. Building 197, Physics laboratory, built 1984.³⁵¹

³⁴⁹ "Site Map," 1997; and Real Property Data Summary, 2002.

³⁵⁰ Building 482, DOE offices, exterior, LLNL photographer, 2003.

³⁵¹ Building 197, Physics laboratory, exterior, LLNL photographer Marcia Johnson, 2003.

From 1990 to 2003, LLNL built few permanent structures. The exceptions are shown in figures 51 and 52: Building 132, the Physics Complex; and Building 581, the NIF. The NIF is one of the largest construction projects ever undertaken at LLNL. Its main

building is the size of a large professional sports stadium. In the 1990s, LLNL also added some modular structures and trailers to accommodate the ongoing shortage of office space.³⁵² Construction continues to follow the Royston Plan.



Figure 51. Building 132, Physics Complex, built 1994-1995.³⁵³



Figure 52. Building 581, NIF, built 2002.³⁵⁴

³⁵² "Site Map," 1997; Real Property Data Summary, 2002; and *Fifty Years of Service to the Nation*, 102-103.

³⁵³ Building 132, Physics Complex, exterior, LLNL photographer Marcia Johnson, 2003.

³⁵⁴ Building 581, NIF, exterior, LLNL photographer Marcia Johnson, 2003.

Site 300 mirrored the construction patterns of the LLNL main campus. The vast majority of the facilities at Site 300 were constructed in the 1950s and 1960s. Construction also slowed in the 1970s and picked up during the 1980s. The 1990s and recent years have also seen less construction.³⁵⁵

Nevertheless, a couple of differences between the two sites should be noted. In 1955, when LLNL took possession of Site 300, there were no existing facilities. Therefore, construction began immediately on all types of structures, including offices, laboratories, test apparatus, and support structures. The other difference in building history at Site 300 involves construction materials. Most of the structures at Site 300 were built to house explosives experiments or manufacture. Therefore, they were designed with cheaper and less durable materials. In the event of an unplanned

explosion, replacement costs would be minimized.

Most buildings at Site 300 are either made of concrete masonry or are Butler-type prefabricated metal structures. In addition to the more standard building types at Site 300, the property also houses multiple high explosive and chemical storage magazines and igloos. These are typically made of concrete and metal and are covered with earth to isolate and contain accidental detonations. All buildings at Site 300 are designed to be functional and have little adornment. A notable exception is the colored cement-asbestos panels on Building 817, the HE Press Complex. Typical examples of construction at Site 300 are depicted in figures 53, 54, 55, and 56: Building 812, the Linac; Building 805, HE Assembly; Building 817, HE Press; and Building 823, Radiography.

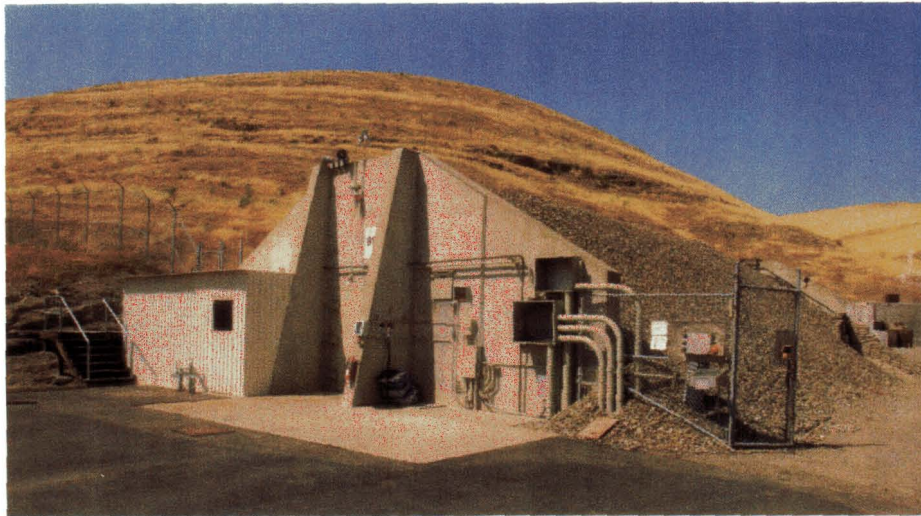


Figure 53. Building 812, Linac, built 1955.³⁵⁶

³⁵⁵ "Site Map," 1997; and Real Property Data Summary, 2002.

³⁵⁶ Building 812, exterior, LLNL photographer, 2003.

7. FACILITIES



Figure 54. Building 805, HE Assembly, built 1957.³⁵⁷

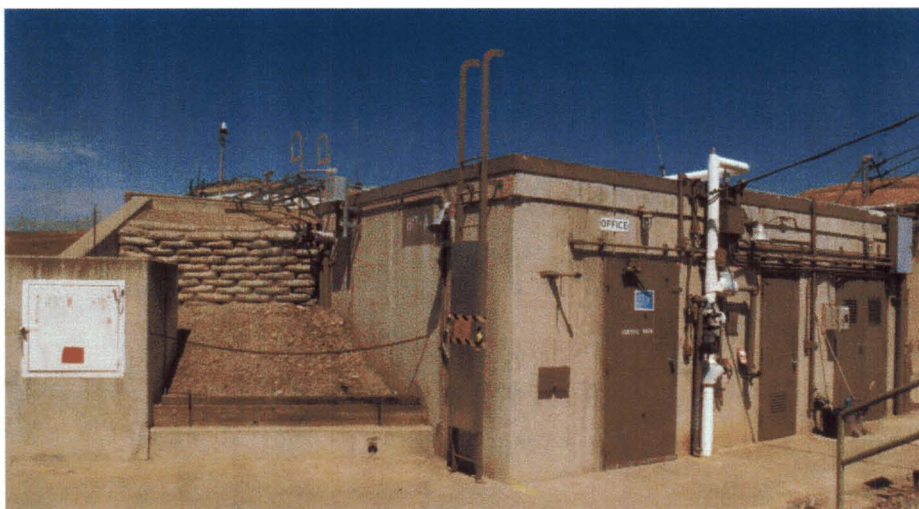


Figure 55. Building 817, HE Press, built 1959.³⁵⁸



Figure 56. Building 823, Radiography, built 1966.³⁵⁹

³⁵⁷ Building 805, exterior, LLNL photographer, 2003.

³⁵⁹ Building 823, exterior, LLNL photographer, 2003.

³⁵⁸ Building 817, exterior, LLNL photographer, 2003.

7.2 Cold War Building Architecture

The primary architectural style of LLNL's Cold War buildings and structures can be characterized as Industrial Vernacular. In the 1940s and 1950s, this type of architecture reflected the vernacular expression of the International Modernist style popular in California and throughout the country after WWII.

The International Modernist style of architecture featured buildings made of mass-produced industrial materials (concrete, glass, steel), modular form, flat surfaces, and the rejection of ornament and color.³⁶⁰ The emphasis was on utility and style idealized by the form-follows-function dictum. The typical International-style building gave the appearance of "machine-like precision and anonymity."³⁶¹ After WWII, California architects built scores of steel, glass, and concrete skyscrapers and large office buildings in cities throughout the state.

The vernacular expression of the International Modernist style worked particularly well in industry, business, and government, where economy and utility already were primary considerations. The local adaptation of the International Modernist style at LLNL similarly emphasized industrial, functional, and utilitarian features over aesthetic ones.

The vast majority of permanent facilities at LLNL built during the 1950s and 1960s reflected an Industrial Vernacular expression of the International Modernist style. LLNL facilities from the 1950s and 1960s were generally industrial, unembellished, and devoid of nonessential

elements or decoration. Laboratories, storage facilities, and office buildings were constructed of steel, concrete, and/or metal. They often were large, one- or two-story structures, with flat roofs, and few windows. They were essentially large, concrete or metal boxes that could accommodate large research equipment or large-scale scientific projects. Few structures from this period displayed any characteristics of other high-style architecture.

In the 1960s, some California architects, in a reaction against the International Modernist style, adopted a style known as Brutalism. This style featured exaggerated structural members; rough, untreated, and unfinished concrete; exposed water pipes and air ducts; and grandiose forms. Examples of this type of architecture are Wurster Hall (1965) at the University of California, Berkeley, and the Fremont Civic Center (1969).³⁶² Wurster Hall is depicted in figure 57.

In 1969, LLNL added a new Director's Office, Building 111, to its main site. This facility is built in the style of Brutalism and is an exception among the Industrial Vernacular buildings of the early 1950s and 1960s. Building 111 is noticeably different, not only from the facilities at LLNL, but also from virtually all other buildings in the Livermore-Amador Valley. The Director's Office is seven stories high—the tallest building in the city and the area. Building 111 is depicted in figure 58. Livermore's downtown is characterized by small storefronts from the pre-WWII era. Post-WWII commercial property in the city, like the majority of buildings at LLNL, is in the Industrial Vernacular.

³⁶⁰ David Watkin, *A History of Western Architecture* (London: Thames & Hudson, 1986).

³⁶¹ Rawls and Bean, *California*, 446.

³⁶² Rawls and Bean, *California*, 436.



Figure 57. Wurster Hall, University of California, Berkeley, c. 1962–1964.³⁶³
Photo courtesy of the University of California, Berkeley.



Figure 58. Building 111, Director's offices, built 1969.³⁶⁴

³⁶³ Wurster Hall, exterior north and central wings and tower, circa 1962–1964, image 02–027–078, SPIRO, University of California, Berkeley.

³⁶⁴ Building 111, exterior, Box 30, Folder 10132, LLNL Archives.

In the late 1960s, LLNL began to diverge from its adherence to strictly functional construction. The *Long-Range Master Development Plan* of 1968 suggested improving the aesthetic environment of LLNL. In the 1970s, LLNL began to do so. The strongest expression of this was the inclusion of landscaping, bicycle paths, and walkways. However, building design also began to reflect deliberate design choices and elements of high-style architecture. This became particularly evident in facilities designed to accommodate industrial partners and clients.

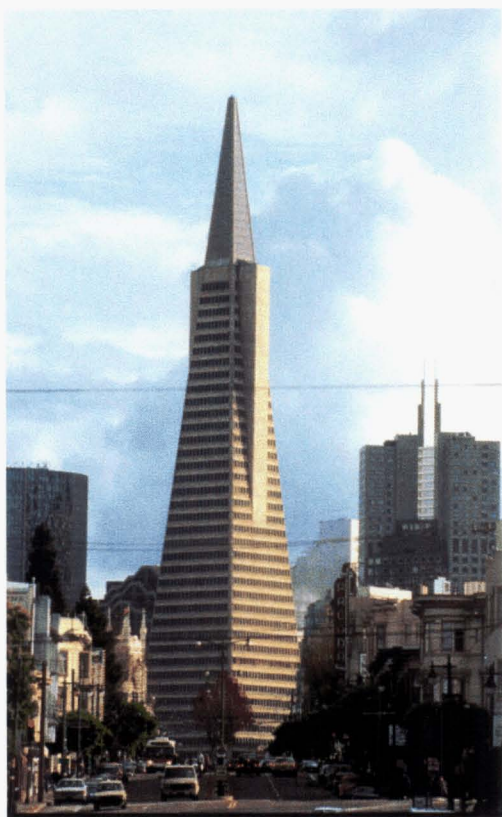


Figure 59. San Francisco TransAmerica Pyramid, 1972.³⁶⁵

One of the high-style architectural influences reflected in LLNL buildings of the 1970s and 1980s is a distinct California design element of the Modern style often referred to as “whimsical.” This style often reflects the use of geometrical shapes in an arbitrary fashion. A good example of this whimsical style of Modern architecture is the San Francisco TransAmerica Pyramid (1972) depicted in figure 59. Examples of such whimsical use of circles and fanciful decoration at LLNL can be seen in Building 381, Laser Fusion Laboratory; Building 482, DOE offices; and Building 551, Plant Engineering/TID offices as depicted in figures 60, 61, and 62.

Also in the 1980s, the more aesthetic design elements of the International Modernist style appeared in new LLNL facilities. Although clearly a vernacular expression of the International Modern style, many LLNL facilities of this period make use of glass and decorative trim for its aesthetic value. Building 481, the NIF offices, and Building 691, the Fabrication Facility (shown in figures 63 and 64), are examples of the aesthetic use of glass and decorative trim.

Despite a stronger emphasis on the aesthetic in later years, LLNL, by no means, reflects the high-style architecture of the 1970s and 1980s. Although some design elements of high-style architecture appear in later facilities, they, like the earliest buildings at the site, clearly interpret architecture into Industrial Vernacular. With few exceptions, facilities at LLNL look like what they were intended to be—research and development laboratories, storage facilities, and offices.

³⁶⁵ Courtesy of the City of San Francisco and the San Francisco Convention and Traveler’s Bureau.

7. FACILITIES



Figure 60. Building 381, Laser Fusion Laboratory, rock façade, 2003.³⁶⁶



Figure 61. Building 482, DOE offices, geometric doors, 2003.³⁶⁷

³⁶⁶ Building 381, rock façade, LLNL, Todd Coble, 2003.

³⁶⁷ Building 482, doors, LLNL photographer Marcia Johnson, 2003.



Figure 62. Building 551, Plant Engineering/TID offices, wraparound windows, 2003.³⁶⁸



Figure 63. Building 481, NIF offices, glass office building, 2003.³⁶⁹

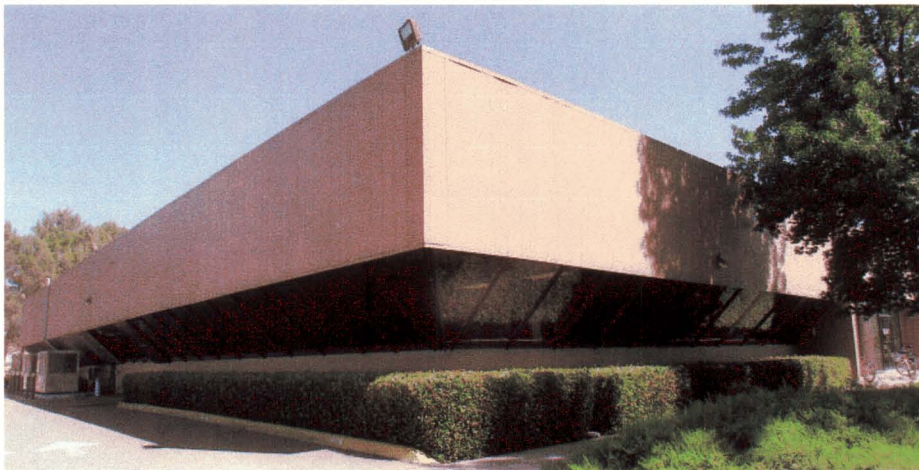


Figure 64. Building 691, Fabrication Facility, geometric shaped glass windows, decorative roof trim, 2003.³⁷⁰

³⁶⁸ Building 551, windows, LLNL photographer Marcia Johnson, 2003.

³⁶⁹ Building 481, exterior, LLNL photographer Marcia Johnson, 2003.

³⁷⁰ Building 691, exterior, LLNL photographer Marcia Johnson, 2003.

7.2.1 Architects and Engineers

By and large, local San Francisco Bay Area architecture and engineering firms designed LLNL facilities. No one firm emerged as the sole designer of LLNL facilities. Instead hundreds of architects and engineers received contracts to design buildings at LLNL over its fifty-year history. In fact, many buildings at LLNL were built in increments over a period of several years. In many cases, different architects and engineers designed separate increments of the same building.

LLNL initially used all the buildings inherited from NAS Livermore and CR&D. However, LLNL's programmatic commitments in weapons, fusion, and reactor work required new facilities almost immediately.

In the 1950s, the architectural and engineering firms of Albert F. Roller and Leland Rosener, Jr., constructed the majority of the early buildings on the LLNL main site. Roller built the Computation Building (Building 115), Chemistry Laboratory (Building 222), the Fabrication and Assembly Facility (Building 231), one of the Rover buildings (Building 261), and the South Cafeteria (Building 312). Roller established his firm in 1926, specializing in large office or government buildings. In the 1960s he built the Federal Courts and Office Building, the United California Bank Data Processing Center, and the Wells Fargo Bank Office, all in San Francisco.³⁷¹ Rosener built the majority of the Rover Complex (Buildings 171, 173, 174, and 176) and the High Flux Research Building (Building 194).

A few other firms also received contracts in the 1950s for some of the programmatic research facilities at the LLNL main site.

Corlett and Spackman, Architects built the Health Chemistry Laboratory (Building 252) and the Gaseous Chemistry Laboratory (Building 331). A local San Francisco firm established in 1951, they specialized in designing schools. Approximately fifteen percent of their business came from designing commercial and institutional buildings. One of their most noted designs was Squaw Valley's Blythe Arena, built for the 1960 Olympic Winter games.³⁷²

Garretson, Elmendorf, Klein and Reibin, Architects and Engineers, built the Pluto Assembly Building (Building 243) and the Engineering Test Building (Building 327). This local San Francisco architectural and engineering firm was established in 1956 and specialized in the design of research laboratories.³⁷³

The Austin Company, Engineers and Builders, built the LPTR building (Building 280) and the Machine Shop Complex (Building 321). The Austin Company was a Cleveland firm noted for industrial and military construction. During WWII the company built aircraft assembly plants, military airports, and air force and naval training stations.

³⁷¹ John F. Gane, ed., *American Architects Directory*, 3rd edition (New York and London: R. R. Bowker Co., 1970), 776.

³⁷² Henry Schirmer, ed., *Pro File: Official Directory of the American Institute of Architects* (Topeka, Kans.: Archimedia, 1978); and Wolf Von Eckardt, *Mid Century Architecture in America: Honor Awards of the American Institute of Architects, 1949-1961* (Baltimore: John Hopkins Press, 1961).

³⁷³ Schirmer, ed., *Pro File*, 1988.

Rogers Engineering constructed the Radio-chemistry Facility (Building 251). This San Francisco firm was owned by Benjamin T. Rogers, who had worked for the Manhattan Engineer District during WWII and then trained with Black and Veatch after the war. Black and Veatch specialized in military construction.³⁷⁴

In the 1950s there were also a number of companies that built only one or two buildings, usually administrative offices or storage structures. Michael Gallis, Architect, built a Computer Building (Building 117); John A. Blume, Engineers, built the Auditorium (Building 123); and Elvin Riley, Architect, built Shipping and Receiving (Building 411) and the Paint Shop (Building 418).

Gallis established his own firm in 1953. He built a number of research facilities for LBNL and LLNL in the 1960s. He also built the Non-Commissioned Officer (NCO) Club at Mather Air Force Base and the San Francisco Defense Area at the Nike Sites.³⁷⁵ John Blume established his own firm in the 1950s and went on to specialize in earthquake analysis engineering.³⁷⁶ Elvin Riley worked for Design Associates and John S. Bolles before establishing his own firm. Some of his projects are the headquarters building of the IEW Local 302 in Pacheco, California, and the Air Traffic Control Tower in Contra Costa County, California.³⁷⁷

³⁷⁴ Gordon Davis, ed., *Who's Who in Engineering*, 9th ed. (Washington D. C.: American Association of Engineering Societies, 1995), 631.

³⁷⁵ Gane, *American Architects Directory*, 307–308.

³⁷⁶ Davis, ed., *Who's Who in Engineering*, 67.

³⁷⁷ George S. Koyle, ed., *American Architects Directory*, 2nd edition (New York: R. R. Bowker Co., 1962), 587.

Site 300 construction began in 1955. Rogers Engineering with Starks and Jozens, Architects; and Indenco Engineering built the majority of the structures in the Hydrodynamic Testing and HE Process Area during the 1950s. Leonard Starks and Joseph Jozens began a partnership in 1954. Starks had worked by himself and in partnership with other architects prior to partnering with Jozens. He had worked on the Panama Pacific International Exhibition of 1913 and had designed the Senator Theatre in Sacramento and the Elks Club, U.S. Post Office, and University of California Library in Davis.³⁷⁸ Jozens had worked with Skidmore, Owings & Merrill before joining with Starks. He had designed buildings for the Federal Housing Authority, the State Garage in Sacramento, and several Bay Area high schools.³⁷⁹ Starks and Jozens specialized in industrial and government facilities. Indenco Engineering was a local firm established by Joe Salley, who had worked for the Manhattan Engineer District during WWII. Indenco specialized in military and industrial facilities.

In the 1960s, LLNL continued to expand its facilities. However, rather than a few firms building the majority of the buildings, many firms built one or two structures each.

Gallis; Rosener; Corlett and Spackman; and Elmendorf, Klein, and Riebin continued to be awarded contracts at the LLNL main site. Gallis built the High Pressure Test Laboratory (Building 343); Rosener built the Sherwood Laboratory (Building 435); Corlett and Spackman built the Toxicology Laboratory (Building 254); and Garretson, Elmendorf, Klein and Reibin built the Pluto Fuel Element

³⁷⁸ George S. Koyle, ed., *American Architects Directory* (New York: R. R. Bowker, 1955), 531.

³⁷⁹ *Ibid.*, 285.

Research Laboratory (Building 241), the Pulsed Energy Building (Building 341), and the Biochemistry Research Laboratory (Building 362).

In addition to firms with established relationships with LLNL, thirteen new firms also received building contracts at the LLNL main site. These architects and engineers, like the firms in the 1950s, specialized in buildings for industry, education, government, and military purposes. A few worked exclusively for the AEC or DoD. However, the majority of firms that designed facilities for LLNL specialized in general Industrial Vernacular types of structures.

Five firms built structures for the weapons program. Skidmore, Owings & Merrill built the Radiochemistry Building (Building 151). California Steel Buildings, Inc., provided two Butler buildings, a Materials Testing Laboratory (Building 162) and a Flash Radiography building (Building 166). Simpson and Stratta built the Radiography Building (Building 239). Robert Synder and Associates, Architects and Engineers built the Detonator Research Building (Building 345). Shaw, Metz, and Dolio built the Metallurgy Building (Building 332).

Two firms built structures for the Biomedical Program. Rockwell and Banwell built the Biological Research Laboratory (Building 361) and the Animal Laboratory (Building 364). Rockwell and Banwell formed a partnership in 1962. They were a San Francisco firm that specialized in public schools.³⁸⁰ Ruth and Going, Architects and Engineers, built the Small Animal Laboratory (Building 363).

Two firms built buildings for Project Sherwood. Falk and Booth, Architects, built the Astron Test Assembly Building (Building 432). Falk and Booth formed a partnership in 1950. They specialized in buildings for colleges and universities. John Sardis and Associates, Engineers, built the Sherwood Physics Building (Building 442.) John Sardis was educated at the University of California, Berkeley, and worked as a structural engineer for the U.S. Army Corps of Engineers, W. P. Ray and Associates, and Bechtel Corporation, before opening his own firm in 1952. Sardis, a local San Francisco firm, specialized in structural engineering.³⁸¹

Four firms designed support and service structures. William B. McCormick, Architect, built a storage structure (Building 233); Maher and Marten, Architects, built the Plant Engineering Building (Building 311); Reynolds and Chamberlain, Architects, built the Telephone Building (Building 313); and Rockwise and Watson, Architects, built the Dry Waste Facility (Building 612).

William B. McCormick established his own firm in 1955. He built a wide variety of structures including commercial, industrial, and educational buildings.³⁸² Maher and Marten became partners in 1961. They are best known for their work on the San Francisco Bay Area Rapid Transit project. Reynolds and Chamberlain, an Oakland firm established in 1937, specialized in educational buildings and had also done some modifications for the Donner Laboratory at UC Berkeley.³⁸³ Rockwise and Watson was a San

³⁸⁰ Gane, *American Architects Directory*, 42.

³⁸¹ See Edward N. Dodge, ed., *Who's Who in Engineering: A Biographical Dictionary of the Engineering Profession* (New York: Lewis Historical Publishing Co., 1964).

³⁸² Koyl, ed., *American Architects Directory*, 1955, 443.

³⁸³ *Ibid.*, 458.

Francisco firm organized in 1960. William Watson had previously been a partner in Skidmore, Owings & Merrill. George Rockwise previously had his own firm and specialized in residential buildings.³⁸⁴

Site 300 also continued to build new facilities in the 1960s. Indenco built the majority of structures at Site 300 during these years, including the Change House (Building 820), the Chemistry Storage Building (Building 821), the new Linac Building (Building 851), and the HE Dynamic Test Facility (Building 854). A few new companies built single buildings. Heffron, Ralston, Dwyer, and Moulton built the Shipping and Receiving Building (Building 818); Ruth and Going built the Chemistry Building (Building 827); Charles Braun built the Thermal Test Building (Building 834); Norman Engineering built the Dynamic Test Complex (Building 836); and B. D. Bohna built the Disassembly Building (Building 855).

Building projects slowed considerably in the 1970s. Most facilities added to the main site during this decade were modular structures to accommodate the need for office space. Some of the firms that built permanent structures in the 1970s were Jerry Willis, Architect; Norman Engineering; Albert C. Martin, Architect; and Reid and Tarics, Architects. Jerry Willis built the Health Effects Building (Building 366), Norman Engineering built the Laser Building (Building 381), Albert C. Martin built the Nova Office Building (Building 481), Keller and Ganon, Engineering, built the Biology and Environmental Building (Building 365), and Reid and Tarics built the Advanced Isotope Separation Building (Building 482).

Albert C. Martin founded his own firm in 1945 in Los Angeles. He specialized in government and industrial buildings. Some of his work includes the Los Angeles Department of Water and Power, Space Park in Redondo Beach, and the Orange County Jail in Santa Ana.³⁸⁵ Keller and Ganon, a California-based firm founded in 1941, engaged in work for the military during WWII and participated in the rebuilding of Guam after the war. They specialized in commercial, industrial, and institutional projects.³⁸⁶

LLNL facilities do not represent the work of architects or engineers recognized as historically significant within the field of architecture or engineering. The only architects of note who designed for LLNL were the members of the nationally prominent firm of Skidmore, Owings & Merrill and the Chicago firm of Shaw, Metz, and Dolio.

Skidmore, Owings & Merrill had offices in New York, Chicago, San Francisco, and Portland. The firm designed the Lever Building (1951) in New York and the Sears Tower (1974) in Chicago. The firm also designed Oak Ridge (1945) in Tennessee and the Air Force Academy Chapel (1956) in Colorado Springs. Nevertheless, the Radiochemistry Building (Building 151) built by Skidmore, Owings & Merrill does not represent the Modernist high-style architecture for which they are best known, but instead is a rather ordinary application of Industrial Vernacular for the period.

Similarly, Shaw, Metz, and Dolio had its headquarters in Chicago and built high-rise apartments and skyscrapers in the

³⁸⁴ Ibid., 467.

³⁸⁵ Gane, ed., *American Architects Directory*, 599.

³⁸⁶ Dodge, *Who's Who in Engineering*, 249.

International Modern Style. Their work included the North State Parkway, Wicker Park Apartments, Armour Square Annex, and the Leo Burnett Building in Chicago. However, the Metallurgy Building (Building 332) does not represent the International Modernist style for which Shaw, Metz, and Dolio are best known but rather is an Industrial Vernacular structure of no significance.

Also of interest in relation to LLNL's built environment are the engineering firms that built special equipment like accelerators or reactors. A number of firms specialized in building accelerators or reactors for a variety of military and civilian applications.

ARCO, William Broebeck and Associates, and the Foster Wheeler Corporation built many of the accelerators and reactors at LLNL. In 1950, ARCO developed one of the first linear accelerators located at LLNL, and in 1967 began development on the 100-MeV Electron-Positron Linear Accelerator. William Broebeck and Associates designed the MTA for CR&D, the 90-inch cyclotron, and Super Kukla; they also worked on the 100-MeV Electron-Positron Accelerator. The Foster Wheeler Company designed and built the LPTR.

ARCO was founded in 1953 by a small group of LLNL engineers and physicists, including Sherwood physicist Richard Post and Pluto physicist Hayden Gordon. ARCO specialized in electron linear accelerators.³⁸⁷

William Broebeck and Associates was established in 1957. Broebeck had worked for Ernest Lawrence at LBNL as chief engineer. The projects he had worked on included the 60-inch cyclotron, the Y-12 Calutron, and the 300-MeV Synchrotron. He established his own company to pursue the design and construction of accelerators and other mechanical designs and inventions. Broebeck and Associates also worked in the areas of magnet design, controls and servo-mechanisms, pressure vessel design, and stress analysis.³⁸⁸

The Foster Wheeler Corporation was founded in 1927 in New York City. The new company merged two older companies—the Power Supply Company founded by the Foster family in 1884 and the Wheeler Condenser Company founded in 1891. The Foster Wheeler Corporation provided a range of products for the power, oil, and gas industries.

7.3 Cold War Building Types

Within the broad category of Industrial Vernacular buildings at LLNL, types of Cold War buildings can be identified. The section below outlines the distinctive features of each of these building types to assist in the assessment of buildings of potential historic interest.

For the most part, buildings at LLNL were designed to be flexible. Flexibility was necessary to accommodate changing programmatic needs. All buildings tended to

³⁸⁷ Applied Radiation Corporation, draft brochure, 22 December 1965, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1967, File Weaponization, LBNL Archives; and Horace Kaiser, draft article on ARCO, 31 March 1954, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1954, Folder AEC Press Releases, LBNL Archives.

³⁸⁸ William Broebeck and Associates, *Engineering Design and Development*, company resume, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1962, Folder Weapons Program, LBNL Archives.

be large box-like structures suitable for a variety of research projects. Nevertheless, a few distinct types of buildings can be identified at LLNL based loosely on their function and/or building material.

Nine Cold War building types are present at LLNL, as follows:

- Light laboratory
- Heavy laboratory
- Site 300 heavy laboratory
- Permanent office building
- Storage facility
- Metal Butler-type building
- Trailer
- Modular
- Explosive Igloo

7.3.1 Cold War Building Features

The nine different types of LLNL Cold War buildings contain the following characteristic features:

Light Laboratory

- Multi-story
- Reinforced concrete
- Built-up roofing
- Heavy steel repetitive-bay structural framing
- Prefabricated wall panels
- Office space
- Laboratory space for smaller equipment and apparatus

Heavy Laboratory

- Single-story with high bay or partial mezzanine
- Heavy-steel repetitive-bay structural framing

- Five to twenty ton crane
- Reinforced concrete slab
- Poured gypsum or metal deck under built-up roofing
- Reinforced-concrete, metal, or corrugated asbestos-cement walls
- Radioactive shielding
- Space for large equipment or fabrication (the nature of the work in heavy laboratories means that the structures are often quite specialized, e.g., nuclear reactors)

Site 300 Heavy Laboratory

- Single-story
- Reinforced concrete or cement-asbestos panels
- Steel-framed
- May include one or more of the following: firing table, Armco arch, earth berm, concrete retaining wall, and/or frangible walls or ceiling

Permanent Office Building

- Single or multi-story
- Concrete block or masonry walls
- Steel-framed
- Prefabricated wall panels
- Office space
- Built-up roofing
- Windows

Storage Facility

- Single-story
- Steel-framed repetitive bay structure
- Reinforced-concrete slab
- Poured gypsum or metal roof decking
- Built-up roofing
- Reinforced-concrete tilt-up walls
- Space for storage

Metal Butler-type building

- Single-story
- Prefabricated steel rigid-frame structure
- Reinforced-concrete slab
- Corrugated metal siding and roofing
- Space for short-term experiments or shops

Trailer

- Single or multiple units
- Metal siding
- Flat-roofed
- Space for offices or light laboratories
- Temporary foundations

Modular

- One- or two-story
- Flat-roofed
- Wood or metal siding
- Finished exterior
- Flexible interior
- Removable undercarriage
- Sleeper-system foundation
- Plumbing
- Space for office or light laboratories

Explosive Igloo

- Small bunker-like structure
- Concrete retaining wall
- Concrete or corrugated-metal arch
- Earth berm
- Storage for chemicals or HE

LLNL also has a variety of one-of-a-kind service/support structures as well as service/support structures that do not conform to any particular building type.

Shops

- Concrete block or metal Butler or Butler-type
- Roll-up doors
- Concrete slab

Security Structures

- Security kiosks
- Guard tower

Utilities

- Communications centers
- Electrical substations
- Pumping stations
- Sewage tanks
- Chill water plant

Service/Support Structures

- Modular, or permanent construction
- Metal siding, wood siding, or concrete block
- Space for services or support functions (cafeteria, auditorium, visitor's center)

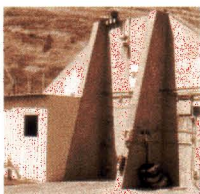
7.4 Thresholds for Integrity

If a Cold War building or object meets the historical significance threshold under one or more of the four criteria, then, in addition to possessing the representative characteristics of a building or object of its type, it must also retain enough of its physical features to reflect the period of its historical importance.

The following characteristics form the thresholds for integrity for Criteria A, B, C, and D.

- The building must remain in the same location as it was during the period of significance.

- The building must not have more than fifty per cent of its original design and construction modified, including the increase or the decrease of gross square footage, during the period of significance.
- Equipment or other objects can be found historically significant whether or not it remains in its original location. If it has not been modified for continued use (i.e., it has been mothballed), this equipment should be at least eighty per cent intact (i.e., returning it to its original state and operability would require negligible effort). If the equipment has been in use since the period of its historic significance, it will be considered to have integrity if it is still used for the basic purpose for which it was deemed historic and if the specific historically significant aspects of its design are intact.
- The building must reflect, look, and feel, as it did during the time period that it was historically significant.
- The building must be the actual place where a historic event occurred, or where a historic person worked during his or her productive life.



8. CONCLUSION

To be eligible for the National Register a property must be associated with a historic event (Criterion A), person (Criterion B), architectural style (Criterion C), or provide otherwise unobtainable information (Criterion D), within the established historic context and preservation themes.

The LLNL site's history spans a time frame that encompasses the following time periods: pre-WWII, WWII, the Cold War, and the post-Cold War. Nevertheless, the primary historical contexts for evaluating LLNL facilities are WWII and the Cold War. LLNL was built in 1942 as a naval air station to train naval pilots and support the naval war effort in the Pacific. The oldest buildings at LLNL date from this WWII period. In 1952, LLNL was created as a second nuclear weapons design laboratory to help maintain the U.S. lead in the nuclear arms race with the Soviet Union. The majority of buildings at LLNL were built during the Cold War. The growth and expansion of LLNL coincides with the push for a larger and more varied nuclear stockpile.

Although this report has explored briefly both the pre-WWII and post-Cold War contexts for LLNL, it is unlikely that the themes for those periods are reflected in the built environment. No buildings or structures remain at LLNL from the pre-WWII period. There are some remains from the industrial town of Carnegie within the boundaries of Site 300 that may be of interest within the regional context of the industrial boom in Corral Hollow between the years 1890 and 1912. However, these remains require further archaeological assessment, which is outside the scope of this report. Similarly, it is unlikely that the post-Cold War period is of relevance in assessing LLNL facilities because not enough time has elapsed to assess their historical significance. Nevertheless, any future undertaking that threatens structures from this period will require a consideration of the relevant preservation themes.

The following preservation themes and subthemes have been established as the ways in which the built environment of LLNL most clearly reflects the history of WWII and the Cold War:

WWII Preservation Themes

- Naval pilot training
- NAS support of the U.S. war effort

Cold War Preservation Themes

- Nuclear Weapons Design
 - *Weapons Design*
 - *Computing*
- Nuclear Weapons Testing
 - *Nuclear Testing*
 - *High Explosives Testing*
- Nuclear Research
 - *Nuclear Physics Research*
 - *Nuclear Chemistry Research*
 - *Nuclear Materials Research*
- Non-weapons Research
 - *Nuclear Energy Research*
 - *Nuclear Propulsion Research*
 - *Plowshare*
 - *Biomedical Research*

Post-Cold War Preservation Themes

- Nuclear Weapons Design
 - *Computing*
- Nuclear Weapons Testing
 - *High Explosives Testing*
- Nuclear Research
 - *Nuclear Physics Research*
 - *Nuclear Chemistry Research*
 - *Nuclear Materials Research*
- Non-weapons Research
 - *Nuclear Energy Research*
 - *Nuclear Propulsion Research*
 - *Biomedical Research*

These are the themes used to evaluate LLNL facilities. Each evaluation determines which theme or themes are represented by a particular structure, how well the building embodies that theme, the level of its

contribution to the relevant context, and the integrity of the building or structure.

To be eligible for the National Register a structure must not only represent one of the preservation themes or subthemes defined above but also meet the thresholds described above for contributing to that theme.

A property must also still clearly reflect the event, person, architectural style, or information during the time period that it was historically significant. In other words it must look and feel much as it did during the time of its historic importance. It must have integrity.

Even if a building embodied a theme at one time, it may not be eligible for National Register consideration any longer due to extensive renovations, relocation of activities, or facility upgrades. Furthermore, some buildings do not represent the historically interesting event in a visible way. For instance, nuclear weapons design work is difficult to actually “see” within buildings because much of the work took place in the minds or via the tools of the designers.

Similarly, equipment or objects deemed historic by virtue of the theme(s) it represents must be intact enough to reflect its original historic significance if it is not still in use. If it is still in use it must be recognizable as representative of its historic moment.

In summary, to be eligible for the National Register, facilities at LLNL must meet one of the four accepted criteria within a historic context and established theme.

The facility must also possess historic integrity. Thresholds for historic interest and integrity are discussed in detail within each preservation theme.

8.1 Initial Building Review Criteria

The following list is a comprehensive accounting of all LLNL buildings taken from the current LLNL building list. The list indicates their current use at LLNL, not necessarily their historic purpose.

004J	Childcare Center
U011	EPD/ERD Treatment Facility A
041	Long Term Storage
U042	EPD/ERD Treatment Facility B
071	Westgate Badge Office
OS071N	Security Kiosk
110	Storage
111	Directors Office
113	Computation/LCC
OS113E	Security Kiosk
115	Computation/LCC
116	Computation/LCC
117	Computation/LCC
118	Teleconference Facility
U119	TSD Node #11
121	Physics & Adv. Technologies
122	Protocol Office
OS122S	Security Kiosk
123	Auditorium
125	West Cafeteria
131	Engineering
132N	DPRF
132S	NAI/Physics
OS132N	Security Kiosk
133	Central Plant/DPRF/NTTC
134	Storage
135	Storage
141	Electronic Shops
151	Isotope Sciences
152	Generator House
153	Microfabrication Lab
154	BSSL
161	Development Lab
162	Research/Crystal GTH
164	Preparation/Lasers
165	Optics/Development Lab
166	Development Lab
169	Vacant
OS169WAA	EPD/RHWM Waste Acc. Area
170	Nat Atmosph Rel Adv Ctr
170A	NARAC Storage
171	Vacant
U172	TSD Node #12
173	Physics & Adv. Technologies
174	Physics & Adv. Technologies
175	Mars Facility
176	Storage

177	Vacant
179	Development Lab
181	Office
182	Physics & Adv. Technologies
U187	EPD/ERD Treatmnt Facility
190	Cams Facility
191	HEAF
193A	EPD/ORAD Srvc-Mntrg Stat
U193	Sewer Diversion Fac
194	Accelerator
194A	PE/Elevator & Crain Maint
195	EPD/ORAD Shop
196	EPD/ORAD Srvc-Mntrng Stt
196A	EPD/ORAD Storage
197	Development Lab
198	Physics & Adv. Technologies
211	Physics & Adv. Technologies
212	Vacant
213	Physics & Adv. Technologies
214	Assurance Review Office
216	Computation
217	Computation
218	Computation
219	UC Institutes
221	Computation
222	Chemistry
230	231 Portal
231	Development & Assbly Eng
232	Vacant
233	Materials Management
OS233 CSU	EPD/RHWM Cont Strge Unit
234	Materials Mgmt Office
235	WMRDF
OS235N	Security Kiosk
239	Radiography
241	Materials Science
243	GGG/GGT Lab Space
251	EPD/RHWM Hvy Elmnt Fclty
252	HC/shipng/receivng Shed
253	HC Dept Offices & Labs
254	HC Bio Assay Lab
255	HC Spd Labs/offices
256	TSD Node #1
261	NAI
OS261W	Security Kiosk
U263	Telephone Filter Fac
U270	UPS 271
271	Protective Force
272	E/O Development Lab
OS273	Line of Site Vault
274	Security Administration
280	EPD/RHWM Storage
281	HEA Labs
282	Applied Science Lab
U283	TSD Node #3

8. CONCLUSION

U291	LCW Station	363	Biology & Biotech Resch
292	Cams Facility	364	Biology & Biotech Resch
293	Cams Storage	365	Biology & Biotech Resch
294	Geocams	366	Biology & Biotech Resch
U295	Pump House	367	Biology & Biotech Resch
297	PE/Paper Disposal	373	BBR Warehouse
297A	PE/Class Doc Destruction	376	Machine Shop
298	Fusion Target	377	Biology & Biotech Resch
OS298 WAA	Building 298 WAA	378	HEA/Marshall Islands
U299	TSD Node #4	379	HEA/Marshall Islands
311	DOE Offices	381	Office/Research
312	South Cafeteria	382	Tech Support
312A	LLESA Storage	383	Machine Shop
313	HC Emrgcy Operation Center	391	Nova
U313A	TSD Node #10	392	Optics Laboratory
U313B	HC Emrgcy Comm Radio Ctr	OS394	Chemical Storage
314	CFO	404	PE/Battery Shop/Warhse
315	CFO	405	PE/Industrial Electronics
316	DOE Office	406	EPD/ERD Offices
OS316N	Security Kiosk	411	Shipping/Receiving
317	LLESA Store	OS411S	Security Kiosk
318	Pool Change Room	412	Vacant
319	University Relation Prog	415	LLES/Science & Techgy Educ Prog
321	Materials Fab Shop	OS415W	Security Kiosk
321D	EE Fabrication	U416	PE/Boiler Room Facility
321E	MMED Boiler Rom	418	PE/Paint Shop
OS321WAA	Building 321 WAA	OS418 WAA	Building 418 WAA
322	Plating Shop	419	EPD/RHWM Indtrl-Mthblld
322A	Plating Shop Annex	423	Accelerator Resch Center
323	HC/Fire Station #1	U424	Electrical Substation
324	HC Respirator/Fire Sci	U430	TSD Node #9
U325	LCW Control	431	Accelerator Resch Center
326	Vacant	432	Mechanical Shop-NIF
327	Radiography	433	Vacant
328	HC Fire Test	435	Fusion Research
328A	HC Fire Science Storage	436	Energy Research
328B	HC Duct & Filter Room	438	EPD/ERD Off-Field Ops
U328C	PE/LCW Control Bldg	439	Computer Ctn/Archives
329	Laser Weld Shop	442	EPD/RHWM Shp/Corp Yd/Strg
331	Tritium Facility	443	PE Storage
332	Pu Facility	444	TSD Storage
OS332 WAA	Building 332 WAA	445	High Field Test Facility
334	HETB	446	Bioreactor Facility
335	Support Facility	U448	TSD Node #8
335A	Emergency Response Facility	451	SC & CD
335B	Emergency Response Facility	OS452	SC & CD Emrgcy Pwr Cover
336	South Security Portal	U470	TSD Node #2
337	NW Security Portal	U472	EPD/ERD Treatmt Fac D
OS338	Guard Tower	473	AIS Storage
341	Physics & Adv. Technologies	481	Office
343	SSSP	482	Office
345	Vacant	490	Demonstration Facility
361	Biology & Biotech Resch	491	Vacant
OS361 WAA	EPD/RHWM Waste Acc Area	492	Vacant
362	Biology & Biotech Resch	493	NIF Storage

8. CONCLUSION

494	NIF Storage	U664	TSD Node #7
OS495 WAA	Waste Accumulation Area	OS665	Medical Triage Area
501	Office	671	Procurement and Materiel
509	PE/Sheet Metal Shop Sto	681	Optics Assmby Bldg
510	PE/FACS/UPS Battery Bank	691	Lodtm Facility
511	PE/Crafts Shop	693	EPD/RHWM Waste Storage
OS511 WAA	Building 511 WAA	694	EPD/RHWM Office
512	PE/Crafts Storage	696	EPD/RHWM Wst Procss-solid
513	EPD/RHWM Waste TSDF-Liq	697	EPD/RHWM Wrhs-chem Exchg
513A	EPD/RHWM Waste TSDF-Liq	1253	Vacant
514	EPD/RHWM Waste TSDF-Liq	1277	DNT Facility
514A	EPD/RHWM Waste TSD-liquid	1280	Physics & Adv. Technologies
515	PE/Crafts Sto/Receiving	1401	GGG/GGT Division Offices
516	PE/Crafts Facility/ME	1402	GGG/GGT Division Offices
517	Elect Utility Offices	1403	Earth Sciences
517A	PE/Custodian Laundry Rm	1404	GGG/GGT Division Offices
518A	Chem Track	1405	GGG/GGT Division Offices
OS518	Gas Cylinder Dock	1406	GGG/GGT Division Offices
519	PE/Equipment Repair	1407	Restroom Trailer
519A	Heavy Equipment Storage	1408	Vending Machine Trl
520	PE Pesticide Storage	1413	GGG/GGT Division Offices
522	PE Restroom Facility	1456	GGG/GGT Division Offices
523	PE/Weld/Carptry Wk Shed	1460	NAI
525	PE/Labor Only Elect	1477	Eng Red Badge Space
531	PE/Cust/Grdnrs Offices	1478	GGG/GGT Division Offices
532	EPD/ORAD Service Bldg	1481	Electronic Engineering
533	EPD/DO Storage	1482	NAI Office
534	EPD/ORAD Storage	1526	Eng Red Badge Space
543	AD/EED Office	1527	Engineering 3
551E	Plant Engineering Offices	1541	Chemistry
551W	TID	1578	Engineering 3
571	Human Resources	1579	Engineering 3
591	Geo Sci & Env Resch Prog	1601	PAT
592	NIF Storage	1602	Vacant
593	Geo Sci & Env Resch Prog	1631	Office
597	EPD/ERD Corp Yard	1632	SSEC
597A	Restroom and Shower Facility	1677	FEESP Office
U599	TSD Nodes 5&6	1678	Office
611	Auto Fleet Maintenance	1680	LS Office
612	EPD/RHWM Waste TSDF	1713	EPD/RHWM Toilet/Shower
612A	EPD/RHWM Waste TSDF	1714	EPD/RHWM Toilet/Shwer
614	EPD/RHWM Waste TSDF	1715	Mobile Lidar Lab
615	Training/Outreach Facility	1726	Physics & Adv. Technologies
616	Donation, Util & Salvage	1727	Tech Support
619	Donation, Util & Salvage	1730	EPD/RHWM Offices
OS621	Cng Fuel Station	1734	Vacant
U622	Storage	1735	Physics & Adv. Technologies
623	Fire Riser Storage	1736	Security
624	EPD/RHWM Office	1739	PCMDI Offices
625	EPD/RHWM Waste TSDF	1802	Toilet Trailer
639	PE/Storage	1826	Storage
651	Visitor Center	1830	Property Management
OS651N	Security Kiosk	1877	Computation
652	Telescope Building	1878	Office
663	Health Services	1879	Laboratory Training Center

8. CONCLUSION

1884	HEA Division Offices	3502	SC & CD
1885	HEA Division Offices	3520	SC & CD
1886	Electronic Shop	3526	Lab Assurance Office
1887	Office	3527	DOE Offices
1888	Telecomm Administration	3550	SC & CD
1889	Computation	3555	Lab Assurance Office
1925	TSD	3577	SC & CD
1927	Chemistry	3629	Biology & Biotech Resch
2127	Physics & Adv. Technologies	3649	Biology & Biotech Resch
2128	Physics & Adv. Technologies	3703	Biology & Biotech Resch
2177	Physics & Adv. Technologies	3724	Office
2180	Computation	3725	Office
2425	Chemistry	3726	Office
2428	Chemistry	3751	Office
2512	HC Bldg Coord Office	3775	Office
2525	HC WSS Off & Elect Shop	3777	Biology & Biotech Resch
2526	HC SPD Offices	3903	Glass Depot
2527	Vacant	3904	E Tech Support
2529	HC Rml Offices	3905	Test Lab/draft
2530	HC Safety Analysis Offices	3907	E Tech Support
2554	HC Bio Assay Offices	3925	Conference Room
2580	Communication Center	3982	Tech Support
2598	Tent	4104	HC EMD Toilet Trailer
2599	HC Storage Tent	4107	Science & Tech Educ Prog
2625	HC Toilet Trailer	4128	LLESA Store
2626	Vacant	4161	Computation
2627	HC Classroom #2	4177	HC EMD Offices
2629	Office	4180	Supplemental Labor Office
2632	Engineering	4181	Computation
2633	HC Offices	4182	HC Team #4
2679	HC Training Center	4184	Computation
2684	Office	4199	Staging Tent
2685	Cain	4297	Engineering Tent
2687	Alarms	4298	NIF Tent
2701	Security Shower Trailer	4299	MFE Tent
2726	Office	4302	EPD/ERD Offices
2727	Office	4316	EPD/ERD Storage
2728	Office	4325	Office Trailer
2775	Office	4377	EPD/ERD Offices
2777	Security Training	4378	EPD/ERD Offices
2787	Security Exercise Trailer	4383	EPD/ERD Offices
2801	Vacant	4384	EPD/ERD Offices
2802	Vacant	4385	Office
2804	Office	4387	EPD/ERD Offices
2806	Rock Prep Lab	4388	EPD/ERD Toilet Trailer
2807	Office	4399	EPD/ERD Storage Tent
2808	Toilet Trailer	4406	Control Room
2825	Office	4407	EPD/ERD Storage
2925	Cams Division Offices	4440	EPD/RHWM Office
3175	University Relation Prog	4442	EPD/RHWM Office
3180	Directors Office Annex	4475	Office Trailer
3203	Material Fabrication Div	4509	TID Chemical Storage
3204	Material Fabrication Div	4525	SC & CD
3226	NDE Facility	4576	SC & CD
3427	Travel Modular	4675	Central Cafeteria

8. CONCLUSION

4725	AIS Office	6203	Plant Engineering
4726	AIS-Operations	6205	PE Heavy Equipment Yard
4727	TID Library	6297	Plant Engineering (Tent)
4728	TID Library	6302	PE/Rigger Trailer
4729	TID Library	6325	EPD/RHWM Offices
4905	PE/Tech Support	6498	MFE Tent/Corp Yard
4906	PE/office	6499	Mfe Tent/Corp Yard
4926	Office	6501	Public Affairs Office
4997	NIF Storage Tent	6525	Visitors Ctr Auditrm
4997A	NIF Storage Tent	6526	Public Affairs Office
4998	NIF Storage Tent	6527	Public Affairs Office
4999	NIF Storage Tent	6575	Public Affairs Office
5104	Industrial Gas Facility	6870	NIF Office
5105	PE Construction	6925	IP&C Offices
5125	PE Construction	6926	IP&C Offices
5198	PE M&O Receiving Tent	6928	IP&C Offices
5207	PE/AC Storage	6951	EPD/RHWM Service Building
5225	EPD/RHWM Office	6952	Vacant
5226	Security	801A	Firing Facility (Fxr)
5399	NIF Storage Tent	801B	Technical Maintnce Shop
5425	EPD/DO Offices	801D	Administration
5426	EPD/ORAD Offices	802A	Camera Test Facility
5475	EPD/DO Office	OS802B	Vehicle Shelter
5477	EPD/ORAD Office	803	EPD/ORAD Storage Wrhse
5626	Audit & Oversight	804	Staging Area
5627	Legal Services	805	HE Assembly/machining
5750	EPD/ERD Service-R&D	806A	HE Machining
5925	Office	806B	HE Machining
5926	Office	806C	HE Machining
5928	Office	806D	Machining Storage
5974	DOE Offices	807	HE Machining
5975	Office	808	Vacant
5976	Office-Computer Supp	809A	Radiography/HE Mach
5977	Office	809C	Oven Facility
5978	Office	810A	HE Assembly
5979	Office	810B	HE Assembly
5980	Office	810C	Assembly Storage
5981	Office	811	PE/Storage
5982	Office	812A	Laboratory
5983	Office	812D	Laboratory
5984	Office	812E	Laboratory
5985	Office	OS812B	Storage
5997	NIF Storage Tent	OS812C	Storage
5999	EPD/ERD Storage Tent	813	Change House
02U6042	Mocho Pot Pump Sta HH	814	Vacant
U6047	Snl Wtr Tnks Cntrl Sta	U815	Cntrl Air Plant/Strg
6127	EPD/RHWM Offices	816	Explse Waste Strg Fac
6178	EPD/RHWM Off/Change House	817A	HE Pressing
6179	EPD/RHWM Office	817B	HE Pressing
6197	EPD/RHWM Storage Tent	817D	HE Pressing
6197B	EPD/RHWM Storage Tent	817E	HE Pressing
6198	EPD/RHWM Storage Tent	817F	HE Pressing
6199	Dus Tent	817G	HE Pressing
6199A	Dus Tent	817H	HE Pressing
6199B	Dus Tent	OS817P	HE Prcss Wst Wtr Pnds

8. CONCLUSION

OSM817C	HE Storage	845B	EWTF Storage
818A	HE Storage Facility	OS845C	EWTF Burn Pad
818C	HE Storage Facility	U846	Electrical Substation
819	PE/Storage C & M Shops	U847	CW Booster Station #2
820	Vacant	848	Weather Station
821	Chemistry Storage	U849	Comm Radio Trans
OSV822AD	Contrl Mtls-Strg Vault	850	Firing Facility
823A	Linac Radiography	851A	Firing Facility
823B	Linac Radiography	851B	Machine Shop
824	HE Storage Facility	851C	Fabrication Shop
825	Chem Process Facility	U853	CW Booster Station #3
826	Chem Process Facility	854A	Dynamic Test Facility
827A	Chemistry Bldg	854B	Storage
827B	Service Shop	854C	Dynamic Test Facility
827C	Chem Processing Fac	854D	Storage
827D	Chem Processing Fac	854E	Dynamic Test Facility
827E	Chem Processing Fac	854F	Storage
828A	HE Machining-inactive	854G	Storage
828B	HE Machining-inactive	854H	Storage
828C	HE Machining-inactive	854J	Storage
830	PE/Storage-Electrical	OSM854V	Storage
832A	Storage	855A	Disassembly Facility
832C	Storage	855B	Disassembly Facility
832E	Material Mngmnt Office	855C	Disassembly Facility
832F	Storage	856	Storage
OSM832B	Explosives Storage	OSM857	Magazine Storage Vault
OSM832D	HE Shipping and Receiving	858	Drop Tower Cplex
833	EPD/ERD Service-R&D	858A	Storage
834A	Thermal Test Facility	OS858B	Drop Tower
834B	Storage	859	Storage
834C	Storage	860	Storage
834D	Storage	865	Vacant
834E	Thermal Test Facility	865C	Vacant
834F	Thermal Test Facility	U866	Instal Comm Hut #2
834G	Thermal Test Facility	867	Bunker Support Facility
834H	Thermal Test Facility	869	PE/Maint Shop Storage
834J	Thermal Test Facility	870	Office
834K	Storage	871	Administration
834L	Storage	872	PE/Paint Shop
OSM834M	Thermal Test Facility	873	PE/C&M Shops
835	EPD/ERD Storage	874	Mechanical Shops
836A	Dynamic Test Facility	874A	Storage
836B	Storage Facility	874B	Storage
836C	Dynamic Test Facility	875	PE/Supply & Maintenance
836D	Dynamic Test Facility	876	Stores & Reclamation
837	DTED Storage	877	Computer Tech Support
838	Vacant	878	PE/Maint Shop Storage
840A	Vacant	879	Motor Pool & Garage
840B	Vacant	880	Cafeteria
841	PE/Storage - C&M Shops	882	PFD Comm Center
U842	Instal Comm Hut #1	OS883	EPD/HWM Container Strg Unit
843A	EPD/ERD Corp Yard	886	Well 3 Storage Building
843B	EPD/ERD Storage	U887	Well 20 Potable Wtr Well
U844	CW Booster Station #1	U888	Well 18 Potable Water
845A	Expl Waste Treatmnt Fac	889	Site 300 Medical Facility

890	Site 300 Fire Station
OS 891	Main Gate Kiosks A
892	Central Control Post
OS 894	Process Area Post
895	Office
OS 896	East Observation Post
OS 897	West Control Post
OS 898	West Observation Post
899A	Gun Shop
899B	Pistol Range Trng/Office
OS 899	Pistol/rifle Range
OS 899C	Live Fire House
OS 899D	Rifle Range
8010	PE Construction Mgmt
8340	EPD/ERD Srv-Mntrng TF834
8710	Administration
8711	Training Facility
8726	EPD/ERD Office
8801	PE Inspection
8806	Vacant
8825	Security Fitness
8826	Shower Facility
8990	B899 A&B Wash Up Facility
8991	Fire Training Facility
OSM1	Magazine-Storage Vault
OSM2	M2 Storage Vault
OSM3	M3 Vault
OSM4	M4 Vault
OSM5	C & MS Magazine
OSM7	Magazine - Storage Vault
OSM8	Magazine - Storage Vault
OSM21	Magazine - Storage Vault
OSM22	Magazine - Storage Vault
OSM23	Magazine - Storage Vault
OSM24	Magazine - Storage Vault
OSM30	Magazine - Storage Vault
OSM31	Magazine - Storage Vault
OSM32	Magazine - Storage Vault
OSM33	M33 Vault
OSM34	Magazine - HE Cubcl Strge
OSM35	Magazine - Storage Vault
OSM36	M36 Storage Vault
OSM37	Magazine - HE Cubcl Strge
OSM38	Magazine - Storage Vault
OSM41	Magazine - Storage Vault
OSM51	M51 Vault
OSM52	Magazine - Storage Vault
OSM70	Magazine - Storage Vault
OSM71	Magazine - Storage Vault
OSM72	Magazine - Storage Vault
OSM80	M80 Ready Vault
OSM82	Magazine - Storage
OSM83	M83 Ready Vault

In the initial attempt to define which LLNL structures should receive full historic assessments, the following sources were consulted:

- Building drawings for structures built from the 1940s through 1979
- Articles from the LLNL *Magnet* and *Newsline* for information about particular structures
- Director's Office Plant Engineering Files from the LBNL Archives for information on construction projects

The following types of structures were eliminated from the list as not likely to be of historic interest unless associated with a historic person or part of a historic district based on the eligibility of a related structure housing technical activities:

- Structures built and used solely for storage
- Shops or support structures
- Office buildings and administrative support buildings.
- All buildings from 1980 forward, unless they are threatened and have housed technical programmatic activities
- All trailers, unless used as laboratories from 1940 to 1970
- All explosive vaults or bunkers (like the other support structures, these will be included in the district consideration of any potentially interesting structure with which they are associated)
- All utilities
- All security posts and guard stations
- All buildings previously consulted on and found to be of no historic interest
- All computing facilities unless they still contain historic computers

- Any structure that does not fit within the historic preservation themes established for the site.

Applying the above criteria to the comprehensive LLNL building list and using the information gleaned from early research, we determined that the following buildings fell within either a WWII or Cold War context and relevant preservation theme. They required further assessment to determine possible eligibility for the National Register.

121	Physics & Adv. Technologies
141	Electronic Shops
151	Isotope Sciences
162	Research/Crystal Gth
166	Development Lab
169	Vacant
174	Physics & Adv. Technologies
176	Storage
194	Accelerator
212	Vacant
213	Physics & Adv. Technologies
216	Computation
217	Computation
218	Computation
219	UC Institutes
230	231 Portal
231	Development & Assbly Engng
239	Radiography
241	Materials Science
243	GGG/GGT Lab Space
255	HC SPD Labs/Offices
261	NAI
280	EPD/RHWM Storage
281	HEA Labs
314	CFO
315	CFO
316	DOE Office
318	Pool Change Room
319	University Relation Prog
331	Tritium Facility
332	Pu Facility
341	Physics & Adv. Technologies
345	Vacant
381	Office/Research
391	Nova
404	PE/Battery Shop/Warhse
405	PE/Industrial Electronics
412	Vacant

415	LLES/Sci & Tech Edu Program
419	EPD/RHWM Indtrl-mthblld
423	Accelerator Resch Center
432	Mechanical Shop-NIF
435	Fusion Research
442	EPD/RHWM Shp/Corp Yd/Strg
511	PE/Crafts Shop
514	EPD/RHWM Waste TSDF-Liq
516	PE/Crafts Facility/ME
517	Elect Utility Offices
802A	Camera Test Facility
805	HE Assembly/Machining
806A	HE Machining
806B	HE Machining
806C	HE Machining
807	HE Machining
809A	Radiography/HE Mach
809C	Oven Facility
812A	Laboratory
817A	HE Pressing
817B	HE Pressing
817E	HE Pressing
817F	HE Pressing
825	Chem Process Facility
826	Chem Process Facility
827A	Chemistry Bldg
827C	Chem Processing Fac
827D	Chem Processing Fac
827E	Chem Processing Fac
828A	HE Machining-inactive
828B	HE Machining-inactive
828C	HE Machining-inactive
845A	Expl Waste Treatmnt Facility
850	Firing Facility
851A	Firing Facility
865A	Vacant

Tours of these facilities and further research about the programs housed in them allowed further paring of the list of buildings requiring assessments. The following buildings were eliminated from the final list because, although they fell within the WWII or Cold War context and were associated with important programs at LLNL, they did not meet the thresholds of historic significance or Criteria Consideration G requirements within an established LLNL preservation theme. These buildings functioned as

support structures to major programs and were not of historic interest in and of themselves.

141	Electronic Shops
151	Isotope Sciences
176	Storage
239	Radiography
255	HC SPD Labs/Offices
341	Physics & Adv. Technologies
345	Vacant
432	Mechanical Shop-NIF
442	EPD/RHWM Shp/Corp Yd/Strg

8.1.1 Property List

The following properties fall within either the WWII or Cold War context and a relevant preservation theme as established for LLNL. They require a written assessment to determine whether they are eligible for the National Register and whether they retain integrity.

121	Physics & Adv. Technologies
162	Research/Crystal Gth
166	Development Lab
169	Vacant
174	Physics & Adv. Technologies
194	Accelerator
212	Vacant
213	Physics & Adv. Technologies
216	Computation
217	Computation
218	Computation
219	UC Institutes
230	231 Portal
231	Devlmt & Assbly Engng
241	Materials Science
243	GGG/GGT Lab Space
261	NAI
280	EPD/RHWM Storage
281	HEA Labs
314	CFO
315	CFO
316	DOE Office
318	Pool Change Room
319	University Relation Prog
331	Tritium Facility

332	Pu Facility
381	Office/Research
391	Nova
404	PE/Battery Shop/Warhse
405	PE/Industrial Electronics
412	Vacant
415	LLS/Sci & Tech Edu Program
419	EPD/RHWM Indtrl-mthblld
423	Accelerator Resch Center
435	Fusion Research
511	PE/Crafts Shop
514	EPD/RHWM Waste TSDF-liq
516	PE/Crafts Facility/me
517	Elect Utility Offices
802A	Camera Test Facility
805	HE Assembly/Machining
806A	HE Machining
806B	HE Machining
806C	HE Machining
807	HE Machining
809A	Radiography/HE Mach
809C	Oven Facility
812A	Laboratory
817A	HE Pressing
817B	HE Pressing
817E	HE Pressing
817F	HE Pressing
825	Chem Process Facility
826	Chem Process Facility
827A	Chemistry Bldg
827C	Chem Processing Fac
827D	Chem Processing Fac
827E	Chem Processing Fac
828A	HE Machining-inactive
828B	HE Machining-inactive
828C	HE Machining-inactive
845A	Expl Waste Treatmnt Facility
850	Firing Facility
851A	Firing Facility
865A	Vacant

8.1.2 Equipment List

Based on the thresholds established within the preservation themes, the following equipment also was found to require further assessment. These particular technologies represent work deemed significant within the preservation themes.

- LARC
- Flash X-Ray Machine
- Brew Furnaces
- Kukla
- 100 MeV Electron-positron Accelerator
- Astron Accelerator
- ATA
- Janus
- Shiva
- Nova
- Toy Top
- Cucumber
- 2XII
- 2XIIB
- TMX
- Tory II
- Tory II-C

Of these identified objects, the following are no longer extant at the Laboratory and will not be assessed:

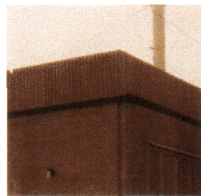
- LARC
- Flash X-Ray Machine
- Kukla
- Astron Accelerator
- Shiva
- Toy Top

- Cucumber
- 2XII
- 2XIIB
- TMX
- Tory II
- Tory II-C

As the remaining objects—Brew furnaces, 100 MeV Electron-Positron Accelerator, ATA, Janus, and Nova—remain in the buildings that housed them, they will be assessed below within the assessments of those buildings, as follows:

- Brew Furnaces (Building 241)
- 100-MeV Electron-positron Accelerator (Building 194)
- ATA (Building 865)
- Janus (Building 174)
- Nova (Building 391)

The building and equipment lists provided a starting point for assessment at LLNL. These properties comprise the potential pool of historic properties at the Laboratory given current understandings of LLNL's place in history. As noted earlier, not all of LLNL's historic impact and significance is captured in its built environment. Nevertheless, as a prominent research and development institution LLNL has developed significant technology within the walls of its buildings using equipment specifically designed for its needs.



9. BUILDING ASSESSMENTS

Based on the historic contexts and preservation themes established in the preceding context statement, individual LLNL buildings were selected for detailed assessment. The specific criteria used to determine which buildings should be assessed were:

- All WWII-era buildings (including those previously assessed)
- Any building, object, or structure associated with a historic preservation theme established for the site
- Any building associated with a person of historic interest (per Criterion B of the U.S. Secretary of the Interior's Guidelines)
- Any support building or structure that is part of a district based on the eligibility of a related structure or set of structures housing technical activities.
- Structures built and used only for storage
- Shops or support structures
- Office buildings and administrative support buildings
- All buildings built from 1980 forward unless they are threatened and have housed technical programmatic activities
- All trailers
- All explosive vaults or bunkers
- All utilities
- All security posts and guard stations
- All buildings previously consulted on and found to be of no historic interest
- All computing facilities unless they still contain historic computers
- Any structure that does not fit within the historic preservation themes established for the site.

The following types of structures were eliminated from the list if they did not meet the above criteria:

Based on these criteria, a limited number of LLNL buildings required assessment. Assessments follow for the following twenty-one buildings and sets of buildings:

- Building 121
- Building 162
- Building 166
- Building 169
- Building 174
- Building 194
- Buildings 230 and 231
- Building 241
- Building 243
- Building 261
- Buildings 280 and 281
- Building 331
- Building 332
- Building 381
- Building 391
- Building 423
- Building 435
- Building 865 Complex
- WWII buildings
- Site 300 Process Area
- Site 300 Hydrodynamic Test Facilities.

The recommendations that resulted from the assessments are that LLNL has five individual historic buildings, two sets of historic objects, and two historic districts eligible for the National Register of Historic Places, as follows:

- Building 194
- Building 280
- Building 332
- Building 391
- Building 865A
- Selected Objects in Building 174 (Janus)
- Selected Objects in Building 241 (Brew furnaces)
- District: Site 300 Process Area
- District: Site 300 Hydrodynamic Test Facilities.

Figure 65 provides a map of the main LLNL site, indicating the buildings that have been assessed there. Figure 66 is a map of Site 300, indicating the sets of buildings assessed there.

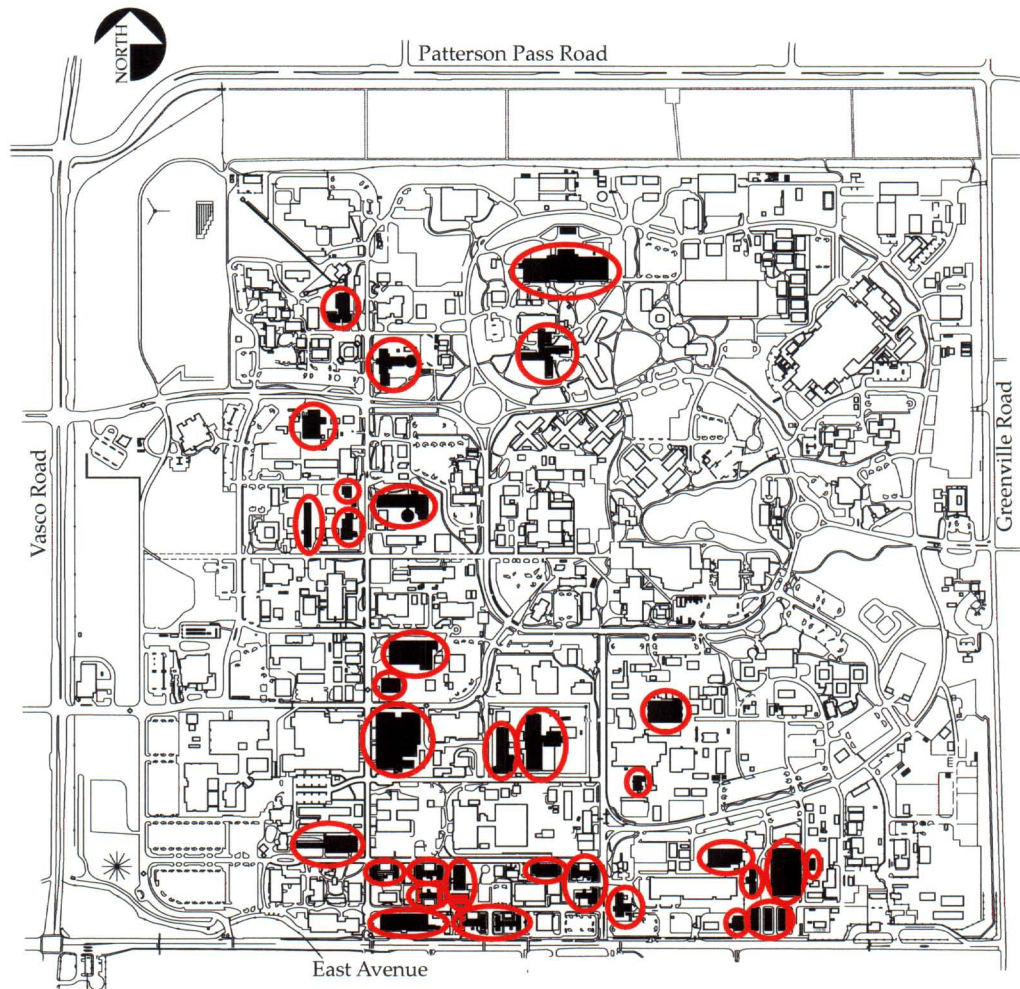


Figure 65. Map of LLNL main site. Buildings assessed are circled.

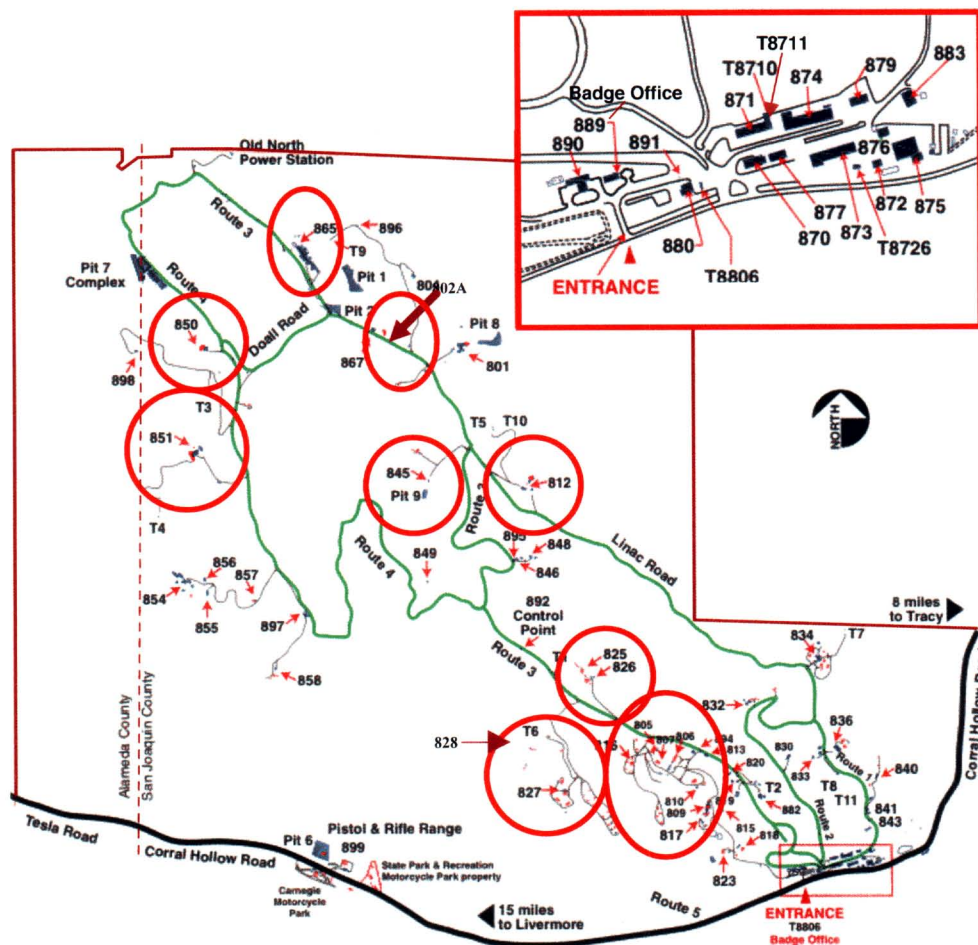


Figure 66. Map of LLNL Site 300. Areas assessed are indicated.

9.1 Building 121

9.1.1 Description

Building 121 is located on the LLNL main site at the corner of First Street and Avenue B. It currently houses the Physics and Advanced Technologies Directorate.

Originally built in 1955, Building 121 was designated Building 112, the Physics Complex Offices and Laboratories. In 1967, during a Laboratory-wide renumbering, Building 112 was redesignated Building 121.³⁸⁹ Building 121 has housed many offices and programs over the years, including Experimental Physics, the Director's Office, the library, and photographic services. Currently, it houses offices for the Physics and Advanced Technologies Directorate. The last of the laboratory space is being converted into additional offices. Figure 67 is a recent photograph of Building 121.

Building 121 is a concrete-block and poured-concrete structure of 91,145 gross square feet.³⁹⁰ The original building is a one-story structure built in an H-shape. The west addition is a three-story rectangle, and the east addition is a one-story rectangle adjoined to the south end of the original structure by a corridor that connects to the original central wing.

9.1.2 Mission History

In 1955, Building 121 housed electronic engineering, accelerator technicians, photography, and the machine shop. In 1958, the Director's Office moved from Building 161 to Building 121, where it remained until 1969, when it moved into the new, larger Building 111. LLNL's first five directors had offices in Room 1041 of Building 121—Herbert York (1957–1958), Edward Teller (1958–1960), Harold Brown (1960–1961), John Foster (1961–1965), and Michael May

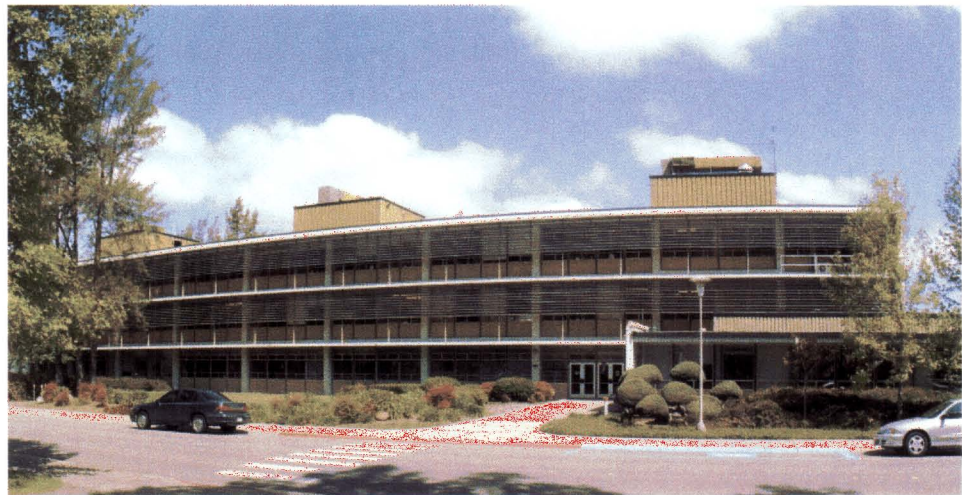


Figure 67. Looking north at Building 121, south elevation, 2003.³⁹¹

³⁸⁹ For the sake of clarity, this report will refer to Building 121 by its current designation.

³⁹⁰ Building 121, exterior, south elevation, LLNL photographer Marcia Johnson, 2003.

³⁹¹ Information on gross square footage, current occupants, and room configurations in this and all subsequent buildings is from the most recent Facility Key Plan, PEL.

(1965–1969).³⁹² Edward Teller continued to maintain an office in Building 121 until 1969, when he moved into Building 111 with the relocation of the Director's Office.

In 1958, the LLNL nuclear weapons and testing programs also moved into Building 121. The programs included Experimental Physics, Project Plowshare, the Test Division, and Weapons Effects. The weapons and testing programs remained in the building until 1969 when they also moved to Building 111. Experimental Physics was made up of A Division and B Division. A Division staff designed nuclear devices, industrial assemblies, and weapons. They also conducted experiments in neutronics and hydrodynamics. B Division staff conceived, designed, and tested special categories of nuclear weapons and Project Plowshare nuclear devices. Experimental Physics was responsible for the design work of all the LLNL nuclear weapons designs that entered the U.S. stockpile between 1958 and 1969, including the historically significant W38, the warhead designed for the Atlas and the Titan ICBMs; W47, the warhead for the SLBM Polaris; and W56, the second-generation warhead for the ICBMs Minuteman I and Minuteman II.

Beginning in 1962, Building 121 also housed the Library and Technical Information Department. They remained in Building 121 until the 1990s.

In the 1970s, Building 121 housed Field Test Operations, High Altitude Physics, Experimental Physics, Mechanical Engineering, and the Test Operations.

In the 1980s and 1990s, Building 121 housed Computation, Electrical Engineering, Field Operations, the Neutron Measurement Group, and Test Operations.

Currently, Building 121 houses the offices of the Physics and Advanced Technology Directorate.

Period of Significance

Building 121 is of historic significance under Criterion B for its association with Herbert York, Edward Teller, and John Foster, who were three of the first five LLNL laboratory directors. They are considered of historic importance for their larger role in the Cold War. Their roles in defining and directing U.S. Cold War strategy and policy extended beyond their respective periods as LLNL directors. Nevertheless, all three maintained their high profile and historic contributions during their respective tenures as Laboratory director.

Edward Teller was involved in most high-level discussions regarding nuclear strategy for the entire forty-six-year Cold War struggle. Herbert York and John Foster served the nation as directors of the U.S. Department of Defense Office of Defense Research and Engineering. They, too, continued to play an important role in nuclear strategy and policy-making decisions during the Cold War. Therefore, Building 121 is of historic interest for its association with historic persons within the context of the Cold War. The period of historic significance for this association is 1958–1965.

³⁹² The dates indicate the years that each director had an office in Building 121 and do not necessarily reflect his tenure in office.

Building 121 is also of historic interest for its role in several of LLNL's nuclear weapons designs. Building 121 housed A Division, B Division, and Experimental Physics during the years that these programs designed the W38, W47, and W56. Therefore, Building 121 is of historic significance for its involvement in nuclear weapons design within the context of the Cold War arms race and the established LLNL preservation theme Nuclear Weapons Design and subtheme Weapons Design. The period of significance is 1958–1969.

9.1.3 Construction History

Building 121 was built in three separate increments.

In 1954, the Austin Company, an Oakland engineering and construction firm, designed Increment 1 of Building 121. Increment 1 was an H-shaped, concrete block structure with a flat, tar-and-gravel roof and square windows with metal frames.³⁹³ The long wings of the H had offices on the south side

and laboratories on the north side separated by a corridor.³⁹⁴ Figure 68 depicts the original H-shaped wing of Building 121.

The interior housed a nuclear film chemical preparation room, microscopy room, densitometer room, electronic camera room, lapping and polishing room, plating room, coating room, light source room, camera test room, control room, optical test room, optical assembly room, apparatus room, electronic shop, shop and assembly room, boiler room, and switch gear room.³⁹⁵

In 1956, John A. Blume, engineer, and John C. Warnecke, architect, both of San Francisco, designed Increment 2, which was added to the south elevation of Increment 1. It consisted of a three-story rectangle of offices at the west end, and a one story-rectangle of offices at the east end. Increment 2 was a reinforced concrete structure with a flat roof. It had large glass windows in metal frames with decorative aluminum

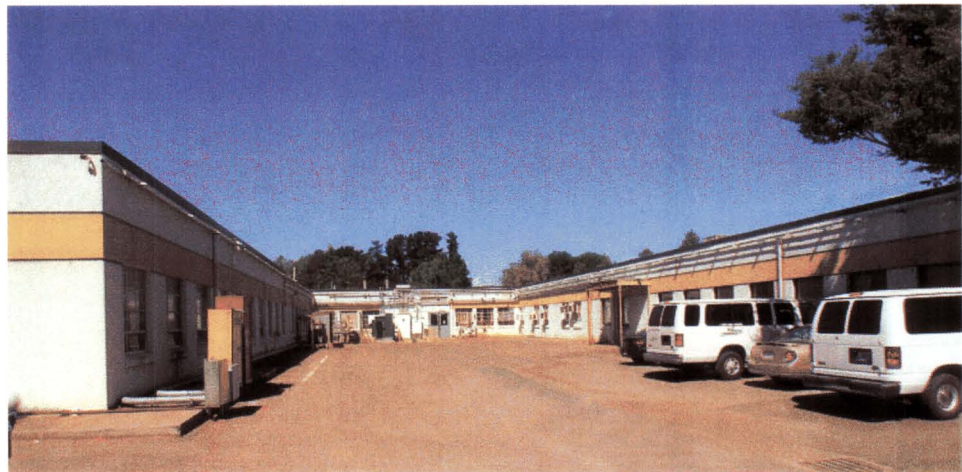


Figure 68. Looking west at Building 121, original H-shape wing, east elevation, 2003.³⁹⁶

³⁹³ "3D Building No. 112, Elevations and Building Sections," 1954, PLZ54-121-008JA, PEL.

³⁹⁴ "3D Building No. 112, Floor Plan," 1954, PLZ54-121-006JB, PEL.

³⁹⁵ "3D Building No. 112, Floor Plan," 1954.

³⁹⁶ Building 121, exterior, east elevation, LLNL photographer Marcia Johnson, 2003.

sunshades.³⁹⁷ The interior of the west end housed the Director's Offices as well as offices for A Division, B Division, and Experimental Physics. The interior of the east end had clerical offices, the library, and a vault for storing classified documents and material.³⁹⁸

In 1965, Michael A. Gallis, a San Francisco architect, designed Increment 3 of Building 121. Increment 3 extended the east end of Increment 2. It too was a concrete one-story structure with a flat roof. It housed additional offices and more space for the library.³⁹⁹

In the 1970s and 1980s, Building 121 was continually remodeled to transform laboratory space into offices or to modernize existing offices. In 1986, the exterior of Increment 1 was modernized by covering the concrete block exterior walls with a coat of stucco. Additionally, decorative bands of color gave the old part of the building a more modern appearance.

In recent years, all the remaining laboratories in Increment 1 have been renovated or are scheduled for renovation into office space.

Building 121 reflects modern industrial architectural design. Increment 1 was designed to be functional and utilitarian and had no adornment or aesthetic design

³⁹⁷ "Office Laboratory Addition to Building 112, Elevations," PLZ56-121-007JA, PEL.

³⁹⁸ "Office Laboratory Addition to Building 112, Second and Third Floor Plans, Mechanical Rooms," PLZ56-121-003JB, PEL.

³⁹⁹ William Self Associates, *Documentation and Assessment of the History of the Lawrence Livermore National Laboratory Livermore Facility*, 27.

features. Increment 2, on the other hand, reflected a more aesthetic design style characteristic of "work for universities, research institutions, and corporations in the late 1950s by the mainstream architecture profession."⁴⁰⁰ It featured concrete walls with panels of glass and stucco. Windows on the south side were covered with metal louvers for sunshade. Increment 3 and subsequent modifications continued to modernize the structure and reflected a more aesthetic emphasis in design. Nevertheless, Building 121 is not an example of high-style architecture but was instead an effort to create an appearance reflective of the status of the individuals and work that it housed.

Building 121 is an LLNL Cold War building of the type referred to as Light Laboratory. It possesses the characteristic features of its type—multi-story, reinforced concrete, built-up roofing, heavy steel repetitive-bay structural framing, prefabricated wall panels, office space, and laboratory space for smaller equipment and apparatus.

9.1.4 Integrity

Building 121 is of historic interest for its association with Herbert York, Edward Teller, and John Foster in their roles as early LLNL directors and important figures in forming nuclear policy and strategy during the Cold War. The period of historic significance for this association is their tenure as LLNL directors in the building from 1958 to 1965. However, Building 121 no longer possesses historic integrity for this time period. The former Director's Office in Room 1041 long since has been renovated. The current Director's Office is not located in Building 121. Were it still in Building 121,

⁴⁰⁰ Ibid.

the continuity of mission perhaps would deserve additional consideration. Building 121 neither looks as it did during the time these historical figures had offices there, nor does it reflect the activities they engaged in while there.

Building 121 is also of historic interest for the nuclear weapons design activities conducted there from 1958 to 1969. Three nuclear weapons designs of particular note were developed there: the W38, W47, and the W56. However, Building 121 no longer possesses integrity for this period of historic significance. The laboratories and offices where nuclear weapons design work occurred have been renovated for other uses. No trace of the weapons design activity remains within the building, and it does not look as it did during the period when this work occurred there.

9.1.5 Recommendation

Building 121 does not qualify for the National Register under Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. The design of the building is of no architectural interest. It is an uninteresting example of the modern industrial design of the period and does not in and of itself reflect the activities of historic interest that occurred there. Building 121 is not, nor will it be, a source of important historic information. The weapons design activities that occurred there are documented in research reports and LLNL archival records.

Building 121 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the design of nuclear weapons for the U.S. stockpile during the Cold War. The particular period of historic significance for these activities within this structure is 1958–1969.

Building 121 also qualifies for National Register consideration under Criterion B, association with historic figures. Building 121 was the site of the Director's Office and housed the first five LLNL directors. The historic profession recognizes three of these directors—Herbert York, Edward Teller, and John Foster—as important Cold War strategy- and policy-makers during their respective tenures as LLNL directors. The period of historic significance for association with these men is 1958–1965.

However, Building 121 no longer possesses integrity for either of its periods of historic significance. Building 121 no longer reflects either its nuclear weapons design activities or its association with the three LLNL directors determined to be historically significant in the context of the Cold War. Therefore, it is recommended that Building 121 not be considered eligible for the National Register under Criterion A or Criterion B despite its historic interest and association with key historic figures.

9.2 Building 162

9.2.1 Description

Building 162 is located on the LLNL main site, east of Avenue B and north of Fifth Street. It currently houses crystal growth laboratories. Originally built in 1960, Building 162 was designated 182C and housed special medical research. In 1967, during a Laboratory-wide renumbering, it was redesignated Building 162.⁴⁰¹ In 1984, it was joined to its neighboring structure, Building 164, by an addition. The combined structure kept the Building 162 designation. Building 164 also was built in the late 1950s to house special research projects. Such projects tended to be prototypes that had not yet blossomed into full research programs. Building 162 has housed a variety of research programs over the years, including Detector Calibration, Electronic Engineering Diagnostics, Laser Research, and, currently, crystal growth laboratories for the Laser Program. Figure 69 is a recent photograph of Building 162.

Building 162 is a long, rectangular, two-story building made of corrugated metal with a pitched roof and an awning over the west elevation. Because of the earlier merge of two distinct structures it is essentially two Butler-type buildings joined together. Currently, it is divided into thirty-four laboratories, seven utility rooms, and ten offices.

9.2.2 Mission History

Building 162 has not had a consistent mission but instead has housed a variety of special research programs. From 1960 to 1962, Building 162 housed medical research. From 1962 to 1970, it contained Detector Calibration and Electronic Engineering Diagnostics. Beginning in 1969, Building 162 began to be used by Q Division, the early laser research program, and after 1972, for Y Division, the reorganized laser research program. Since 1969, it has maintained a continuous association with research and development for laser research. Building 162 laser scientists developed materials



Figure 69. Looking west at Building 162, east elevation, 2003.⁴⁰²

⁴⁰¹ For the sake of clarity, this report will refer to Building 162 by its current designation.

⁴⁰² Building 162, exterior, LLNL photographer, 2003.

and techniques before they were used in full-scale laser experiments. Some of the research conducted by Y Division included neodymium-doped (Nd) laser glass development, frequency conversion techniques, laser pulse shaping, and materials damage studies.⁴⁰³ In 1984, the building was expanded to accommodate high-temperature crystal growth research. Currently, Building 162 houses both high-temperature and fast-growth crystals for laser applications.

Period of Significance

From the late 1960s, Building 162 has housed laser research. LLNL embarked on laser research during its formative years and pioneered work in the field of laser fusion. Several of the LLNL Inertial Confinement Fusion (ICF) laser experiments of the 1970s are of historic note. In 1974, LLNL developed Janus, one of the first ICF lasers. In 1977, the Laboratory introduced the twenty-armed Shiva laser, the most powerful in the world at the time. The Novette laser experiments of 1982 and the Nova experiments of 1985 demonstrated the feasibility of ICF ignition.

From 1969 to 1975, Building 162 often housed prototype systems and experimental materials research for the laser program. Therefore, it is of historic interest for its contributions to LLNL's breakthroughs in laser research within the context of the Cold War and the theme of Nuclear Research and subtheme of Physics Research. The period of significance for these activities

is 1969 to 1975. In 1975, many experimental research programs moved into Building 381, the Laser Fusion Laboratory and Building 162 no longer represented LLNL's prototype laser research, key research, or its subsequent scientific breakthroughs.

9.2.3 Construction History

California Steel Buildings, Inc., an Oakland construction firm, designed Building 162 in 1959. It was a corrugated-metal, steel-framed, two-story structure with a high bay, a pitched metal roof, and roll-up doors on the west and south elevations.⁴⁰⁴

In 1962, a mezzanine was added to Building 162.⁴⁰⁵ In 1969, a beam trap was installed for laser research. In the 1970s, several modifications were made to accommodate Y Division research, including the installation of a gas gun.

In 1984, Building 162 was connected to Building 164, and a second floor of offices and laboratories was installed. Since 1984, Building 162 has housed crystal growth laboratories on both the first and second floors. These laboratories have constantly been modified and upgraded over the past twenty years.

Building 162 is an industrial building made of corrugated metal. It does not represent any type of high-style architecture. It is the type of utilitarian and functional construction common to industrial settings throughout the United States.

⁴⁰³ M. Weber, "Experimental Laser Research Group," Box 419, Folder 4017, Laser Program Annual Report, 1973–1977, LLNL Archives.

⁴⁰⁴ "Butler 4020 RF Bldg. 81'–10" for University of California Radiation Laboratory," 1959, PLZ59-162-001JA, PEL.

⁴⁰⁵ "Mezzanine Addition to Existing Mezzanine, Plans, Elevations, Sections, and Details," 1962, PLA-62-162-131D, PEL.

Building 162 is an LLNL Cold War building structure of the Metal Butler-type. It features the characteristics common to its type—single-story, prefabricated steel rigid-frame structure, reinforced-concrete slab, corrugated-metal siding and roofing, and space for short-term experiments or shops.

9.2.4 Integrity

From 1969 to 1975, Building 162 housed laser research and development activities of critical importance to the ICF program. Therefore, it is of historic interest for the materials research that has contributed to LLNL laser breakthroughs in ICF research. However, it no longer possesses integrity for these historic activities. The rooms where laser material research occurred or prototype laser systems operated have been renovated significantly. Building 162 does not retain any equipment from the period of its historic significance.

9.2.5 Recommendation

Building 162 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this

building. The design of the building is of no architectural interest. It is a type of industrial structure found in countless industrial settings throughout the country and does not reflect the activities of historic interest that occurred there. Building 162 is not, nor will it be, a source of important historic information. The laser research that occurred there is documented in research reports and archival collections.

Building 162 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War, and specifically LLNL's research and development of materials and prototype systems for laser applications. The period of historic significance for these activities within this structure is 1969–1975.

However, Building 162 no longer possesses integrity for the period of its historic significance. It possesses neither the original laboratories nor the equipment used in the research and development of prototype laser systems and materials. Therefore, it is recommended that Building 162 not be considered eligible for the National Register.

9.3 Building 166

9.3.1 Description

Building 166 is located on the LLNL main site at the corner of Fifth and Avenue B, and currently houses Physics Development Laboratories. It was originally built in 1960 as Building 182A, Special Research. In 1967, during a Laboratory-wide renumbering, it was redesignated Building 166.⁴⁰⁶ It housed a variety of projects over the years, including pulsed X-ray research for Site 300, Project Plowshare, and laser research. From 1971 to the present it has housed part of LLNL's laser research program. Figure 70 is a recent photograph of Building 166.

Building 166 is a steel-framed, high-bay, Butler-type building with a pitched metal roof and a concrete block addition on the east end of the building. Building 166 currently contains fourteen laboratories, five utility rooms, and two service shops.

9.3.2 Mission History

Building 166 was built in 1960 for a variety of both short-term and long-term special research projects. It initially housed Site 300's flash radiography program, which involved the use of pulsed X-ray sources to photograph the movement of objects at high velocities. The building also provided space for the development of a magnet system for LLNL's 35-MeV linear accelerator.⁴⁰⁷

From 1965 to 1971, Building 166 housed Project Plowshare experimental research, including a three-inch gun.

Beginning in 1971, Building 166 housed laser research. In 1971, the building was modified to accommodate early Q Division gas laser research. Gas laser research was pursued as a possible technology for use in laser fusion and laser isotope separation. The main emphasis was on electronic transition gas



Figure 70. Looking southeast at Building 166, north and west elevations, 2003.⁴⁰⁸

⁴⁰⁶ For the sake of clarity, this report will refer to Building 166 by its current designation.

⁴⁰⁷ "More Livermore Buildings Completed," *The Magnet* (August 1960), 6.

⁴⁰⁸ Building 166, exterior, LLNL photographer, 2003.

lasers.⁴⁰⁹ In 1975, Building 166 staff turned to research on copper laser technologies. In 1989, work in the growth of semiconductor crystals began in the building.

From 1975 to the present, important aspects of laser research for the ICF program occurred in Building 166. Work supporting this program currently includes heat sink fabrication, laser diode array assembly, anodic bonding and inspection, development and testing of the pyrochemical demonstration system, high-average power diode-pumped solid-state laser design and testing, rapid crystal growth storage, and growth of semiconductor crystals.⁴¹⁰

Period of Significance

From 1971 to the present, Building 166 housed laser research. LLNL embarked on laser research during its formative years and pioneered the field of laser fusion. Several of the LLNL ICF laser experiments of the 1970s are of historic note. In 1974, LLNL developed Janus, one of the first ICF lasers. In 1977, LLNL developed the twenty-armed Shiva laser, the most powerful in the world at the time. The Novette laser experiments of 1982 and the Nova experiments of 1985 demonstrated the feasibility of ICF ignition.

Building 166 provided research and development for the laser program from 1971 to the present. From 1971 to 1975, it housed important laser research on technology and materials for the ICF program. The

research conducted in Building 166 contributed directly to the breakthroughs in laser technology noted above. Therefore, the building is of historic interest for its contributions within the context of the Cold War and the theme of Nuclear Research and subtheme Physics Research. The period of significance for these activities is 1971–1975. In 1975, many experimental research programs were centralized in Building 381, the Laser Fusion Laboratory and Building 166 no longer played such a high profile role in LLNL’s laser research program.

9.3.3 Construction History

Building 166 was built in five separate increments over a thirty-year period.

In 1959, California Steel Buildings Inc., of Oakland California, designed Increment 1 of Building 166. It was a high-bay, steel-framed, corrugated-metal Butler-type building with a mezzanine. There were plastic light panels in the upper part of the building on the east and west elevations and a roll-up door on the south elevation.⁴¹¹ The interior housed a high-bay area, storeroom, and bathroom.⁴¹²

In 1961, Plant Engineering designed Increment 2, a concrete blockhouse, to the east end of the building. The blockhouse was made of interlocking concrete shielding blocks. The structure had a flat, raised roof above the shielding blocks and had no external doors or windows. The interior contained two rooms—one of which could

⁴⁰⁹ “Program Task and Level of Effort,” Box 419, Folder 4017, Laser Program Annual Report, John L. Emmett, 1973–1975, LLNL Archives.

⁴¹⁰ James L. Vigus, *Hazards Analysis Report: Building 166 Development Lab National Ignition Facility (NIF) Programs* (Livermore: Lawrence Livermore National Laboratory, 2002), 3.

⁴¹¹ “Butler 4020 R.F. Bldgs. 8’–10” for University of California Radiation Laboratory,” 1959, PLZ59–166–008JA, PEL.

⁴¹² “Special Research Bldg. 182–A, Floor Plan, Elevations, and Sections,” 1959, PLA59–166–111D, PEL.

be sealed off from the other by a rolling door.⁴¹³ Site 300 initially used this space as a flash radiography facility. Later, it was taken over and used by the Laser Program.

In 1965, LLNL's Plant Engineering Department designed Increment 3, a single-story addition to the northwest end of the building. The interior was also remodeled to accommodate Project Plowshare experimental research. The addition was similar in design to Increment 1. It was a corrugated-metal structure with a pitched roof and rolling door on the north elevation. The interior housed a grouting room, wet process room, dry process room, shop, office, cable testing laboratory, electronics laboratory for the three-inch gun, dark room, and shipping and receiving area.⁴¹⁴

In 1971, LLNL added Increment 4, a large addition to the north end of the building to house gas laser research.

In 1978, LLNL Plant Engineering designed Increment 5 an addition to the west side of the building.⁴¹⁵

Other modifications include the renovation of laboratory space in 1989 to accommodate semiconductor research and the remodel of Room 1107 in 1992.

Building 166 is an industrial building made of corrugated metal. It does not represent

any type of high-style architecture. It is the type of utilitarian, functional construction common to industrial settings throughout the United States.

Building 166 is an LLNL Cold War building structure of the Metal Butler-type. It features most of the characteristics common to its type—prefabricated steel rigid-frame structure, reinforced concrete slab, corrugated-metal siding and roofing, and space for short-term experiments or shops.

Building 166 also possesses some features common to the LLNL Cold War building type referred to as a Heavy Laboratory. The features of Building 166 characteristic of a Heavy Laboratory include a high bay in Increment 1 and radiation shielding in Increment 2.

9.3.4 Integrity

From 1971 to 1975, Building 166 housed laser research and development activities of critical importance to the ICF program. Therefore, it is of historic interest for the laser technology and materials research it contributed to LLNL laser breakthroughs in ICF research. However, Building 166 no longer possesses historic integrity for these activities. The rooms in which gas and copper laser research occurred have been renovated completely. The building also does not retain any equipment from the period of its historic significance.

⁴¹³ "Bldg. 182-A Temporary Addition, Plans, Elevations, and Sections," 1961, PLA61-166-128D, PEL.

⁴¹⁴ "Building 182A, New Lab and Shops, Bldg. Modifications for Plowshare, Architectural Plan, Elevation, Sections, and Details," 1965, PLA65-166-012DC, PEL.

⁴¹⁵ "Construct Building Addition West Side, Elevations, Cover Plate, Sprinkler Plan," 1978, PLA78-166-002D, PEL.

9.3.5 Recommendation

Building 166 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. Nor is the design of the building of architectural interest. It is a standard industrial metal building and does not reflect the activities of historic interest it once housed. Building 166 is not, nor will it be, a source of important historical information. The laser research that occurred there is documented in research reports and archival collections.

Building 166 does qualify for National Register consideration under Criterion A, association with a historic event or pattern

of events. In this case, the historic pattern of events is the Cold War, more specifically the LLNL research and development of laser technology and materials for the ICF program. The particular period of historic significance for these activities within this structure is 1971–1975.

Building 166 no longer possesses integrity for the period of its historic significance. None of the research equipment for the gas or copper laser systems developed in the building is extant and the building provides no indication of such research having been there. Therefore, it is recommended that Building 166 not be considered eligible for the National Register.

9.4 Building 169

9.4.1 Description

Building 169 is located on the LLNL main site at the corner of Sixth Street and Avenue B and is currently being used for storage. Building 169 was constructed in 1953 and originally used for Laboratory support services. From the mid-1960s to the 1980s it was primarily used for special laser research projects. In 1999, most of Building 169 was demolished, leaving only the blockhouse used to shield the PulseRad 310 laser. Figure 71 is a recent photograph of Building 169.

Building 169 is a rectangular concrete blockhouse with a flat roof. It was originally 3,397 gross square feet and consisted of the blockhouse and a large corrugated-metal structure with a pitched roof. It is currently 903 gross square feet with only one room.

9.4.2 Mission History

Building 169 did not have a consistent mission, but rather housed a variety of support services and special research projects. It was built in 1953 as a shop building. In the mid-1960s it housed a variety of special laser research projects. In 1971, the PulseRad 310 machine, an electron beam laser, was installed in a concrete block addition. Electron beam laser research was one of the early laser systems that pre-dated the Janus and the Cyclops lasers. In 1972, the laser program was re-organized, and efforts focused on ICF and glass laser systems like Janus. Thereafter, other systems were slowly phased out. In 1975, a new research facility, Building 381, eclipsed earlier laser facilities like Building 169. In 1984, the PulseRad 310 was removed from the building.⁴¹⁶ In the 1980s, Building 169 housed a variety of other



Figure 71. Looking north at Building 169, south elevation, 2003.⁴¹⁷

⁴¹⁶ "Laser Lab Removal Plan," 1984, PLE1984-0169-0001D, PEL.

⁴¹⁷ Building 169, exterior, LLNL photographer, 2003.

projects, including a machine to pressure-test vacuum systems for the Laser Isotope Separation (LIS) program, metalworking, and painting.⁴¹⁸ In 1999, the majority of Building 169 was demolished, leaving only the concrete blockhouse.

Period of Significance

In 1971, electron beam laser research on the PulseRad 310 machine for Q Division began in Building 169. Q Division was the early laser research program at LLNL. The electron beam laser was an early laser system at LLNL and is, therefore, of historic interest for its contributions to LLNL's later ICF research. LLNL made several historic breakthroughs in ICF research in the 1970s and 1980s. Early laser efforts were integral in developing the Janus, Shiva, and Nova lasers, which represented significant breakthroughs in laser research. Therefore, Building 169 is of historic interest for its electron beam laser research within the Cold War context, theme of Nuclear Research, and subtheme of Physics Research. The period of historic significance for these activities is 1971–1975.

9.4.3 Construction History

Building 169 was built in two separate increments.

In 1953, Increment 1 of Building 169 was constructed. This was the largest increment of the building. It was a corrugated-metal, Butler-type building with a pitched metal

roof. It was originally intended as a shop area and contained a high bay with one large work area.⁴¹⁹

In 1971, LLNL's Plant Engineering Department added Increment 2, a concrete blockhouse, to the north end of Building 169. At the same time, a control room and laboratory were installed in the high-bay portion of the building.⁴²⁰ The concrete blockhouse was made of keyed shielding blocks approximately three feet by three feet. The roof of the blockhouse was made of wood and did not sit directly on the walls of shielding but was raised off the shielding by one-foot-thick wooden beams. Each concrete block weighed approximately three and one-half tons. The east elevation contained a roll-up door and a pedestrian door. The shielding room housed the PulseRad 310 electron beam laser.

In 1972, additional offices were built inside the high-bay portion of the building. In 1984, LLNL Plant Engineering designed building modifications to accommodate the LIS vacuum pressure-testing facility.⁴²¹ In 1988, the building was modified for use as a sheet metal shop. In 1991, a waste accumulation area was built to the north of the concrete blockhouse. The waste accumulation area consists of a concrete pad covered by a metal awning and surrounded by a wire mesh fence.

⁴¹⁸ Monty Herr to Sarah Lane, memorandum, 20 June 1988, Building 169 Files, Folder 7–169–2, Building 490, LLNL; and "SAT Closeout Report for B168, 169, 594," Building Book for Buildings 168 and 169, Building 490, LLNL.

⁴¹⁹ "SAT Closeout Report for B168, 169, 594," 1.

⁴²⁰ "Building 169 Proposed Shielded Room for PulseRad 310 Machine, Floor Plan, East Elevation," 1971, PLA71–169–007D, PEL.

⁴²¹ "Building 169 Laser Laboratory, Plan and Elevation," 1984, PLA84–169–002DA, PEL.

In 1999, the high bay portion of the building was decommissioned and demolished. Currently, the concrete blockhouse is empty and used only for storage.

The remainder of Building 169 is an industrial structure made of concrete blocks. It does not reflect any influence of high-style architecture but is a utilitarian and functional building meant to shield workers from radiation.

Building 169 is a remnant of a much larger structure that originally possessed a combination of features common to the LLNL Cold War building types referred to as a Metal-Butler-type building and a Heavy Laboratory. The Metal-Butler-type portion of the building had a prefabricated steel rigid-frame structure, reinforced-concrete slab, corrugated-metal siding and roofing, and space for short-term experiments or shops. This portion of the building has been demolished. The features of Building 169 characteristic of a Heavy Laboratory included a high bay and radiation protection. Only the radiation protection remains. The shielding blocks do not represent high-style architecture. Although they do indicate that work with radioactive materials occurred there, they do not reflect the specific nature of that work. Shielding blocks are indicative of a number of research activities including research with weapons, accelerators, or lasers. The shielding blocks themselves are not sufficient to represent the work of historic interest that occurred there.

9.4.4 Integrity

Building 169 is of historic interest for its electron beam research, an early precursor to the ICF program. The PulseRad 310 electron beam laser was housed in Building 169 from 1971 to 1984. The period of historic significance for this research is 1971–1975, when the ICF laser program eclipsed earlier approaches.

However, Building 169 no longer possesses historic integrity for its period of significance. In 1999, more than half of the building's gross square footage was demolished. The control room for the laser and the laboratory in the high-bay portion of the building no longer exist.

As the electron beam laser research of interest was entirely equipment dependent, historic integrity depends on the retention of the PulseRad 310 electron beam laser. The laser was removed from the concrete blockhouse in 1984 and is no longer extant.⁴²² The only reflection of the laser research that occurred in Building 169 is the concrete shielding blocks that housed the laser. However, such shielding blocks are ubiquitous in a variety of activities that require radiation shielding, including accelerator, laser, and weapons research. They are not sufficient to reflect the specific historic laser research that occurred there.

Building 169 no longer looks as it did during the time of its historic interest, nor does any trace remain of the electron beam research that occurred there.

⁴²² "Laser Lab Removal Plan," 1984.

9.4.5 Recommendation

Building 169 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. The design of the building is of no architectural interest. It is a standard industrial structure and does not reflect the activities of historic interest that occurred there. Building 169 is not, nor will it be, an important source of historical information. The laser research that occurred there is documented in reports and archival records.

Building 169 does qualify for National Register consideration under Criterion A,

association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War, and specifically LLNL's electron beam laser that pre-dated the ICF program. Within LLNL's Cold War context the relevant theme is Nuclear Research and the relevant subtheme is Physics Research. The particular period of historic significance for this structure is 1971–1975.

However, Building 169 no longer possesses integrity for the period of its historic significance. Building 169 neither reflects the particular historic research it housed nor retains the historically important equipment used in it. Therefore, the recommendation is that Building 169 is not eligible for the National Register.

9.5 Building 174

9.5.1 Description

Building 174 is located on the LLNL main site, south of Westgate Drive and west of Avenue B. The facility is a Physics and Advanced Technology Directorate building and currently houses optics research in support of LLNL's laser programs. Building 174 was originally built in 1957 as part of the Rover complex and was designated Building 154D. In 1967, during a Laboratory-wide renumbering, Building 154D was redesignated Building 174.⁴²³ Building 174 is a generic laboratory space that has housed a variety of activities over the years, including Project Pluto research, chemistry experiments, and early laser research. The building itself is a metal Butler-type warehouse and does not reflect the activities that occurred there. However, some of the actual experiments are of historic interest. Figure 72 is a recent photograph of Building 174 looking northeast.

Building 174 is a single-story, corrugated-metal building of 19,360 gross square feet, with three bays. Each bay has its own pitched, metal roof. In essence, it resembles three separate Butler-type buildings joined together side by side. Building 174 currently contains twenty-four laboratories, four mechanical utility rooms, and one office.⁴²⁴

9.5.2 Mission History

In 1955, LLNL began work on the Nuclear Rocket Propulsion Program—code-named Rover. The project's goal was to develop nuclear-powered space vehicles. A complex of buildings was constructed to support the new program. Building 174 was built in 1957 as a control room and maintenance building for the Rover Complex.

In 1957, when LLNL ceased work on the Rover program, Building 174 was renovated for use in Project Pluto, a program to develop a low-flying nuclear reactor, or ramjet engine, to power a supersonic



Figure 72. Looking northeast at Building 174, west and south elevations, 2003.⁴²⁵

⁴²³ For the sake of clarity, this report will refer to Building 174 by its current designation.

⁴²⁴ "Facility Key Plan," 1999 revised, PKB96-174-001BC, PEL.

⁴²⁵ Building 174, exterior, LLNL photographer, 2003.

cruise missile. Building 174 served Pluto as a materials research laboratory for the Chemistry Division.

In 1964, Project Pluto was cancelled after the successful demonstration of the Tory II-C, a full-scale nuclear reactor. Building 174 was closed briefly along with other Pluto buildings and then used temporarily for general research and chemistry tests.⁴²⁶

In the late 1960s, Building 174 housed some of the early Q-Division laser research projects. In the early 1970s, it was expanded for the newly re-organized laser research program. Additional increments were added to accommodate ICF research, a program designed to produce thermonuclear micro-explosions by laser for both weapons and energy applications. Several early breakthroughs in ICF research occurred in Building 174.

In 1974, the Janus laser produced the first ICF direct-drive implosions and fusion neutrons. The Janus laser was located in Room 1101 in Increment 1 of Building 174. In 1975, the Cyclops laser, located in the middle bay of Building 174, produced the first ICF radiation-driven implosions and fusion neutrons.

In the 1980s, the Janus laser was upgraded. It currently includes two arms that originally belonged to the twenty-armed Shiva laser, an ICF laser built in 1977 that was the most powerful laser in the world at that time. Later, the Janus laser also incorporated some of the components that belonged to Nova, an ICF laser built in 1985 that demonstrated the feasibility of ICF ignition.

Building 174 currently houses several other ICF laser experiments. Room 1106 houses the Comet laser, and Room 1110 houses the JAN-USP, a second-generation short-pulse Janus laser.

Period of Significance

From 1957 to 1964, Building 174 was part of the Nuclear Propulsion Research Complex. In 1957, it served first as a control room and storeroom for the Rover Project and then from 1957 to 1964 as a materials research laboratory for the Pluto Program.

The Rover Project was at LLNL from 1955 to 1957 before being transferred to LANL. During LLNL's brief involvement in Project Rover, only preliminary experimentation occurred and no scientific breakthrough in nuclear propulsion was achieved. Building 174 served as a support structure to the Rover Complex.

Project Pluto, on the other hand, did successfully develop a nuclear ramjet engine capable of flight. In particular, LLNL made important scientific breakthroughs in reactor design with the development of unique ceramic fuel elements—made out of a homogenous mixture of highly enriched uranium dioxide and beryllium oxide.⁴²⁷ However, the important scientific breakthrough in fuel element design did not occur in Building 174. In 1959, LLNL developed a pilot plant for the fabrication of beryllia fuel elements in Building 167, which is no longer in existence. Although the activities that took place in Building 174 between 1957 and 1964 fall within the LLNL Cold War context, theme of Non-Weapons Research, and

⁴²⁶ "Pluto Mothball Operations," Box 477, Folder 4740, LLNL Archives.

⁴²⁷ *Interim Status Report: Fiscal Year 1964*, vii.

subtheme of Nuclear Propulsion Research, they are of no historic interest. Rather than representing significant breakthroughs, they were routine research activities that provided support to Project Rover and Project Pluto.

From the late 1960s, Building 174 housed laser research. LLNL embarked on laser research during the new technology's formative years and pioneered in the field of laser fusion. Several of the LLNL ICF laser experiments of the 1970s are of historic note. In 1974, LLNL developed one of the first ICF lasers—Janus. In 1977, LLNL developed Shiva, a twenty-armed laser that was the most powerful in the world at that time. The Novette laser experiments of 1982 and the Nova experiments of 1985 demonstrated the feasibility of ICF ignition.

Most breakthroughs in LLNL ICF laser research are associated with Buildings 381 and 391, laser facilities built in the mid-1970s and specifically dedicated to ICF research. However, the Janus laser was developed and successfully used in Room 1101 of Building 174. As one of the first successful ICF lasers, Janus is of historic interest within the LLNL Cold War context, theme of Nuclear Research, and subtheme of Physics Research for the period 1972–1974.

The Janus laser was an Nd glass laser composed of laser oscillators and amplifiers. Nd laser systems were a special approach to laser fusion pioneered by LLNL and adopted by many other government and industry fusion researchers. LLNL's unique design employed "a set of neodymium-doped glass slabs" instead of a solid

rod.⁴²⁸ Initially, Janus was "configured for one-sided irradiation of targets in a single-beamline."⁴²⁹ In 1975, the laser was upgraded to "two-beam operation for two-sided irradiation targets."⁴³⁰

The Janus system was the first ICF system to attain a verified 10^7 -neutron fusion yield.⁴³¹ Figure 73 is a photo of the original configuration of Janus in 1974.

9.5.3 Construction History

Building 174 was built in five separate increments.

In 1956, Leland Rosener, Jr., a San Francisco engineering firm, designed Increment 1, as part of the Rover Complex. Increment 1 was a corrugated-metal Butler-type building with a double-pitched roof. It resembled two Butler-type buildings set side by side. There were two roll-up doors on the south elevation and windows on the east elevation.⁴³² The building housed two test stands and was used as a control and storage building for Project Rover.⁴³³

In 1957, the Rover project transferred to LANL. LLNL began work on Project Pluto, a program to develop nuclear reactors to power low-altitude missiles. The Rover

⁴²⁸ Bromberg, *The Laser in America*, 215.

⁴²⁹ University of California Lawrence Livermore Laboratory, *Laser Program: Annual Report, 1975*, UCRL-50021-75 (Livermore: University of California Lawrence Livermore Laboratory, 1975), 64.

⁴³⁰ Ibid.

⁴³¹ Ibid., 6.

⁴³² "Test Stands No. 1&2 154B, No. 3&4 154D, Rover Complex, Plan, Elevations, Sections, and Details," 1957, PLZ57-174-001JA, PEL.

⁴³³ "Estimated People Working in each Rover Facility," Box 476, Folder 4739, LLNL Archives.

Complex was renovated to accommodate the Pluto project. The Chemistry Division used Building 174 to develop materials and propellants of interest to the Pluto program.⁴³⁴

In 1963, LLNL's Plant Engineering Department designed Increment 2 as an addition to the west end of Building 174. Increment 2 housed one large laboratory.⁴³⁵ In 1964, Soulé Steel designed some structural building modifications.⁴³⁶

After Project Pluto ended, Building 174 was remodeled and renovated for the laser research program in the 1970s. Bay Area

architects Garretson, Elmendorf, Klein, and Reibin designed Increments 3, 4, and 5 of Building 174. Increment 3 added five additional laser laboratories to the structure; Increment 4 added another six laser laboratories; and Increment 5 added a clean room facility to the building.⁴³⁷

No significant modifications to the building have occurred since the late 1970s.

Building 174 is an industrial steel building of undistinguished architectural design. It is typical of countless buildings found in



Figure 73. Building 174, original Janus laser, 1974.⁴³⁸

⁴³⁴ Hayden Gordon to Charlie Blue, memo, 1 May 1957, Box 462, Folder 4725, LLNL Archives.

⁴³⁵ "Addition to West End of Building 154D, Plan, Legend, and Notes," 1963, PLA63-174-006DB, PEL.

⁴³⁶ "Soulé Steel Co. Standard Structural Sections Shop Drawing," PLZ1964-0174-001J, PEL.

⁴³⁷ "Building 174 Modifications, Floor Plan," 1972, PLZ72-174-002JA, PEL; and "Building 174 Increment V Solid State Laser Facility, Plan, Roof Plan, Elevations, Building Section, Details, Door and Room Finish Schedule," 1975, PLZ75-174-004JA.

⁴³⁸ Janus laser, 1974, LLNL Archives.

industrial and military settings across the country. Building 174 is an LLNL Cold War Building of the Metal Butler-type. It possesses features characteristic to its kind—prefabricated steel rigid-frame structure, reinforced-concrete slab, corrugated-metal siding and roofing, and space for short-term experiments or shops

9.5.4 Integrity

The Janus laser—one of the first ICF lasers—is an object of historic interest for the period 1972–1974. Janus possesses integrity for the period of its historic interest. The Janus laser is still in use in Room 1101 of Building 174. Although it has been upgraded and modified since 1974, it is still used for ICF research and maintains integrity in the continuity of its research since the period of

its historic significance. Figure 74 depicts the current configuration of the Janus laser.

Room 1103 is the control room for the Janus laser, and also looks much as it did during the 1972–1974 period of significance. Figure 75 depicts the control room for Janus as it looks today.

9.5.5 Recommendation

Buildings, structures, and objects under fifty years of age are generally not considered eligible for the National Register. The Janus laser will not be fifty years of age until 2022.

However, under Criteria Consideration G, properties under fifty years of age can be considered eligible to the National Register if it can be demonstrated that they are of exceptional significance.

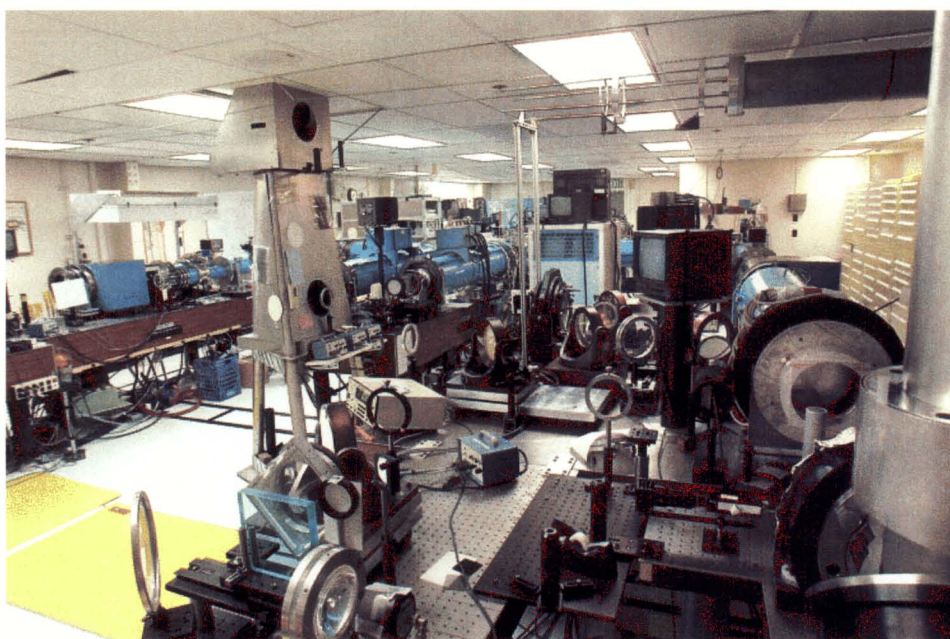


Figure 74. Building 174, Janus laser, 2003.⁴³⁹

⁴³⁹ Building 174, Janus laser, LLNL photographer Marcia Johnson, 2003.

The development of the Janus laser meets the threshold for historic significance within the established LLNL Cold War preservation theme of Nuclear Research, and subtheme of Physics Research. Janus played a pivotal role in demonstrating the feasibility of obtaining fusion via laser technology and was key in the development of Nd laser systems. The early breakthroughs on Janus directly advanced both weapons and energy research at LLNL, making it of exceptional significance.

The Janus laser does not qualify for National Register consideration under Criterion B, association with a historic figure; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this laser. The Janus laser does not provide the historical record with

information that cannot be found elsewhere. The laser research activities that occurred there are documented in research reports and archival collections.

However, the Janus laser does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War, and specifically LLNL's development of the ICF lasers for both nuclear weapons and energy applications. The particular period of historic significance for these activities within this structure is 1972–1974.

The Janus laser also qualifies for National Register consideration under Criterion C, exceptional design or architectural significance. The design of the Janus laser was



Figure 75. Building 174, Room 1103, Janus control room, 2003.⁴⁴⁰

⁴⁴⁰ Building 174, control room, LLNL photographer Marcia Johnson, 2003.

a unique combination of oscillators and amplifiers with Nd glass slab drivers. The particular period of historic significance for the laser within Criterion C is 1972–1974.

The Janus laser also possesses integrity for the period of its historic significance. Although, the Janus has been upgraded several times since the 1970s, it still retains enough of its original components and configuration to maintain integrity. Contributing elements to historic significance include the amplifiers, oscillators, and beamlines

that make up the laser as fully assembled on the tables in Room 1101, and the entire control panel as standing in Room 1103. These are the key components of the Janus laser. It is an object of historic interest.

The final recommendation is that the Janus laser system in Building 174 (Rooms 1101 and 1103) is eligible for National Register consideration as an object of historic interest under Criterion A and Criterion C.

9.6 Building 194

9.6.1 Description

Building 194 is located at the LLNL main site, at the corner of Eighth Street and Avenue B. It is the 100-MeV Electron-Positron Linear Accelerator Facility. The facility currently houses two electron accelerators and a high-power short-pulse laser. Building 194 was originally built in 1958 as the High Flux Research Building. It has always housed some form of accelerator research. Figure 76 is a recent photograph of the front entrance to Building 194.

Building 194 is a complex of three structures: the south building, the central building, and the north building. A shared south wall connects the south and central buildings, and a breezeway connects the central and the north buildings. An underground basement area beneath the north building houses the accelerators. A concrete, circular silo-shaped neutron cell is located slightly

to the northwest of the north building. Accelerator beam tubes connect the neutron cell to targets in the east, west, and south ends of the site. The entire complex is 42,031 gross square feet and contains twenty-one laboratories, nine mechanical equipment rooms, twenty offices, and four shops.

9.6.2 Mission History

Building 194 was built in 1958 to house the 16-MeV electron linear accelerator. ARCO designed the 16-MeV linac. The Physics Department at LLNL operated the linac in Building 194 for experimental purposes and to support the weapons program. The linac was used for photonuclear, time-of-flight, and radiation damage studies. In 1960, the 16-MeV linac was modified so that it could operate at 25 MeV. From 1960 to 1967, LLNL scientists used the Building 194 linac to conduct pioneering research in the use of “monoenergetic photons to study the basic dynamics of the electromagnetic force.”⁴⁴¹

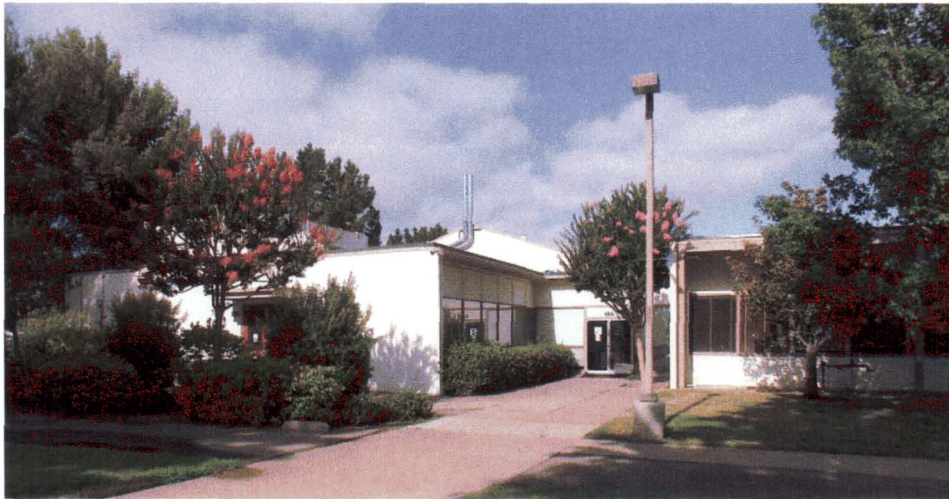


Figure 76. Looking west at Building 194, east elevation, 2003.⁴⁴²

⁴⁴¹ “‘Electron-Positron’ Linac to be Built at Livermore Lab,” *The Magnet* (July 1967), 4.

⁴⁴² Building 194, front entrance, LLNL photographer Marcia Johnson, 2003.

In 1967, Building 194 was expanded. The 100-MeV Electron-Positron Linear Accelerator Facility was added to house a more powerful linear accelerator. The 100-MeV linac was also designed by ARCO. The new facility had “capabilities for studies of electromagnetic interactions, neutron physics, and applied reactor technology.”⁴⁴³ From 1969, when it was completed, to the present, the 100-MeV linac has been used for a variety of physics experiments for both the weapons program and fundamental nuclear physics research. In addition to photonuclear, time-of-flight, and radiation damage studies, the new accelerator was used for experiments in nuclear shape parameters, positron and electron scattering, fission measurements, and gamma ray absorption.

Currently, programs at the facility include experiments in fundamental nuclear, atomic, solid-state, plasma, and particle physics. Other projects involve laser-electron interactions and applied research in materials science. The 100-MeV linac has been modified to produce a broad range of energies from 10 MeV to 165 MeV. The building also houses several new pieces of equipment—an intense, short-pulse laser facility and the pelletron, a type of Van de Graaff accelerator that accelerates positrons or electrons to 3 MeV. The facility also houses the Electron Beam Ion Trap (EBIT), a program moved from Building 212 in 2000, which traps atomic species and measures them using an electron beam.

Period of Significance

The majority of accelerator research in the United States over the last fifty years has focused on high-energy physics—the

study of matter and its properties. The primary centers of high-energy physics accelerator research are Brookhaven National Laboratory, Stanford Linear Accelerator Facility, and Fermi National Accelerator Laboratory. Brookhaven National Laboratory built the first particle accelerator in 1952. In 1966, Stanford University built the next-generation particle accelerator—the Stanford Linear Accelerator. In 1972, Fermi National Accelerator Laboratory built the largest particle accelerator in the world at the time.⁴⁴⁴

Most technological breakthroughs in accelerator development and scientific breakthroughs in high-energy physics have occurred at one of the above facilities. LLNL’s accelerator research has largely been related to nuclear weapons applications. Nevertheless, LLNL has made several notable breakthroughs in accelerator research with special application to nuclear weapons design and development.

From 1960 to 1969, LLNL scientists pioneered the use of the positron beam to create photonuclear processes, culminating in the development of the 100-MeV electron-positron linear accelerator, the only facility in the United States at the time to have the capabilities to work with annihilation photons. Annihilation photons occurred when positrons collided with bound electrons during an accelerator experiment. They were used to make photo-neutron cross-section measurements.⁴⁴⁵

From 1960 to 1967, LLNL scientists used the 25-MeV linear accelerator, housed in Increment 1 of Building 194, to develop the

⁴⁴³ Ibid., 1.

⁴⁴⁴ U.S. Department of Energy, *The Ultimate Structure of Matter*, 1.

⁴⁴⁵ “‘Electron-Positron’ Linac To Be Built At Livermore Lab,” 1, 6.

process of using electrons and positrons to create monoenergetic photons to study electromagnetic processes. From 1967 to 1969, they developed the 100-MeV linear accelerator in Room 1201C of Building 194, the only electron-positron linac in the world at the time. Therefore, for its contributions to accelerator research and neutron physics for the period 1960–1969, Building 194 is of exceptional historic interest within the LLNL Cold War context preservation theme of Nuclear Research, subtheme Physics Research.

From 1969 to 1984, Building 194 is also of historic interest within the LLNL Cold War preservation theme of Nuclear Weapons Design for its time-of-flight studies and neutron reaction cross-section measurements—both notable contributions to LLNL’s nuclear weapons development. All neutron cross-section measurements for

the LLNL-developed nuclear weapons that entered the stockpile after 1969 were taken on the 100-MeV linac in Building 194. Therefore, Building 194 is of exceptional historic interest for its contributions to nuclear weapons design for the period 1969–1984.

9.6.3 Construction History

Building 194 was built in three separate increments.

In 1957, Leland S. Rosener, Jr., a San Francisco engineering firm, designed Increment 1 of Building 194. Increment 1 was the High Flux Building and housed the 16-MeV electron linear accelerator. Increment 1 was a steel-framed, high-bay, corrugated-metal building with a pitched metal roof. The roof had corrugated-plastic skylights. There were rolling metal doors on the west side.⁴⁴⁶ Figure 77 is a current photo of Increment 1.



Figure 77. Looking north at Increment 1, Building 194, south elevation, 2003.⁴⁴⁷

⁴⁴⁶ “High Flux Building 194, Sections and Elevations and Details,” 1957, PLZ-57-194-002JA, PEL; and “High Flux Building 194 Steel Framing, Elevations, Sections, and Details,” 1957, PLZ-57-194-004.

⁴⁴⁷ Building 194, Increment 1, LLNL photographer Marcia Johnson, 2003.

In 1959, Corlett and Spackman, a San Francisco architectural firm, designed Increment 2 of Building 194. Increment 2 was a steel-framed concrete block addition of approximately 3,000 gross square feet. It contained a control and counting room, set-up room, dark room, mechanical equipment room, and three offices.⁴⁴⁸ The new increment was “connected to the existing building by an enclosed passageway.”⁴⁴⁹ The distance between the two increments shielded occupants of the control room from the accelerator. Figure 78 is a current photo of Increment 2.

In 1967, Allied Engineering Corporation, in cooperation with LLNL Plant Engineering, began building Increment 3 of Building 194 to house the new 100-MeV Electron-Positron Linear Accelerator Facility. Increment 3 consisted of two above ground

buildings and an underground accelerator facility. The main above ground facility (central building) was an office laboratory building of approximately 9,700 gross square feet connected to Increments 1 and 2 by a shared south wall. The other above ground structure (north building) was the radio frequency power building of approximately 6,300 gross square feet, which was connected to the office/laboratory structure by a breezeway. The above ground structures also included a neutron cell, targets, and beam lines. The beam of the accelerator could be brought above ground to a target located in the neutron cell and then directed into drift tubes that radiated from the cell in varying lengths up to 800 feet long.⁴⁵⁰ Figures 79 and 80 depict the central and north buildings of the Electron-Positron Linear Accelerator Facility. Figure 81 illustrates the neutron cell and drift tube.



Figure 78. Looking northwest at Increment 2, Building 194, south and east elevations, 2003.⁴⁵¹

⁴⁴⁸ “High Flux Building 194 Increment 2, Floor Plan, Exterior Elevations, Finish Schedule, and Door Schedule,” 1959, PLZ-59-194-002JA, PEL.

⁴⁴⁹ “Building 194, Increment 2—High Flux Building,” 7.

⁴⁵⁰ “‘Electron-Positron’ Linac to be Built at Livermore Lab,” 4.

⁴⁵¹ Building 194, Increment 2, LLNL photographer Marcia Johnson, 2003.

The underground accelerator facility was approximately 13,500 gross square feet and consisted of five sections, each eight feet long and powered by a klystron located above it at ground level. Also housed underground were several neutron drift tubes

and five experimental cells or caves.⁴⁵² The caves included a magnet cave, detector cave, high-flux cave, and two low-background caves. Figure 82 depicts the underground cave complex.



Figure 79. Looking west at Building 194, central wing, east elevation, 2003.⁴⁵³

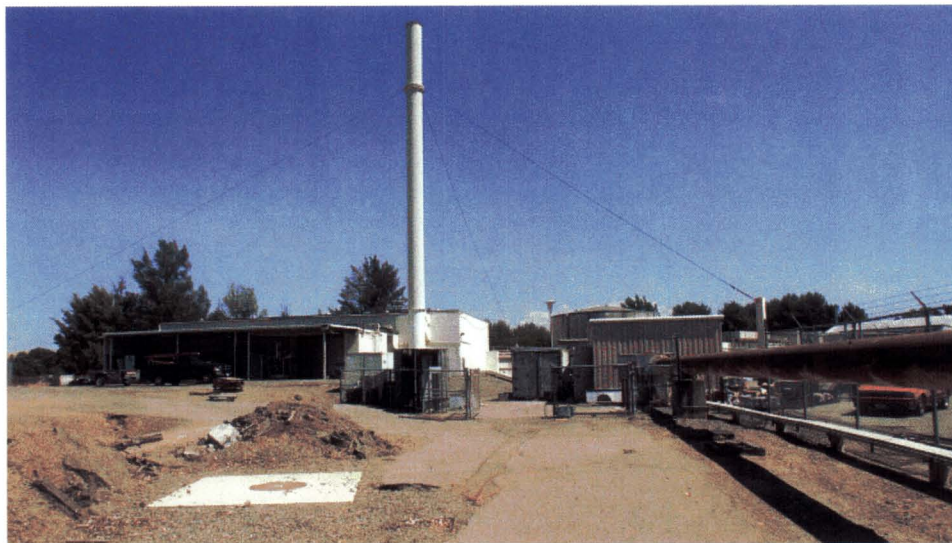


Figure 80. Looking south at Building 194, north wing, north elevation, 2003.⁴⁵⁴

⁴⁵² "‘Electron-Positron’ Linac to be Built at Livermore Lab," 4.

⁴⁵³ Building 194, central building, LLNL photographer Marcia Johnson, 2003.

⁴⁵⁴ Building 194, north building, LLNL photographer Marcia Johnson, 2003.

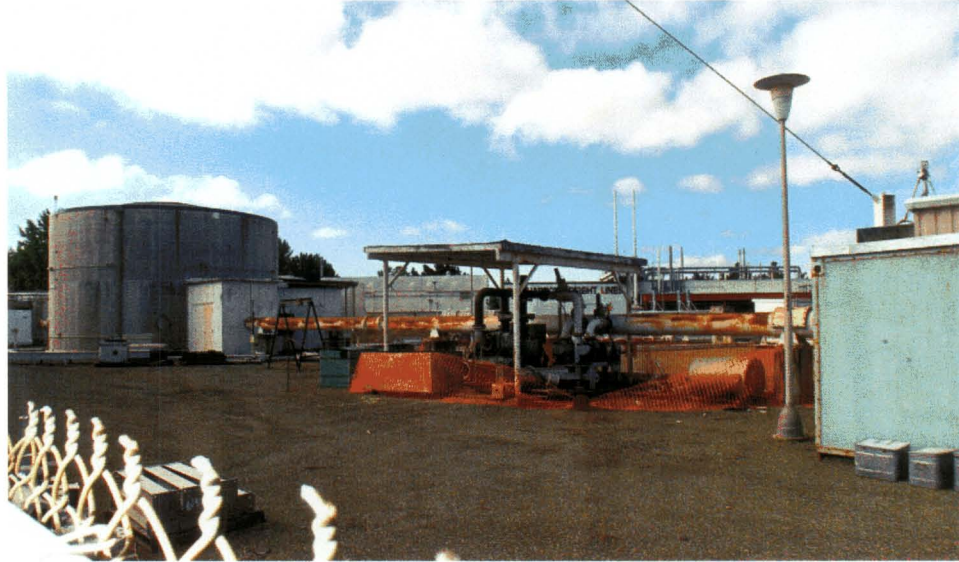


Figure 81. Building 194, neutron cell and drift tube, 2003.⁴⁵⁵

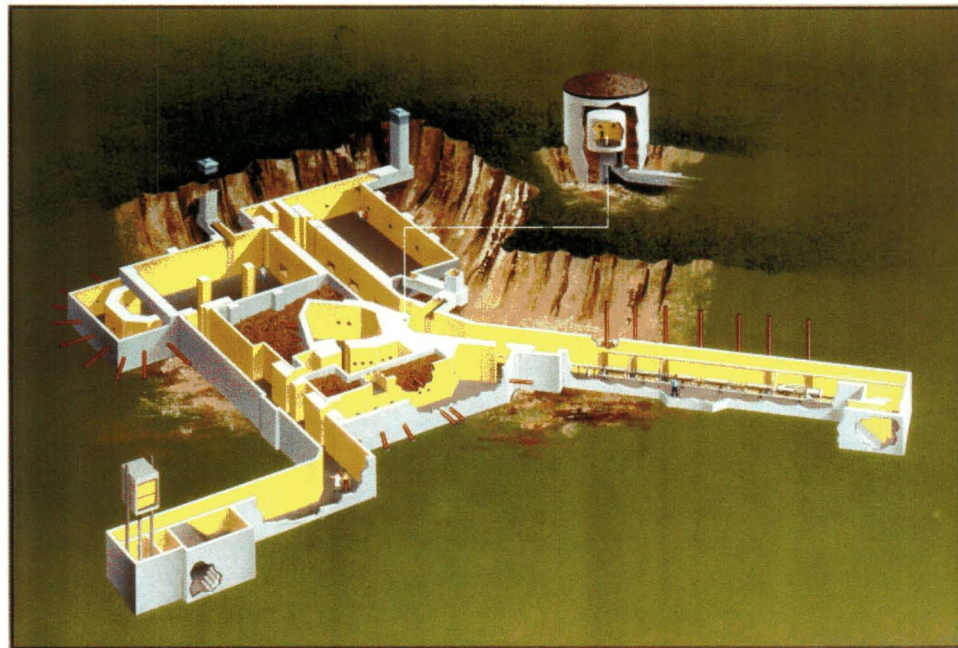


Figure 82. Artist's drawing of Building 194, basement cave complex, 1967.⁴⁵⁶

⁴⁵⁵ Building 194, neutron cell and drift tube, LLNL photographer Marcia Johnson, 2003.

⁴⁵⁶ Building 194, artist's drawing, 1967, LLNL Archives.

Increments 1 and 2 of Building 194 are metal and concrete industrial structures common to research and military facilities across the United States. They possess no feature of high-style architecture. Increment 1 and 2 are LLNL Cold War building types of the Heavy Laboratory and Metal Butler-type variety. They possess features common to these types—single-story with high bay; radioactive shielding; prefabricated steel rigid-frame structure; reinforced-concrete slab; corrugated-metal siding and roofing; and space for large equipment or fabrication.

Similarly, the two above ground buildings of Increment 3 are also of little architectural interest. They are concrete office and research facilities common in many industrial and military settings across the country. They are LLNL Cold War buildings of the Permanent Office Building and Service/Support Structure type. They possess the characteristic features of these types—single-story; masonry walls; steel-framed; prefabricated wall panels; space for offices or equipment; built-up roofing; and windows.

However, the underground accelerator facility of Increment 3 is of architectural interest. It possesses design features unique to the specific purpose of the building. It is in essence a footprint of the accelerator and separate in function and design from the other buildings and structures associated with Building 194.

9.6.4 Integrity

Building 194 is of exceptional historic interest within the LLNL Cold War context preservation theme of Nuclear Research, subtheme Nuclear Physics Research, for its

contributions to neutron physics and accelerator research and development for the period 1960–1969. It also is of exceptional historic interest within the LLNL Cold War context preservation theme of Nuclear Weapons Design for its neutron cross-section research in support of weapons development for the period 1969–1984.

Building 194 no longer possesses historic integrity for the 1960–1967 period for the pioneering research in monoenergetic photons done on the 25-MeV linear accelerator located in Increment 1. This accelerator was dismantled and replaced by the new 100-MeV linac in the basement accelerator cave in Increment 3. Increment 1 now houses the EBIT program. Increment 1 of Building 194 no longer resembles the high-bay accelerator facility that housed the 25 MeV during the period it was historically significant.

However, Building 194 does possess historic integrity for its contributions to accelerator development within the LLNL Cold War preservation theme of Nuclear Physics Research for the period 1967–1969. It also possesses historic integrity for its contributions to the weapons program within the LLNL Cold War preservation theme of Nuclear Weapons Design for the 1969–1984 period.

The 100-MeV Electron-Positron Accelerator is still in operation in Building 194. The 100-MeV linac has had new magnets installed and has been retrofitted to reach the lower energy ranges. It has also had all the vacuum tubes replaced with solid-state tubes. Despite these modifications, it still looks much as it did during the time of its historic use and maintains a continuity of purpose. Figures 83 and 84 depict the 100-MeV Electron-Positron Accelerator.

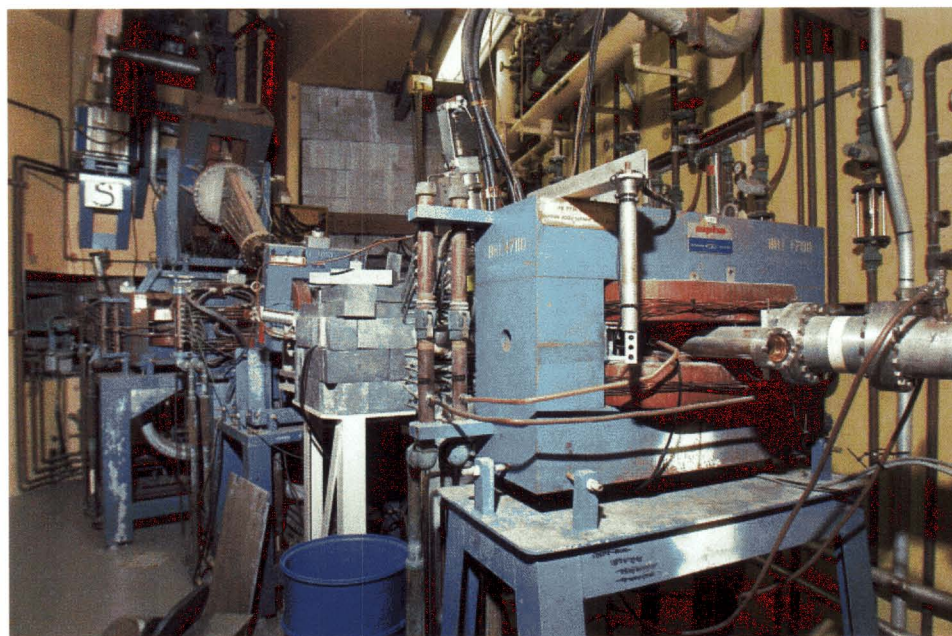


Figure 83. 100-MeV Electron-Positron Accelerator, retrofitted magnets, 2003.⁴⁵⁷



Figure 84. 100-MeV Electron-Positron, beamline, 2003.⁴⁵⁸

⁴⁵⁷ Building 194, 100-MeV Electron-Positron accelerator magnets, LLNL photographer Marcia Johnson, 2003.

⁴⁵⁸ Building 194, 100-MeV Electron-Positron accelerator beam line, LLNL photographer Marcia Johnson, 2003.

Room 117A, the control room for the accelerator, located in the central building, also retains integrity from the period of its historic significance. Despite recent upgrades to its digital processes, the control room still looks much as it did thirty years ago. Figure 85 depicts the Electron-Positron accelerator control room.

The experimental caves have different set-ups than they did during the period of historic significance. Room 134, one of the original low-background caves, now referred to as the north cave, houses the pelletron. Room 124, originally another low-background cave, now referred to as the south cave, houses the Positron Microprobe. Room 122, originally the high flux cave, now houses Plasma Physics. All of the caves house new programs and new equipment. However, they still retain historic integrity in their architectural design. The actual architecture and construction of the basement caves has undergone

no modification. The rooms themselves reflect the historic purpose that they were constructed for—separate rooms that the beamline of the accelerator could be directed into for various experiments.

9.6.5 Recommendation

Buildings and structures under fifty years of age are generally not considered eligible for the National Register. Building 194 will not be fifty years of age until 2010.

However, under Criteria Consideration G, properties under fifty years of age can be considered eligible to the National Register if it can be demonstrated that they are of exceptional significance.

The Cold War has been recognized as a period of exceptional significance within U.S. and world history. Additionally, Building 194 is of exceptional significance for its contributions to accelerator research and LLNL weapons design work within



Figure 85. Building 194, Room 117A, Electron-Positron accelerator control room, 2003.⁴⁵⁹

⁴⁵⁹ Building 194, Room 117A, control room, LLNL photographer Marcia Johnson, 2003.

the context of the Cold War arms race. Therefore, it meets the threshold for exceptional historic significance within the established LLNL Cold War preservation theme of Nuclear Weapons Design; and also the preservation theme Nuclear Research, and subtheme of Physics Research.

Building 194 does not qualify for National Register consideration under Criterion B, association with a historic figure; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. Building 194 is not a source of historical information. The neutron physics research and reactor studies that occurred there are documented in research reports and archival collections.

However, Building 194 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the development of the use of annihilation photons for research and the design of the 100-MeV Electron-Positron Accelerator. These activities represent a significant contribution to accelerator research and development and to the history of neutron physics. The particular period of historic significance for these activities within this structure is 1960–1969. Building 194 does not possess historic integrity for the early research done on the 25-MeV accelerator from 1960 to 1967. However, it does still possess historic integrity for the 1967–1969 period.

The other pattern of events of historic interest associated with Building 194 are the neutron cross-measurement studies done for the LLNL nuclear weapons program

from 1969 to 1984. These experiments are of historic interest because they can be directly linked to specific nuclear weapons designs during this time period. Building 194 also possesses historic integrity for this period.

Building 194 also qualifies for National Register consideration under Criterion C, exceptional design or architectural significance. Both the design of the 100-MeV Electron-Positron Accelerator and the underground cave complex are of exceptional interest.

The 100-MeV linac was designed and built by ARCO. During the Cold War, accelerator design was a specialized field with only a handful of companies with the technical expertise necessary to make this type of research equipment. ARCO was a leader in its field and designed more linacs than any other commercial concern. ARCO developed linacs for both scientific and industrial applications. ARCO's customer list included: New York University Medical Center, New York City, New York; Phillips Petroleum Company, Bartlesville, Oklahoma; U.S. Naval Weapons Station, Yorktown, Virginia; Argonne National Laboratory, Lemont, Illinois; Yale University, New Haven, Connecticut; National Aeronautics and Space Administration (NASA) Space Radiation Effects Laboratory, Langley Field, Hampton, Virginia; and California Institute of Technology, Pasadena, California.

A small group of engineers and physicists from the University of California Lawrence Radiation Laboratory founded ARCO in 1953. They specialized in the development of the "microwave electron linear accelerator

as a powerful high energy source of pulsed electron energy for science and industry.”⁴⁶⁰ Their early commercial linac designs followed closely those designs developed at Stanford. LLNL physicist and ARCO founder, Richard Post, trained with William Hansen at Stanford.⁴⁶¹ In 1959, ARCO developed a prototype accelerator that operated in the L-band frequency rather than the more standard S-band. These machines set records for energy, power, and precision.⁴⁶²

The 100-MeV Electron-Positron Accelerator qualifies for National Register consideration under Criterion C as an exceptional example of the engineering designs of ARCO. ARCO is of historic interest as one of the important engineering firms designing accelerators during the Cold War. The period of historic significance for the Electron-Positron Linac in Building 194 under Criterion C is 1967–1969.

The underground accelerator cave complex is also an exceptional design. The underground cave complex was built specifically to accommodate the accelerator research it housed and its structure directly reflects the work. It is essentially an imprint of the Electron-Positron Accelerator. Originally, beam lines ran into each of the five cave rooms so that multiple experiments could take place at once. Beam lines also ran above

ground to the neutron cell and out into several targets on the site. The cave complex reflects the work in Increment 3 of Building 194 in a way that the high bay of Increment 1 does not. Increment 1 could house any number of standard industrial activities. However, the design and construction of the concrete cave complex reflected the work that occurred there. The period of historic interest for the design of the underground cave complex is 1967–1969.

The recommendation is that Building 194 and the 100 MeV Electron-Positron Accelerator are eligible for National Register consideration under Criterion A, association with a historic pattern of events. The period of significance is 1967–1984.

Building 194 and the 100 MeV Electron-Positron Accelerator are also eligible for National Register consideration under Criterion C, exceptional design significance. The period of historic significance for design is 1967–1969.

Contributing elements to historic significance under Criteria A and C are Room 117A (the 100-MeV linac control room) in the central building, the underground cave complex, the 100-MeV Electron-Positron Linear Accelerator, the neutron cell, and the above ground beam lines and targets.

⁴⁶⁰ “Applied Radiation Corporation,” brochure, 1965, Donald Cooksey Files, 1967, LBNL Archives.

⁴⁶¹ Morris Jeppson to Donald Cooksey, 31 March 1954, Administrative Files Donald Cooksey, Atomic Energy Commission Press Releases, LBNL Archives.

⁴⁶² “Applied Radiation Corporation,” brochure, 1965.

9.7 Buildings 230 and 231

9.7.1 Description

Buildings 230 and 231 are located on the LLNL main site at the corner of Fourth Street and Avenue D. Building 230 is currently used as a storage structure and Building 231 houses Development and Assembly Engineering. Buildings 230 and 231 were originally built in 1954 as Building 102, Fabrication and Assembly. In 1967, during a Laboratory-wide renumbering, Building 102 was redesignated Building 230 and Building 231.⁴⁶³ Building 230 was a small, one-room guard station or security entrance for Building 231 when it was an exclusion area. The area was originally fenced and access was monitored by guards. Building 231 was used as a heavy laboratory to fabricate and assemble nuclear weapons components. It currently houses a variety of engineering development laboratories, including a plastics

laboratory, electronics laboratory, materials testing laboratory, and hazards control laboratory. Figures 86 and 87 are recent photographs of Buildings 230 and 231.

Building 230 is a wood-framed, single-story guard structure originally built to control access to Building 231. It has wood siding and a sloped roof. It resembles two small sheds joined together. It currently has three small storage rooms.

Building 231 is a steel-framed concrete structure with a slightly pitched roof. It was built in ten separate increments over a twenty-eight-year period. It has clerestory windows on both levels on all four sides of the structure. It houses sixteen industrial shops, ninety-three laboratories, thirty utility rooms, ninety-eight offices, and three service shops.



Figure 86. Looking north at Building 230, south elevation, 2003.⁴⁶⁴

⁴⁶³ For the sake of clarity, this report will refer to Buildings 230 and 231 by their current designations.

⁴⁶⁴ Building 230, exterior, LLNL photographer, 2003.



Figure 87. Looking northeast at Building 231, west and south elevations, 2003.⁴⁶⁵

9.7.2 Mission History

Building 231 was one of the first permanent structures built at LLNL. From 1954 to 1992 its primary mission was the fabrication and assembly of components and materials for the nuclear weapons program. The original building had a machine shop, uranium shop, chemistry laboratories, and a main high bay with a crane to handle and assemble large experimental devices and diagnostic equipment.⁴⁶⁶ Additional laboratories and capabilities were added over the years. In 1954, Building 231 added a vault for the storage of plutonium and other special nuclear materials. In 1956, Building 231 began to machine beryllium, conduct physical testing on components, perform materials testing, and X-ray materials and parts. In 1962, Building 231 began to develop and manufacture its own plastic components.

In addition to its primary mission, Building 231 also housed a variety of technical specialties, including mechanical engineering,

electrical engineering, and device design. In 1967, the Purchasing Department moved upstairs into the second-floor offices.

As the Cold War came to an end, Building 231 housed more and more engineering and technical groups and ceased its work on weapon components. Currently, it is primarily a support building, housing members of the Engineering Department as well as materials testing, plastics, hazards control, and electronics staff.

Period of Significance

From 1953 to 1992, Building 230 acted as a security support structure for Building 231. As such, it is of no independent historic interest separate from Building 231.

From 1953 to 1992, Building 231 performed the fabrication, handling, and assembly of nuclear components and materials for the LLNL weapons program. Fabrication, materials testing, and the assembly of nuclear test devices and components formed a crucial phase of weapons design. LLNL was one of two nuclear weapons laboratory during the Cold War that designed and developed nuclear weapons for the U.S. stockpile.

⁴⁶⁵ Building 231, exterior, LLNL photographer, 2003.

⁴⁶⁶ William Self Associates, *Documentation and Assessment of the History of the Lawrence Livermore National Laboratory Livermore Facility*, 32–33.

Therefore, Building 231 is of historic interest within the Cold War context of the arms race and the established LLNL preservation themes of Nuclear Weapons Design (subtheme Weapons Design), and Nuclear Weapons Testing (subtheme Nuclear Testing). The period of significance for these activities is 1953–1992.

9.7.3 Construction History

Building 230 was built in 1954. It is a wood-framed, single-story structure with wood siding and a sloped roof. It resembles two small sheds joined together. The interior has three rooms. It functioned as a security checkpoint for employees and visitors to the Fabrication and Assembly Facility. There have been few modifications to Building 230. It is currently used for storage.

Building 231 was built in ten separate increments from 1954 to 1981.

Albert F. Roller, architect, and H. J. Brunnier, engineer, both of San Francisco, designed Increments 1 and 2 in 1953. Increments 1 and 2 consisted of a large high-bay assembly area flanked by several wings. The wing to the east was a one-story laboratory and conference area. The northwest wing was a two-story machine shop. The southwest wing was a two-story office wing. The southeast wing was a two-story chemistry wing.⁴⁶⁷ The building was a steel-framed, concrete high-bay structure with clerestory windows in steel sashes. The roof of the assembly area was slightly pitched and the wings had flat composite roofing.⁴⁶⁸

⁴⁶⁷ "Plan for Future Floor Framing (Wings) and Bottom Chord of Laboratory Area," 1953, PLZ53–231–006JO, PEL.

⁴⁶⁸ "Fabrication and Assembly Building 102, Clerestory and Roof Plan, Exterior Elevations, Sections, and Details," 1953, PLZ–231–002J, PEL.

In 1954, Albert Roller and H. J. Brunnier designed Increment 3, a two-story office wing to the northeast of the building. It was also a steel-framed concrete structure with a low-pitched roof and clerestory windows in steel sash frames.⁴⁶⁹

In 1956, Increment 4, also designed by Albert Roller, was built. It was a one-story concrete addition that housed a vault for storing nuclear material. It had a flat roof, no windows, and personnel doors on the north elevation. It housed storage racks for nuclear material, a shop, office, shipping area, sample room, chemistry laboratory, mint, balance room, and bottle room.⁴⁷⁰

Increments 5 and 6, designed by Albert Roller, and built in 1956, were large additions to the north of the main assembly area, which more than doubled the structure's size. The new space consisted of a second high-bay assembly area flanked by two areas to the east and west for additional laboratories. The east side of the new high-bay area housed environmental test laboratories. The west side of the new high-bay area housed a development laboratory, radiography laboratory, physical test laboratories, metallurgy laboratory, inspection shop, and beryllium machine shop.⁴⁷¹ In 1959, Increment 6 also housed the plastic shop and the simulator for the Tory II.⁴⁷²

⁴⁶⁹ "Northeast Wing Building 102, Elevations, Sections, and Details, Door and Window Schedules," 1954, PLZ54–231–002JA, PEL.

⁴⁷⁰ "Increment No. 4 Building 102, Plans, Sections, and Elevations," 1954, PLZ54–231–011JA, PEL.

⁴⁷¹ William Self Associates, *Documentation and Assessment of the History of the Lawrence Livermore National Laboratory Livermore Facility*, 33.

⁴⁷² "Tory II Simulator Control Room, Building 102 Increment 6, 1959, PLA59–231–174DO, PEL.

In 1962, Increment 7, an addition for metallurgy, materials, and plastics storage, was added to the west side of the building.⁴⁷³

In 1967, the second floor was renovated into offices for the Purchasing Department. In 1968, Increment 8, a boiler plant, was added to the south of Increment 7.⁴⁷⁴ In 1969, Increment 9, a technician shop, was added to the north of Increment 8.⁴⁷⁵

Finally, in 1981, Increment 10, a Filament Winding Facility, was added to the end of the southwest office wing.⁴⁷⁶

Other modifications have changed the interior of the structure to accommodate various offices, laboratories, and shops. The exterior of the building has also been upgraded with a coat of decorative stucco.

Building 230 is a wood-framed structure of undistinguished architectural style. It is a functional structure devoid of ornamentation built to house a security function. It falls within the LLNL Cold War building type referred to as a Security structure.

Building 231 is a concrete industrial building common in a variety of industrial, government, and business settings across the country. It is of undistinguished architectural design.

⁴⁷³ William Self Associates, *Documentation and Assessment of the History of the Lawrence Livermore National Laboratory Livermore Facility*, 33.

⁴⁷⁴ "Building 102, Increment 8, Architectural Floor Plan, 1965, PLA65-231-265DA, PEL.

⁴⁷⁵ William Self Associates, *Documentation and Assessment of the History of the Lawrence Livermore National Laboratory Livermore Facility*, 33.

⁴⁷⁶ Ibid.

Building 231 is an LLNL Cold War building type referred to as Heavy Laboratory. It possesses the requisite features of its type—single-story with high bay or partial mezzanine, heavy-steel repetitive-bay structural framing, five to twenty ton crane, reinforced concrete slab, poured gypsum or metal deck under built-up roofing, reinforced-concrete, metal, or corrugated asbestos-cement walls, and space for large equipment or fabrication.

9.7.4 Integrity

Building 231 fabricated, handled, and assembled weapon components and materials for the LLNL nuclear weapons program. The period of historic interest for these activities is 1953–1992. However, Building 231 no longer possesses integrity for the period of its historic significance. Due to the equipment-dependent nature of these historic activities, the building's integrity depends on the existence of equipment used in materials testing, fabrication, and assembly of nuclear weapons components and devices. Building 231 currently contains only a very few pieces of equipment that were used to perform these activities. The few remaining presses do not clearly reflect the assembly and fabrication work that occurred in the structure. The interior of Building 231 also has been modified continually over the years. Most notably, since 1992, the high-bay assembly areas have been divided into smaller laboratories. Building 231 no longer looks as it did during the period of its historic significance.

Building 230 was the security checkpoint for Building 231. As such it was a support structure and of no historic interest separate from Building 231. Building 230 would

be assessed as a potential contributor to a historic district if Building 231 were of historic interest and maintained its integrity for the period of its historic significance. However, because Building 231 no longer possesses integrity for the period of its historic interest, Building 230 is of no historic interest. Although it maintains integrity as a guard shack for the period of Building 231's historic significance, the historically important work did not occur there and it does not sufficiently represent the work of significance that occurred in Building 231 to be of interest.

9.7.5 Recommendation

Building 231 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. The design of the building is of no architectural interest. The building does not reflect the activities of historic interest that occurred there. Building 231 is not, nor will it be, a source of important

historical information. The fabrication and assembly activities that occurred there are documented in research reports and archival collections.

Building 231 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War design of nuclear weapons for the U.S. stockpile. Building 231 fabricated, handled, and assembled nuclear components and devices for the LLNL nuclear weapons program. The particular period of historic significance for these activities within this structure is 1953–1992.

However, Building 231 does not possess integrity for the period of historic significance. Therefore, Building 231 is not eligible for the National Register despite its historic significance under Criterion A.

9.8 Building 241

9.8.1 Description

Building 241 is located on the LLNL main site, south of Fourth Street and east of Avenue B. It is currently the Materials Science Building. It was originally built in 1960 as Building 173B, the Fuel Element Research Laboratory, for Project Pluto. In 1967, during a Laboratory-wide renumbering of facilities, Building 173B was redesignated Building 241.⁴⁷⁷ The goal of the Pluto project was to develop a nuclear ramjet to power guided missiles. The building has also housed a variety of materials research over the years, including lithium hydride and deuteride for the weapons program, ceramics materials for a high space reactor, hot press armor for helicopters used in Vietnam, and synthetic rocks developed for disposing of radioactive waste. Figure 88 is a recent photograph of Building 241.

Building 241 is a single-story, fireproof building with mezzanines and a high bay. It

has a concrete foundation and concrete walls with metal siding on the upper half of the north elevation. The high bay has a ten-ton crane and concrete pits in the floor to accommodate heavy presses. Building 241 is 53,627 gross square feet. It houses forty-one laboratories, nine mechanical equipment rooms, four shops, and thirty-one offices.

9.8.2 Mission History

In 1957, LLNL's work on Project Rover was transferred to LANL. LLNL shifted its focus to Project Pluto, a program to design a low-flying nuclear reactor—a ramjet engine—to power a supersonic cruise missile. Project Pluto took over existing Project Rover facilities.

Building 241 was built in 1960, expanding the Project Pluto complex. The Materials Science group of the Chemistry Division inhabited the new Pluto building. Its main mission was to develop ceramic fuel elements for the Pluto reactor with



Figure 88. Looking east at Building 241, west elevation, 2003.⁴⁷⁸

⁴⁷⁷ For the sake of clarity, this report will refer to Building 241 by its current designation.

⁴⁷⁸ Building 241, exterior, LLNL photographer Marcia Johnson, 2003.

efficient neutron properties and the ability to withstand extreme temperature and moisture. The work involved research with pure inorganic materials, such as beryllium oxide. This type of material research required special equipment and facilities.

Building 241 included such features as an X-ray diffractometer to determine the nature of materials, a petrographic laboratory to study the microscopic structure of materials, a mechanical properties laboratory for testing material strength and deformation under stress, a chemical laboratory, a fuel preparation room, a high temperature research laboratory, and offices. A high bay area with a traveling crane provided space for developing prototypes.⁴⁷⁹

LLNL material scientists successfully pioneered the development of unique ceramic fuel elements made out of a homogenous mixture of highly enriched uranium dioxide and beryllium oxide. In 1961 and again in 1964, LLNL tested two prototype ramjet engines, both equipped with beryllia fuel elements, the Tory II-A and the Tory II-C.⁴⁸⁰

In 1964, shortly after the successful testing of the full-scale Tory II-C, the AEC cancelled Project Pluto because no firm military commitment materialized to pursue this technology.⁴⁸¹

In 1966, Materials Science researchers in Building 241 began work on the Space Reactor project. The Space Reactor

program's goal was to develop a one- to ten-megawatt reactor for cosmological probes, manned planetary landings, and manned space stations.⁴⁸² Studies involved the development of unique metals that could withstand extremes in temperature yet still demonstrate chemical compatibility. LLNL space power scientists experimented with tungsten, uranium nitride fuel, and alkali-metal heat transport fluids.⁴⁸³

In 1967, Materials Science converted the electrical equipment room (Room 1627) and the silicon carbide research laboratory (Room 1629) into the Plasma Spray Torch Facility and the Cryogenics Laboratory, respectively. Both laboratories did research on reactors. In addition, the Plasma Spray Torch Facility also did work for the weapons program. Other research for the weapons program included the materials testing of lithium hydride and deuteride.

In the 1970s, Materials Science researchers in Building 241 worked on coal gasification for Project Plowshare and a hot press armor project for helicopters used in Vietnam.

In the 1980s, Building 241 housed work on Synroc, a synthetic rock designed for use in nuclear waste disposal.

Currently, Building 241 houses a variety of materials research for the Chemistry Division. Building 241 laboratories are also used for biomedical research and other programs in the complex.

⁴⁷⁹ "New Building Erected for Project Pluto Work," *The Magnet* (August 1960), 3.

⁴⁸⁰ *Interim Status Report: Fiscal Year 1964*, vii.

⁴⁸¹ Press Release, 1 July 1964, Administrative Files Donald Cooksey, 1964, Folder Pluto Program, LBNL Archives.

⁴⁸² "New Livermore 'Space Reactor' Program," 1.

⁴⁸³ LLNL history, unpublished manuscript, 1966–1967, 25; and "20 years in Livermore," 16–17.

Period of Significance

From 1957 to 1964, Materials Science researchers at LLNL were involved in developing ceramic fuel elements for Project Pluto. In 1960, LLNL built Building 241 specifically as a fuel element laboratory. The fuel elements developed for the Pluto reactor represent a historic breakthrough in fuel element design. Each element was about four inches long and hexagonal in section with a circular air passage. The elements were made of a homogenous mixture of highly enriched uranium dioxide and beryllium oxide. The Tory II-A and Tory II-C required the assembly of several hundred thousand carefully arranged ceramic elements. Therefore, Building 241 is of historic interest due to its role in fuel element research for the Pluto Project within the LLNL Cold War context preservation themes of Nuclear Research (subtheme Materials Research) and Non-Weapons Research (subtheme Nuclear Propulsion Research). Building 241 was the site of pioneering materials research in fuel element design, giving it historic significance for the period 1960–1964.

9.8.3 Construction History

Building 241 was built in two increments.

In 1959, Garretson and Elmendorf, a San Francisco engineering firm, designed Increment 1 of Building 241. It was a single-story concrete building with a high bay. It had metal siding on the upper half of the north elevation and cement-asbestos panels on the lower half. A roll-up door was installed on the east side, and personnel doors were installed on all sides of the building.⁴⁸⁴

⁴⁸⁴ "Fuel Element Laboratory, Building No. 173B, Elevations," 1959, PLZ59-241-006JA, PEL.

Increment 1 was approximately 39,000 gross square feet. The south side of the building housed a petrographic laboratory, instrument room, developing room, printing room, properties testing laboratory, offices, purification laboratory, high-temperature research laboratory, and a basic ceramics materials research laboratory. Across the hall were a materials property laboratory, silicon carbide research laboratory, counting room, analytical chemistry laboratory, fuel stability studies laboratory, general chemistry laboratory, health chemistry room, special fuel preparation room, electronics shop, and basic ceramics laboratory. The north side of the building had a large general research area, mechanical room, electrical equipment room, high bay, shop, and finishing room. The mezzanine housed a mechanical equipment loft.⁴⁸⁵

In 1967, Maher and Martens, a San Francisco architectural firm, designed Increment 2 of Building 241. Increment 2 was built for the study of refractory materials. It was a one-story concrete addition to the east end of the building. It had a flat roof and cement-asbestos panels and windows on the north, south, and east elevations. The building addition consisted of four offices, a solid-state kinetics laboratory, and an equipment room.⁴⁸⁶ In addition to the new increment, Room 1627, Increment 1's electrical equipment room, was renovated into the Plasma Spray Torch Facility for the weapons and reactor program; and Room 1629, the silicon carbide laboratory, was renovated

⁴⁸⁵ "Fuel Element Laboratory, Building No. 173B, Ground Floor Plan," 1959, PLZ59-241-004JA, PEL.

⁴⁸⁶ "Refractory Metals Building Addition, Building 173B, Increment II, Floor Plans, Finish Schedule, Exterior Elevations," 1967, PLZ67-241-004JA, PEL.

into the Cryogenics Laboratory for the reactor program.⁴⁸⁷

Subsequent modifications to Building 241 included the addition of coal gasification towers for energy research, to the north exterior side of the building in 1975; a technician shop addition to the northwest corner of the high bay in 1984; and an additional laboratory, Room 1586, in 1990.

Building 241 is a concrete industrial building of no architectural distinction. It represents no high-style architectural features. It is an industrial structure typical of those found in industry and the military during the Cold War. Building 241 is an LLNL Cold War building type known as a Heavy Laboratory. It possesses the characteristic features of its type—single-story with high bay or partial mezzanine, heavy-steel repetitive-bay structural framing, five- to twenty-ton crane, reinforced concrete slab, poured gypsum or metal deck under built-up roofing, reinforced-concrete, metal, or corrugated asbestos-cement walls, and space for large equipment or fabrication.

9.8.4 Integrity

Building 241, although of historic interest for its pioneering development of beryllia fuel elements in support of Project Pluto between 1960 and 1964, no longer possesses historic integrity. The development of beryllia fuel elements was completely dependent upon and only reflected in the equipment used in the project. Shortly after the cancellation of Project Pluto in 1964, most of the

equipment used specifically for fuel element research and development was removed. Other equipment, such as the presses and furnace, were less specialized in design and were used in other programs. Building 241 has had a constant turnover of programs and research over the years and no longer reflects its Project Pluto mission.

The building does not present a cohesive or significant representation of the other Cold War activities it housed. The central research area, Room 1600, still contains Cold War-era equipment. There are mills, presses, glove boxes, and two Brew furnaces. Most of this equipment is disassociated from its original programs. It is also predominantly off-the-shelf laboratory equipment that reflects no particular program or specific achievement.

The exceptions to the above are the two Brew furnaces located in the northwest corner of Room 1600. They were purchased in 1959 and 1960 specifically for use in Project Pluto. Used in the development of the beryllia ceramic fuel elements for the Pluto reactor, they are the last vestiges of the technical work from the program. They are not unique in design, but do represent the specific laboratory research techniques and effort that resulted in the historic breakthrough in fuel element design. Moreover, the specific technical breakthrough of creating the beryllia fuel elements was achieved in the Brew furnaces.

The rest of the laboratories in Building 241 were completely modernized and renovated in the last fifteen years.

⁴⁸⁷ W. B. Harford to P. M. Goodbread, 13 October 1967, Administrative Files Donald Cooksey, Plant Engineering, LBNL Archives.

9.8.5 Recommendation

Buildings and structures under fifty years of age are generally not considered eligible for the National Register. Building 241 will not be fifty years of age until 2010.

However, under Criteria Consideration G, properties under fifty years of age can be considered eligible to the National Register if it can be demonstrated that they are of exceptional significance.

The Cold War has been recognized as a period of exceptional significance within U.S. and world history. Therefore, as Building 241 meets the threshold for historic significance within the established LLNL Cold War preservation themes of Nuclear Research (subtheme Materials Research) and Non-Weapons Research (subtheme Nuclear Propulsion Research) it is of exceptional significance.

Building 241 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. The design of the building is of no architectural interest. It is an industrial building typical of the period and does not reflect the activities of historic interest it

once housed. Building 241 is not, nor will it be, an important source of historical information. The fuel element research that occurred there is documented in research reports and archival collections.

Building 241 qualifies for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War development of unique beryllia ceramic fuel elements for the Project Pluto ramjet engine. The particular period of historic significance for these activities within this structure is 1960–1964.

However, Building 241 does not possess integrity for the period of historic significance. It is, therefore, not eligible for National Register consideration under Criterion A.

Although Building 241 is not eligible for National Register consideration, the two Brew furnaces in Room 1600 noted above are of interest under Criterion A, and do possess integrity. They are, therefore, eligible for the National Register as historic objects under Criterion A.

9.9 Building 243

9.9.1 Description

Building 243 is located on the LLNL main site, at the corner of Third Street and Avenue B. It is currently the Earth Sciences Laboratory. It was built in 1959 as Building 173A, Pluto Assembly. In 1967, during a Laboratory-wide renumbering, Building 173A was redesignated Building 243.⁴⁸⁸ Over the years, it has also housed diagnostic engineering, gas gun research, geothermal research, and energy research. Currently, it contains earth sciences laboratories involved in crystal growth, clay mineralogy, mineral spectroscopy, and diamond anvil cell spectroscopy. Figure 89 is a recent photograph of Building 243.

Building 243 is a high-bay, concrete, steel-framed structure with a flat roof. It has steel roll-up doors on the south, east, and west elevations. It has 17,884 gross square feet. It currently houses nineteen laboratories, twenty-nine utility rooms, two offices, and three shops.

9.9.2 Mission History

In 1957, LLNL began work on Project Pluto, a program to design a low-flying nuclear reactor to power a supersonic cruise missile. Project Pluto took over existing Project Rover facilities after Rover was transferred to LANL in 1957.

Building 243 was built in 1958 as part of the Project Pluto complex, a group of eight separate structures. Building 243 was the Assembly Building, a large high-bay space where the non-nuclear assembly activities for the Pluto ramjet engine occurred.

LLNL material scientists successfully pioneered the development of unique ceramic fuel elements made out of a homogenous mixture of highly enriched uranium dioxide and beryllium oxide. In 1961 and again in 1964, LLNL tested prototype ramjet engines, both equipped with beryllia fuel elements, the Tory II-A and the Tory II-C.⁴⁸⁹



Figure 89. Looking northeast at Building 243, west and south elevations, 2003.⁴⁹⁰

⁴⁸⁸ For the sake of clarity, this report will refer to Building 243 by its current designation.

⁴⁸⁹ *Interim Status Report: Fiscal Year 1964*, vii.

⁴⁹⁰ Building 243, exterior, LLNL photographer, 2003.

In 1964, shortly after the successful testing of the full-scale Tory II-C, the AEC cancelled Project Pluto because no firm military commitment materialized to pursue this technology.⁴⁹¹

From 1965 to 1975, Building 243 was used to house Diagnostic Engineering. This included support staff for larger programs. For instance, electrical engineering technicians for the Physics Division, mechanical engineering technicians for the vacuum process laboratory, and equation-of-state mechanical engineering technicians all had space in the building.

In 1966, a Gas Gun Facility was added to the north end of the building for shock testing.

From 1975 to the present, Building 243 has housed energy research. In the 1970s and 1980s, Building 243 housed the Geothermal Research Program. Currently, it houses laboratories for the Earth Sciences Program.

Period of Significance

From 1957 to 1964, LLNL was involved in Project Pluto. Building 243 was built in 1958 as part of the Project Pluto complex. Its mission was to assemble the non-nuclear components and casings for the ramjet engine. Therefore, Building 243 has historic interest for its contributions to the Pluto ramjet engine design within the LLNL Cold War context preservation theme of Non-Weapons Research, subtheme Nuclear Propulsion Research.

9.9.3 Construction History

In 1958, Garretson and Elmendorf, a San Francisco engineering firm, designed

Building 243. It was a high-bay, steel-framed structure with a flat roof. It had exterior concrete panel walls. There were steel roll-up doors on the east, north, and west elevations and no windows.⁴⁹² The interior housed an assembly area, pre-assembly area, electronics area, machine shop, bathrooms, office, and mechanical equipment room.⁴⁹³

In 1962, LLNL Plant Engineering designed a modification for the mezzanine to enclose the reactor control area.⁴⁹⁴

In 1966, Plant Engineering designed a single-story concrete addition to the north exterior elevation of Building 243 to house the Gas Gun Facility. The addition was made of concrete blocks and had a flat roof. The interior contained a control room and room for the gun.⁴⁹⁵

In 1974, Plant Engineering designed another single-story concrete addition for the Geothermal Research Program, which extended the northwest exterior of Building 243. The Gas Gun Facility was also renovated for the Geothermal Research Program.⁴⁹⁶

During the 1970s, the main portion of the laboratory was renovated several times to accommodate various energy program tenants. In the same period a partial second

⁴⁹¹ Press Release, 1 July 1964, Administrative Files, Donald Cooksey, 1964, Folder Pluto Program, LBNL Archives.

⁴⁹² "Pluto Assembly Building, No. 173, Elevations and Door Schedule," 1958, PLZ58-243-005JA, PEL.

⁴⁹³ "Pluto Assembly Building, No. 173, Floor Plan and Room Finish Schedule," 1958, PLZ58-243-004JB, PEL.

⁴⁹⁴ Building 173A, Mezzanine Modification to Enclose Reactor Control Area, Floor, Plan, Details, Architectural, Mechanical, Structural, 1962, PLA62-243-133D, PEL.

⁴⁹⁵ "Gas Gun Facility, Plans, Sections, Details, and Notes," 1966, PLA66-243-012D, PEL.

⁴⁹⁶ "Building 243, Room 1008, Addition for Geothermal Research, Plans, Section, and Detail," 1974, PLA74-243-004D, PEL.

floor was added to accommodate more laboratories and offices. Little remodeling has occurred since the 1980s.

Building 243 is a concrete industrial building of undistinguished architectural style. It possesses no windows or adornment. Building 261 is an LLNL Cold War building type known as a Heavy Laboratory. It possesses the characteristic features of its type—single-story with high bay or partial mezzanine, heavy-steel repetitive-bay structural framing, five- to twenty-ton crane, reinforced concrete slab, poured gypsum or metal deck under built-up roofing, reinforced-concrete, metal, or corrugated asbestos-cement walls, and space for large equipment or fabrication.

9.9.4 Integrity

Building 243, although of historic interest for its contributions to the design of a successful ramjet engine for Project Pluto between the years 1958 and 1964, no longer possesses historic integrity. The work in the building was highly dependent on the equipment used for the assembly of the non-nuclear components and casings of the Project Pluto ramjet engine. Shortly after the cancellation of Project Pluto in 1964, most of the equipment used for assembly activities was removed. Building 243 has experienced a constant turnover of programs and research over the years and no longer reflects its Project Pluto mission.

9.9.5 Recommendation

Building 243 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. The design of the building is of no architectural interest. It is a standard Industrial Vernacular design and does not itself reflect the activities of historic interest that occurred there. Building 243 is not, nor will it be, a source of important historical information. The assembly activities that occurred there are documented in research reports and archival collections.

Building 243 qualifies for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War assembly of non-nuclear components and reactor casing for the Project Pluto ramjet engine. The particular period of historic significance for these activities within this structure is 1958–1964.

However, Building 243 no longer possesses integrity for the period of its historic significance. Therefore, Building 243 is not eligible for the National Register under Criterion A.

9.10 Building 261

9.10.1 Description

Building 261 is located on the LLNL main site, north of Fifth Street and east of Avenue B. It currently houses the Non-Proliferation, Arms Control, and International Security (NAI) Directorate offices. It was originally built in 1954 as Building 110, the Sub-critical Assembly (SAGA) Building, for the LLNL Weapons Program. In 1967, during a Laboratory-wide renumbering, Building 110 was redesignated Building 261.⁴⁹⁷ Figure 90 is a recent photograph of Building 261.

In its earlier years, Building 261 also housed nuclear propulsion research for both Project Rover and Project Pluto, programs investigating nuclear power for space vehicles and weapons, respectively. Building 261 has also housed the Neutronics Division, which performed reactor studies, and Special Projects, or Z Division,

which provided counterintelligence on foreign nuclear weapons programs to the intelligence community.

Building 261 is a concrete, two-story building with a flat roof. It is 51,221 gross square feet. It was constructed in six separate increments over a thirty-three year period. It currently contains one hundred thirty offices, nine laboratories, nine computer laboratories, four electronics laboratories, nine mechanical utility rooms, and five service shops.

9.10.2 Mission History

Building 261 was initially constructed in 1953 as the Sub-critical Assembly building for the Nuclear Weapons program at LLNL. Two types of experiments were conducted there. Principally, experiments involved determining that all weapon cores designed at LLNL were safely sub-critical at all stages



Figure 90. Looking south at Building 261, north elevation, 2003.⁴⁹⁸

⁴⁹⁷ For the sake of clarity, this report will refer to Building 261 by its current designation.

⁴⁹⁸ Building 261, exterior, LLNL photographer, 2003.

of the design process, including fabrication, assembly, and loading. The second type of experiment tested critical masses of fissionable material to aid in weapons design and the interpretation of nuclear tests.⁴⁹⁹ In 1955, the Weapons Program moved this work out to Site 300.

From 1956 to 1957, Building 261 housed critical assembly experiments for the Project Rover effort to develop a reactor to propel a space vehicle. The critical assembly experiments that occurred in Building 261 were called Puppy I and involved a prototype reactor with a graphite core.

In 1957, Building 261, along with other Rover facilities, was re-equipped for Project Pluto. Project Pluto was a program to design a low-flying ramjet engine to power a supersonic cruise missile. In 1958, LLNL expanded Building 261 to include a reactor containment vessel to conduct critical assembly experiments for Project Pluto. The Spade and the Snoopy assembly experiments for Project Pluto studied the critical characteristics of “moderated or alloy systems.”⁵⁰⁰

In 1964, after testing the full-scale Tory II-C, the AEC cancelled Project Pluto because no firm military commitment materialized to pursue this technology.⁵⁰¹

From 1964 to 1969, Building 261 continued to be used by the Neutronics Division for reactor studies.

In 1970, Building 261 was taken over by Z Division, which provides the intelligence community with assessments of foreign nuclear weapons and energy programs—primarily those of Russia and China. In the early decades of the Cold War, Z Division collected and analyzed radiological samples of foreign nuclear tests. The division also developed seismic and other equipment to detect nuclear tests.

Today, Z Division, now part of the NAI Directorate, is responsible for intelligence on all types of weapons of mass destruction. A few laboratories remain in Building 261, but the primary work of most NAI personnel involves computer research.

Period of Significance

From 1953 to 1955, Building 261 was used as the SAGA facility for the LLNL nuclear weapons program, but in 1955 a new SAGA facility was located at Site 300, away from the main site.

The work done in the SAGA facility was extremely important to the LLNL nuclear weapons design program because it allowed weapon cores to be tested before being finally assembled in test devices. This work meant scientists could make adjustments to weapons designs before a full-scale nuclear test took place. It also ensured that a device would not become critical before a detonation. Therefore, Building 261 has historic interest for its criticality experiments within the context of the Cold War arms race within the preservation theme Nuclear

⁴⁹⁹ A. Kirschbaum, “Proposal and Justification for a Sub-Critical Assembly Building: Livermore Site,” 19 June 1953, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1953, Project Whitney, LBNL Archives.

⁵⁰⁰ Donald Kraft, “Assembly Procedure—Spade and Snoopy Experiments,” 12 April 1960, Box 179, Folder 1685, LLNL Archives.

⁵⁰¹ Press Release, 1 July 1964, Administrative Files Donald Cooksey, 1964, Folder Pluto Program, LBNL Archives.

Weapons Design, subtheme Weapons Design. The period of significance for these activities is 1953–1955.

From 1957 to 1964, Building 261 housed nuclear propulsion research for the Pluto program. Project Pluto is of historic interest for its scientific achievements in fuel element research and reactor design. In 1964, the LLNL Pluto Program successfully designed and tested a reactor-powered ramjet engine, the Tory II-C, with unique ceramic fuel elements. Researchers in Building 261 also conducted experiments in neutron fission in support of the reactor core design. Criticality experiments conducted in Building 261 determined the amounts of fissionable material necessary for a sustained nuclear chain reaction. Therefore, Building 261 is of historic interest for its reactor core assembly experiments within the context of the Cold War preservation theme Non-Weapons Research, subtheme Nuclear Propulsion Research. The period of significance for these activities is 1957–1964.

9.10.3 Construction History

In 1953, Albert Roller, a San Francisco architect, designed Increment 1 of Building 261. The original structure was a one-story building with a high bay in the center. The building was made of concrete block with cement-asbestos panels along the top half of the high bay. The west elevation had no windows but had a roll-up door into the high bay. The north elevation had windows the length of the building. The south elevation had a roll-up door.⁵⁰² The interior

of the building housed two blockhouses, one measured twenty feet by fifteen feet, and one twenty feet by thirty feet. In addition, there were two control rooms, four laboratories, a machine shop, electronics shop, and a utility room.⁵⁰³

In 1956, Increment 2, a suite of offices, was added to the northeast end of Building 261 to house SAGA personnel.

In 1958, Building 261 was expanded to the southeast to accommodate Pluto critical assembly research. The addition, Increment 3, housed an assembly room, laboratory, counting room, and assembly area. A concrete reinforced circular cell for testing measurements on critical reactor core mockups was added directly to the south of the new addition.⁵⁰⁴

In 1963, Increment 4, a small addition, was built onto the east end of Building 261 for the Pluto program.

In 1970, Increment 5, a two-story wing of offices, was added to the southeast of Building 261 to house Z Division.

In 1985, Increment 6 added another two-story wing of offices for Z Division to the south end of Increment 5.

In 1988, a small west-end addition completed Building 261's transformation into its current configuration.

Building 261 has been significantly upgraded and modernized since 1988.

⁵⁰² "SAGA Building 110, Elevations and Sections," 1953, PLZ53-261-003JA, PEL.

⁵⁰³ "SAGA Building 110, Floor Plan," 1953, PLZ53-261-002JA, PEL.

⁵⁰⁴ "We Build," *The Magnet* (March 1958), 4.

Building 261 is a local expression of modern industrial architecture. It is typical of industrial structure found in industry and the military. It does have some design features indicative of working with radioactive materials—the concrete blockhouse in Increment 1 and the circular cell in Increment 3. The concrete blockhouse is a typical concrete block construction used in a variety of work requiring protection from radiation. The circular cell resembles a reactor containment vessel, making its design more unusual.

Building 261 is an LLNL Cold War building type referred to as a Heavy Laboratory. It possesses all the characteristics of a building of this type—single-story with high bay or partial mezzanine; heavy-steel, repetitive-bay structural framing; five- to twenty-ton crane; reinforced-concrete slab; poured gypsum or metal deck under built-up roofing; reinforced-concrete, metal, or corrugated asbestos-cement walls; and space for large equipment or fabrication.

9.10.4 Integrity

Building 261 is of historic interest for its sub-critical experiments for the LLNL nuclear weapons program during the years 1953–1955. It is also of historic interest for its reactor core experiments in support of Project Pluto during the years 1957–1964. However, Building 261 no longer possesses historic integrity for either of these periods.

No trace exists of the original blockhouses in Increment 1, where important sub-critical experiments on nuclear weapons designs were conducted. The shielding blocks have long since been removed and

only some reinforced concrete in the west end of the building is evidence that any heavy laboratory work ever took place in the building.

Similarly, the Pluto reactor work that occurred in Increment 3 of Building 261 is no longer reflected in the building. The control and counting rooms have been remodeled into office space. The circular reactor test cell is the only reminder left of the Pluto project. However, it too has been significantly altered so that it is not clear what type of research occurred there. It is essentially a shell of reinforced concrete.

The increments added to the building have more than doubled its size, and the interior renovation has been extensive, leaving no trace of the historic work it once housed.

9.10.5 Recommendation

Building 261 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. The design of the building is of no architectural interest. The building itself is an example of the Industrial Vernacular design and does not reflect the activities of historic interest it once housed. Building 261 is not, nor will it be, a source of important historical information. The sub-critical assembly research for the LLNL weapons program and the reactor core research for Project Pluto that occurred there are documented in research reports and archival collections.

Building 261 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the sub-critical testing of weapon cores for all LLNL-designed nuclear weapons and devices and the development of a nuclear reactor for the Project Pluto ramjet engine. The particular periods

of historic significance for these activities within this structure are 1953–1955 and 1957–1964, respectively.

Building 261 no longer possesses integrity for the periods of its historic significance. Therefore, Building 261 is not eligible for the National Register under Criterion A.

9.1.1 Buildings 280 and 281

9.1.1.1 Description

Buildings 280 and 281 are located on the LLNL main site north of Westgate Drive and south of Eighth Street. They are currently unoccupied and Chemistry laboratories, respectively. Building 280 and 281, originally built in 1956, were considered one building and designated Building 193. In 1967, during a Laboratory-wide renumbering, Building 193 was redesignated Building 281. More recently, the buildings were assigned separate numbers.⁵⁰⁵ Building 280 was the Livermore Pool-Type Reactor (LPTR). It was decommissioned in 1980 and has not been used since. Building 281 originally housed chemistry laboratories as well as the control

room for the LPTR. The control room was dismantled in the 1980s, but the rest of the building still houses chemistry laboratories. Figures 91 and 92 are recent photographs of Buildings 280 and 281.

Building 280 is a round, concrete-block structure covered with stucco containing 5,343 gross square feet. The roof is rounded with a stack in the center. Building 281 is a single-story, concrete-block structure of 18,549 gross square feet, connected to 280. It has a slightly pitched roof and windows on the north and south elevations. Currently, it contains sixteen laboratories, five utility rooms, and thirty offices.

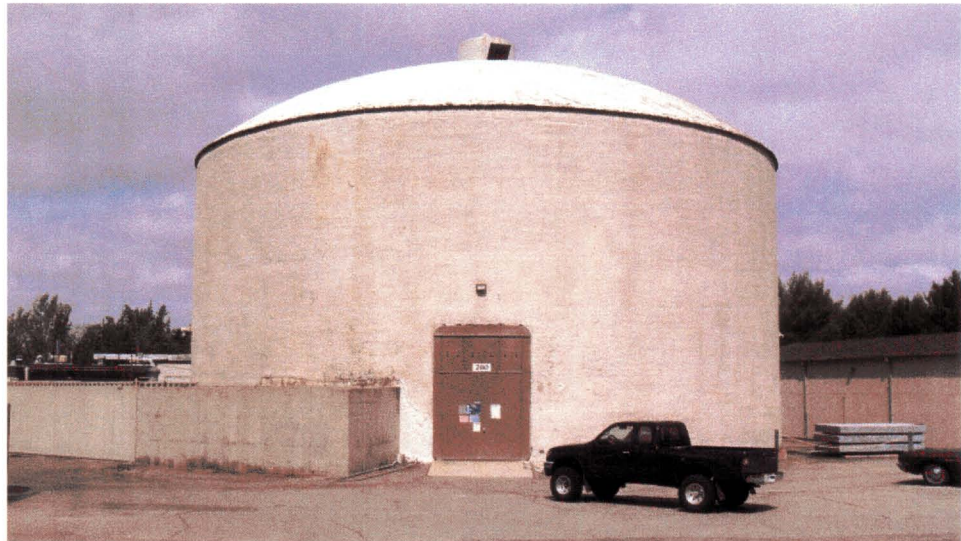


Figure 91. Looking west at Building 280, east elevation, 2003.⁵⁰⁶

⁵⁰⁵ For the sake of clarity, this report will refer to Buildings 280 and 281 by their current designations.

⁵⁰⁶ Building 280, exterior, LLNL photographer, 2003.

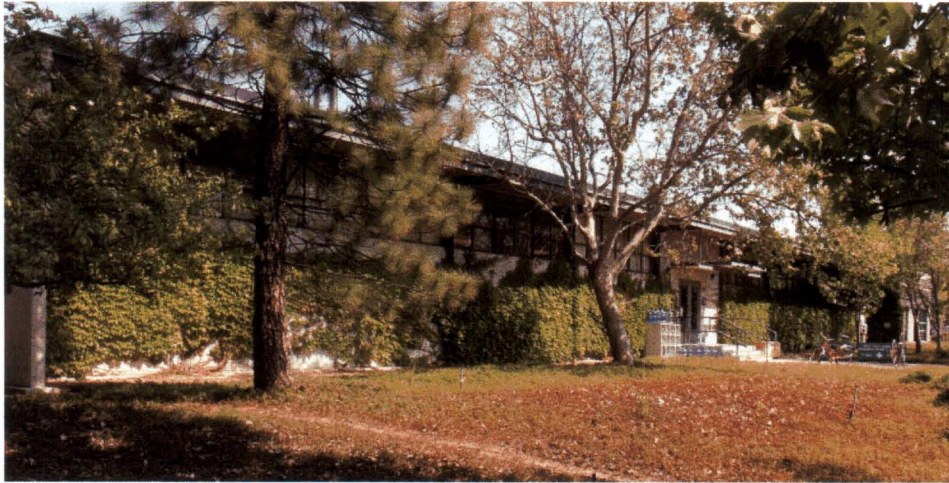


Figure 92. Looking northwest at Building 281, south elevation, 2003.⁵⁰⁷

9.11.2 Mission History

In 1955, construction began on the LPTR Facility, Buildings 280 and 281. The LPTR facility was intended to replace the old Water-Boiling Neutron Source Reactor (WBNS) built by CR&D in 1953. The WBNS was considered an old model reactor, not large enough or suitable for weapons research. Building 280 housed the LPTR and Building 281 housed research laboratories for the reactor. The LPTR was designed as a flexible research reactor primarily to support the LLNL weapons program but also intended for use by the chemistry, physics, and biomedical research programs at both LLNL and LBNL.

From 1958, when it first went critical, until 1980, the LPTR was a workhorse for the weapons program. The LPTR was used for a variety of chemistry and physics experiments, including weapon radiochemical analysis, bomb fraction measurements, analysis of samples from nuclear tests, capture-to-fission ratio measurements of uranium 235, cross-section measurements, calibration of instruments for determining

fission yield, instrument testing, and radiation damage studies.⁵⁰⁸

The LPTR provided valuable information regarding nuclear processes, nuclear testing, and nuclear weapons design. Without its own research reactor LLNL would have had to contract this work to LANL or ARCO, limiting its ability to come up with new techniques and designs.⁵⁰⁹

From 1958 to 1980, the LPTR also provided support to a variety of non-weapons-related research programs including the biomedical research programs at LBNL and LLNL. The research for biomedical programs included studying the effects of radiation on living things, using tracers to monitor biological processes, and creating isotopes for medical purposes.⁵¹⁰

In 1980, after more than twenty years of service, the LPTR was decommissioned. Figure 93 depicts the reactor vessel of the LPTR.

⁵⁰⁸ "Proposed UCRL-Livermore Research Reactor," 1953, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, Folder Project Whitney, LBNL Archives.

⁵⁰⁹ Ibid.

⁵¹⁰ "The Livermore Pool Type Reactor," *The Magnet* (June 1958), 4–5; and "Shopping for Isotopes," *The Magnet* (June 1962), 4–5.

⁵⁰⁷ Building 281, exterior, LLNL photographer, 2003.

Period of Significance

From 1958 to 1980, the LPTR performed neutron experiments in support of the LLNL nuclear weapons and testing programs. These experiments provided critical information regarding weapons design and diagnostics for nuclear testing. Therefore, Buildings 280 and 281, the laboratories and the reactor, respectively, are of exceptional historic interest within the LLNL Cold War context preservation themes of Nuclear Weapons Design (subtheme Weapons Design) and Nuclear Weapons Testing (Nuclear Testing). The period of significance for these activities is 1958–1980.

9.1.1.3 Construction History

The Austin Company, an Oakland engineering and building company, designed Building 280 and Increment 1 of 281 in 1955.



Figure 93. Building 280, LPTR reactor vessel, 2003.⁵¹¹

⁵¹¹ Building 280, LPTR reactor vessel, LLNL photographer Frank Nunez, 2003.

Building 280 was a concrete-block structure in the shape of a rounded igloo.⁵¹² It was eighty feet in diameter and fifty-two feet high. Inside, it had an airtight, insulated steel shell with a steel dome. The foundation and all flooring were made of reinforced concrete. Personnel doors were sealed with rubber gaskets to prevent the release of radiation in the event of an accident.⁵¹³

The Foster Wheeler Corporation designed and built the LPTR, which was housed inside Building 280. The LPTR was a “one megawatt solid fuel, light water moderated and cooled reactor of the pool type” very similar to the Omega West Reactor at LANL.⁵¹⁴ The core was submerged in an aluminum tank, six feet seven inches in diameter, and three-eighths inch thick, surrounded by biological shielding. The fuel elements of the reactor core were modeled after those in the Material Test Reactor located at the National Reactor Testing Station in Idaho. There was a thirty-five-element array. Each fuel element was made of uranium and measured three inches by three inches by thirty-five inches. There were four control rods and one regulating rod.⁵¹⁵

The LPTR went critical in 1958. It was shut down in 1960 to modify the containment system and upgrade the power from one to two megawatts.

Increment 1 of Building 281 was a single-story, concrete-block structure with a flat roof. It was connected via an airlock to the west end of the reactor building. There were windows on the north and south elevations

⁵¹² “LPTR Lab/Reactor Building, Foundations and Column Loading,” 1955, PLZ55–281–016JH, PEL.

⁵¹³ Dettermen, *Safeguard Report: Livermore Pool Type Reactor*, 16–18.

⁵¹⁴ *Ibid.*, 16.

⁵¹⁵ *Ibid.*, 18.

and personnel doors on the north, south, and west elevations. The interior housed the LPTR control room, office, physics laboratory, electrical maintenance shop, chemistry laboratory, mechanical shop, health chemistry/physics laboratory, and mechanical equipment room.⁵¹⁶

In 1957, Increment 2 added additional laboratory facilities to Building 281.

In 1961, Increment 3, the Instrument Calibration Facility, was added to Building 281. Increments 2 and 3 were added to the west end of the building.

In 1991, Kaiser Engineers designed a concrete-block addition to the southwest end of Building 281. Figure 94 depicts the 1991 addition.

9.11.4 Integrity

Buildings 280 and 281 are of exceptional historic interest for their neutron research in support of the LLNL weapons program for the period 1958–1980. Furthermore, Building 280 possesses historic integrity for its period of significance. Although the

core of the reactor has been removed, the containment vessel is still intact. The interior and exterior of Building 280 still look much as they did during the period of historic significance. However, Building 281 does not possess historic integrity. The control room for the LPTR was stripped and remodeled in 1981. The research laboratories associated with the reactor experiments also have been remodeled. The additions and the renovations to the building have transformed it significantly. Building 281 no longer possesses any trace of the reactor research that occurred there.

9.11.5 Recommendation

Buildings and structures under fifty years of age are generally not considered eligible for the National Register. Building 280 will not be fifty years of age until 2006.

However, under Criteria Consideration G, properties under fifty years of age can be considered eligible to the National Register if it can be demonstrated that they are of exceptional significance.

The Cold War has been recognized as a period of exceptional significance within U.S. and



Figure 94. Looking northeast at west and south elevations of Building 281, 2003.⁵¹⁷

⁵¹⁶ "Livermore Pool Type Reactor and Associated Buildings, Plans, Elevations, and Details," 1955, PLZ55-281-001JF, PEL.

⁵¹⁷ Building 281, southwest addition, LLNL photographer Frank Nunez, 2003.

world history. Additionally, building 280 is of exceptional historic significance for its neutron research in support of LLNL nuclear testing and weapons design. Therefore, Building 280 meets the threshold for exceptional historic significance within the established LLNL Cold War preservation themes of Nuclear Weapons Design (subtheme Weapons Design) and Nuclear Weapons Testing (subtheme Nuclear Testing).

Building 280 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. The design of the building is of no architectural interest. The building is a typical example of pool-type reactor construction. The LPTR itself was a typical pool-type reactor, a standard research reactor model found in many laboratories and universities in the United States. Building 280 is not, nor will it be, a source of important historical information. The reactor research that occurred there is documented in research reports and archival collections.

Building 280 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is Cold War neutron research experiments conducted for the LLNL nuclear weapon and nuclear testing programs. The LPTR represents LLNL weapons design and nuclear testing for the period 1958–1980.

Building 280 also possesses integrity for the period of historic significance. The contrib-

uting element to its historic significance under Criterion A is the containment vessel inside Building 280. It is recommended that Building 280 is eligible for the National Register.

Building 281, however, does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No historic event or pattern of events is associated with Building 281. No person of historic note is associated with this structure. The design of the building is of no architectural interest. The building is concrete block with no adornment. Building 281 is not, nor will it be, a source of important historical information. The activities that occurred there are documented in research reports and archival collections.

Building 281 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War laboratory research associated with the LPTR in support of the LLNL weapons program. The particular period of historic significance for these activities within this structure is 1958–1980.

However, Building 281 no longer possesses integrity for the periods of its historic significance. Historic integrity for these activities depends on the retention of research equipment and laboratories for the LPTR experiments that occurred there. Building 281 possesses neither the equipment used in these activities nor any visible sign that these types of research activities ever occurred there. Therefore, Building 281 is not eligible for the National Register under Criterion A.

9.12 Building 331

9.12.1 Description

Building 331, the Tritium Facility, is located on the LLNL main site within the Superblock, a limited-access area surrounded by an alarmed double-security fence and monitored by LLNL Protective Forces. Building 331, built in 1959, was originally called Building 172, the Gaseous Chemistry Laboratory. In 1967, during a Laboratory-wide renumbering, Building 172 was re-designated Building 331.⁵¹⁸ Its primary purpose, both historically and currently, is to house tritium research and development. All modern nuclear weapons

include tritium, deuterium, and lithium-6 in their designs.⁵¹⁹ Building 331 is one of two main tritium research and development laboratories in the United States.

Building 331 is a single-story, concrete building of 28,893 gross square feet. It is 300-feet long, 14-feet high (except for Rooms 1117 and 1124, which are eighteen-feet high), 131-feet wide at the south end, and 68.5-feet wide at the north end. It currently contains sixteen laboratories and a wing of offices. The walls of the building are constructed of thick reinforced concrete.⁵²⁰ Figure 95 is a recent photograph of Building 331.



Figure 95. Looking southeast at Building 331, north and west elevations, 2003.⁵²¹

⁵¹⁸ For the sake of clarity, this report will refer to Building 331 by its most recent designation.

⁵¹⁹ Loeber, *Building the Bomb*, 94.

⁵²⁰ *Building 331 Safety Analysis Report*, draft (Livermore: Lawrence Livermore National Laboratory, May 2003).

⁵²¹ Building 331, exterior, LLNL photographer, 2003.

9.12.2 Mission History

In 1952, when LLNL first opened, scientists conducted tritium research in the former women's restroom of Building 161, a former U.S. Navy building used as LLNL's first headquarters.⁵²² This early tritium research consisted of preparing tritium-loaded targets for investigations of deuterium-tritium reactions.⁵²³ Requiring more space, tritium research was relocated to Building 231, where the first tritium-processing system was set up. This building, too, quickly became inadequate to handle the increasing amount of work in tritium research.⁵²⁴

LLNL approved a new Tritium Facility in 1957, and work was completed on Increment 1 in 1959. From the early 1960s through the late 1980s, the LLNL Tritium Facility, Building 331, was a "workhorse for the nation's weapons-development efforts."⁵²⁵ In 1965, the addition of Increment 2 doubled the size of the facility, providing laboratory space for the Light Isotopes Group to conduct gaseous chemistry research.

From 1961 until 1989, Building 331 was used primarily for research and development on tritium and its components for nuclear weapons applications. Building 331 scientists and technologists also prepared device components for the Nuclear Testing Program. Non-weapons work included fusion energy and neutrino mass experiments—especially in the 1970s and 1980s. In the 1990s, with the end of the Cold War and a subsequent lack of demand for new weapons designs, the demand for tritium

services declined along with financial support for the facility. A decision to close the facility was implemented and plans proceeded for the Tritium Inventory Removal Project (TIRP).

However, while the TIRP was underway, a renewed demand for tritium services and expertise surfaced within DOE as the nuclear weapons complex engaged in weapons disassembly and facility clean-up operations. LLNL decided to continue Building 331 operations indefinitely.

Currently, Building 331 is engaged in tritium recycle, tritium decontamination, legacy waste processing, and tritium systems design and operational support. Other work includes actinide chemistry operations, computed tomography, carbon dioxide cleaning systems, and the operation of the High-Sensitivity Neutron Instrument.

Period of Significance

From 1958 to 1992, Building 331 housed research and development of tritium for nuclear weapons applications. Tritium is an essential constituent of a nuclear weapon. All modern nuclear weapons include components with tritium as an essential ingredient. Building 331 also produced device components for nuclear testing. LLNL was one of two laboratories that designed and developed nuclear weapons for the U.S. stockpile. The tritium research conducted in Building 331 contributed to every weapon design LLNL placed in the enduring U.S. nuclear stockpile. Therefore, tritium research at LLNL is of exceptional historic interest within the context of the Cold War arms race and the established LLNL preservation themes of Nuclear Weapons Design, Nuclear Weapons Testing, and Nuclear Research.

⁵²² Building 161 has since been demolished.

⁵²³ *LLL Tritium Facility* (Washington, D.C.: United States Government Printing Office, 1978), 1.

⁵²⁴ *Ibid.*

⁵²⁵ *Ibid.*

All tritium research and development work associated with LLNL nuclear weapons designs during this period occurred in Building 331. In addition, all device components involving tritium for LLNL nuclear tests conducted during this period also were created in this building. Much of the textbook knowledge accumulated about tritium and its properties is a result of the nuclear chemistry research conducted in this facility during these years.

9.12.3 Construction History

Building 331 was constructed in three separate increments.

Corlett and Spackman, a San Francisco architectural firm, designed Increment 1 in 1958. Increment 1 was a single-story building with a flat roof. The exterior walls were concrete panels. The largest sections of the walls were tilt-up concrete panels and the smaller sections were poured in place. Increment 1 housed a synthesis laboratory, two analytical laboratories, a cryogenics laboratory, fabrication box line laboratory, liquefier room, three additional laboratories, four offices, a shop, and a mechanical room.⁵²⁶

In 1964, Maher and Martens, also a San Francisco architectural firm, designed Increment 2, which added 11,290 gross square feet of laboratory and office space to the original structure.⁵²⁷ The majority of the new space was for additional laboratories on the north side of the building; a gaseous research laboratory, assembly laboratory, and a box line fabrication laboratory

were built for the Light Isotopes Group of the Chemistry Division in support of the weapons program. Additional office space was also added on the west side of Increment 1.⁵²⁸ Increment 2 closely resembled Increment 1 in construction—it featured pre-cast and poured-in-place concrete exterior walls, a flat roof, and a roof screen.⁵²⁹ Two 100-foot tall stacks were also built for the facility to filter and release the air from work areas.

In 1985, Building 331 underwent a \$4.63-million renovation, identified as the Tritium Facility Upgrade.⁵³⁰ At that time, a tritium Vacuum Effluent Recovery System (VERS) and Secondarily Contained Tritium Systems (SCOTS) were installed, and 2,000 square feet of existing office space were modified. In addition, a freestanding steel structure called the Special Tritium Area Cold Shop (STACS) was built to accommodate technical shops and offices. The STACS is approximately 5,000 gross square feet and is connected to the main building by a breezeway.⁵³¹

Building 331 is currently undergoing interior renovation to upgrade its laboratory facilities and provide additional capabilities in radioactive element research.

Like most LLNL structures built in the 1950s and 1960s, Building 331 reflects an Industrial Vernacular expression of the International

⁵²⁶ "Gas Laboratory Building 172, Site Location and Roof Plans," 1958, PLZ58-331-001JA, PEL.

⁵²⁷ "Big Computer Center, Other Major Projects Oked for Livermore," *The Magnet* (February 1964), 4.

⁵²⁸ "Building No. 172 Increment II Gaseous Chemistry Building Additions, Floor Plan," 1964, PLZ64-331-003JC, PEL.

⁵²⁹ "Building No. 172 Increment II Gaseous Chemistry Building Additions, Elevations," 1964, PLZ64-331-005JB, PEL.

⁵³⁰ "For Weapons Program: Construction Nears on 2 Projects," *The Weekly Bulletin* (October 30, 1965), 1.

⁵³¹ "Building 331 Safety Analysis Report," 2-4.

style. It is devoid of ornamentation and is utilitarian in design. Building 331 is a Cold War LLNL building type referred to as a Heavy Laboratory. It possesses features common to this type—reinforced concrete walls, steel framing, radioactive shielding, and a flat roof.

9.12.4 Integrity

Although Building 331 is of historic interest for its tritium research and development activities between the years 1958 and 1989, the building no longer possesses historic integrity. The historic activities conducted in the building were completely dependent upon, and reflected in, the equipment used for the processing of tritium. Beginning in 2002, most of the rooms in Building 331 were stripped of equipment in preparation for the most recent addition to its mission—actinide

chemistry and tritium legacy work. Many of the rooms currently hold temporary equipment or are empty.

Despite its overall lack of integrity, a few reminders of its Cold War activities remain. Room 149 still houses remnants of a Cold War-era gaseous chemistry laboratory. Figure 96 depicts the equipment remaining in Room 149. The original control panel for the tritium alarm system is also still intact. However, the lack of integrity in the building as a whole leaves the control panel without an appropriate context and it does not represent—either directly or fully—the technical research work that was conducted in the building. Building 331 as a whole no longer possesses integrity for the period of its historic significance.

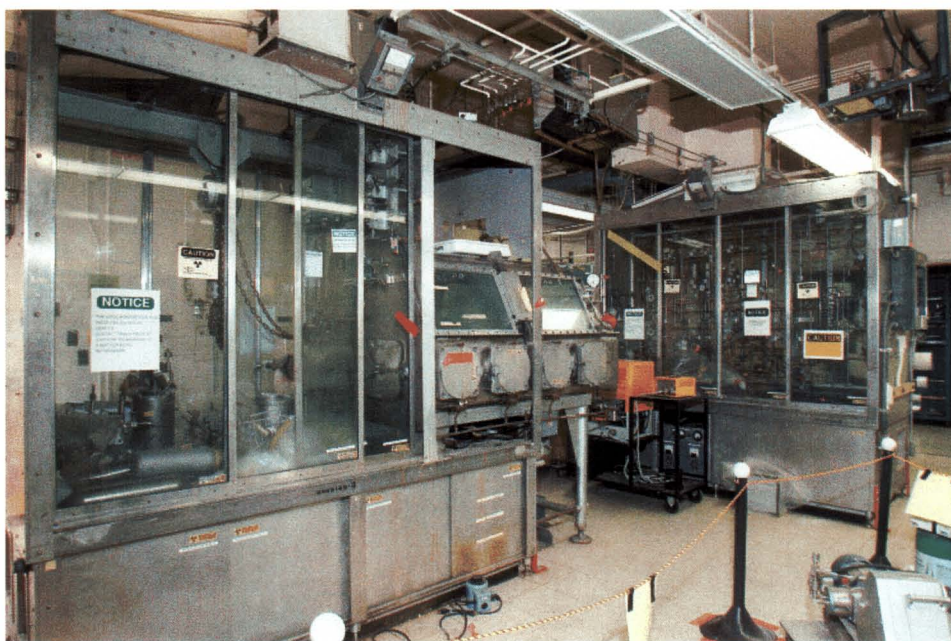


Figure 96. Building 331, Room 149, Cold War-era gaseous chemistry laboratory, 2003.⁵³²

⁵³² Building 331, Room 149, LLNL photographer Marcia Johnson, 2003.

9.12.5 Recommendation

Buildings and structures under fifty years of age are generally not considered eligible for the National Register. Building 331 will not be fifty years of age until 2009.

However, under Criteria Consideration G, properties under fifty years of age can be considered eligible to the National Register if it can be demonstrated that they are of exceptional significance.

The Cold War has been recognized as a period of exceptional significance within U.S. and world history. Additionally, tritium research for LLNL-designed nuclear weapons and device components for nuclear testing are of exceptional significance within the context of the Cold War arms race. Therefore, Building 331 is of exceptional historic significance as defined within the established LLNL Cold War preservation themes Nuclear Weapons Design, Nuclear Weapons Testing, and Nuclear Research.

Building 331 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. The design of the building is of no architectural interest. It is a typical example of an LLNL Cold War Heavy Laboratory.

Building 331 is not, nor will it be, an important source of historical information. The tritium research activities that occurred there are documented in research reports and archival collections.

Building 331 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War design of nuclear weapons for the U.S. stockpile. Building 331 is associated with tritium research and development for all LLNL nuclear weapons designs between 1958 and 1989. Other patterns of events of historic interest in the context of the Cold War that occurred in Building 331 are the development of device components for nuclear testing and nuclear research on the chemical properties of tritium. The period of significance for these activities is also 1958–1989.

However, Building 331, as a whole, does not possess integrity for the period of historic significance under Criterion A. Most of its laboratories have been stripped of the equipment that would have reflected its historic mission and the elements that remain are insufficient to meet the thresholds established for building or object integrity. Therefore, Building 331 is not eligible to the National Register.

9.13 Building 332

9.13.1 Description

Building 332, the Plutonium Facility, is located on the main LLNL site within the Superblock, a limited-access area surrounded by an alarmed, double-security fence and monitored by LLNL Protective Forces. Building 332, built in 1961, was originally called Building 171, the Metallurgy Building. In 1967, during a Laboratory-wide renumbering, Building 171 was redesignated Building 332.⁵³³ Building 332 is a single-story building with a loft and basement; it contains 104,682 gross square feet. Its primary purpose, both historically and currently, is to house research and development on plutonium for use in nuclear weapons designs.

Building 332 currently contains forty laboratories, ten mechanical rooms,

forty-eight offices, and two shops. The loft houses all heating, ventilating, and air-conditioning (HVAC) equipment and the basement is used for mechanical and electrical equipment. Building 332 is made of reinforced concrete block with concrete panels on the exterior upper walls.⁵³⁴ Figure 97 is a recent photograph of Building 332.

9.13.2 Mission History

In 1955, when LLNL first proposed the construction of a plutonium facility, only a handful of people at Los Alamos, Hanford, and Argonne national laboratories were conducting research on plutonium. Little was known about plutonium metallurgy at the time. As the Laboratory illustrated in making its case for developing such a research capability, the “critical importance of this material to our defense program means that we must increase this effort

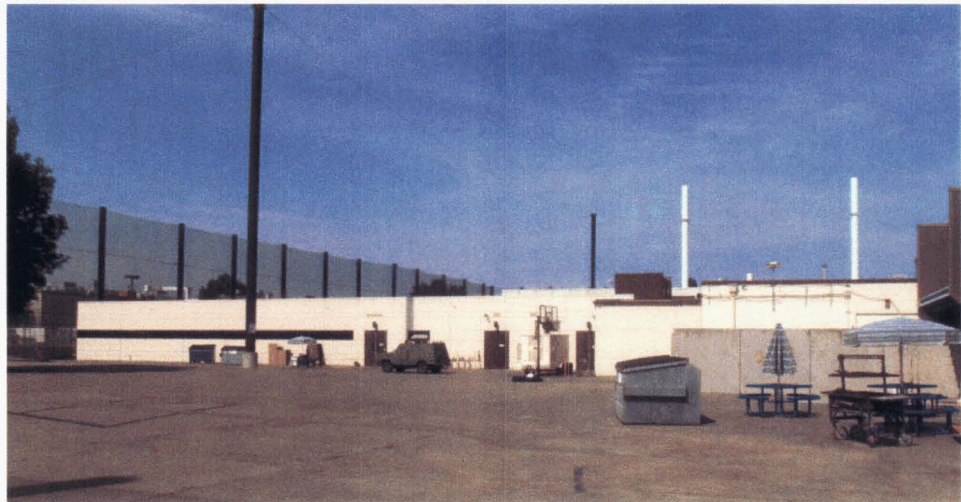


Figure 97. Looking west at Building 332, east elevation, 2003.⁵³⁵

⁵³³ For the sake of clarity, this report will refer to Building 332 by its current designation throughout.

⁵³⁴ Duane Sewell to Fortney Stark, 4 June 1979, Box 486, Folder 4905, LLNL Archives.

⁵³⁵ Building 332, exterior, LLNL photographer, 2003.

markedly. Especially for weapons.”⁵³⁶

Although arguments for efficiency and co-location of research efforts were included in the explication of the need for such a facility, the strongest case lay in the repeated assertion of the lack of similar capabilities on which LLNL could rely.

From 1961 to 1989, the primary mission of Building 332 was the research and development of plutonium and alloys for the weapons program. The Metallurgy Group of the Chemistry Division was the primary user of the facility. Building 332 chemists worked on plutonium alloys, impurities, tensile strength, corrosion inhibition, compounds, and fabrication techniques. The Plutonium Facility staff fabricated and developed parts for test shot devices and tested weapons parts.⁵³⁷ This mission remained constant throughout the 1961–1989 period.

As weapons design work began to slow in the 1980s, Building 332 facilities were also used for the Laser Isotope Separation Program and Centrifuge Research Program. Currently, Building 332 is engaged in plutonium research and development activities for stockpile maintenance.

Period of Significance

From 1961 to 1989, Building 332 engaged in research and development of plutonium for weapons applications. Building 332 handled plutonium for all LLNL nuclear weapon pit design and prototype pit production. LLNL was one of two laboratories that designed and developed nuclear weapons for the

U.S. stockpile. The arms race played a crucial role in the events of the Cold War. LLNL and LANL were responsible for the design of all of the nuclear weapons in the U.S. stockpile. The creation of the U.S. nuclear weapons stockpile is a series of events of exceptional significance in U.S. and world history.

LLNL and LANL used similar equipment and facilities and many of the same processes in plutonium research and development. However, LLNL and LANL made distinct and distinctly important contributions to weapons design. Building 332 represents LLNL’s significant contribution to nuclear weapons design, having contributed to all the LLNL-designed weapons that entered the U.S. stockpile after 1961, including those in the current, enduring nuclear weapons stockpile. In addition to contributing to weapons design, the research in Building 332 also contributed to the development of processes for fabricating plutonium weapon parts, enabling the manufacture of the nuclear weapons for the stockpile. Therefore, plutonium research at LLNL is of exceptional historic interest within the context of the Cold War arms race and the established LLNL preservation themes of Nuclear Weapons Design, Nuclear Weapons Testing, and Nuclear Research.

All plutonium research and development work associated with LLNL’s nuclear weapons design took place in Building 332 during this period. Building 332 scientists studied the chemical properties of plutonium, developed processes for fabricating plutonium weapon parts, and tested all plutonium used in LLNL weapons designs.

⁵³⁶ W. A. Reynolds to H. A. Fidler, 10 September 1955, E. O. Lawrence Declassified Records, Box 4, File 19–10–364, LBNL Archives, 1.

⁵³⁷ Ibid.

9.13.3 Construction History

Building 332 was designed and built in three separate increments over period of nearly two decades.

In 1958, Shaw, Metz, and Dolio, a Chicago architectural firm, designed Increment 1. Increment 1 was a single-story building made of concrete block and pre-cast concrete panels with a flat roof. It had a large fan loft that housed all HVAC and air filtration systems.⁵³⁸ Increment 1 formed the main portion of the building. Rooms on the west side of the building housed a cold instrument machine shop, stores and solution preparation, analysis and X-ray, testing, canning and welding, assembly, machining, casting, and reduction. Separated by a corridor on the east side of the building were rooms for solid recovery, liquid recovery, inspection, assembly, thermodynamics, physical properties, experimental metallurgy, radiography, health chemistry, and a vault. The building also had a decontamination room, locker room, equipment room, and twelve offices.⁵³⁹

In 1968, B. D. Bohna & Company, a San Francisco engineering firm, designed Increment 2, the Microprobe Laboratory. Increment 2 was a small addition on the east side of the building consisting of two laboratories. It was a single-story structure made of concrete block. It had a flat roof and a roof screen.⁵⁴⁰

In 1971, planning began for Increment 3, an addition of approximately 15,000 gross square feet. Plans for Increment 3 were delayed for five years due to the stringent building requirements for plutonium-handling facilities. In 1976, C. F. Braun, an Alhambra architecture firm, completed the design of Increment 3. The addition increased the size of Building 332 by twenty-five percent.⁵⁴¹

Increment 3 was designed to withstand earthquakes, fires, tornadoes, and lightning without releasing any radioactive material. The Plutonium Building was designed to be "one large containment vessel."⁵⁴² To meet these criteria, LLNL Plant Engineering and C. F. Braun designed Increment 3 as a windowless structure of reinforced concrete. Additional safety features included air-lock entrances, sophisticated air filtering systems, a dedicated water supply, and earthquake resistant equipment for processing plutonium.⁵⁴³

Increment 3 was a single-story structure attached to the east side of Building 332. It consisted of four additional laboratories and a control room. A basement housed all mechanical equipment.⁵⁴⁴

Additional modifications and renovations over the years included an upgrade to Increment 1 in 1979, a structural upgrade

⁵³⁸ "Facility 171, Elevations and Sections," 1961, PLZ61-332-004J, PEL.

⁵³⁹ "Facility 171, First Floor Plan," 1961, PLZ61-332-003J, PEL.

⁵⁴⁰ "Microprobe Laboratory Building 332, Plans, Elevations, and Details," 1968, PLZ68-332-002JA, PEL.

⁵⁴¹ "Plutonium Addition Dedicated," *Newsline Weekly Bulletin* (6 October 1976), 1.

⁵⁴² "Plutonium Addition to Cost \$2.9 Million," *Newsline* (February 1972), 2.

⁵⁴³ Ibid.

⁵⁴⁴ "Plutonium Materials Engineering Building 332, First Floor Plan and General Notes," 1971, PLZ71-332-014J, PEL; and "Basement Floor Plan, Legend, Symbols, and Abbreviations," 1971, PLZ71-332-013J, PEL.

to the entire building in 1980, a new air conditioning system in 1986, and an office addition to the south side of the building in 1989. Currently, the air filtration systems and glove-box exhaust system are being renovated. The building's equipment has been upgraded and replaced periodically over the years.

Like most LLNL structures built in the 1950s and 1960s, Building 332 reflects a local expression of the International style. It is devoid of ornamentation and is utilitarian in design. Building 332 is a Cold War LLNL building type referred to as a Heavy Laboratory. It possesses many of the features common to this type—reinforced concrete walls, steel framing, radiation protection, and a flat roof. Additionally, the structure has some features that are designed for the handling of plutonium and other hazardous materials, including thick concrete shielding walls, air-lock doors, and special air filtration systems in Increment 3. Increment 3 was built as a state-of-the-art plutonium-handling facility and its construction reflects its purpose.

9.13.4 Integrity

Building 332 is of exceptional historic interest for its plutonium research and development activities in support of the Cold War arms race and the creation of the U.S. nuclear stockpile during the period 1961–1989. Building 332 also possesses integrity for this period of historic significance. The historic activities conducted in Building 332 were dependent upon the equipment used for processing plutonium. Building 332 still retains some of the original equipment used in

the processing of plutonium. Furthermore, equipment that has been upgraded or replaced is still used in pursuit of the same type of research that is considered of historic interest. Building 332 had and continues to have a consistent mission of exceptional historic interest. Building 332 looks and feels much as it did during its period of historic significance.

9.13.5 Recommendation

Buildings and structures less than fifty years of age are generally not considered eligible for the National Register. Building 332 will not be fifty years of age until 2011.

However, under Criteria Consideration G, properties under fifty years of age can be considered eligible to the National Register if it can be demonstrated that they are of exceptional significance.

The Cold War has been recognized as a period of exceptional significance within U.S. and world history. As established in the discussion of the LLNL Cold War preservation themes, LLNL buildings can be found eligible to the National Register if they played an exceptional role in the development of nuclear weapons for the U.S. nuclear stockpile. The research, development, and production of plutonium for LLNL-designed nuclear weapons is of exceptional significance within the context of the Cold War arms race. Building 332 directly contributed to the design of the physics package of every LLNL-designed nuclear weapon placed in the U.S. stockpile during the period of significance (1961–1989). Therefore, Building 332 is of exceptional historic significance as defined within the LLNL Cold War preservation themes Nuclear Weapons Design (subtheme Weapons Design) and Nuclear Weapons Testing (subtheme HE Testing).

Building 332 does not qualify for National Register consideration under Criterion B, association with a historic figure; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. Building 332 is not, nor will it be, an important source of historical information. The plutonium research activities that occurred there are documented in research reports and archival collections.

However, Building 332 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War design of nuclear weapons for the U.S. stockpile. The particular period of historic significance for these activities within this structure is 1961–1989.

Building 332 also qualifies for National Register consideration under Criterion C, exceptional design or architectural significance. Increment 3 of Building 332, designed in 1976, represented a state-of-the-art plutonium handling facility with features that directly represent the work of historic interest that occurred there. While the building's design features are not unique, Increment 3 is an excellent example of the period's hazardous confinement design and is of historic interest. The period of historic interest for Building 332's design significance is 1976–1989.

Building 332 possesses integrity for the periods of significance. It is recommended that the building be considered eligible for the National Register. While individual elements of the structure and the equipment it contains are not themselves eligible as

solitary items, together they contribute to an overall structure of historic interest. Contributing elements to historic interest for Criterion A are the Cold War-era milling and machining equipment, furnaces and ovens for creating and shaping products,⁵⁴⁵ the Cold War-era founding and casting equipment, and the original steel vault doors in Increment 1.

Contributing elements to exceptional design significance include the special design features of Increment 3—thick concrete shielding walls, door locks, renovated air-filtration system, dedicated water supply, and earthquake resistant plutonium-handling equipment.

⁵⁴⁵ As the tour of Building 332 did not allow for viewing of the milling and machining equipment, the decision was made to include all such pre-1990 equipment as contributing elements to the overall reflection of the historic activity that took place in the facility. The specific property related to milling, machining, and product shaping dating from the Cold War era is identified by the LLNL Sunflower Assets Property Identifier, name, purchase date, and serial number as follows:

- 1376294, Lathe, 1968, 49649
- 1431115, Universal Milling Machine, 1977, 5776108
- 1431276, Lathe, 1962, 9050014
- 3571215, Lathe, 1962, no serial number; located in Room 1309
- 4181079, Lathe, 1960, 2D1425
- 4181116, Milling Machine, 1983, 231468
- 4199609, Welder, 1964, 204
- Metal Band Saw 290-8312444
- Drill Press 294354
- 4242411, Refractory Furnace, 1983, no serial number, located in Room 1010
- 4293529, Lathe, 1959, 2F1114
- 4293659, Numerical Control Lathe, 1962, 3630
- 4396848, Lathe, 1983, no serial number, located in Room 1353
- 4501501, Milling Machine, 1986, 244647
- 4814526, Lathe, 1987, 14C-507
- 8517010, Induction Furnace, 1986, no serial number, located in Room 1010
- 8517027, Induction Furnace, 1987, no serial number, located in Room 1010
- 8517331, Vacuum Oven, 1984, 0133142169

9.14 Building 381

9.14.1 Description

Building 381 is located on the LLNL main site, north of the North Inner Loop Road and east of the North Outer Loop Road. It currently houses offices and laboratories for the National Ignition Facility (NIF) and Inertial Confinement Fusion (ICF) programs. It was first built in 1975 and called the Laser Fusion Laboratory. Over the years, it has housed the Argus, Novette, and Beamlet laser systems, as well as other laser research. Figure 98 is a recent photograph of Building 381.

Building 381 is made of three distinct segments: a two-story, three-wing office area; a mechanical equipment area; and a two-story laboratory area. The office segment of the building is made of solar-tinted glass and has three wings to the east, south, and west. The mechanical equipment

area connects the offices to the laboratory portion of the building and is the north wing of the office complex. The laboratories are located in an east and west high bay, a low bay of laboratories, and a basement under the high bay containing more laboratories. The laboratory and mechanical equipment areas have exterior walls made of pre-cast concrete panels. The entire structure has a flat, built-up roof over insulating concrete on a metal deck.⁵⁴⁶ Building 381 currently houses five computer laboratories, twenty-four laboratories, eleven utility rooms, and one hundred seventy offices.

9.14.2 Mission History

Building 381 was built in 1975 as the Laser Fusion Laboratory. Building 381 was the first dedicated laser laboratory building at LLNL. It contained special environments that controlled such adverse factors to laser operation as vibration, humidity, air flow,



Figure 98. Looking north at Building 381, west and south wings, 2003.⁵⁴⁷

⁵⁴⁶ Walter Wajda, *Hazards Analysis Report Building 381 National Ignition Facility (NIF) Programs* (Livermore: Lawrence Livermore National Laboratory, 2002), 3–5.

⁵⁴⁷ Building 381 exterior, LLNL photographer, 2003.

dust, temperature, and noise. The building was intended to house a variety of basic laser research and the development of prototype systems. The building was not designed for any specific laser system but rather with an eye toward flexibility. Types of work planned for the facility included the development of high-energy glass lasers, laser/plasma interaction experiments, and the construction of multi-beam laser systems for plasma studies.⁵⁴⁸

The first laser system in the building was the Argus laser, which was housed in the high-bay portion of the laboratory wing of Building 381. The Argus laser began operation in 1976 and was in operation until 1982. The Argus was a two-arm laser used to study laser/target interactions and laser propagation limits. In the 1980s, the Argus laser demonstrated improved coupling—a necessary requirement for the success of later-generation lasers.⁵⁴⁹

In 1983, the Novette laser system came online in Building 381. The Novette laser system demonstrated the efficient coupling of higher-harmonic laser light to fusion targets and created the first soft X-ray laser. The Novette laser was a prototype for the Nova laser built in Building 391, the High Energy Laser Facility. The Novette and Nova laser experiments of the 1980s demonstrated characteristics necessary for ICF ignition.⁵⁵⁰

After the Nova experiments ended in the mid-1980s, the high-bay portion of the building was used as a staging area for the

ICF Imaging and Detection Program. In 1985, the basement was modified for the Neutron Laboratory.

In 1992, the Beamlet laser system was installed in the high bay. In 1997, the Mercury laser system was installed in the low-bay laboratory portion of the building. In 1998, the high bay was renovated as the NIF assembly area.

The office wing of the building housed administrative and staff personnel associated with various laser programs from 1975 to the present.

Period of Significance

From 1975 to the present, Building 381 has housed basic laser research and prototype laser systems used for testing new concepts in the ICF program. It has also housed most administrative and scientific personnel associated with the ICF program. LLNL made several historic breakthroughs in ICF research in the 1970s and 1980s. The Argus and the Novette prototype laser systems were integral in developing the Shiva and the Nova lasers, which represented significant breakthroughs in laser research. Therefore, Building 381 is of historic interest for its development of prototype laser systems within the LLNL Cold War context preservation themes and subtheme of Nuclear Research, subtheme Physics Research. The period of significance for these activities is 1975–1982.

⁵⁴⁸ *Laser Program: Annual Report, 1975*, 13.

⁵⁴⁹ *Physics and Advanced Technologies: 2001 Annual Report*, 65.

⁵⁵⁰ *Ibid.*

9.14.3 Construction History

Construction of Building 381 was completed in 1975. Norman Engineering, a Los Angeles firm, designed Building 381 as three separate but connected buildings or segments.

The first segment was a three-wing, two-story office complex with wings facing east, south, and west.⁵⁵¹ The office segment of Building 381 was made of solar-tinted glass and had a much more modern aesthetic than previous LLNL buildings.

The second segment of Building 381 is the mechanical equipment area. It was made of pre-cast concrete exterior panels. The interior housed bays for air conditioning, heating, electrical switchgear, and building ventilation.

The mechanical equipment area joins the laboratory segment of the building to the office segment of the building.

The third segment of the building consists of a low-bay laboratory area immediately north of the mechanical equipment segment of the building and a high-bay laboratory space on the far north of the structure.

In 1976, a small diagnostic shed for the Argus laser system was designed by LLNL Plant Engineering and added to the far northeast end of the high-bay portion of the building. It was a corrugated-metal building with a sloped roof.⁵⁵²

Modifications to Building 381 have consisted primarily of internal renovations to the

laboratories to accommodate new laser systems and programs. Similarly, the office areas have been renovated over the years as program staff has moved in and out.

In 1981, Ruth and Going, a San Jose architectural and engineering firm, designed a glass and steel addition with a connecting bridge to Building 481.⁵⁵³ The addition originally provided offices for the Nova Program.

Building 381, one of the few permanent structures built at LLNL during the 1970s, followed the dictates of the 1968 Royston Plan. It was built on one of the large plots of land set aside to accommodate future construction for the laser program. It was also surrounded by pedestrian walkways and landscaping—an attempt in the 1970s to create a more campus-like atmosphere.

Building 381 is an industrial expression of the International style with a slight emphasis on the more aesthetic qualities of high-style architecture common in California during the 1970s and 1980s. It featured separate but connected buildings—a laboratory, office, and equipment building. The structure featured banks of windows made of one-way glass. However, these features are not so much representative of high-style architecture as reflective of the Royston Plan's emphasis on improving the aesthetic quality of the LLNL work environment.

Building 381 is a combination of two LLNL Cold War building types—the

⁵⁵¹ "Building 381 Laser Fusion Laboratory, High-Bay Partition and Curtain, Floor Plan and Section," 1975, PLA75-381-001DA, PEL.

⁵⁵² "Building 381 Argus T.O.F. Diagnostic Facility, Plan, Elevation, and Sections," 1976, PLA76-381-002D, PEL.

⁵⁵³ "Fusion Experiments Analysis Facilities, First and Second Floor Plan," 1981, PLZ81-381-004J, PEL.

Heavy Laboratory and the Permanent Office Building. It possesses characteristics common to both types. The Heavy Laboratory portion of the building possesses high bays, reinforced concrete walls, steel framing, radiation shielding, and a flat roof. The Permanent Office portion of the building possesses multistories, masonry walls, a steel frame, office space, and windows.

In addition to these features, Building 381 also possesses architectural features built to accommodate the laser research that occurred there. The building was built on an isolated floor slab to eliminate vibration.⁵⁵⁴ Norman Engineering also designed special systems to control the dust and humidity. These features facilitated the precise alignments between lasers and their targets and also lengthened the life of laser components.⁵⁵⁵ However, these features are common in a variety of work environments that require controlled conditions, including laser, medical, and computer research.

9.14.4 Integrity

Building 381 is of historic interest for its basic laser research and the development of important prototype laser systems for the Shiva and the Nova lasers. The Argus and the Novette laser systems contributed important information for the successful operation of later-generation lasers. The period of historic significance for the Argus and Novette research is 1975–1982.

However, Building 381 no longer possesses historic integrity for its period of significance. In this case, historic integrity depends

on the retention of the equipment used in Argus and Novette laser research. The Argus laser system was dismantled in 1981 and the Novette laser system in the mid-1980s. Building 381 no longer reflects any of the Argus or Novette laser research that occurred there.

9.14.5 Recommendation

Building 381 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. The building's design is architecturally undistinguished. It does not reflect the work of historic interest that occurred there. Building 381 is not, nor will it be, an important source of historical information. The laser research that occurred there is documented in research reports and archival collections.

Building 381 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War prototype laser research in support of the ICF program. The particular period of historic significance for these activities within this structure is 1975–1982.

However, Building 381 no longer possesses integrity for the period of its historic significance. Therefore, Building 381 is not eligible for the National Register under Criterion A.

⁵⁵⁴ "Laser Fusion Lab to be Built," *Newsline* (April 1973), 5.

⁵⁵⁵ "More About the Laser Building," *Newsline* (September 1974), 2.

9.15 Building 391

9.15.1 Description

Building 391 is located on the LLNL main site, in the north central section of the property. Currently the Nova Facility, Building 391 was built in 1976 as the High Energy Laser Facility. It housed the Shiva and the Nova lasers, as well as basic laser research. It has also housed administrative and scientific staff for the ICF Program. Currently, it houses a variety of support programs for the NIF. Figure 99 is a recent photograph of Building 391.

Building 391 is a three-story concrete and steel structure with a combination of offices, laboratories, and machine rooms. It contains 186,596 gross square feet and houses eighty-four laboratories, nineteen utility rooms, sixteen offices, three shops, and three computer laboratories.

9.15.2 Mission History

As the High Energy Laser Facility, Building 391 provided “the basic structure and supporting equipment necessary for developing a laser system capable of providing 10^4 joules onto a laser-fusion target.”⁵⁵⁶ It was built to house the scaled-up versions of the successful prototype systems designed in Building 381. The first full-scale laser housed in Building 391 was Shiva, a twenty-beam laser system. In 1977, Shiva was the most powerful laser system in the world, delivering 10.2 kilojoules of energy in less than a billionth of a second. In 1979, Shiva compressed fusion fuel to a density fifty to a hundred times greater than its liquid density. Shiva provided more power, better fuel compression, higher temperatures, and more control than any previous laser system.

Beginning in 1981, work began in Building 391 on Nova, the next full-scale laser



Figure 99. Looking west at Building 391, east elevation, 2003.⁵⁵⁷

⁵⁵⁶ “Lawrence Livermore Laboratory High Energy Laser Facility,” unpublished paper, 10 March 1972, Box 436, Folder 4347, LLL High Energy Laser Facility Plan, LLNL Archives.

⁵⁵⁷ Building 391, exterior, LLNL photographer, 2003.

system. Nova became fully operational in 1985. It was a ten-beam laser system capable of producing 100 to 150 kilojoules of energy in three nanoseconds. Nova was capable of converting the fundamental laser wavelength to its second and third harmonies.⁵⁵⁸ Nova operated from 1985 to 1999. In 1986, Nova produced ten-trillion neutrons during a fusion burst, setting a world record.⁵⁵⁹ Nova demonstrated the feasibility of ICF ignition.

Since 1999, Building 391 has been renovated to house a variety of support programs for the NIF program, including flash lamp inspection and testing, power conditioning system prototype module testing, amplifier testing, capacitor testing, optics processing, potassium dihydrogen phosphate (KDP) crystal processing, analytical X-ray laboratory, and various other laser research.

Period of Significance

From 1976 to 1999, Building 391 housed ICF laser research. Specifically, it housed two of LLNL's most important lasers—Shiva and Nova—both of which made important scientific breakthroughs in ICF research. The Shiva laser demonstrated fusion fuel compression 100 times greater than the fuel's liquid density. It was the most powerful laser in the world at the time. Its period of historic significance is 1970–1981.

The Nova laser operated for nineteen years. It demonstrated the feasibility of ICF ignition and exceeded the power levels of Shiva by at least a factor of ten. The period of its historic significance is 1985–1999.

⁵⁵⁸ "Nova Laser Facility," *Energy and Technology Review* (July 1984), 41.

⁵⁵⁹ "Laser Research," *Energy and Technology Review* (June/July 1986), 37.

Therefore, Building 391 is of historic interest for its development of breakthrough laser systems within the LLNL Cold War context preservation theme of Nuclear Research, subtheme Physics Research. The periods of significance for these activities are 1977–1981 and 1985–1999.

9.15.3 Construction History

Building 391 was constructed in two separate increments.

In 1974, Norman Engineering, a Los Angeles firm, designed Increment 1 of Building 391. Increment 1 had approximately 66,000 square feet. It was a high-bay structure built of pre-cast concrete, cast-in-place concrete, and painted steel panels over a steel frame.⁵⁶⁰ The interior included a basement and main floor. The building had five main spaces: a main laser bay, target room, energy storage area, laboratory area, and building support systems. The laser bay, measuring fifty-feet wide by one-hundred-sixty-feet long, was on the first floor. It had a twelve-inch thick concrete floor and was framed and sheathed in steel. The target room, sixty feet square and sixty-five feet high, was located in the basement. It had substantial radiation shielding—concrete walls four feet thick and a concrete ceiling two feet thick. The laboratories were housed in a one-story wing on the south side of the laser bay and target room on the ground level.⁵⁶¹

⁵⁶⁰ "High Energy Laser Building 391, North and South Elevations," 1974, PLZ74-391-034JA, PEL; and "High Energy Laser Building 391, East and West Elevations," 1974, PLZ74-391-035JA, PEL.

⁵⁶¹ University of California Lawrence Livermore Laboratory, *Laser Program Annual Report, 1976*, UCRL-50021-76 (Livermore: Lawrence Livermore Laboratory, 1976), 1.6; "High Energy Laser Building 391, First Floor Plan," 1974, PLZ74-391-027JA, PEL; and "High Energy Laser Building 391, Basement Floor Plan," 1974, PLZ74-391-027JA, PEL.

In 1976, Norman Engineering designed Increment 2 of Building 391. Increment 2 was an almost mirror image of Increment 1, adding 84,000 square feet of space to the structure. Increment 2 was a high-bay structure with a one-story wing along the south end for laboratory and office space. The high-bay area housed the target room, seventy-five feet square. Figures 100 and 101 depict the frame for the target and the target chamber doors.

The laser bay was about sixty feet longer than the one in Increment 1. Figure 102 depicts the remaining optics and frame of the Nova laser.

A basement below the laser bay housed the energy storage system and plasma diagnostics. Additionally, a laminar clean room

was located adjacent to the laser bay to assemble laser components.⁵⁶² Construction of Increment 2 was completed in 1981.

Modifications to the building have consisted primarily of the renovation of laboratory space for newer laser programs and support laboratories. In particular, the west side of the building was renovated after Shiva was dismantled in 1981.

In 1990, a petawatt chamber and large aperture neutron scintillator array were added to the target chamber of the Nova laser. Figure 103 depicts the petawatt chamber.

Little modification has occurred to the east wing of the building that housed Nova. It was built specifically to house Nova and



Figure 100. Building 391, Nova target chamber, 2003.⁵⁶³

⁵⁶² University of California Lawrence Livermore Laboratory, *Laser Program Annual Report, 1975*, UCRL-50021-75 (Livermore: University of California Lawrence Livermore Laboratory, 1976), 14.

⁵⁶³ Building 391, Nova target chamber, Todd Coble, 2003.

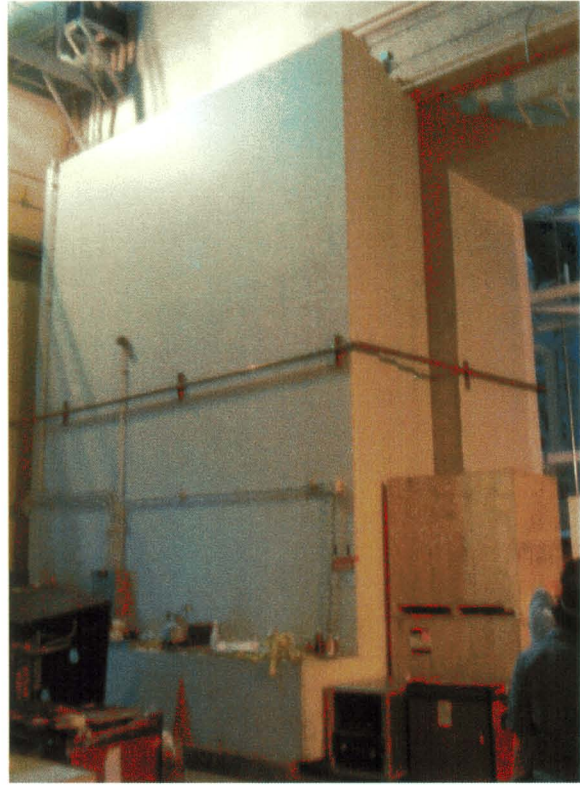


Figure 101. Building 391, Nova target chamber door, 2003.⁵⁶⁴



Figure 102. Building 391, remains of Nova laser, 2003.⁵⁶⁵

⁵⁶⁴ Building 391, Nova target chamber door, Todd Coble, 2003.

⁵⁶⁵ Building 391, Nova optics and frame, Todd Coble, 2003.



Figure 103. Building 391, Nova petawatt chamber, 2003.⁵⁶⁶

would be too costly to renovate. Nova ceased operations only in 1999 and much of the laser equipment remains in the building.

Building 391, one of the few permanent structures built during at LLNL during the 1970s, followed the dictates of the 1968 Royston Plan. It was built on one of the large plots of land set aside to accommodate future construction for the laser program. It was also surrounded by pedestrian walkways and landscaping—an attempt in the 1970s to create a more campus-like atmosphere.

Building 391 is an Industrial Vernacular expression of the Modernist style with a slight emphasis on the more aesthetic qualities of high-style architecture common in California during the 1970s and 1980s. It was largely unadorned and functional yet featured ribbed concrete walls and arbitrary

combinations of geometrical shapes. However, these features are by no means representative of high-style architecture but instead reflect the Royston Plan's emphasis on improving the aesthetic quality of the LLNL work environment.

Building 391 is an LLNL Cold War building of the Heavy Laboratory type. It possesses features common to this type—high bays, reinforced-concrete walls, steel framing, radiation shielding, and a flat roof. In addition to these features Building 391 also possesses unique architectural features that reflect the specific laser research of historic interest that occurred there. In particular, the target bays of both increments had unusually thick concrete shielding—twenty-four to forty-eight inches thick in both the walls and ceiling. In Increment 2, the target bay built for the Nova laser has fifty-ton doors on rails to seal in the target chamber, a non-load-bearing floor, and a laser frame that is sunk into the bedrock. These features

⁵⁶⁶ Building 391, petawatt chamber, Todd Coble, 2003.

specifically reflect the laser research that occurred there.

9.15.4 Integrity

Building 391 is of historic interest for its breakthroughs in ICF laser research on the Shiva and the Nova lasers. From 1977 to 1981, Shiva was the most powerful laser in the world, demonstrating the compression of fusion fuel to 100 times greater density than in its liquid state. From 1985 to 1999 the Nova laser demonstrated the feasibility of ICF ignition, setting world records in power and neutron generation.

Building 391 no longer possesses historic integrity for its 1977–1981 period of significance. The Shiva laser system was dismantled in 1981 and the laboratory space renovated for subsequent programs. Building 391 no longer reflects any of the Shiva laser research that occurred there.

Building 391 does retain historic integrity for the 1985–1999 period, however. The Nova

laser is sufficiently intact to reflect the breakthrough research that occurred in the east wing of Building 391. Both the laser bay and target room have enough equipment left to represent Nova's design and historic mission. The frame and many of the optics and amplifiers of the Nova laser still remain in the laser bay. Although the Nova target chamber has been moved to France, the target room is much as it was during Nova's operation. The petawatt chamber is still in the target chamber. The large aperture scintillator array pit is beneath the target chamber floor. The former control room on the first floor and the visitor areas also reflect the period of historic significance. Although the control panel has been removed, a mural of the Nova laser beam still remains. Figure 104 depicts the laser mural in the former control room.

The visitor areas also still possess educational exhibits from the Nova laser experiment. The east wing of Building 391 looks much as it did during its period of historic significance.



Figure 104. Building 391, Nova control room, laser mural, 2003.⁵⁶⁷

⁵⁶⁷ Building 391, Nova control room, Todd Coble, 2003.

9.15.5 Recommendation

Buildings and structures under fifty years of age are generally not considered eligible for the National Register. Building 391 will not be fifty years of age until 2026.

However, under Criteria Consideration G, properties under fifty years of age can be considered eligible to the National Register if it can be demonstrated that they are of exceptional significance.

The Cold War has been recognized as a period of exceptional significance within U.S. and world history; LLNL's laser research has been critical in the development of U.S. Cold War physics research, particularly in the area of ICF. Therefore, as Building 391 meets the threshold for historic significance within the established LLNL Cold War preservation theme of Nuclear Research, subtheme Physics Research, it is of exceptional significance.

Building 391 does not qualify for National Register consideration under Criterion B, association with a historic figure; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. Building 391 is not, nor will it be, a source of important historical information. The laser research that occurred there is documented in research reports and archival collections.

Building 391 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War breakthrough ICF laser research that occurred on the Shiva and the Nova lasers. The particular period of historic significance for these activities

within this structure is 1977–1981 for the Shiva laser and 1985–1999 for the Nova laser.

Building 391 no longer possesses integrity for the 1977–1981 period of historic significance. Therefore, Building 391 is not eligible for the National Register under Criterion A, for its 1977–1981 period.

However, Building 391 does possess integrity for the 1985–1999 period of historic significance. The east wing of Building 391, which at 84,000 gross square feet represents more than half of the entire structure, possesses sufficient integrity to reflect the scientific breakthroughs in ICF research that occurred on the Nova laser. Contributing elements of historic interest under Criterion A include the laser frame, optics, and amplifiers left in the Nova laser bay (Room 1340); the petawatt compression chamber, large-aperture neutron scintillator array pit, and high-energy electron detector in the Nova target bay (Room B225); the capacitor banks (Room B350); the mural in the control room (Room 1302A); and the viewing room (Room 1310).

Building 391 also qualifies for National Register consideration under Criterion C, exceptional design or architectural significance. Building 391 was built as a dedicated laser facility for both the Shiva and the Nova lasers. The design of Building 391 reflects the laser research of historic interest that occurred there. Contributing elements to design significance under Criterion C include the shielding in the target bays, the flooring in the Nova laser bay, the frame of the Nova laser, the construction of the target mount in the Nova target bay, and the fifty-ton doors in the Nova target bay.

9.16 Building 423

9.16.1 Description

Building 423 is located on the LLNL main site, east of Southgate Drive and north of the South Outer Loop. It is currently a machine shop. Building 423 was built in 1953 as part of the Project Sherwood complex. It was originally designated Building 158 and housed the research power supply for Building 431. In 1967, during a Laboratory-wide renumbering, Building 158 was redesignated Building 423.⁵⁶⁸ During the 1970s and 1980s, Building 423 also housed accelerator and beam research. Figure 105 is a recent photograph of the structure.

Building 423 is a single-story, L-shaped structure. It is a steel-framed, corrugated-metal building with a pitched roof. It has banks of windows on the west elevation and personnel doors on the west and north

elevations. Building 423 currently houses three industrial shops, one laboratory, five utility rooms, three offices, and one service shop.

9.16.2 Mission History

From 1953 to 1978, Building 423 acted primarily as a support structure for Building 431 and other Project Sherwood buildings. It housed the research power supply for experiments connected to magnetic mirror research.

In 1976, Stanford University demonstrated one of the first free-electron lasers (FELs), “a device for extracting intense laser like light from a beam of electrons.”⁵⁶⁹ LLNL began research on FELs shortly thereafter, and, in 1978, Building 423 was modified for free-electron beam research. LLNL’s beam research focused on two primary avenues,



Figure 105. Looking northwest at Building 423, south and east elevations, 2003.⁵⁷⁰

⁵⁶⁸ For the sake of clarity, this report will refer to Building 423 by its current designation.

⁵⁶⁹ Lawrence Livermore National Laboratory, *The ELF Electron Laser Facility* (Livermore: Lawrence Livermore National Laboratory, 1987), 1.

⁵⁷⁰ Building 423, exterior, LLNL photographer, 2003.

the propagation of electron beams through the atmosphere and the development of high-current, high-energy electron accelerators.⁵⁷¹

In the 1980s, LLNL's beam research became part of the Strategic Defense Initiative organization's effort to develop a directed-energy defense against ballistic missiles.⁵⁷²

Building 423, the Accelerator Research Center (ARC) housed a small two-MeV electron accelerator, the High Brightness Test Stand, approximately eight feet long. The High Brightness Test Stand sat in the bottom of a tiled pit, which was flooded with water during operation to shield technicians from radiation.⁵⁷³

The ARC researched and developed "brighter electron sources, high repetition rates, and high-average-power nonlinear magnetic drivers."⁵⁷⁴

These advances in accelerator design were later incorporated into successive generations of LLNL accelerators—the Experimental Test Accelerator (ETA) and the Advanced Test Accelerator (ATA).

Building 423 was one of three facilities dedicated to beam research at LLNL. The

other two facilities were Building 431, which housed the ETA, and Building 865, which housed the ATA.⁵⁷⁵

In 1979, LLNL designed the ETA and installed it in the south wing of Building 431. The ETA was a prototype accelerator designed as a directed-energy weapon.⁵⁷⁶

In 1983, LLNL built a larger and more energetic accelerator, the ATA, at Site 300 in Building 865. The beam of the ATA was used as a driver for a FEL. The ATA was the most powerful induction linear accelerator in the world at the time of its development.

In 1987, LLNL installed a new induction linear accelerator, the ETA II, to conduct further FEL studies and to power a FEL to heat plasma in the Microwave Tokamak Experiment (MTX), also located in Building 431.⁵⁷⁷ In 1992, the ETA II was dismantled. In 1997, scientists refurbished the ETA II for use in advanced radiographic experiments for stockpile stewardship.⁵⁷⁸

Building 423 housed accelerator research until 1997, when it was renovated into a machine shop.

⁵⁷¹ Lawrence Livermore National Laboratory, *Induction Accelerator and Free-Electron Laser Development—1986–1987*, LLL-TB-86 (Livermore: Lawrence Livermore National Laboratory, 1986), 1.

⁵⁷² Ibid.

⁵⁷³ "High Brightness Test Stand," photograph, Box 183, Folder 11294, LLNL Archives.

⁵⁷⁴ Lawrence Livermore National Laboratory, *Beam Research Program*, LLL-TB-97 (Livermore: Lawrence Livermore National Laboratory, 1988), 1.

⁵⁷⁵ Building 431 primarily housed magnetic fusion research. It has been previously assessed and found of historic interest under Criterion A for its contributions to magnetic fusion research during the period 1954-1992. However, it no longer possesses integrity for the period of its historic significance. Building 865, located at Site 300, was built specifically to house the ATA. It has been assessed for historic significance in this report and found to be of historic interest under Criterion A, because of its contributions to accelerator design and research for the period 1983-1990 and eligible for National Register consideration. It is also eligible under Criterion C for its interesting design elements.

⁵⁷⁶ *Serving the Nation for Fifty Years*, 23; and *Experimental Test Accelerator (ETA)*.

⁵⁷⁷ "New Linear Induction Accelerator," 58–59; and "Microwave Tokamak Experiment," 48–49.

⁵⁷⁸ J. T. Weir et al., *ETA II Experiments for Determining Advanced Radiographic Capabilities of Induction Linacs*, 1.

Period of Significance

As noted above and in the Context Statement, LLNL made several important breakthroughs in accelerator technology with special applications to weapons development. From 1978 to 1997, Building 423 housed accelerator research in support of the LLNL Beam Research program. From 1985 to 1997, Building 423, as the ARC, made advances in high-brightness electron sources and klystron research, which were important to the continuing development of the ETA and the ATA accelerators. The ATA is considered an important scientific breakthrough in accelerator technology for its directed-energy weapon application. Therefore, Building 423 is of historic interest for its FEL research in support of the ETA and the ATA accelerators within the LLNL Cold War context preservation theme of Nuclear Research, subtheme Physics Research. The period of historic significance for this research is 1985–1997.

9.16.3 Construction History

Building 423 was built in 1953 to house the energy supply for Project Sherwood. It was an L-shaped, steel-framed, corrugated-metal Butler-type building with a flat roof. It had banks of paned windows on the west elevation and personnel doors on the north and west elevations.

In 1978, LLNL Plant Engineering renovated Building 423 for beam research. A pit for beam research was dug in the floor of the south wing of the building.⁵⁷⁹

In 1981, Associated Professions Incorporated, a Livermore architectural and engi-

neering firm, designed an addition to the west side of Building 423, transforming the L-shaped structure into a rectangle.⁵⁸⁰

In 1984, a tile pool was installed in Building 423 for the High Brightness Test Stand accelerator.⁵⁸¹ Figure 106 depicts the tile pool for the High Brightness Test Accelerator.

In 1997, the building was renovated for use as a machine shop.

Building 423 is a corrugated-metal industrial building of undistinguished architectural design. It does not represent high-style architecture. It is typical of structures found in countless industrial and military settings across the country. Building 423 is an LLNL Cold War building of the Metal Butler type. It possesses features characteristic of this kind of structure. It has a single-story, prefabricated steel rigid-frame structure, reinforced-concrete slab, corrugated-metal siding and roofing, and space for short-term experiments or shops.

9.16.4 Integrity

Building 423, although of historic interest for its accelerator research in support of the LLNL Beam Research program between the years of 1985 and 1997, no longer possesses historic integrity. Building 423 no longer possesses the High-Brightness Test Stand accelerator used in beam research. The only remnant of this work is the tiled pool that housed the accelerator. Building 423 no longer reflects the beam research that occurred there.

⁵⁷⁹ "Building 423 Building Modification for Beam Research, Floor Plan," 1978, PLA78-423-001D, PEL.

⁵⁸⁰ "Building 423 Expansion Project, Site Plan," 1981, PLZ81-423-001JA, PEL.

⁵⁸¹ "Building 423 Pool Construction, Plans, Sections," 1984, PLA84-423-001D, PEL.

9.16.5 Recommendation

Building 423 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. The design of the building is of no architectural interest. It is an undistinguished example of an industrial building and does not reflect the historic activities it housed. Building 423 is not, nor will it be, a source of important historical information. The beam research that occurred there is documented in research reports and archival collections.

Building 423 qualifies for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War klystron research and development of bright electron sources for beam research for the ETA and the ATA accelerators. The particular period of historic significance for these activities within this structure is 1985–1997.

Building 423 no longer possesses integrity for the period of its historic significance. Therefore, Building 423 is not eligible for the National Register under Criterion A.

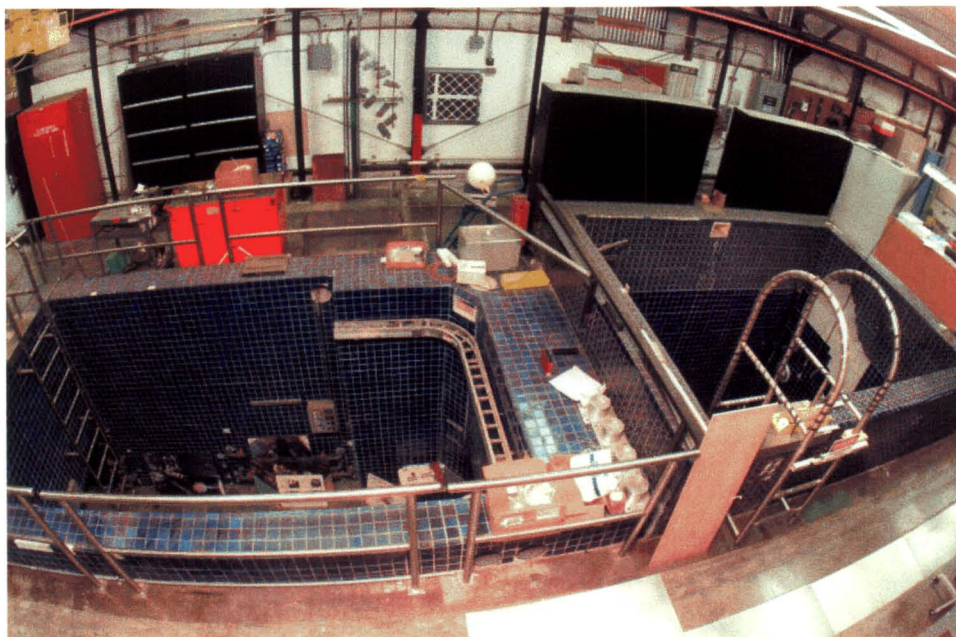


Figure 106. Building 423, tile pool, 2003.⁵⁸²

⁵⁸² Building 423, tile pool, LLNL photographer, 2003.

9.17 Building 435

9.17.1 Description

Building 435 is located on the LLNL main site, east of Southgate Drive and south of the South Inner Loop. It is currently the Fusion Research Laboratory. It was built in 1960 as Building 180, part of the Sherwood Complex. In 1967, during a Laboratory-wide renumbering of facilities, Building 180 was redesignated Building 435.⁵⁸³ In 1951, the AEC established Project Sherwood to explore the possibility of harnessing thermonuclear fusion for energy applications. LLNL became involved in Project Sherwood in 1952. Building 435 housed a succession of Sherwood research machines, including Alice, Baseball I, Baseball II, 2X, 2XII, 2XIIB, Tandem Mirror Experiment (TMX), and the TMX-Upgrade. Building 435 still houses fusion research. Figure 107 is a recent photograph of Building 435.

Building 435 is a corrugated-metal, high-bay building three stories high. It has a roll-up door on the east side and one-story wings to the north and south. A bridge on the third floor connects to Building 436. Building 435 is 54,179 gross square feet. It houses thirty-three laboratories, thirteen mechanical utility rooms, two service shops, and nine offices.

9.17.2 Mission History

In 1952, LLNL began work on Project Sherwood, a program to achieve controlled thermonuclear fusion for power. Project Sherwood was a multi-laboratory, AEC-sponsored program. Several different avenues to solving the problem of controlled thermonuclear fusion were pursued simultaneously at LLNL, LBNL, LANL, Oak Ridge National Laboratory, the Naval Research Laboratory, New York University, Massachusetts Institute of Technology, and Princeton University.

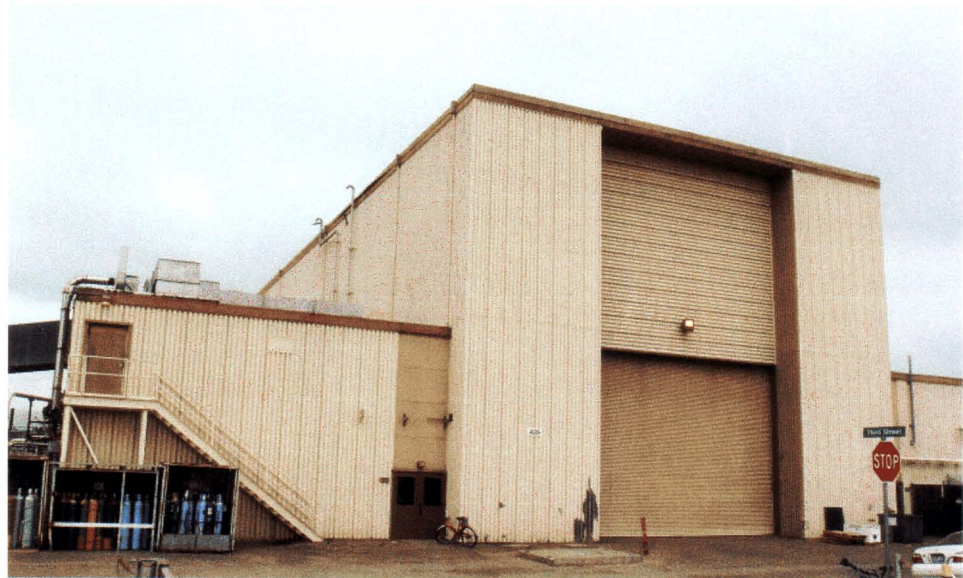


Figure 107. Looking east at Building 435, west elevation, 2003.⁵⁸⁴

⁵⁸³ For the sake of clarity, this report will refer to Building 435 by its current designation.

⁵⁸⁴ Building 435, exterior, LLNL photographer, 2003.

LLNL pioneered what became known as the magnetic mirror concept. The magnetic approach attempted to confine plasma in a straight tube with an external axis magnetic field. From 1952 to 1986, LLNL built a succession of magnetic mirror machines that had varying levels of success at confining and heating plasma to the temperature necessary to achieve a sustained fusion reaction.

In 1952, Building 212 housed the first magnetic mirror machines. In 1954, Sherwood work moved over to Building 431, which formerly housed E. O. Lawrence's MTA project. In 1959, Building 435 was constructed to house the growing program.

Building 435 was initially built to house the Adiabatic Low-Energy Injection and Capture Experiment (ALICE). This machine was intended to confine plasma in a magnetic bottle created by two strong magnetic fields. Neutral deuterium atoms were injected into a chamber, where they would be ionized, trapped, and formed into a very hot plasma.⁵⁸⁵ The ALICE machine was active in Building 435 from 1960 to 1965. In 1965, a major change was made to the magnetic field on the ALICE experiment by placing the magnets in a baseball configuration, so-called because its surface texture resembled the seams of a baseball. The succeeding machines, Baseball I and Baseball II, operated in Building 435 until 1975.

In 1963, the main experimental high bay of Building 435 was remodeled to accommodate the 2X, another magnetic mirror

machine. The 2X machine was the lineal descendent of Toy Top, the 1960 experiment that first successfully confined and heated plasma in a mirror system at LLNL. The 2X was the third Toy Top machine; it was moved from Building 431 to Building 435 in 1963.

In 1968, the 2X made a significant breakthrough in fusion research. It overcame plasma instabilities by "evaporatively coating the vacuum chamber walls with a thin, clean, titanium metal surface that removed impurity atoms by surface absorption."⁵⁸⁶

In 1969, the 2X machine was replaced by the 2XII. In 1973, the 2XII machine was replaced with the 2XIIB. In 1975, the 2XIIB machine made the next breakthrough in fusion research at LLNL—successfully confining and heating plasma to the required temperature, density, and duration necessary for fusion.⁵⁸⁷ The 2XIIB accomplished this through the addition of cold plasma near the ends of the device.⁵⁸⁸

In 1977, the success with the 2XIIB led to the creation of another mirror machine, the TMX. In 1980, the TMX succeeded in creating a thermal barrier at the ends of the machine by heating electrons to retain the plasma—a major breakthrough in magnetic mirror technology.⁵⁸⁹

In 1983, the TMX-Upgrade was built "to test fundamental improvements in the

⁵⁸⁵ Helen Black, "Notes to D. C. Sewall," 24 November 1965, Box 221, Folder 2123, LLNL Archives.

⁵⁸⁶ Post, "LLL Magnetic Fusion Research, 7; and "A New Stability for 'Bottled' Plasmas," 5.

⁵⁸⁷ *30 Years of Technical Excellence*, 34.

⁵⁸⁸ Post, phone interview, 3 April 2003; and Hooper, phone interview, 3 April 2003.

⁵⁸⁹ *Ibid.*

design of tandem-mirror reactors.”⁵⁹⁰ The TMX-Upgrade was retired in 1987, when the magnetic mirror program at LLNL was terminated.

Over the last sixteen years, Building 435 has continued to house magnetic fusion research. Several other approaches to magnetic fusion have been pursued since LLNL abandoned magnetic mirrors, including the tokamak and the spheromak concepts. Building 435 currently houses the Spheromak Physics Experiment (SSPX), which began at LLNL in 1999. Building 435 also houses laser research.

Period of Significance

Built in 1959 for Project Sherwood, Building 435 has continuously housed some form of fusion research. Many of the magnetic mirror machines housed in Building 435 are of historic interest because they made significant breakthroughs in magnetic mirror fusion research.

In 1968, the 2X machine made a breakthrough in fusion research by successfully overcoming plasma instabilities that previously had been problematic.

In 1975, the 2XIIB machine finally achieved the necessary conditions for a fusion reaction to occur.

In 1980, the TMX machine finally succeeded in containing plasma in the machine without any leaks.

Therefore, Building 435 is of historic interest for its breakthroughs in magnetic mirror

research within the LLNL Cold War context preservation theme of Non-Weapons Research, subtheme Nuclear Energy Research. The period of historic significance for these activities is 1963–1980.

9.17.3 Construction History

In 1958, Rosener Engineering, Inc., a San Francisco firm, designed Building 435. Building 435 was built in one increment, although the structure was modified to accommodate succeeding generations of fusion research.

Building 435 is a three-story, corrugated-metal, high-bay structure. The high bay has insulated, metal wall panels and a flat roof. There are one-story wings on the north and south, with windows along the entire length of the building. The one-story wings, like the high-bay portion of the building, have flat roofs. Rolling metal doors are located on the west and north elevations.⁵⁹¹

The interior has a large experimental bay with a pit and concrete shielding, which housed the main magnetic mirror machine. The main floor included laboratories, ion gunroom, ion gun control room, electronics installation shop, electronic maintenance shop, mechanical equipment room, research shop, and electrical equipment room. The mezzanine held offices and a conference room.⁵⁹²

In 1958, Corlett and Spackman, a San Francisco architectural firm, designed a modification for the building, adding more

⁵⁹⁰ “TMX-Upgrade,” *Energy and Technology Review* (July 1983), 26.

⁵⁹¹ “Sherwood Laboratory Building 180, Exterior Elevations and Typical Cross-Sections,” 1958, PLZ58-435-005JA, PEL.

⁵⁹² “Sherwood Laboratory Building 180, First Floor and Mezzanine, Floor Plans and Door Schedule,” 1958, PLZ58-435-003JA.

laboratories to both the main floor and the mezzanine. The modification was not completed until 1960.⁵⁹³

In 1962, the pit of Building 435 was modified to accommodate the 2X machine. In 1969, it was modified again for the 2XII machine. Three successive modifications occurred in 1972 for the 2XIIB machine, in 1980 for the TMX machine, and in 1983 for the TMX-Upgrade. In 1980, the pit itself was extended for the TMX.

Since the elimination of magnetic mirror research from the Magnetic Fusion Energy Program, few large-scale modifications have been made to Building 435. The only changes in the building have been small upgrades in the last ten years to accommodate a variety of unrelated research programs.

Building 435 is a corrugated-metal industrial building of undistinguished architectural design. It is a functional structure with no adornment and is typical of buildings found in both industrial research facilities and military installations during the Cold War. Building 435 is an LLNL Cold War building type referred to as a Heavy Laboratory. It possesses the features common to its type—single-story with high bay, heavy-steel repetitive-bay structural framing, reinforced concrete slab, poured gypsum or metal deck under built-up roofing, metal walls, radioactive shielding, and space for large equipment.

⁵⁹³ "Sherwood Laboratory Building 180, Mezzanine Addition No. 1, Floor Plans, Sections, And Details," 1958, PLZ58-435-048JA, PEL; and "Sherwood Laboratory Building 180, Mezzanine Addition No. 2, Floor Plans, Sections, and Details," 1958, PLZ58-435-048JA, PEL.

9.17.4 Integrity

Building 435 is of historic interest for its magnetic mirror fusion research activities for the time period 1963–1980. However, Building 435 no longer possesses integrity for the period of its historic significance. Integrity for Building 435 would depend on maintaining the magnetic mirror machines that made significant scientific breakthroughs in fusion research. Building 435 no longer possesses any of the machines—the 2X, 2XIIB, or TMX—that made important scientific breakthroughs in magnetic mirror research. All traces of these machines are gone. Each of these magnetic mirror machines was removed to accommodate its successor. The last, the TMX, was removed in 1983 to make way for the TMX-Upgrade. The TMX-Upgrade was removed in 1987.

The structure of Building 435 does not reflect any of the magnetic mirror research that occurred during the time of its historic significance. All relevant laboratories and their equipment have long since been removed.

The only trace of the magnetic mirror fusion research that occurred during the years 1963–1980 is the concrete block shielding in the main experimental pit. However, the concrete shielding alone does not reflect the specific nature of the work that occurred in the building. It is generic concrete shielding of the sort used to provide protection from radiation in accelerator, laser, or fusion research. Figure 108 shows the remains of the concrete shielding pit in Building 435.

Currently, laboratories supporting various programs, all of which have moved into the building within the last decade, occupy the building.

9.17.5 Recommendation

Building 435 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. The design of the building is of no architectural interest. Building 435 is not, nor will it be, a source of important historical information. The magnetic mirror fusion research that occurred there is documented in research reports and archival collections.

Building 435 does qualify for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War, and specifically the breakthroughs in magnetic mirror research for Project Sherwood, later the Magnetic Fusion Energy Program, that attempted to control thermonuclear reactions for power applications. The particular period of historic significance for these activities within this structure is 1963–1980.

However, Building 435 no longer possesses integrity for its period of historic significance. Therefore, Building 435 is not eligible for the National Register under Criterion A.

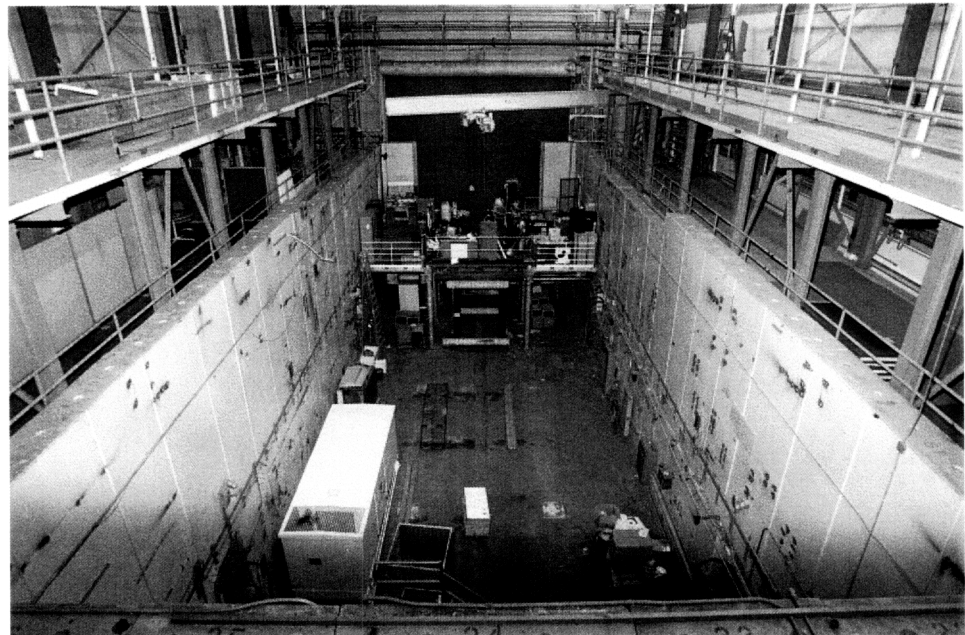


Figure 108. Building 435, remains of concrete shielding pit, 2003.⁵⁹⁴

⁵⁹⁴ Building 435, remains of concrete pit, LLNL photographer Marcia Johnson, 2003.

9.18 Building 865 Complex

9.18.1 Description

The Building 865 Complex is located in the northwest portion of LLNL's Site 300, a 7,000 acre experimental HE test facility located in the counties of Alameda and San Joaquin, fifteen miles from the main site. It is currently not in use. The Building 865 Complex was built between 1980 and 1985 to house the Advanced Test Accelerator (ATA). The Building 865 Complex originally consisted of the main ATA building, 865A, and seven support structures 865B, C, D, E, F, G, and H. Of these eight structures, Building 865A and 865E represented the core of the complex and are of historic interest. Building 865E has been demolished. Buildings 865B, C, D, E, G, and H were minor support structures. This assessment will therefore focus primarily on Building 865A. Figure 109 is a recent photograph of the Building 865 Complex.

Building 865A is a two-story, steel-frame, concrete and corrugated-metal, modified rectangular industrial structure. It contains 60,319 gross square feet and currently houses sixteen laboratories, two utility rooms, six offices, and two service shops. Figure 110 depicts Building 865A.

9.18.2 Mission History

The Building 865 Complex was built specifically to house the ATA, an accelerator designed to investigate the feasibility of directing intense electron beams through the atmosphere for use as a defensive weapon.

The 865 Complex was one of three facilities dedicated to beam research at LLNL. The other two are Building 431, which housed the Experimental Test Accelerator (ETA), a prototype induction accelerator; and Building 423, which housed the High Brightness Test Stand, a small two-MeV

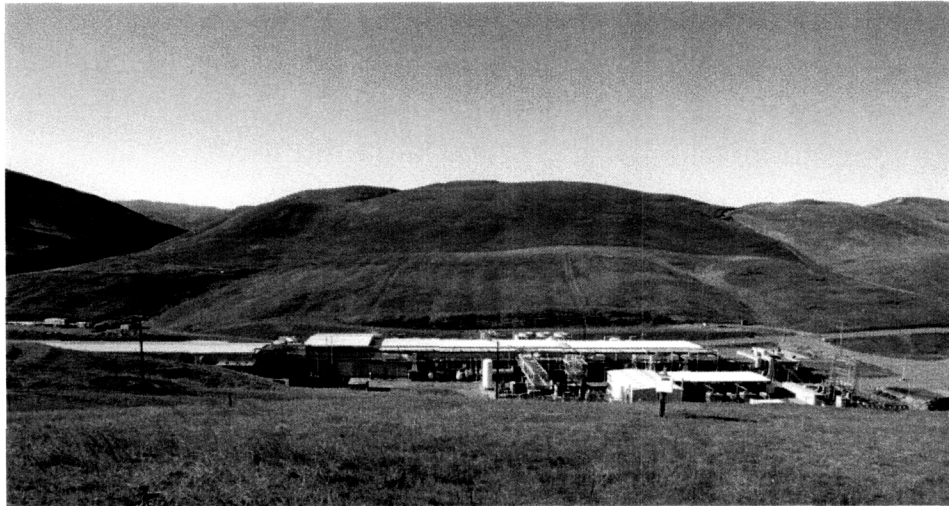


Figure 109. Building 865 Complex, 2002.⁵⁹⁵

⁵⁹⁵ Building 865 Complex, LLNL photographer Marcia Johnson, 2002.



Figure 110. Building 865A, north and east elevations, 2001.⁵⁹⁶

electron accelerator.⁵⁹⁷ Both Building 431 and Building 423 are at the main site.

LLNL's beam research has its roots in both accelerator development and electron beam research.⁵⁹⁸ The ATA descended from Astron, the first induction linear accelerator developed by LLNL engineer Nicholas Christofilos in 1963. It also stemmed from increasingly successful research in free-electron lasers (FEL).

LLNL began its beam research program in 1978, shortly after Stanford University demonstrated one of the first FELs, "a device for extracting intense laser-like light from a beam of electrons."⁵⁹⁹

In 1979, LLNL designed the ETA and installed it in the south wing of Building 431. The ETA was a prototype accelerator designed as a directed-energy weapon.⁶⁰⁰

In 1983, LLNL completed the ATA, an even larger and more energetic accelerator than the ETA. The ATA was built at Site 300 in Building 865A. The beam of the ATA was used as a driver for a FEL. The ATA was the most powerful induction linear accelerator in the world at the time of its development.

In 1986, LLNL's beam research became part of the Strategic Defense Initiative (SDI) Organization's effort to develop a directed-energy defense against ballistic missiles.⁶⁰¹

Popularly known as "Star Wars," SDI research focused on developing laser weapons and satellites to serve as a shield against incoming missiles. LLNL's work in laser research made it a large recipient—the largest in California—of funding for SDI research.

⁵⁹⁶ Building 865A exterior, LLNL photographer Marcia Johnson, 2001.

⁵⁹⁷ Building 423 housed klystron research and development of bright electron sources for beam research for the ETA and ATA. It was assessed earlier in this report and found of historic interest for that work for the 1985-1997 period. However, it lacks integrity and is not eligible for the National Register. Building 431 primarily housed magnetic fusion research. It has been previously assessed and found of historic interest under Criterion A for its contributions to magnetic fusion research during the period 1954-1992. However, it no longer possesses integrity for the period of its historic significance.

⁵⁹⁸ *Induction Accelerator and Free-Electron Laser Development—1986-1987*, 1.

⁵⁹⁹ *The ELF Electron Laser Facility*, 1.

⁶⁰⁰ *Serving the Nation for Fifty Years*, 23; and *Experimental Test Accelerator (ETA)*.

⁶⁰¹ *Ibid.*

Research on the ATA tested how electron beams behaved in the open air, how electron beams could be used as a military application, and the basic physics of beam propagation.

Scientists at the Building 865 Complex determined through comprehensive electron-beam propagation experiments on the ATA that a FEL could be used as the ground-based portion of the Star Wars defensive system to destroy incoming missiles.

As the Cold War came to an end, both the feasibility and necessity of SDI were challenged. In 1991, President Bush severely scaled back SDI research.

LLNL conducted the last full-scale experiment at the ATA in 1990. From 1990 to 1995, a small group of scientists used the ATA for microwave production experiments. No experiments have been conducted since.

Period of Significance

LLNL made several important breakthroughs in accelerator technology with special applications to weapons development. The ATA represents the development of an accelerator as a directed weapon. The period of historic significance for this breakthrough is 1983, the year the ATA was completed.

From 1983 to 1990, the Building 865 Complex conducted beam propagation experiments with the ATA. The ATA was the largest and most powerful induction linear accelerator in the world at the time. Furthermore, the ATA is considered an important scientific breakthrough in accelerator technology for its potential directed energy weapon application. Therefore, Building 865A is of exceptional historic interest for

its contributions to accelerator development and FEL research within the LLNL Cold War context and established preservation theme of Nuclear Research and subtheme of Physics Research. The period of historic significance for this research is 1983–1990.

9.18.3 Construction History

Kaiser Engineering designed Building 865A in 1980. Six additional support structures were built between 1980 and 1985—Buildings 865B, C, D, E, F, G, and H. Of these, Buildings 865A and 865E were the core of the complex, housing the ATA and the FEL, respectively. 865B, C, D, F, G, and H were support structures.

Building 865A is a two-story steel-framed building made of concrete and corrugated metal with a slightly pitched roof. HVAC units, vents, industrial piping and fuel tanks sit on the roof and on the sides of the building. There are metal roll-up doors on the east elevation and pedestrian doorways on the north elevation.

Building 865A contained the Experimental Tunnel, Power Conditioning Area, Mechanical Assembly Room, control room, conference rooms, fabrication areas, and offices. The actual ATA accelerator and its components were housed in the Experimental Tunnel. The ATA consisted of four units—the 2.5-MeV 10-KA triode injector, 50-MeV accelerator, beam transport line, and experimental tank. Figure 111 is a photograph of the remnants of the ATA accelerator.

Electrical power traveled from a sub-station at the ATA site through the injector and along the accelerator and sequentially through its 190 cells. Each cell increased the energy of the electrons until it reached

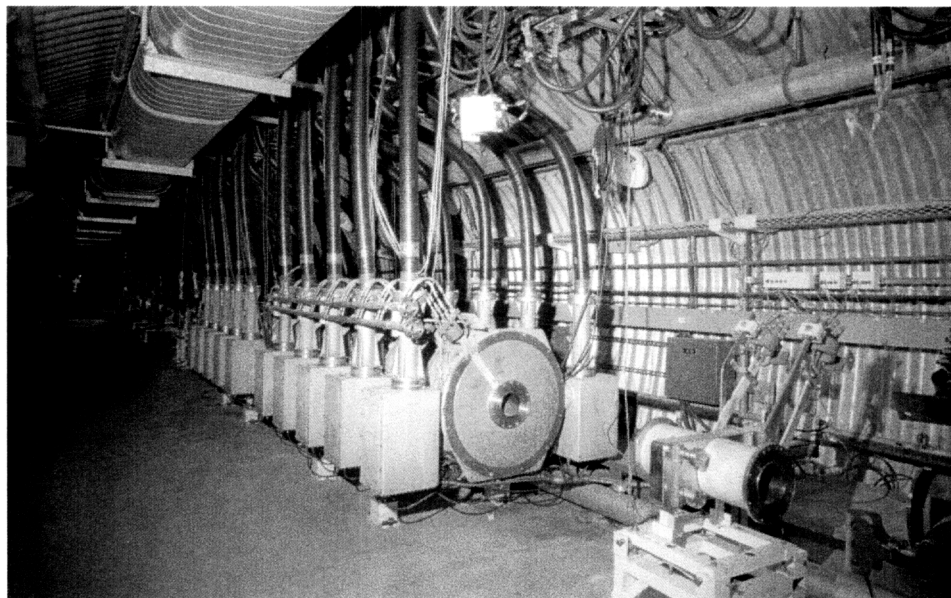


Figure 111. Building 865A, ATA cells, 2001.⁶⁰²

50 MeV. Once at the end of the accelerator the beam was guided through the 140-foot beam transport line and into an experimental tank. The Paladin FEL located in the beam line converted the electrons into a coherent laser beam. The laser beam was then guided into the experimental tank or out into the atmosphere. The tank contained gases of different composition and pressure.⁶⁰³

Kaiser also designed Building 865B in 1980.⁶⁰⁴ It was a small concrete structure to the east of Building 865A.

The other support structures at the 865 Complex were designed by LLNL's Plant Engineering Department. Building 865C was a 2,221-foot square building to the northeast of Building 865A. It was used as an electrical

engineering shop. Building 865D was a gas pad to the west of Building 865A.

In 1985, Plant Engineering designed Building 865E, the FEL Diagnostic Support Structure. It was to the east of Building 865A and was a steel-frame building with concrete walls, a slightly pitched roof, and no windows. It had a roll-up door on the east elevation and personnel doors on the east and west elevations.⁶⁰⁵ The interior housed a laser room, assembly room, maintenance room, conference room, and three offices.⁶⁰⁶

In 1986, Plant Engineering designed 865F, a small concrete extension that connected Building 865A with 865B. It had a slightly sloped roof, roll-up door on the north elevation, and personnel doors on the north and east elevations.⁶⁰⁷

⁶⁰² Building 865A, ATA cells, LLNL photographer, Marcia Johnson, 2001.

⁶⁰³ David Harvey, *Primary Record: Building 865* (Livermore: Lawrence Livermore National Laboratory, 2001), 2.

⁶⁰⁴ "Advanced Test Accelerator Facility, Diagnostic Bunker, Plans, Sections, and Details," 1980, PSZ80-865-088DB, PEL.

⁶⁰⁵ "Building 865E, FEL Diagnostic Support Building, Site 300," 1985, PSZ85-865-502D, PEL.

⁶⁰⁶ "Structure 865E, FEL Diagnostic Support Structure," 1985, PSA85-865-503D, PEL.

⁶⁰⁷ "Structure 865F, Airline Support Structure," 1986, PSA86-865-602D, PEL.

Also in 1986, Plant Engineering designed Buildings 865G and 865 H. Building 865G was a small structure to the west end of Buildings 865E and 865B. It was a corrugated-metal structure with a pitched roof.⁶⁰⁸ Building 865H, the Airline Laser Structure, sat to the east of Building 865A. It was a corrugated metal structure with a pitched roof that housed a concrete shielded room.⁶⁰⁹

Building 865A is a corrugated-metal and concrete industrial building. It is an LLNL Cold War building of the Site 300 Heavy Laboratory type. It possesses features characteristic of its kind. It has a steel frame, reinforced concrete slab foundation, and concrete block walls.

Building 865A does not represent high-style architecture. Its exterior design is typical of utilitarian buildings found on countless industrial and military sites across the country.

However, Building 865A includes design features that reflect the activities of historic interest that occurred there. The ATA is housed in a 250-meter-long, 8-meter-wide, and 4-meter-high Experimental Tunnel made of corrugated metal located below the main floor. The Experimental Tunnel is arched with a concrete floor and no windows. It is covered with earth and concrete fill. It housed the injector, accelerator beam line and cells, and mirror. The design of the Experimental Tunnel directly reflects the purpose for which it was built. Figure 112 is the ATA tunnel in Building 865A.

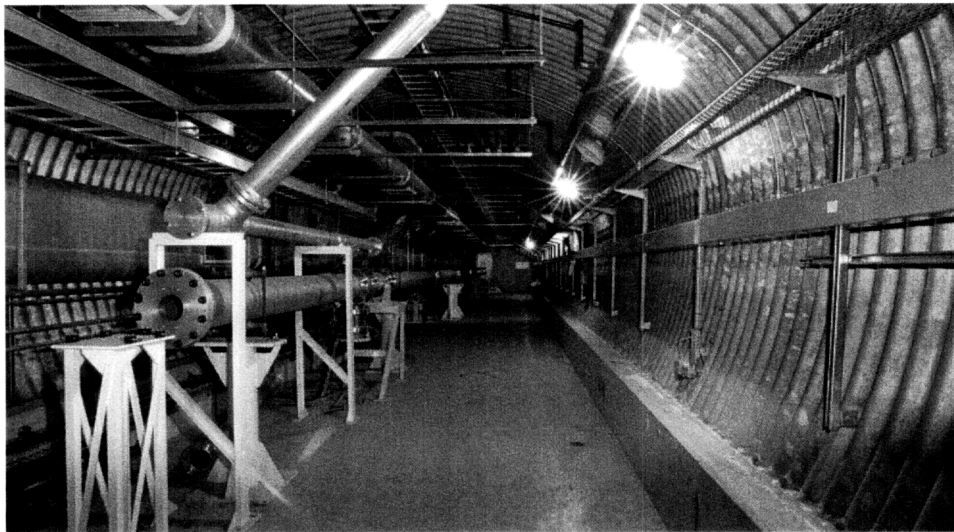


Figure 112. Building 865A, ATA tunnel, 2001.⁶¹⁰

⁶⁰⁸ "Building 865G, FEL extension," 1986, PSA86-865-702D, PEL.

⁶⁰⁹ "Airline Laser Diagnostic and Airline Laser Structures, Section and Elevations," 1986, PSA86-865-803D, PEL.

⁶¹⁰ Building 865A, ATA tunnel, LLNL photographer, Marcia Johnson, 2001.

9.18.4 Integrity

From 1983 to 1990, researchers conducted beam propagation experiments on the ATA, in Building 865A, to determine the feasibility of the use of a FEL as a directed energy weapon. The ATA was the largest and most powerful induction linear accelerator in the world at the time of its development. Therefore, Building 865A is of historic interest within the context of the Cold War and the LLNL established preservation theme of Nuclear Research, and subtheme of Physics Research.

Furthermore, Building 865A has integrity for its period of historic significance. Considerable scientific and technical equipment associated with the ATA is still present in the building, including the injector, remnants of the beamline and accelerator, individual accelerator cells, and the mirror box at the end of the tunnel.

9.18.5 Recommendation

Buildings and structures under fifty years of age are generally not considered eligible for the National Register. Building 865A will not be fifty years of age until 2030.

However, under Criteria Consideration G, properties under fifty years of age can be considered eligible to the National Register if it can be demonstrated that they are of exceptional significance.

The Cold War has been recognized as a period of exceptional significance within U.S. and world history. Additionally, Building 865A is of exceptional historic interest for its contributions to accelerator and FEL research within the established LLNL Cold War preservation theme of Nuclear Research and the preservation subtheme of Physics Research.

Building 865A does not qualify for National Register consideration under Criterion B, association with a historic figure; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this building. Building 865A is not, nor will it be, a source of important historical information. The beam research that occurred there is documented in research reports and archival collections.

Building 865A qualifies for National Register consideration under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War beam propagation research and the development of a high-energy electron accelerator for use as a directed energy weapon. The particular period of historic significance for these activities within this structure is 1983–1990. Contributing elements representative of historic activities under Criterion A include the injector, remnants of the beamline and accelerator, the accelerator cells, mirror, and power conditioning area equipment.

Building 865A also qualifies for National Register consideration under Criterion C, exceptional design or architectural significance. The Experimental Tunnel underneath the main floor that housed the ATA was built specifically for the accelerator and reflects the historic activities that occurred there. The period of significance for exceptional design is 1980. Building 865A possesses integrity for its design significance. The contributing element to exceptional design under Criterion C is the Experimental Tunnel.

9.19 Site 300, High Explosive Process Area: Buildings 805, 806, 807, 809, 817, 825, 826, 827, and 828

9.19.1 Description

The High Explosive Process Area (Process Area) is located in the southern part of LLNL's Site 300, a 7,000-acre experimental HE test facility in the Altamont Hills fifteen miles from the main site. The main Process Area consists of four buildings and five building complexes—a total of twenty-six buildings—that form the core of the Process Area.⁶¹¹

These structures are:

- Building 805, HE Assembly Facility
- Building 806, HE Machining Complex
- Building 807, Explosive Preparation Facility
- Building 809, Radiography/Oven Complex
- Building 817, HE Pressing Complex
- Building 825, HE Chemical Process Facility
- Building 826, HE Chemical Process Facility
- Building 827, Chemistry Development Complex
- Building 828, Experimental HE Machining Complex.

From its beginning in 1957, the Process Area mission was the formulation, mixing, casting, pressing, machining, and assembling of conventional HE for use in the physics package of nuclear weapons.

The HE compresses the fissionable materials in a nuclear weapon to criticality, producing and sustaining the nuclear explosion.⁶¹²

Today, the Process Area continues its association with nuclear weapons work via the Stockpile Stewardship Program. In addition, it provides HE research and development for conventional weapons and industrial applications. The Process Area was built between 1957 and 1968.

Most of the buildings in the Process Area are made of poured concrete, concrete block, or cement-asbestos panels with frangible walls to direct the blast in case of an accidental explosion. A few structures are made of corrugated metal. For the most part, Process Area buildings are unadorned and functional in design. The cement-asbestos panels used on some of the buildings are in color, but this appears to be a result of the available materials rather than an active attempt to introduce a decorative element into Site 300. In general, Site 300 buildings were constructed with inexpensive and sometimes less durable materials than the main site.

9.19.2 Mission History

In 1953, LLNL administrators first noted the need for a remote site to conduct HE tests for the weapons program. They felt that obtaining land for a self-sufficient high explosive test site was critical to the long-term success of their weapons design program. Without one they would be reliant on LANL to provide both fabrication and test firing of various devices. So, LLNL began the search for suitable land within

⁶¹¹ *Site-Wide Remedial Investigation*, 13–1–1.

⁶¹² "Inside Site 300," 5.

an hour's drive of the main site.⁶¹³ In 1955, LLNL purchased 3,400 acres of ranch land from William J. Kelley, F. B. Kelley, and Bert Banta to conduct these HE experiments.⁶¹⁴ As program needs expanded over the years, LLNL purchased additional acreage, bringing the Site 300 total to 7,000 acres.

From 1957, when the first buildings in the Process Area were constructed, until the end of the Cold War in 1991, the HE Process program had a single mission—the development and fabrication of HE for LLNL's nuclear weapons designs. The technicians at the Process Area built on the HE research and development done at the main site.

Initial research and development for HE originally took place on the LLNL main site in the Building 222 Complex (which included Buildings 222, 223, and 227). Buildings 223 and 227 no longer exist. Building 222 has also recently been demolished.

When the High Explosives Applications Facility (HEAF), Building 191, opened in 1989, preliminary HE development work transferred there. Building 191 did not meet the initial criteria for historic evaluation in this set of assessments, because it is too young. The Building 222 Complex, and, later, HEAF worked with very small quantities of HE (less than one gram). When chemists at the main site developed a suitable formula,

then the Site 300 Process Area technicians took over, scaling up the formula and transforming it into actual HE billets to shape and test for particular weapons designs.

The process of making HE billets involves chemical formulation, mixing, blending, drying, pressing, and machining. There are two types of HE billets—paste and plastic. Paste HE is mixed and then extruded into molds to form shape charges. When dry these shape charges are machined to exact specifications.

HE was also mixed with plastic and either mechanically or isostatically pressed into specified shapes. Mechanical pressing produces shapes ready to use, but isostatically pressed shapes need to be machined. Most machining is done remotely, although some HE is stable enough for an operator to machine the billet directly at the equipment.

HE billets are X-rayed several times during the fabrication process to ensure that there are no cracks, imperfections, or impurities. Once the HE billets are finished, they are assembled into device designs. Some devices have as many as 100 parts and take several weeks to complete.

Initially, from 1957–1958, the Process Area consisted of Buildings 805 and the Building 806 Complex. HE billets were machined in the 806 Complex and trimmed and assembled for hydrodynamic test shots in 805.⁶¹⁵ Figures 113 and 114 depict Building 805 and the 806 Complex respectively.

By 1960, the Process Area expanded to include buildings that specialized in each

⁶¹³ "Preliminary Proposal for Site 300," 1 July 1953, Ernest Orlando Berkeley National Laboratory Declassified Records, 43-95, Box 4, File 19-10-364, LBNL Archives; and Herbert York to General Kenneth E. Fields, "UCRL High Explosive Test Requirements," Ernest Orlando Lawrence Berkeley National Laboratory Declassified Records, 434-95-19-10-364, Box 1, File 13, LBNL Archives.

⁶¹⁴ "Proposed Weapons Research Remote Site," Site 300 Memorandum, 18 October 1954, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1960, Folder Reactors, Plant, Livermore Site 300, LBNL Archives.

⁶¹⁵ A. J. Hulse, "Site 300 Facilities," memo, 1957, Site 300 Files.

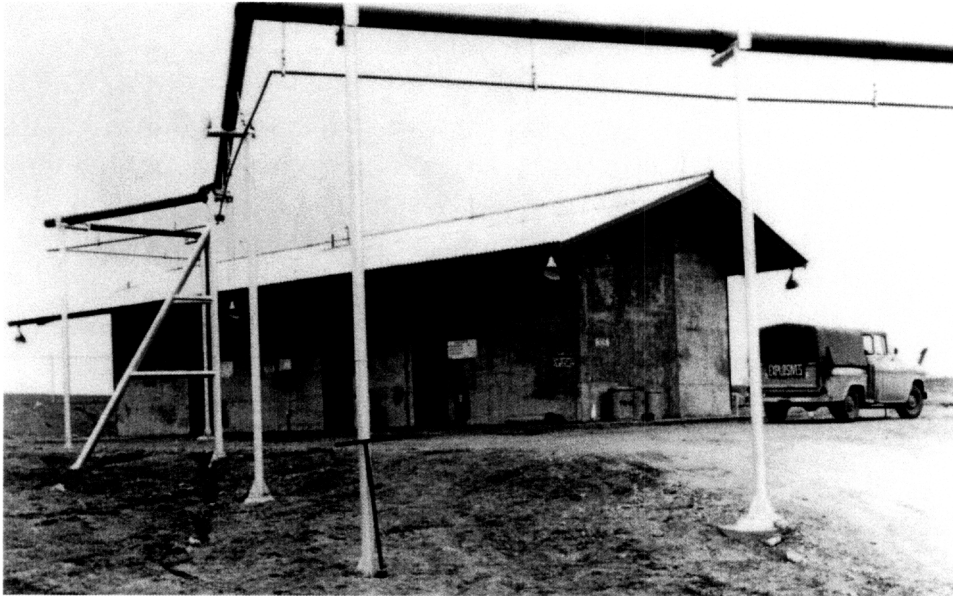


Figure 113. Building 805, HE Trim Building, 1957-1958.⁶¹⁶



Figure 114. Building 806 Complex, HE Machining, 1957.⁶¹⁷

⁶¹⁶ Building 805, HE Trim, 1957-1958, Negative Number 9428, LLNL Archives.

⁶¹⁷ Building 806 Complex, HE Machining, 1957, Negative Number 15243, LLNL Archives.

aspect of the development and fabrication of HE.

Building 825, completed in 1959, housed chemistry laboratories for formulation and testing of HE in larger batches than could be used at the main site. Chemists in Building 825 prepared batches of HE in quantities up to 1,000 grams. The facility housed small ovens and a one-inch and a four-inch press. Figure 115 depicts the Building 825 Chemistry Laboratory.

Building 807, completed in 1960, housed all the large-scale mixing and blending activities. There were facilities for receiving, inspecting, weighing, and screening raw explosive material in granular or pellet form. There were also mixers to blend explosives with inert materials. Building 807 had the capacity to blend fifty to one hundred pounds of explosives at a time.⁶¹⁸ Figure 116 depicts the Building 807 mixing and blending facilities.

The Building 817 Complex, built between 1959-1964, housed the ovens and isostatic

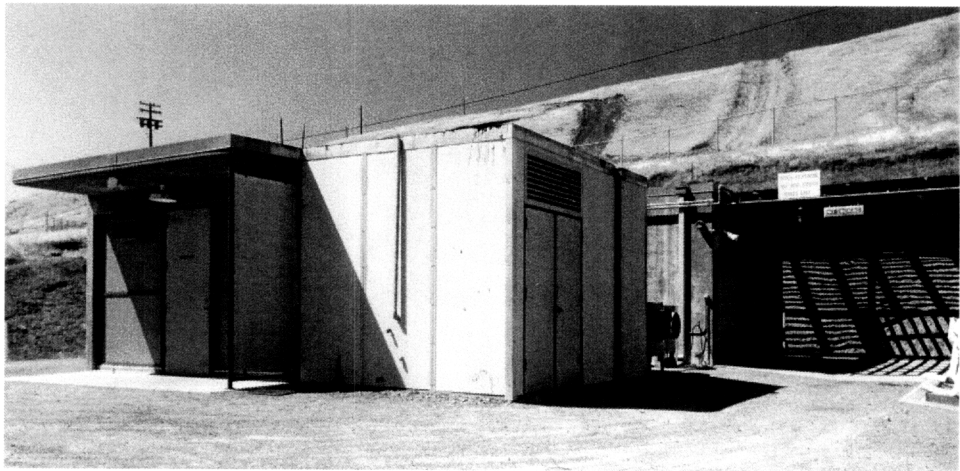


Figure 115. Building 825, Chemistry Laboratory, under construction, 1957.⁶¹⁹

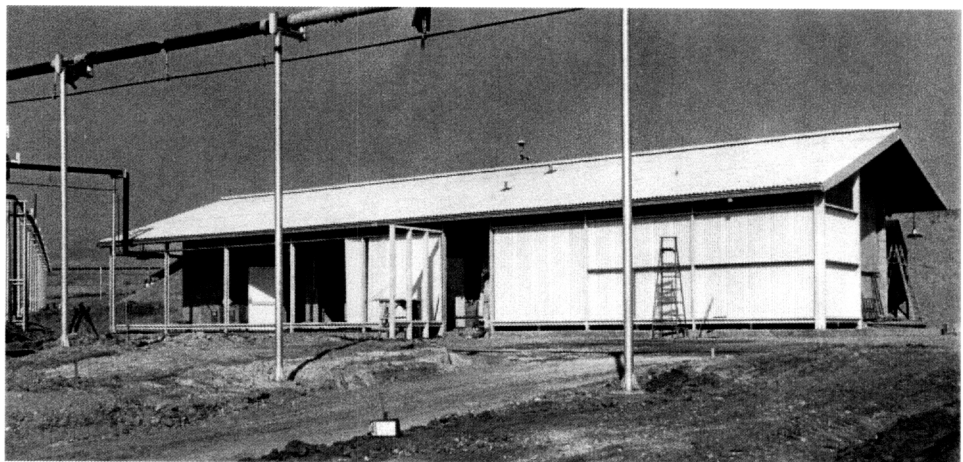


Figure 116. Building 807, HE Preparation, 1957.⁶²⁰

⁶¹⁸ "Buildings Go Up At Site 300 to Provide New Facilities," *The Magnet* (January 1961), 2.

⁶¹⁹ Building 825, Chemistry Laboratory, 1957, Negative Number 25844, LLNL Archives.

⁶²⁰ Building 807, HE Preparation, 1957, Negative Number 17664, LLNL Archives.

presses. HE in powdered form was first dried on sheets in the ovens and then formed into various shapes at one of the isostatic presses.⁶²¹ Pressing was remote-controlled to prevent injury from an accidental detonation. Figure 117 depicts the early construction of the Building 817 Complex.

In Building 809, completed in 1959, technicians X-rayed pressed and machined HE billets to make sure there were no deformities, foreign objects, or cracks in the explosive pieces. Radiography of HE billets occurred several times during the process of making finished pieces.⁶²² Figure 118 depicts Building 809.

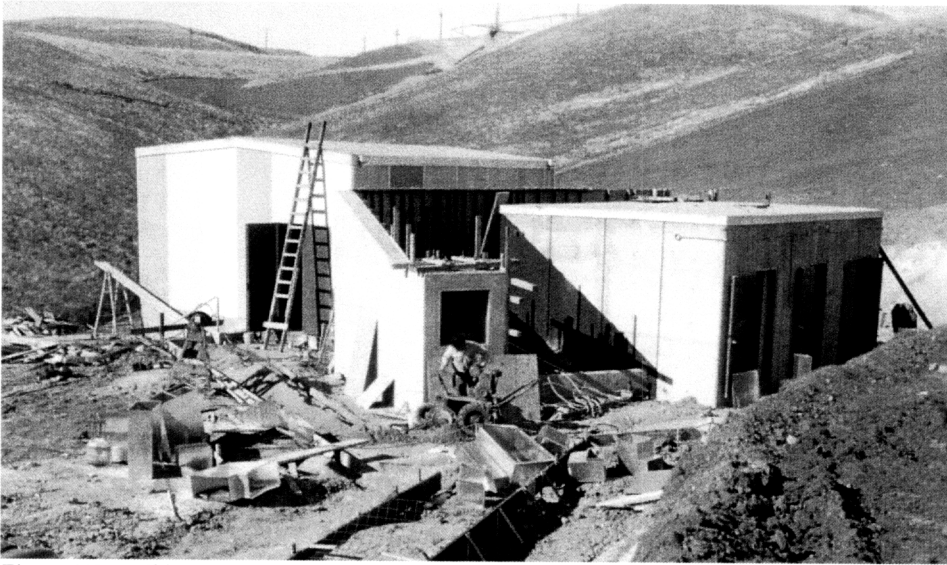


Figure 117. Buildings 817A and 817B, HE press facilities, 1959.⁶²³

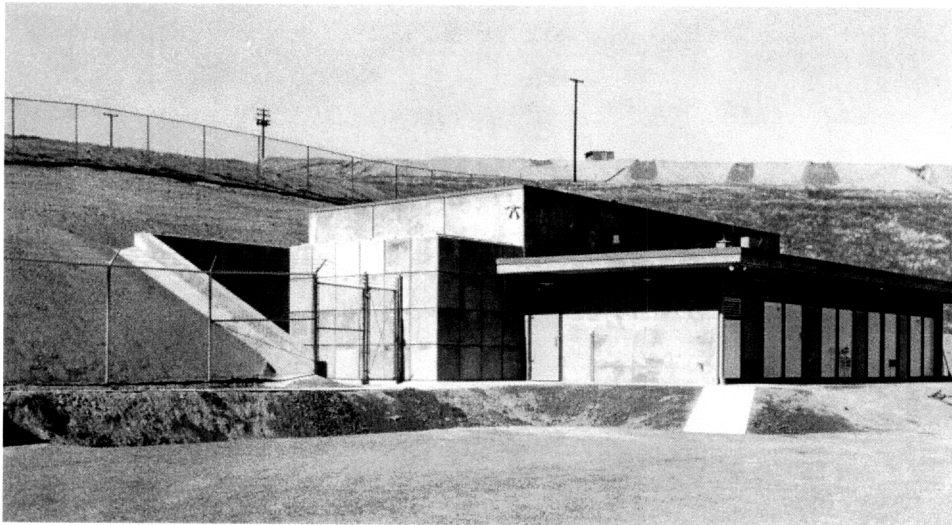


Figure 118. Building 809, Radiography, 1959.⁶²⁴

⁶²¹ "Site 300 Adds Land and Buildings," *The Magnet* (October 1959), 7.

⁶²² "New Buildings Completed At Site 300," *The Magnet* (June 1959), 3.

⁶²³ Early construction at the Building 817 Complex, HE presses, 1959, LLNL Archives.

⁶²⁴ Building 809, Radiography, 1959, Negative Number 15237, LLNL Archives.

Building 825 and 826, completed in 1959 and 1960 respectively, provided Site 300 with additional chemistry facilities. Building 825 housed initial chemical formulation activities. New recipes for HE were tried in small quantities before being scaled up. Building 826 activities used small mixers and blenders, a one-inch press, and an area loader. Figures 119 and 120 depict Buildings 825 and 826.

Between 1964 and 1967, Site 300 added the Building 828 Complex as an experimental remote-machining facility. This site was used to try new machining techniques. It was built away from the rest of the Process Area and the buildings were made of inexpensive materials. If an accidental detonation occurred, the main HE machining compound would not be damaged and the affected buildings easily could be replaced.

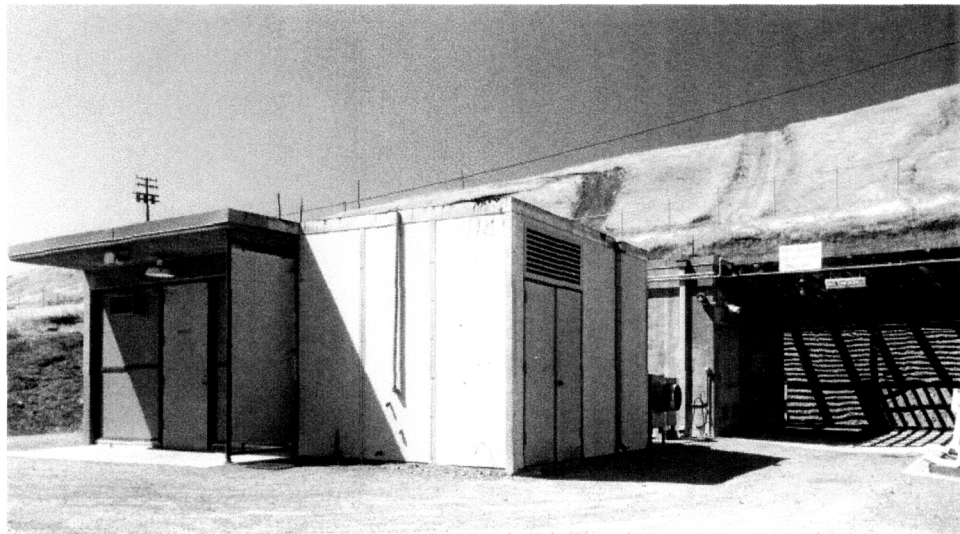


Figure 119. Building 825, HE Chemistry Laboratory, 1959.⁶²⁵



Figure 120. Building 826, HE Chemistry Laboratory, 1960.⁶²⁶

⁶²⁵ Building 825, HE Chemistry Laboratory, 1959, Negative Number 25844, LLNL Archives.

⁶²⁶ Building 826, HE Chemistry Laboratory, Negative Number 25850, LLNL Archives.

In 1968, Site 300 added the 827 Chemistry Complex, which took over many of the large-scale mixing, blending, and casting activities of Building 807. The 827 Complex had extensive mixing capabilities, including vertical and horizontal mixers, roll mills, and a ball mill. It also housed large-scale area loaders and extrusion presses, a 500-ton press, large kettles for synthesis work, and ten- and thirty-liter kettles for slurry work.

In 1975, Building 805, the Trim and Assembly Facility, was renovated into an HE Lens facility, complete with its own ovens, press, X-ray machine, and firing tank.

In 1983, Building 809 was renovated to accommodate some machining activities as well as radiography.

Although some phases of the HE process shifted from one building to another over the years, the core mission of making HE billets for nuclear weapons has remained remarkably consistent in the Process Area. Changes in facilities tended to consolidate related activities in one place. For example, when large-scale mixing and blending activities moved from Building 807 to the new Building 827 Complex in the late 1960s, Building 807 provided additional machining capabilities for neighboring Building 806. For the most part, the Process Area had a consistent process—formulation, mixing and blending, drying, casting and/or pressing, machining, radiography, and assembly—of making HE billets for nuclear weapons applications.

Since the end of the Cold War, the HE Process Area's prime mission has been the development and fabrication of HE in support of LLNL's Stockpile Stewardship

Program. The Process Area also provides conventional HE research, development, and test and evaluation services for the military and industry.

Period of Significance

From 1957 to 1991, the HE Process Area Buildings 805, 806, 807, 809, 817, 825, 826, 827, and 828 engaged in research and development of HE for LLNL nuclear weapons designs. LLNL was one of two laboratories that designed and developed nuclear weapons for the U.S. stockpile. HE is critical to the successful design and performance of nuclear weapons. In the Process Area scientists and technicians developed and fabricated prototype HE billets for all LLNL-designed nuclear weapons in the U.S. stockpile. The HE Process Area physically represents a significant element of the process of the nuclear weapons design work at LLNL.

An example of how the HE Process Area is involved in important design developments is the testing of the 1976 breakthrough on the IHE TATB, which led to increased safety in nuclear weapons design and handling. TATB is highly insensitive to external shocks from explosion, fire, or crash. The W87, designed by LLNL, was the first nuclear weapon to employ TATB in both the detonator and main explosive charge. Subsequently, TATB was widely used in nuclear weapons.

Therefore, HE formulation and fabrication at LLNL is of historic interest within the context of the Cold War arms race under the LLNL preservation theme Nuclear Weapons Design and the subtheme Weapons Design. HE formulation and fabrication activities are

also of interest within the LLNL theme of Nuclear Weapons Testing and the subtheme of High Explosives Testing. The period of historic significance for the Process Area for all relevant themes and subthemes is 1957–1991.

9.19.3 Construction History

Prior to 1955, LLNL scientists relied on other facilities in the nuclear weapons complex to provide HE for nuclear weapons design. Obtaining Site 300, allowed LLNL a HE process area to produce prototype HE for the weapons program.

The Process Area was largely built between 1957 and 1960. Additional construction took place in 1968 and modifications to existing structures continued into the 1970s.

Building 805

In 1957, Building 805, the Trim and Assembly Building, was one of two Process Area structures built at Site 300. It is a concrete building with 6,802 gross square

feet. Constructed in three separate increments, it currently houses nine shops, one mechanical room, five offices, and three service shops. Figure 121 is a current picture of Building 805.

LLNL's Plant Engineering designed Increment 1 in 1955. Construction was completed in 1957. It had poured concrete exterior walls on the east, west, north, and south elevations, and a concrete block wall on the south elevation. It had a pitched roof of corrugated-cement-asbestos panels and doors on the east, west, and south elevations. Increment 1 consisted of two large rooms—one for HE trim and one for HE assembly—separated by a utility room.⁶²⁷

In 1958, Indenco Engineers, a San Leandro firm, designed Increment 2, an addition to the northeast end of the building that doubled the structure's size and handling capability. Construction was completed in 1959. Increment 2 followed the style of Increment 1. It was a concrete addition with a corrugated cement-asbestos roof. Increment 2 housed identical



Figure 121. Looking east at Building 805, west elevation, 2002.⁶²⁸

⁶²⁷ "Trim and Assembly Building, Building No. 805, Plans, Elevations, and Sections," 1955, PSZ55-805-003JA, PEL.

⁶²⁸ Building 805, exterior, LLNL photographer, 2002.

facilities to Increment 1—trim and assembly rooms separated by a utility room.⁶²⁹

In 1973, Garretson, Elemendorf, Zinov, and Reibin, a San Francisco firm, designed Increment 3 of Building 805. Construction was completed in 1975. Increment 3 added 5,450 gross square feet of space and modified the entire structure to house an HE lens facility. The Increment 3 addition extended the building on the entire length of the west side. The addition was made of pre-cast and cast-in-place concrete with a flat roof. The walls on the north and west elevations were frangible.⁶³⁰ The existing part of the structure on the east side was renovated to house a 100-ton press room, small press room with an oven, HE storage vault, inspection room, X-ray room, environmental test chamber, support machine room,

firing tank, camera room, and dark room. The new addition on the west side housed an explosives preparation room, inert preparation room, utility room, machine room and technical area, storage room, data reduction room, and office.⁶³¹ Figure 122 depicts the control room for remote machining activities.

806 Complex

In 1957, LLNL also constructed the Building 806 Complex for HE Machining. This complex consists of four separate buildings—806A, B, C, and D—connected by breezeways. Building 806A is a concrete block building of 3,408 gross square feet. Building 806B is a concrete building of 4,074 gross square feet. Building 806C is a small, metal Butler-type building of 640 gross square feet that separates 806A and

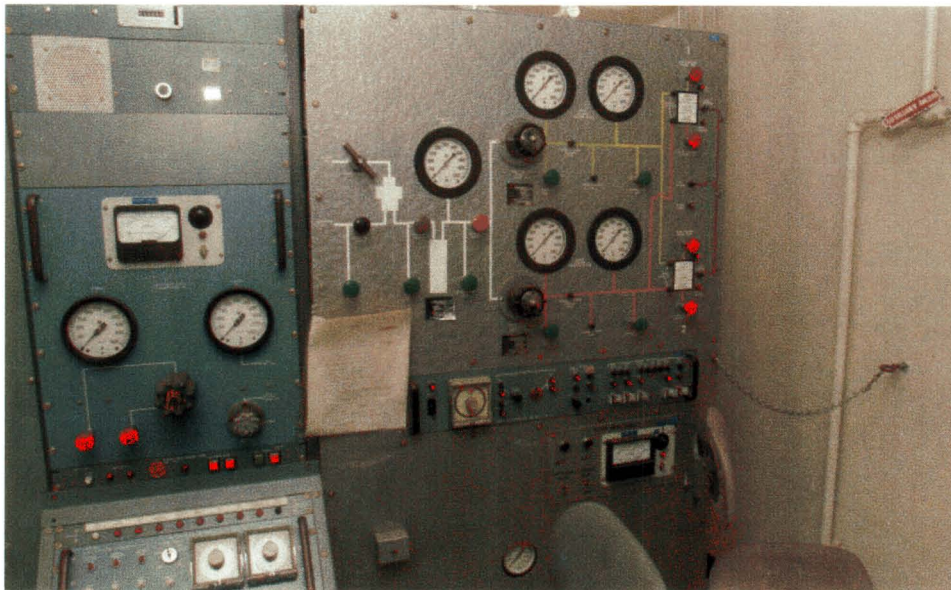


Figure 122. Partial view of control panel for remote machining equipment in Building 805, 2003.⁶³²

⁶²⁹ "Site 300 Building 805, Site, Grading, and Plot Plan," 1958, PSZ58-805-002JA, PEL; "Site 300 Building 805, Elevations," 1958, PSZ58-805-009JA, PEL; and "Site 300 Building 805, Floor Plan, Sections, and Finish Schedule," PSZ58-805-008JA, PEL.

⁶³⁰ "H.E. Lens Facility Building 805, Floor Plan, Roof Plan, and Elevations," 1973, PSZ73-805-002JA, PEL.

⁶³¹ "H.E. Lens Facility, Floor and Site Plan," 1973, PSA73-805-001D, PEL.

⁶³² Building 805, control room, LLNL photographer, 2003.

B. Building 806D is a small, metal support structure. Figure 123 shows the Building 806 Complex.

Rogers Engineering designed Buildings 806A and 806B in 1955 and 1957, respectively. All construction was completed in 1957. 806A had concrete walls on the north, west, and east elevations and a concrete block wall on the south elevation. Doors were on the east, west, and south walls. The building had a pitched cement-asbestos paneled roof. It housed two large machining rooms separated by two rooms—a utility and control room. There were also a tool room and small storage closet.⁶³³ An office was added in 1966 and a lunchroom in 1986.⁶³⁴ Building 806B was slightly larger than Building 806A, but almost identical in construction. It had concrete walls, a concrete asbestos pitched roof, and doors on the north, east, and west elevations. The interior included an office and control room, inert storage room, remote control

machining room, utility room, machining room, and an inspection room.⁶³⁵ Figures 124 and 125 depict the control room and remote machining capabilities in Building 806B, respectively.

Buildings 806C and D are small, metal Butler buildings built in 1961 for additional storage. Building 806C separates Buildings 806A and B and was used to store fixtures for HE. Building 806D was used as a washroom.⁶³⁶

Building 807

Indenco Engineers designed Building 807, the Explosive Preparation Building, in 1958. Construction was completed in 1960. It is a concrete building of 1,575 gross square feet. It is currently used for HE machining and for shop space. Figure 126 is a recent photograph of Building 807.

Building 807 was made of concrete and concrete block with a pitched concrete



Figure 123. Looking north at the 806 Complex, south elevation, 2003.⁶³⁷

⁶³³ "Machine Building, Building No. 806, Plans, Elevations, and Details," 1955, PSZ55-806-106JB, PEL.

⁶³⁴ "Building 806A Lunch Room Addition, Floor Plan, Reflected Ceiling Plan and Details," 1986, PSA86-806-101D, PEL.

⁶³⁵ "Building 806B Process Area, Architectural Plan, Section, Elevations, and Detail," 1957, PSZ57-806-205JA, PEL.

⁶³⁶ "Site 300 Building 806D, Plans and Elevations," 1960, PSZ60-806-103JB, PEL.

⁶³⁷ 806 Complex, exterior, LLNL photographer, 2003.

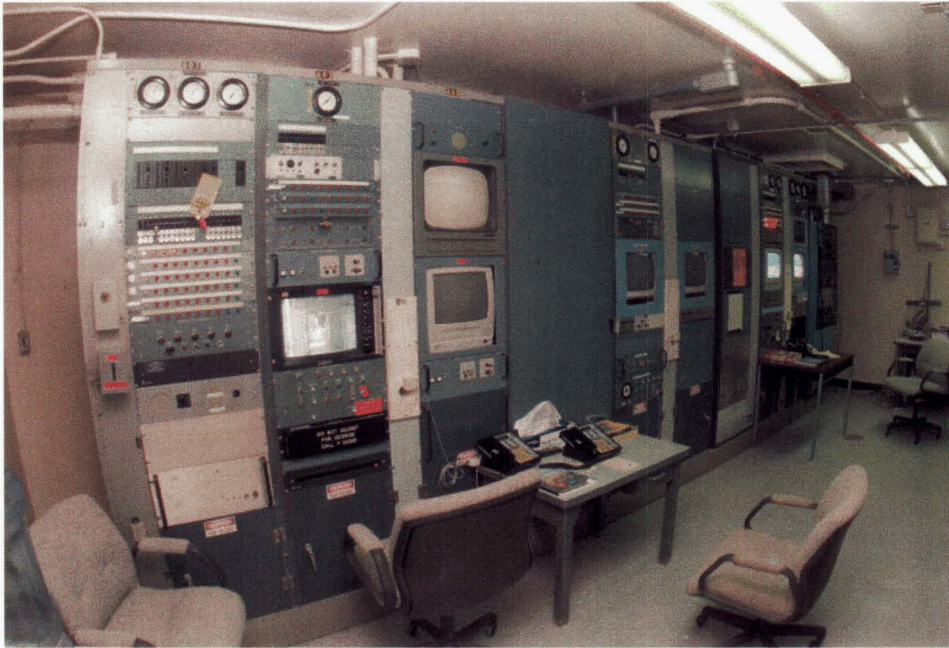


Figure 124. Control panel for remote machining equipment, Building 806B, 2003.⁶³⁸

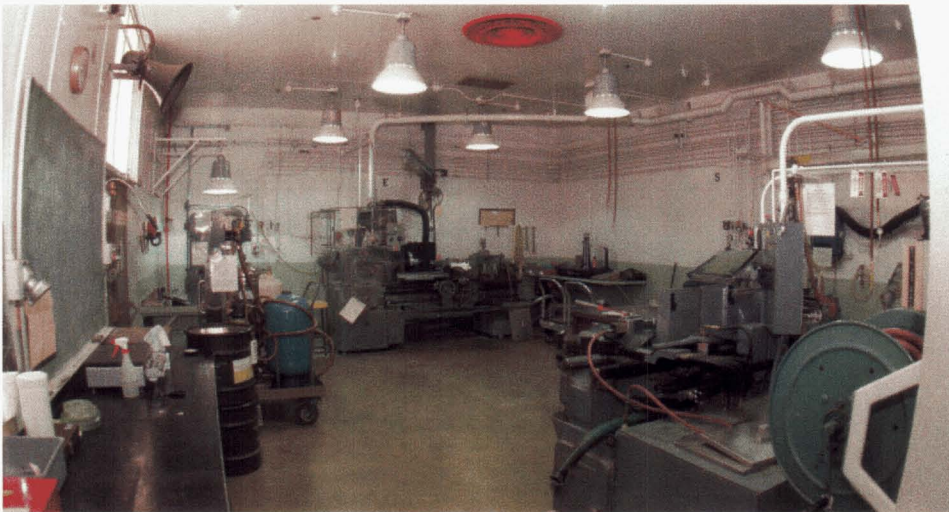


Figure 125. Remote machining equipment, Building 806B, 2003.⁶³⁹

⁶³⁸ Building 806B, control room, LLNL photographer, 2003.

⁶³⁹ Building 806B, remote machining equipment, LLNL photographer, 2003.

asbestos paneled roof.⁶⁴⁰ It housed the mixing and blending operations of HE fabrication. An inert storage room, HE storage vault, and utility room separated two remote control mixing rooms.⁶⁴¹

Building 809

Rogers Engineering and Stark, Jozens, and Nacht Architects, both San Francisco firms, designed Building 809, the Radiography Facility, in 1957. Construction was completed in 1959. Currently, Building 809 is under renovation to house a new oven facility for HE processing. It is a poured concrete structure with 2,289 gross square feet. It has four industrial shops, two mechanical utility rooms, one office, and one storage vault. Figure 127 is a recent photograph of Building 809.

Building 809 was made of two-foot-thick, reinforced concrete walls to provide shielding around the X-ray machine. The

roof was a frame construction designed to blow off in case of an accidental detonation. Concrete asbestos panels topped the concrete walls on the east, north, and south elevations. Doors were on the north and south entrances. Building 809 originally housed two cells for radiography, a utility room, dark room, and office and control room.⁶⁴² In 1984, one of the radiography cells was renovated for HE machining. Most recently, a basement was added to house a new, twenty-five-inch isostatic press for the HE Process Area.

In 1963, Heffron, Ralston, Dwyer, and Moulton, a San Francisco architectural and engineering firm, designed Building 809C (originally called M-9) as a storage magazine for HE. Construction was completed in 1964. This building was a concrete, earth-barricaded bunker with a single room for storage.⁶⁴³ It was recently remodeled to house new ovens. Figure 128 is a recent photograph of Building 809C.



Figure 126. Looking north at Building 807, south elevation, 2003.⁶⁴⁴

⁶⁴⁰ "Site 300 Building 807, Architectural, Elevations and Sections," PSZ58-807-014J, PEL.

⁶⁴¹ "Site 300 Building 807, Architectural, Floor Plan and Finish Schedule," PSZ58-807-012JA, PEL.

⁶⁴² "Building 809 Process Area, Architectural, Plan, Section, Elevations, and Details," PSZ57-809-004-JA, PEL.

⁶⁴³ "Site 300 Magazine M-9, Grading Sections and Details," PSZ63-809-003JA, PEL.

⁶⁴⁴ Building 807, exterior, LLNL photographer, 2003.



Figure 127. Looking northwest at Building 809, south and east elevations, 2003.⁶⁴⁵

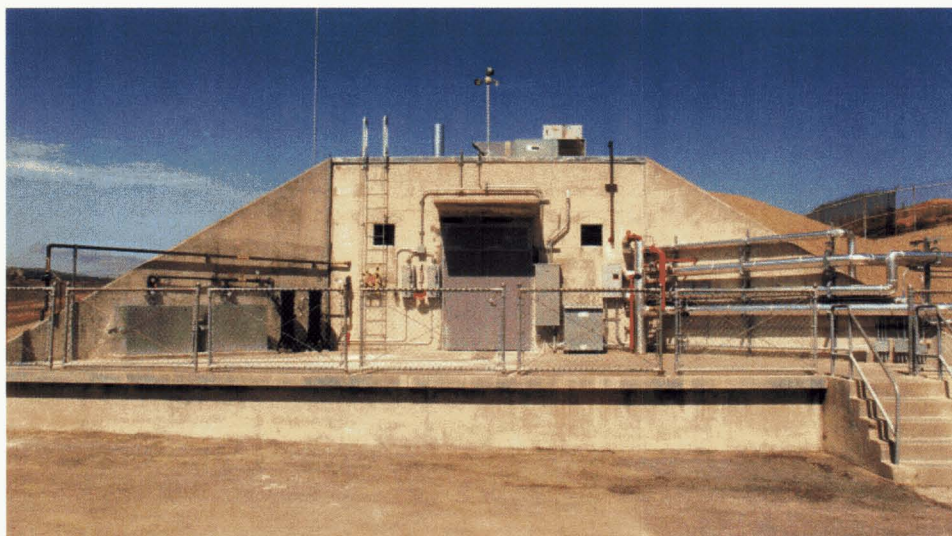


Figure 128. Looking west at Building 809C, east elevation, 2003.⁶⁴⁶

⁶⁴⁵ Building 809, exterior, LLNL photographer, 2003.

⁶⁴⁶ Building 809C, exterior, LLNL photographer, 2003.

817 Complex

The Building 817 Complex is the HE Press and Oven Facility. The Building 817 Complex, a total of eight buildings, was built between 1959 and 1964. It was designed to turn powdered HE into pressed and dried billets of explosives and has been in use for over forty years. Site 300 is now in the process of upgrading these capabilities.

The eight structures in the Building 817 Complex are Buildings 817A, B, C, D, E, F, G, and H. Of these eight structures, Buildings 817A, B, and F are the primary buildings. Buildings 817C, D, E, G, and H are either support structures or have been decommissioned. Figures 129, 130, and 131 provide views of Buildings 817A, 817B, and 817F, respectively.

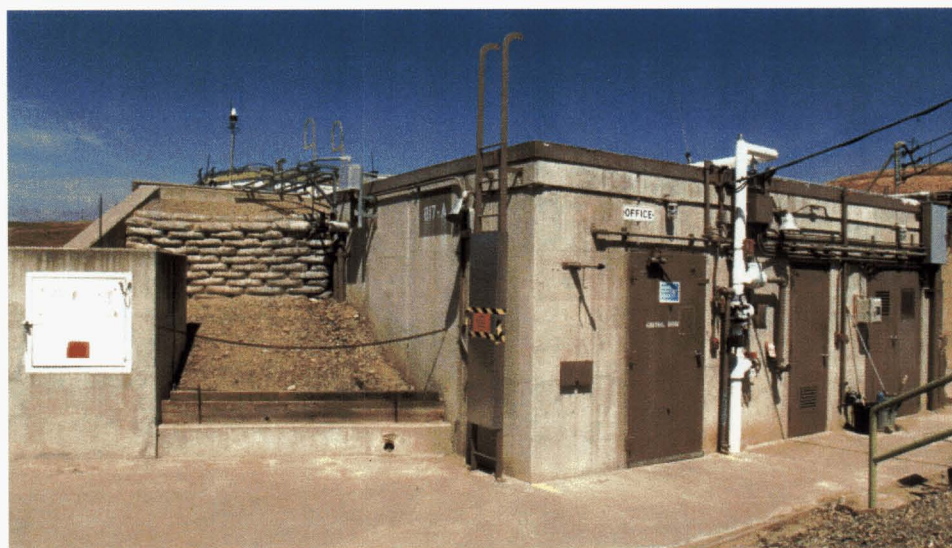


Figure 129. Looking southwest at Building 817A, east elevation, 2003.⁶⁴⁷



Figure 130. Looking north at Building 817B, south elevation, 2003.⁶⁴⁸

⁶⁴⁷ Building 817A, exterior, LLNL photographer, 2003.

⁶⁴⁸ Building 817B, exterior, LLNL photographer, 2003.

In 1957, Rogers Engineering designed Buildings 817A, B, and C, the original HE Press and Oven Facility. Construction was completed in 1959.⁶⁴⁹ Building 817A is a concrete bunker with 459 gross square feet.

It has a flat roof and an earth-filled, concrete retaining wall. 817A housed a control room/office and an equipment room. The control room operated the ovens and presses.⁶⁵⁰ Figure 132 depicts the control room in Building 817A.



Figure 131. Looking northwest at Building 817F, east elevation, 2003.⁶⁵¹



Figure 132. Control panel for remote-controlled ovens and presses, Building 817A, 2003.⁶⁵²

⁶⁴⁹ "Press and Oven Complex 817 Weaponizing Area, Architectural, Plans, Elevations, and Details," 1957, PSZ57-817-104JA, PEL; and *Site-Wide Remedial Investigation*, 13-4-53.

⁶⁵⁰ "Press and Oven Complex 817 Weaponizing Area, Structural, Press Building, Plans and Sections," PSZ57-817-110JA, PEL.

⁶⁵¹ Building 817F, exterior, LLNL photographer, 2003.

⁶⁵² 817A, control room, LLNL photographer, 2003.

Building 817B is a metal building on a concrete foundation with a slightly pitched metal roof. Exterior walls had insulated cement-asbestos panels. There were doors on the north and west elevations. Building 817B had a single room housing a fourteen-inch press and an eighteen-inch press.⁶⁵³ Figure 133 portrays the presses in Building 817B.

Building 817C is a concrete bunker building with a pitched roof. It is surrounded by a wood and earth-filled berm.⁶⁵⁴ 817C housed the original ovens.

In 1960, Indenco Engineering designed 817D, a small metal Butler-type building to house

machinery.⁶⁵⁵ This building is currently not in use.

In 1964, Ruth and Going, an engineering firm from San Jose, designed the rest of the 817 Complex—817E, F, G, and H.⁶⁵⁶ All construction was completed in 1965. Building 817E is a concrete building of 183 gross square feet with a corrugated-steel roof and upper walls. It was built as a press facility but is no longer in use. Building 817F is a concrete bunker of 565 gross square feet, with a flat roof. The interior had a single room that housed two ovens.⁶⁵⁷ Figure 134 depicts the ovens in Building 817F.



Figure 133. Isostatic presses in Building 817B, 2003.⁶⁵⁸

⁶⁵³ "Press and Oven Complex 817 Weaponizing Area, Architectural, Plans, Elevations, Details," 1957.

⁶⁵⁴ *Ibid.*

⁶⁵⁵ "Site 300 Buildings 817, Architectural, Buildings 817B, 817C, and 817D Plans, Elevations, and Sections," PSZ60-817-204JA, PEL.

⁶⁵⁶ "Additions and Modifications to Press and Oven Complex, Building 817 Site 300, Site Plan and Details," 1964, PSZ64-817-102JB, PEL.

⁶⁵⁷ "Additions and Modifications to Press and Oven Complex, Building 817 Site 300, Building 817F, Plans, Elevations, and Details," 1964, PSZ64-817-305JB, PEL.

⁶⁵⁸ Building 817B, presses, LLNL photographer, 2003.

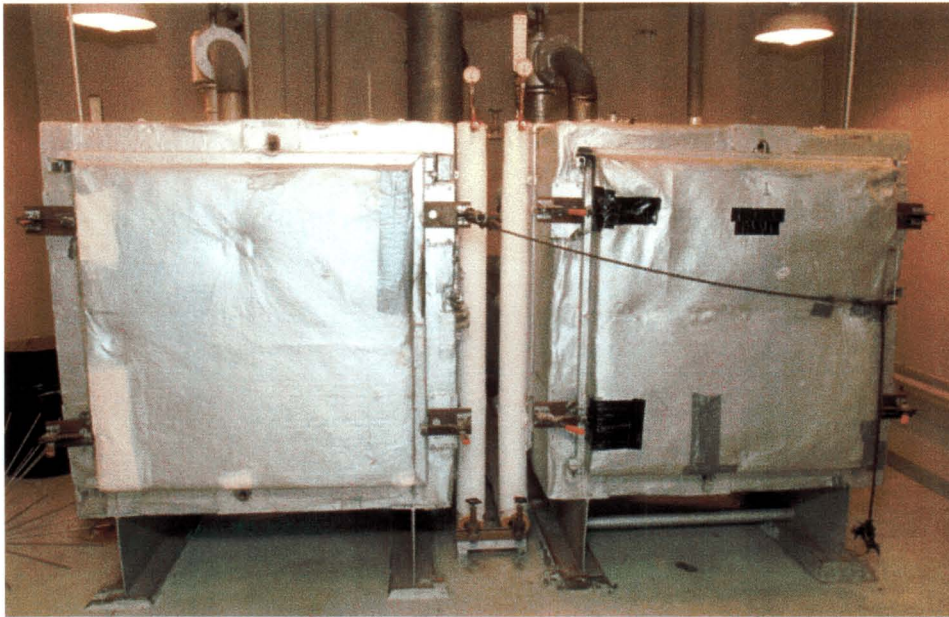


Figure 134. Ovens in Building 817F, 2003.⁶⁵⁹

Building 817G is a metal Butler-type building with a pitched roof and corrugated-fiberglass panel skylights. It housed the water boilers for the facility.⁶⁶⁰ Building 817H is also a corrugated-metal Butler-type building with a pitched roof.⁶⁶¹ It originally housed flammable liquids but currently is used to store the supply of pressing bags.

Building 825

In 1957, Rogers Engineering designed Building 825, the Chemistry Research Building. Construction was completed in 1959. It is a single-story, concrete structure of 1,323 gross square feet with a flat, gravel roof. There are cement-asbestos panels on

the north and south elevations. Building 825 has two test cells separated by a mechanical equipment room. The control room jutted out to the northeast forming a "T" with the rest of the building.⁶⁶² The building was designed for the test and development of new HE. In the 1970s, the frangible walls blew out during an accidental explosion. Currently, the building is used for mechanical pressing. Figure 135 is a recent photograph of Building 825, and figure 136 depicts the frangible walls.

⁶⁵⁹ Building 817F, ovens, LLNL photographer, 2003.

⁶⁶⁰ "Additions and Modifications to Press and Oven Complex, Building 817 Site 300, Building 817G, Plans, Elevations, and Details," 1964, PSZ64-817-104JB, PEL.

⁶⁶¹ "Additions and Modifications to Press and Oven Complex, Building 817 Site 300, Building 817H Plans and Elevations," PSZ64-817-304J, PEL.

⁶⁶² "Building 825 Weaponizing Area, Architectural, Plans, Elevations, and Sections," PSZ57-825-004JA, PEL.



Figure 135. Looking northwest at Building 825, east elevation, 2003.⁶⁶³



Figure 136. Building 825, frangible exterior walls, west elevation, 2003.⁶⁶⁴

⁶⁶³ Building 825, exterior, LLNL photographer, 2003.

⁶⁶⁴ Building 825, frangible walls, LLNL photographer, 2003.

Building 826

In 1959, Indenco Engineering designed Building 826 as an additional Chemistry Facility for the development and testing of HE. Construction was completed in 1960. Building 826 is a single-story structure of 1,678 gross square feet. Similar in construction to Building 825, it has concrete walls, a slightly pitched roof, and cement-asbestos panels. It housed two chemistry cells with frangible back walls, a control room, mechanical equipment room and storage room.⁶⁶⁵ Currently, Building 826 houses mixers, a one-inch press, and an area loader. Figure 137 is a recent photograph of Building 826.

827 Complex

In 1965, Ruth and Going designed the entire Building 827 Complex. Construction was completed in 1968. The Building 827 Complex consisted of five buildings—827A, B, C, D, and E. Of these five buildings, 827A, C, D, and E make up the main chemistry laboratories. Building 827B was a machine shop and is of no historic interest. Figures 138, 139, 140, and 141 are recent photographs of Buildings 827A, C, D, and E.

Building 827A is a single-story, concrete structure with a basement and a flat roof.⁶⁶⁶ It has 4,489 gross square feet. There are doors on the north, west, and east elevations. The basement housed the utility



Figure 137. Looking southwest at Building 826, north and east elevations, 2003.⁶⁶⁷

⁶⁶⁵ "Site 300, Chemistry Building 826, Architectural, Floor Plans, Elevations, and Finish Schedules," PSZ59-826-005JA, PEL.

⁶⁶⁶ "Chemistry Development Facilities Building 827 Complex, Site 300, Building 827A, Elevations and Details," PSZ65-827-108JA, PEL.

⁶⁶⁷ Building 826, exterior, LLNL photographer, 2003.

9. BUILDING ASSESSMENTS

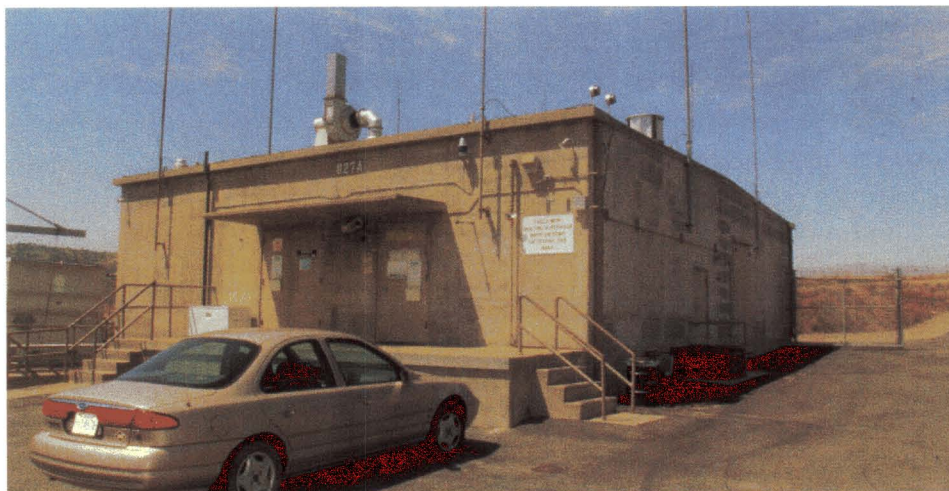


Figure 138. Looking southwest at Building 827A, north and east elevations, 2003.⁶⁶⁸

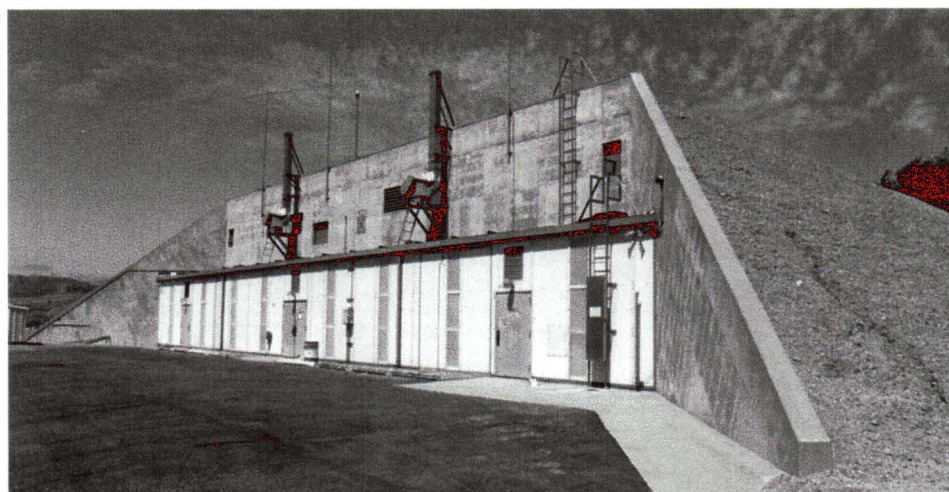


Figure 139. Looking northwest at Building 827C, south and east elevations, 2003.⁶⁶⁹



Figure 140. Looking north at Building 827D, south elevation, 2003.⁶⁷⁰

⁶⁶⁸ Building 827A, exterior, LLNL photographer, 2003.

⁶⁷⁰ Building 827D, exterior, LLNL photographer, 2003.

⁶⁶⁹ Building 827C, exterior, LLNL photographer, 2003.

and equipment rooms. The main floor housed a control room, workshop, office, service room, storage room, and analytical laboratory.⁶⁷¹ Figure 142 depicts the control room in Building 827A.

Building 827B is a metal Butler building with galvanized metal siding and a pitched metal roof. It housed a storage room and

machine shop.⁶⁷² Currently, it is used as a machine shop for Building 826, the 827 Complex, and the 828 Complex.

Buildings 827C, D, and E are identical in construction. They are poured concrete structures with sloped roofs.⁶⁷³ They had two high bay cells with an equipment room on a mezzanine. They housed a variety



Figure 141. Looking southeast at Building 827E, west elevation, 2003.⁶⁷⁴

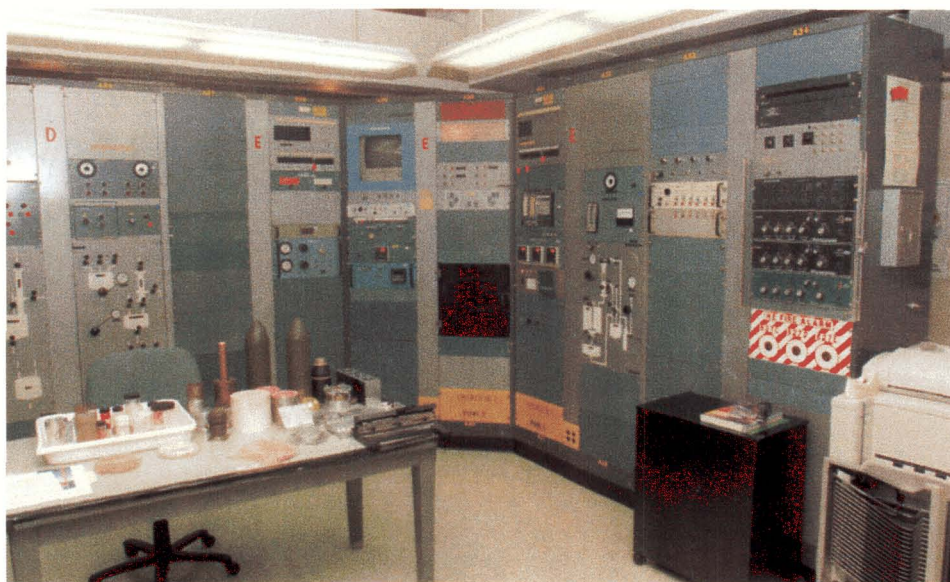


Figure 142. Partial view of control room in Building 827A, 2003.⁶⁷⁵

⁶⁷¹ "Development Facilities Building 827 Complex, Site 300, Building 827A, Floor Plan and Basement Plan," PSZ65-827-107JA, PEL.

⁶⁷² "Chemistry Development Facilities Building 827 Complex, Site 300, Building 827B, Plans, Sections, and Details," PSZ65-827-114JA, PEL.

⁶⁷³ "Chemistry Development Facilities Building 827 Complex, Site 300, Grading Sections," PSZ65-827-105JA, PEL.

⁶⁷⁴ Building 827E, exterior, LLNL photographer, 2003.

⁶⁷⁵ Building 827A, control room, LLNL photographer, 2003.

of equipment to melt, heat, mix, and cast explosives. Currently, 827C houses mixers in Cell 1 and an area loader in Cell 2.

Figure 143 illustrates the various mixers in Building 827C.

Building 827D currently houses cast kettles in Cell 1 and a pilot plant reactor vessel in

Cell 2. Figure 144 depicts the pilot plant reactor vessel experiment in Building 827D.

Building 827E currently houses kettles in Cell 1 and equipment for particle sizing in Cell 2.

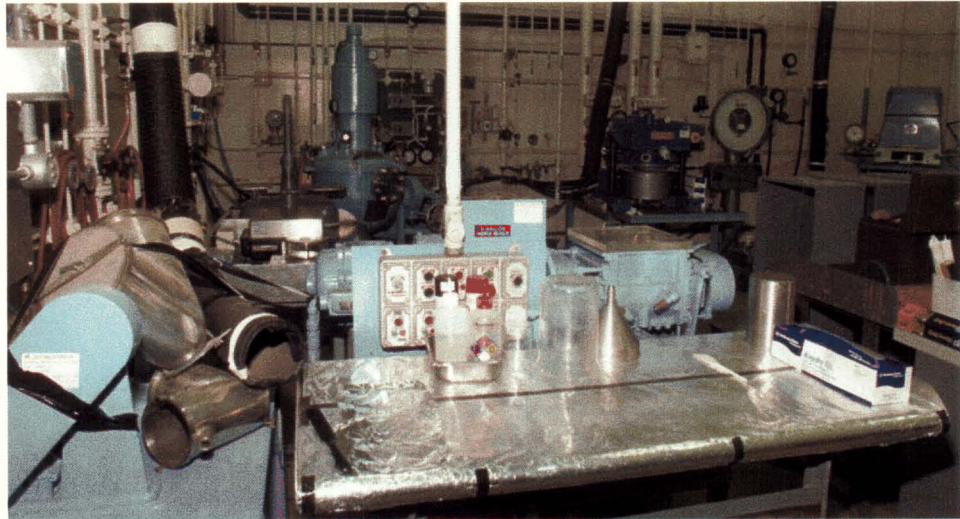


Figure 143. Horizontal and vertical mixers in Building 827C, 2003.⁶⁷⁶

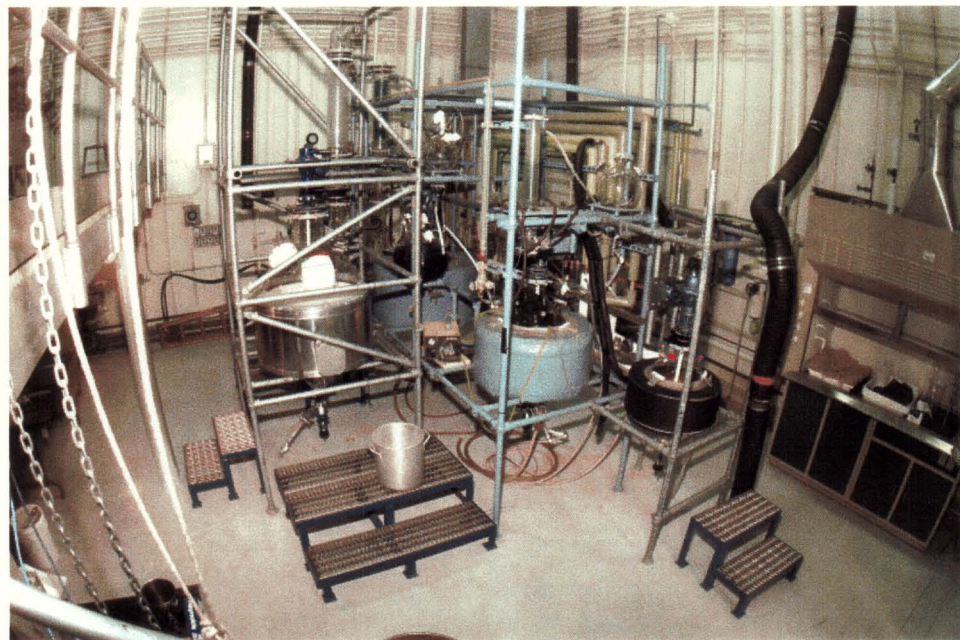


Figure 144. Pilot reactor vessel in Building 827D, Cell 2, 2003.⁶⁷⁷

⁶⁷⁶ Building 827C, mixers, LLNL photographer, 2003.

⁶⁷⁷ Building 827D, reactor vessel, LLNL photographer, 2003.

828 Complex

Buildings 828A, B, and C were built between 1964 and 1967 to house non-nuclear HE chemical test laboratories. They were inexpensively constructed structures of corrugated-metal and wood. In the event of an accidental explosion, they could easily be replaced. Billets of explosives were brought to the 828 Complex and were cut into shapes or had keys cut into them. Building 828A is a steel box with sloping north and south exterior walls. The north and south elevations have corrugated-metal sides with a metal vault door in the north side. The west and east walls are flat. A metal pipe

protrudes from the south end into a bucket funnel with a valve to release process water during machining operations. Building 828A housed the control room for remote machining operations. Building 828B is a square plywood building that housed air compressors and electronics equipment. Building 828C is a wooden structure with concrete floors that housed the lathes. In the 1990s, the facility was remodeled for a molten salt experiment that was canceled before it was completed. Currently, the area is decommissioned. Figures 145, 146, and 147 are recent photographs of Buildings 828A, 828B, and 828C.

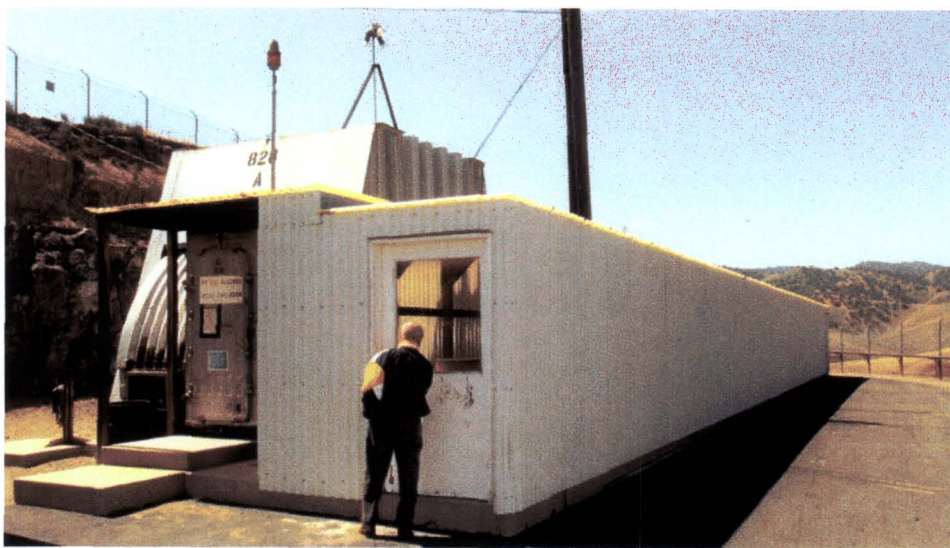


Figure 145. Looking southwest at Building 828A, 2003.⁶⁷⁸

⁶⁷⁸ Building 828A, exterior, LLNL photographer, 2003.



Figure 146. Looking southwest at Building 828B, 2003.⁶⁷⁹



Figure 147. Looking west at Building 828C, east elevation, 2003.⁶⁸⁰

⁶⁷⁹ Building 828B, exterior, LLNL photographer, 2003.

⁶⁸⁰ Building 828C, exterior, LLNL photographer, 2003.

The Process Area of Site 300 contains functional, industrial structures of undistinguished architectural design typical (although with regional variations) of military and industrial installations working with HE. Buildings in the Process Area were built from mass-produced industrial materials—concrete, steel, wood, and corrugated metal. Site 300 buildings tended to be even more utilitarian in design than buildings at the main site. They had little adornment and were designed of inexpensive materials that could be replaced in the event of an accidental explosion. Most were rectangular concrete boxes designed to house explosives research and development experiments. Support structures—i.e., storage sheds and shops—were usually Butler-type steel structures. The exception to the strictly utilitarian aesthetic was the use of colored concrete asbestos panels on Buildings 809, 817B, 825, and 826.

The Process Area includes two LLNL Cold War building types—the Site 300 Heavy Laboratory and the Metal Butler-type Building. Laboratories that housed HE processing activities fall into the Site 300 Heavy Laboratory building category and possess the characteristic features of that type—reinforced concrete or cement-asbestos paneled walls, gravel or cement-asbestos paneled roof, and a reinforced-concrete slab foundation. In addition, some possess frangible walls (Buildings 805, 809, 825, and 826), earth berms (Buildings 809C and 817C), or concrete retaining walls (Building 817A). Support structures (storage or shop areas) fall into the Metal Butler-type Building category and possess the characteristic

features of that type—prefabricated steel rigid-frame structure, reinforced-concrete slab, corrugated-metal siding and roofing, and space for short-term experiments or shops.

The Process Area buildings do not represent exceptional examples of architectural style or design. Although they possess some features (reinforced concrete, earth berm, or concrete retaining walls) that reflect the hazardous nature of the work that occurred there, they do not possess historically interesting or exceptional design characteristics. The Process Area buildings are typical of a number of different kinds of structures in the military and the weapons complex that are used to handle or store explosive material.

The Building 828 Complex, the experimental HE chemical test laboratories, are the only structures that do not fall easily into established building categories. The 828 Complex buildings were built of plywood and corrugated metal. New techniques for machining explosives were developed there. In case of an accidental explosion, these buildings could easily be replaced. They were intended to be temporary and expendable structures, reflecting no high architectural design or noteworthy design elements.

9.19.4 Integrity

The HE Process Area of Site 300—Buildings 805, 806, 807, 809, 817, 825, 826, 827, and 828—is of historic interest for the period 1957–1992 for its HE formulation and fabrication activities in support of LLNL nuclear weapons design. The Process Area is also of historic significance for its role in the 1976 breakthrough in developing the IHE TATB.

Some of the functions in the HE process have migrated from one building to another over time, leaving a few of the individual buildings without integrity for the early part of the period of significance. As will be discussed below, Buildings 809, 817C, 817D, 817E, 827D, and the 828 Complex no longer possess integrity.

The remainder of the Process Area retains integrity for the 1975–1991 period.

The Process Area still formulates and fabricates HE in much the same way and using much of the same equipment as it did in the period 1957–1991.

Building 805 no longer possesses integrity for its original trim and assembly activities but does possess historic integrity for the 1975–1991 period when it manufactured HE lenses.

Building 806 still possesses historic integrity for the entire 1957–1991 period for its machining capabilities.

Building 807 no longer possesses historic integrity as a casting facility but does retain integrity for machining activities from 1968–1991.

Building 809 no longer possesses any historic integrity as a radiography or machining facility. In the last several years it has been completely renovated to accommodate a new twenty-five inch isostatic press.

The Building 817 Complex still possesses historic integrity for its oven and isostatic pressing activities. The Building 817 Oven and Press Complex has been operating for over forty years.

The original 1957 Oven and Press Complex consisted of Buildings 817A, B, and C. Building 817A, the control room, is still intact and operational. Building 817B still operates the original fourteen-inch and eighteen-inch isostatic presses.

Building 817C, the oven building, has been decommissioned and no longer retains integrity. Building 817D, the mechanical equipment room built in 1960, is also no longer in use and does not retain integrity. However, it was a support structure, not a core building.

In 1964, Buildings 817E, F, G, and H were built to expand drying and pressing capabilities for the Oven and Press Complex. Of these structures Buildings 817F, G, and H still possess integrity. Building 817F still has its original ovens, and Buildings 817G and H are still used as support facilities. Only Building 817E, which was used for presses, has been decommissioned.

The Building 817 Complex still dries powdered HE and presses it into billets. Although a few of its buildings no longer possess individual integrity, the complex as a whole does possess integrity for its drying and pressing activities from 1975 to 1991.

Buildings 825 and 826 both still retain historic integrity for the HE formulation work they housed. Building 825 still retains two original presses, the original calorimeter, and a largely intact control room. It retains integrity for the 1959–1991 period. Building 826 also has an intact control panel and many of the original mixers. It retains integrity for the 1960–1991 period.

The Building 827 Chemistry Complex still retains historic integrity for its heating, mixing, and casting activities. Building 827A, the control building, still retains the original control panel. Building 827B still functions as a support structure; Building 827C retains many of the original mixing and extruding equipment. Building 827E still has some original heating and casting equipment. Only Building 827D has been significantly modified. Currently, it houses a pilot plant for reactor vessels. The Building 827 complex retains its integrity for the 1968–1991 period.

The Building 828 Complex, the remote machining area, no longer has integrity. The buildings are dilapidated and empty of equipment. However, this area was not vital to the HE process area. It functioned more as a support machining capability to prevent damage to the main area when new machining techniques were developed and tried.

9.19.5 Recommendation

This report recommends that the Process Area, consisting of Buildings 805, 806, 807, 817, 825, 826, and 827, is eligible for National Register consideration as a historic district for the 1975–1991 period.

The Process Area buildings were designed and built together as a group to develop HE for LLNL nuclear weapon designs. Each building or complex performed a separate but integral part of the HE development process—chemical formulation, mixing and blending, drying, casting and/or pressing, machining, radiography, and assembly. The integrated nature of the process is reflected in the ordered location and close proximity of the buildings to one another.

Buildings and structures under fifty years of age are generally not considered eligible for the National Register. The Process Area of Site 300 will not be fifty years of age until 2007.

However, under Criteria Consideration G, properties under fifty years of age can be considered eligible to the National Register if it can be demonstrated that they are of exceptional significance.

The Cold War has been recognized as a period of exceptional significance within U.S. and world history. Additionally, the development, production, and testing of HE is a critical element of the process of nuclear weapons design. The HE Process Area physically represents the design and testing of all LLNL nuclear weapons in both the historic and enduring stockpile. Therefore, it is of exceptional historic significance as defined within the LLNL Cold War preservation themes Nuclear Weapons Design (subtheme Weapons Design) and Nuclear Weapons Testing (subtheme HE Testing).

The Process Area of Site 300 does not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this district. Nor are the designs of the buildings of architectural interest. The Process Area is not, nor will it be, a source of important information. The process activities that occurred there are amply documented in the written record.

However, the Process Area does qualify for National Register consideration as a district under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War and the specific role of LLNL's HE work in nuclear weapons design. The Area processed and developed HE billets for all LLNL-designed nuclear weapons during the Cold War. The particular period of historic significance for these activities within this district is 1957–1991. Furthermore, the Process Area also qualifies for National Register consideration for its role in the design breakthrough on the IHE TATB, which led to increased safety in nuclear weapons design. The period of historic significance for this activity is 1976.

The HE Process Area of Site 300 possesses integrity for the period of historic significance. Therefore, the Process Area is eligible for National Register consideration under Criterion A. Features of particular note as illustrations of the area's historic significance that are still extant include the control room in Building 805; the machining equipment in Buildings 806A and B; the machining equipment in Building 807; the

control room in Building 817A; the fourteen-inch and eighteen-inch press in Building 817B; the ovens in Building 817F; the control room, two-inch press, and calorimeter in Building 825; the control room, one-inch press, and mixer in Building 826; the control room in Building 827A; and the mixers, extruders and area loaders in Building 827C. Although some of the Process Area lacks integrity as noted above, these specific features within the context of the building designs and exteriors represent the HE Process Area in sufficient detail to illustrate the story of HE Processing at Site 300.

The Process Area forms a non-contiguous historic district composed of each of the buildings contributing to it (805, 806A, 806B, 807, 817A, 817B, 817F, 825, 826, 827, 827A, and 827C) and bounded by the land ten feet in all directions around each of them.

9.20 Site 300, Hydrodynamic Test Facilities: Buildings 802A, 812A, 845A, 850, and 851A

9.20.1 Description

The Hydrodynamic Test Facilities consist of two separate firing areas located in the east and west sections of LLNL's Site 300. The Hydrodynamic Test Facilities originally consisted of seven main underground bunkers with nine support structures. Of these sixteen original buildings, five are still extant and aligned with the mission of the Hydrodynamic Test Facilities. These remaining five Hydrodynamic Test Facilities (referred to by their current designations) are the east area firing facilities:

- Building 802A, the Camera Test Facility
- Building 812A, the Physics Laboratory
- Building 845A, the Explosive Waste Treatment Facility

and the west area firing facilities:

- Building 850, the Firing Facility
- Building 851A, the Linac Firing Facility.

The Hydrodynamic Test Facilities' mission was to conduct non-nuclear destructive tests on weapons assemblies and components to verify design specifications for the LLNL nuclear weapons program. Today, researchers at the Hydrodynamic Test Facilities conduct "destructive testing and evaluation of high explosives materials, components, and assemblies" for the Stockpile Stewardship Program.⁶⁸¹ The majority of the Hydrodynamic Test Facilities were built between

1955 and 1960. The hydrodynamic structures were underground concrete and/or corrugated-metal bunkers with firing tables above them. The support structures were generally small, metal Butler-type buildings used for storage or mechanical equipment. A few support structures are made of concrete.

9.20.2 Mission History

LLNL administrators bought the land for Site 300 in 1953. The first structures built at Site 300 were those designed for hydrodynamic testing. Hydrodynamic testing involved the explosion of non-fissile weapon components and assemblies to determine how materials behaved during detonation. From 1955–1957, five underground bunkers were constructed in what was called the east firing area

- Building 801, Pin and Optics Bunker
- Building 802A, Small Spot Pin Bunker
- Building 804, Storage Magazine
- Building 812A, Linac Bunker
- Building 845A, Diagnostics Bunker.

Of these structures, the main explosive firing sites were Buildings 801, 802A, and 812. Building 801 was equipped with high-speed cameras to record test explosions. Events could be viewed via a mirror system. Pin studies on weapon assemblies were conducted in Building 802A. Assemblies were fitted with pins (electrical contacts) and connected to electronic equipment in the bunker. The motion of inner parts could be determined by recording the instant of contact between the pins and the portion

⁶⁸¹ Jim Lane, "Introduction to Site 300," slide presentation, n.d., Site 300 Deputy Manager Files.

of the assembly that they struck. Building 812 was equipped with a linear accelerator (linac), the XR2 machine, which took X-rays of assemblies as they exploded.⁶⁸²

Building 804 was a storage magazine for explosives and Building 845A was a small bunker that provided limited diagnostics on small explosive shots.

In 1958, construction began on the west firing area. The first structure constructed was Building 850, the Diagnostics Bunker. Building 850 was equipped with pin-optics and flash X-ray diagnostic capabilities. The building also had three firing tables and could accommodate much larger HE testing. In 1960, the west firing area was completed by the addition of Building 851A, the Helac (high explosive linear accelerator) Bunker. Building 851A housed a more powerful linac than the XR2 machine in 812A.

From 1955 to 1992, after which U.S. nuclear testing ceased, Site 300's Hydrodynamic Testing Facilities had a single mission—to conduct non-nuclear explosive testing on nuclear weapons components and assemblies prior to large scale nuclear testing. These tests determined the following kinds of information: empirical determination of theoretical values, determination of ballistic performance values of HE components, transit times, and simultaneity. This information established “ultimate design criteria” for test devices. Prior to every LLNL nuclear test conducted at the Pacific Proving Grounds or the Nevada Test Site, anywhere from ten to fifty test devices were fired at Site 300.⁶⁸³

With the construction of Buildings 850 and 851A, the west area firing facilities became the focal point of hydrodynamic testing at Site 300.

In 1962, the old linear accelerator was removed from Building 812A, and a forty-eight-channel raster scope system, twelve-channel four-gun scope system, and four-channel high-speed camera system were installed.

The east and west firing areas were active throughout the 1960s and 1970s. Activity began to wind down in some of the east firing facilities (Buildings 802A, 812A, 845A) in the 1980s as nuclear testing slowed. In 1982, Building 801 was completely renovated into a state-of-the-art firing facility. Hydrodynamics testing gradually migrated to the new Building 801, the Flash X-Ray Radiography Facility; and Building 851A, the Linac Firing Facility.

Currently, hydrodynamic testing at Site 300 takes place in Buildings 801 and 851A. These remaining Hydrodynamic Test Facilities perform destructive testing of HE and other non-nuclear materials in support of the Stockpile Stewardship Program.

Period of Significance

From 1955 to 1992, the Hydrodynamic Test Facilities—Buildings 802A, 812A, 845A, 850, and 851A—engaged in hydrodynamic testing of non-fissionable nuclear weapons components and devices in support of the LLNL weapons program. LLNL was one of two laboratories that designed and developed nuclear weapons for the U.S.

⁶⁸² *Status Report: Fiscal Year 1958*, 176.

⁶⁸³ *Ibid.*

stockpile. Hydrodynamic testing of nuclear weapons components and devices provided critical weapons design information prior to a full-scale nuclear test at the Pacific Proving Grounds or Nevada Test Site. The Hydrodynamic Testing Facilities at Site 300 performed empirical testing of theoretical weapons designs—a critical phase in the weapons design process—establishing the final specifications for a particular weapon.

Therefore, hydrodynamic testing at LLNL is of historic interest within the context of the Cold War preservation themes of Nuclear Weapons Design (subtheme Weapons Design), and Nuclear Weapons Testing (subtheme High Explosives Testing).

Two buildings, 801 and 804, will receive no further attention here. Building 801, the Pin and Optics Building, no longer exists in its original form, but was rebuilt in 1982 as a state-of-the-art Flash X-Ray Radiography Facility. Building 801, in its present form, is too young to be of historic interest. Building 804, the Storage Magazine, is also of no historic interest because it functioned as a minor support structure and does not fall within any of the LLNL preservation themes.

Buildings 802A, 812A, and 845A represent hydrodynamic activities conducted during the Cold War and determined to be of historic interest within the LLNL preservation themes of Nuclear Weapons Design (subtheme Weapons Design) and Nuclear Weapons Testing (subtheme HE Testing).

The period of historic significance for the east firing area facilities—Buildings 802A, 812A, and 845A—is 1955–1982. Most hy-

drodynamic testing began to shift to the new Building 801 Flash X-Ray Radiography Facility and Building 851A Linac Firing Facility by 1982.

The period of historic significance for the west firing area facilities—Buildings 850 and 851A—is 1958–1992. Buildings 850 and 851A were important centers of hydrodynamic testing throughout the entire Cold War period.

9.20.3 Construction History

The Hydrodynamic Test Facilities were among the first structures built at Site 300. The east area firing facilities were built between 1955 and 1957; and the west area firing facilities were added between 1958 and 1960.

East Area Firing Facilities

The original east area firing facilities—built between 1955 and 1957—consisted of five underground bunkers and their support structures. They were

- Building 801, Pin and Optics Bunker
- Building 802A, Small Spot Pin Bunker
- Building 804, Storage Magazine
- Building 812A, Linac Bunker
- Building 845A, Diagnostics Bunker.

Buildings 802A, 812A, and 845A will be assessed further below. As described earlier, Buildings 801 and 804 are of no historic interest within the LLNL Cold War context and established preservation themes.

Building 802A

Building 802A, the Pin and Optics Bunker, was built in 1955. It is an underground concrete and corrugated-metal bunker of 2,805 gross square feet. The original structure was a corrugated-metal Armco arch—an elliptical metal cylinder—set on a concrete slab and covered with earth. The underground metal structure housed a control room, and the firing table was above the bunker. In 1958, Indenco Engineers, a San Leandro firm, designed an addition that housed a darkroom, electrical magnetic room, equipment rack, and office.⁶⁸⁴ The addition was an underground concrete structure that extended south and west of the original building.⁶⁸⁵ Figure 148 is a recent photograph of 802A.

Building 802A has not been used as a firing facility since the early 1980s. Figure 149 depicts the interior of Building 802A.

Building 812A

Building 812A is a concrete and corrugated-metal bunker of 2,283 gross square feet. Rogers Engineering designed Building 812A in 1957 to house a linear accelerator (linac), the XR2, which could X-ray the inner motions of test assemblies during firing. Construction was completed in 1957.⁶⁸⁶ Figure 150 is a recent photograph of Building 812A, and figure 151 depicts the firing table.

Building 812A is a corrugated-metal Armco arch on a concrete pad covered with earth. There are concrete retaining walls on the

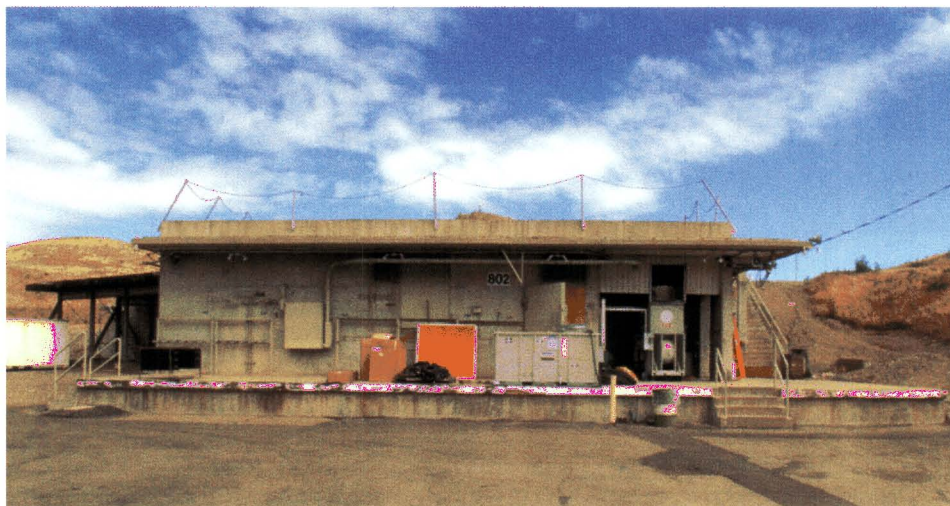


Figure 148. Looking north at Building 802A, south elevation, 2003.⁶⁸⁷

⁶⁸⁴ "Site 300 Building 802A Architectural, Floor Plan," 1958, PSZ58-802-111J, PEL.

⁶⁸⁵ "Site 300 Building 802A Architectural, Elevations and Sections," 1958, PSZ58-802-112JA, PEL; and "Site and Grading Plan," 1958, PSZ58-802-110JA, PEL.

⁶⁸⁶ *Status Report: Fiscal Year 1958*, 176.

⁶⁸⁷ Building 802A, exterior, LLNL photographer, 2003.



Figure 149. Original Armco arch in Increment 1 of Building 802A, 2003.⁶⁸⁸



Figure 150. Looking northeast at Building 812A, south elevation, 2003.⁶⁸⁹

⁶⁸⁸ Building 802A, interior, LLNL photographer, 2003.

⁶⁸⁹ Building 812A, exterior, LLNL photographer, 2003.

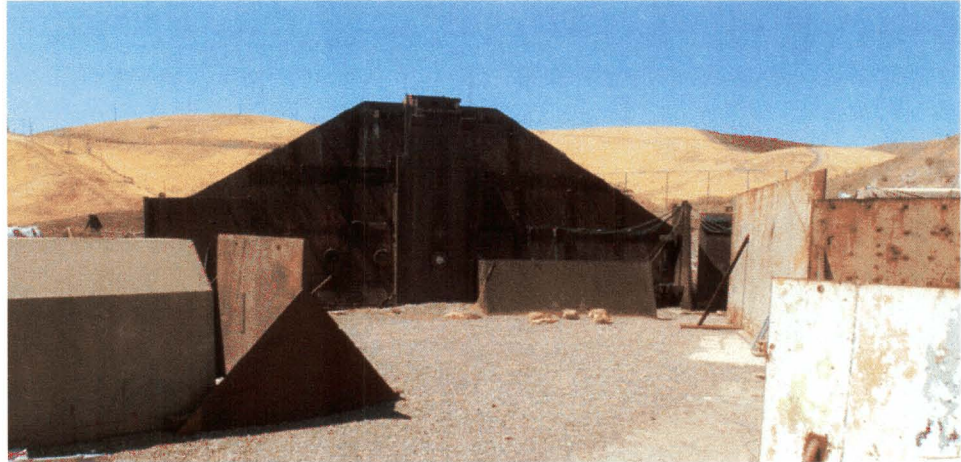


Figure 151. Building 812A firing table looking toward optics ports, north elevation, 2003.⁶⁹⁰

north and south elevations. The interior was a single room that housed the linac.⁶⁹¹ In 1962, the XR2 was removed from Building 812A when a more powerful linac was built in 851A. Building 812A was remodeled to house additional pin-and-optics diagnostic equipment for hydrodynamic testing.

In addition to the main bunker, designated Building 812A, there were also four support structures at the Building 812 site: Buildings 812B, C, D, and E. In 1957, Rogers Engineering designed Building 812B as a carport and storage shelter and Building 812C as a car shelter. They were made of corrugated-metal with an arched roof on a concrete pad.⁶⁹² Building 812D was built in the early 1960s as a firing pad. In 1961, Indenco Engineers designed Building 812E to house the 155-millimeter gun. Building 812E was made of concrete with a flat roof and has metal blast doors on the north and south elevations.⁶⁹³

Currently, Building 812A is being used in testing of the three-inch gun. Building 812B is being used as a shower and changing room. Building 812C is being used for photo-chemical processing. Building 812D is inactive. Building 812E is being used as storage for the Cobalt-60 source once used in the X-Ray Calibration and Standards Laboratory for the Nuclear Test Program. Building 812E has not been in active use since the early 1990s.⁶⁹⁴ Buildings 812B, C, D, and E were used as support structures for Building 812A. As support structures they are of no historic interest.

Building 845A

Building 845A is a concrete and corrugated-metal underground bunker of 416 gross square feet. It was one of the original Armco arches built in 1955 and used as a small firing facility. Figure 152 is a recent photograph of Building 845A.

⁶⁹⁰ Building 812A, firing table, LLNL photographer, 2003.

⁶⁹¹ "Linac Building, Building 812, Architectural, Plans, Elevations, and Details," 1957, PSZ57-812-102JB, PEL.

⁶⁹² "Linac Bunker & Appurtenant Structures, Site and Grading Plan," 1957, PSZ57-812-101JB, PEL; and "Site 300 Building 812 Modifications and Additions, Plans Elevations, and Sections," 1960, PSZ60-812-203JA, PEL.

⁶⁹³ "Site 300 Building 812E, Architectural, Plan, Elevations, and Sections," 1961, PSZ61-812-506JB, PEL.

⁶⁹⁴ Criticality and Safety Analysis Group, "Building 812E X-Ray Calibration and Standards Laboratory at Site 300" (Livermore: 1993), 1.



Figure 152. Looking south at Building 845A, north elevation, 2003.⁶⁹⁵

Building 845A consisted of a metal arch on a concrete pad covered with earth. The front wall was made of steel and had a door, while the back wall was concrete. The firing table was above the structure in a natural bowl. Building 845A was capable of handling small shots or muster shots with limited diagnostics.⁶⁹⁶ The interior of the bunker was used as a control room for the firing facility behind it.

Building 845A is no longer part of the East Area Firing Facility. Currently, it is used as the Explosive Waste Treatment Facility (EWTF) for the HE Processing Area. In addition to the main bunker, Building 845A, the facility has one support structure. Building 845B is an incinerator used in the treatment of explosive waste.

West Area Firing Facilities

The west area firing facilities consisted of two underground bunkers and their support structures.

- Building 850, the Diagnostics Bunker
- Building 851A, the Helac Building.

After their construction in 1960, Buildings 850 and 851A became the center for hydrodynamic testing. The west area firing facilities could handle larger HE shots than the east area.

Building 850

Building 850 is a concrete block building of 4,834 gross square feet with a flat roof. In 1958, Indenco Engineers designed Building 850 as a diagnostics bunker for hydrodynamic testing. Construction was completed in 1960. Figure 153 is a recent photograph of Building 850.

⁶⁹⁵ Building 845A, exterior, LLNL photographer, 2003.

⁶⁹⁶ Lawrence Livermore Laboratory, *Site 300 1973 Annual Report* (Livermore: Lawrence Livermore Laboratory, 1973), 12.

The west firing area Hydrodynamic Facilities of Site 300 do not qualify for National Register consideration under Criterion B, association with a historic figure; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with this district. The west area Hydrodynamic Test Facilities are not, nor will they be, important sources of historical information. The hydrodynamic testing that occurred there is documented in research reports and archival collections.

However, the west firing area Hydrodynamic Facilities do qualify for National Register consideration as a district under Criterion A, association with a historic event or pattern of events. In this case, the historic pattern of events is the Cold War hydrodynamic testing of all LLNL-designed nuclear weapons components and materials. The particular period of historic significance for these activities within this district is 1960–1992.

The west firing area Hydrodynamic Facilities of Site 300 possess integrity for the period of historic significance. Therefore, they are eligible for National Register consideration under Criterion A. Notable features reflecting the firing area's historic significance under Criterion A include the control room, camera room, camera ports, cable ports, and firing table of Building 850; and the linac, linac control room, camera room, and firing table of Building 851A.

Building 851A also qualifies for National Register consideration under Criterion C, exceptional design or architectural significance.

Building 851A is an exceptional example of a hydrodynamic test facility and firing table. It also incorporates unique design features that reflect its historic work—the concrete shielding built surrounding the linac, the bull-nose on the exterior of the building, camera ports, and firing table. These features reflect the precise nature of the technical design of the equipment used in the structure. The building is congruent with and directly reflects the testing activities it housed. The particular period of historic significance for design is 1960.

Building 851A does possess design integrity for the period of its historic significance. Contributing elements to design significance under Criterion C include the bull-nose, firing table, camera ports and concrete shielding surrounding the linac.

However, Building 850 does not qualify for National Register consideration under Criterion C, exceptional design significance. It is an undistinguished example of an industrial building designed for explosives testing purposes.

In summary, it is recommended that the west area Hydrodynamic Test Facilities, Buildings 850 and 851A qualify for National Register consideration as a non-contiguous historic district under Criterion A. This district will consist of Buildings 850 and 851A, the test pads above them, and the land ten feet in all directions around each of them. Building 851A also qualifies for National Register consideration under Criterion C.

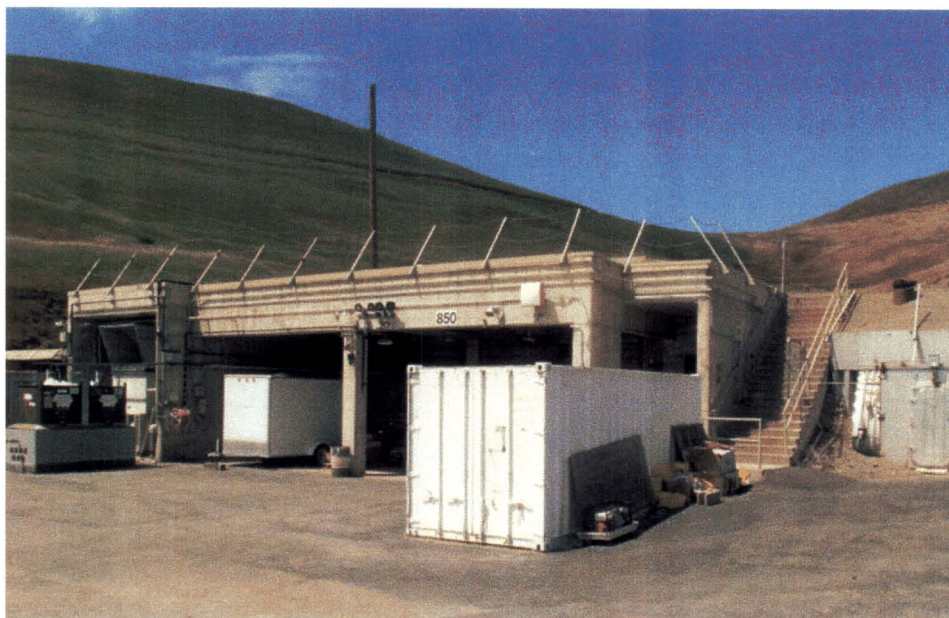


Figure 153. Looking west at Building 850, east elevation, 2003.⁶⁹⁷

Building 850 was a “semiburied structure of reinforced concrete.”⁶⁹⁸ The interior housed a large electronic racks room, camera room, darkroom, electronics maintenance room, mechanical equipment room, workspace, and office. A firing table was located two feet above the bunker and to the northwest of the building. Building 850 was designed for HE detonations of up to 200 pounds. The testing could occur as close as ten feet from the bunker walls. Building 850 was equipped with a 770 streak camera, pin hydros, and raster oscilloscopes for diagnostics.

In 1961, a changing room addition was built for Building 850.

Building 850 was used as a hydrodynamic test facility until 1986, when it was decommissioned.

In 1994, Building 850 was converted into a camera maintenance repair facility for the firing areas.

⁶⁹⁷ Building 850, exterior, LLNL photographer, 2003.

⁶⁹⁸ “Site 300 Adds Land and Buildings,” 7.

Building 851A

Building 851A is a high-bay concrete building of 13,559 gross square feet. In 1958, Indenco Engineers designed Building 851A, originally called the Helac Building, to house a new linear accelerator for hydrodynamic testing in support of the LLNL weapons program. Construction was completed in 1960. Figure 154 is a recent photograph of Building 851A.

The structure is concrete with a flat roof and blowout doors on the east and north elevations.⁶⁹⁹ The bull-nose of the linac beam emerges on the south end of the building amid concrete block shielding. The firing table is above and to the south of the structure and has camera ports that look up from the main floor of the building below it.⁷⁰⁰ Figure 155 depicts the bull-nose of the linac.

⁶⁹⁹ “Site 300 Helac Building No. 851A, Architectural, Exterior Elevations and Roof Plan,” 1958, PSZ58-851-110JA, PEL.

⁷⁰⁰ “Site 300 Helac Building No. 851A, Architectural, Bullnose Details,” 1958, PSZ58-851-118JA, PEL.



Figure 154. Looking west at Building 851A, east elevation, 2003.⁷⁰¹



Figure 155. Looking toward bull-nose of linac on Building 851A firing table, 2003.⁷⁰²

The interior has a mezzanine and main floor. The mezzanine housed the linac and target room. Figure 156 portrays the linac.

The main floor housed the control room, camera room, detector room, flash X-ray equipment room, camera repair room, electrical magnetic shop, and offices.⁷⁰³ Figure 157 depicts the linac control room.

ARCO designed and built the new linac for Building 851A.⁷⁰⁴ The machine was thirty-five feet long, six feet high, and three feet wide. The linac could accelerate pulsed electrons to 35 MeV. The accelerated electrons produced gamma rays, which were used to X-ray objects moving at high speed—HE assemblies as they exploded. The Building 851A accelerator was unique in that

⁷⁰¹ Building 851A, exterior, LLNL photographer, 2003.

⁷⁰² Building 851A, bull-nose, LLNL photographer, 2003.

⁷⁰³ "Helac Room and Mezzanine Plans," 1958, PSZ58-851-109JC, PEL.

⁷⁰⁴ J.S. Norton to D. A. Bruce, memorandum, 8 January 1959, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1959, LBNL Archives.

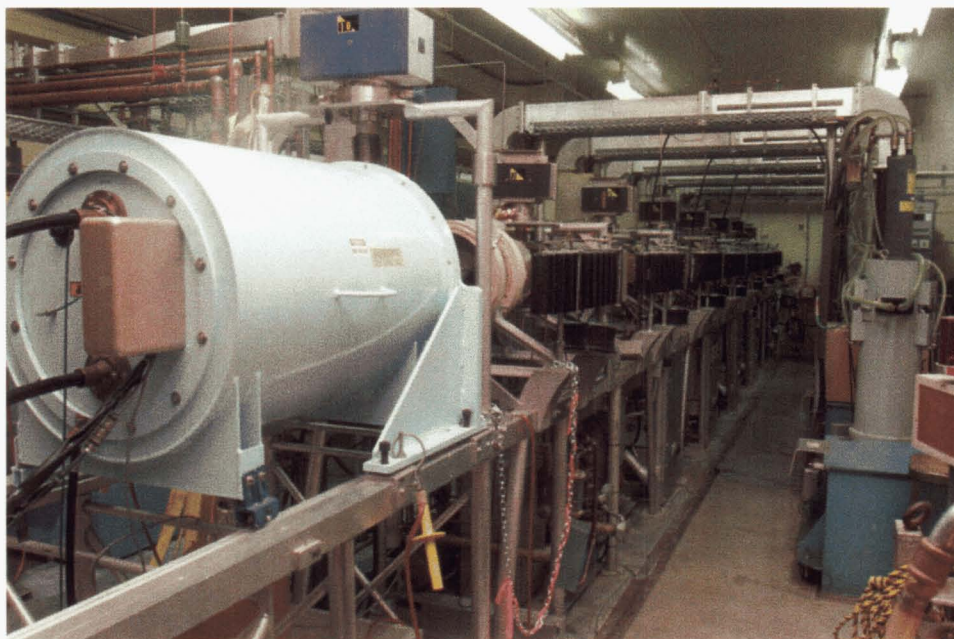


Figure 156. Building 851A, linac, 2003.⁷⁰⁵

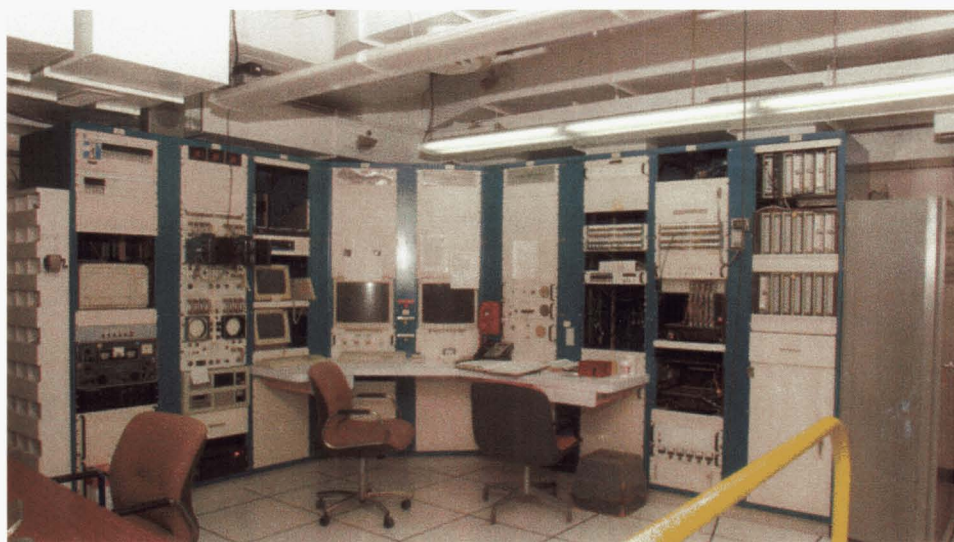


Figure 157. Building 851A, linac control room, 2003.⁷⁰⁶

⁷⁰⁵ Building 851A, linac, LLNL photographer, 2003.

⁷⁰⁶ Building 851A, control room, LLNL photographer, 2003.

it was one of the first to produce long pulses of energy for radiography.⁷⁰⁷

In 1978, an addition to Building 851A included a ready room. In 1996, another addition accommodated a ruby laser and image converter (IC) cameras.

Currently, Building 851A is still in operation and performing the same kind of work as it did historically. The accelerator is still intact, although upgraded, and is being used to photograph implosions of weapon components for the Stockpile Stewardship Program.

Additionally, Building 851A has two support structures: Buildings 851B and 851C. Indenco Engineers also designed Building 851B in 1958. Construction was completed in 1960. Building 851B is a concrete building with a flat roof of 1005 gross square feet. It was originally used as a development building for the linac. Currently, it is in use as a machine shop. Building 851C is a small building built in 1994. It is also currently in use as a machine shop. Neither of these support structures is of historic interest.

Buildings in the east and west firing areas of the Site 300 Hydrodynamic Test Facilities represented functional industrial structures typical of (although with regional variations) military and industrial installations working with HE throughout the United States. Buildings in the Hydrodynamic Testing Facilities were built from mass-produced industrial materials—concrete, steel, and corrugated metal. Hydrodynamic Test

Facilities buildings tended to be utilitarian in design with little adornment. Most were concrete bunkers with firing tables designed to house diagnostic equipment for hydrodynamic experiments. Support structures (storage sheds and shops) were usually Butler-type steel structures.

The Hydrodynamic Test Facilities consist of two LLNL Cold War building types—the Site 300 Heavy Laboratory and the Metal Butler-type Building. The buildings that housed hydrodynamic diagnostic activities fall into the Site 300 Heavy Laboratory building category and possess the characteristic features of their type—reinforced concrete walls, gravel roof, reinforced concrete slab, frangible walls, earth berms, firing tables, and concrete retaining walls. Some of the Site 300 Heavy Laboratories also possess an Armco arch (Buildings 802A, 812A, and 845A). Support structures (storage or shop areas) fall into the Metal Butler-type Building category and possess the characteristic features of their type—prefabricated steel rigid-frame structure, reinforced-concrete slab, corrugated-metal siding and roofing, and space for short-term experiments or shops.

For the most part, buildings in the Hydrodynamic Test Facilities do not represent exceptional examples of architectural style or design. Although they possess some features (reinforced concrete, berm, firing tables, or concrete retaining walls) that reflect the hazardous nature of the work that occurred there, they do not possess exceptional design characteristics. Site 300 Hydrodynamic Test Facilities are typical of a number of different kinds of structures in the military and the weapons complex

⁷⁰⁷ "New Linear Accelerator Completed at Site 300," *The Magnet* (July 1960), 6.

that are used to handle or store explosive material.

The exception to this is Building 851A, the Helac Building. Building 851 was built specifically to house the linac and its architectural design reflects the nature of the work that occurred there. The mezzanine that houses the linac and the target room are built of reinforced concrete blocks. The exterior of the building has a steel bull nose to protect the linac vacuum tubes. Additionally, camera ports on the main floor of the building look up onto the firing table.

Although other Hydrodynamic Test Facilities also possess some of these features (e.g., camera ports and firing tables), they do not reflect hydrodynamic testing in the same way. For instance, Buildings 802A, 812A, and 845 are essentially Armco arches buried in earth and protected by a concrete retaining wall. These facilities are quite similar to explosives bunkers used on a wide variety of U.S. military bases to store explosives. Building 851A, in contrast, has unusual features like the bull-nose that, in combination with the camera ports and firing table, reflect the hydrodynamic testing of historic interest that occurred there.

9.20.4 Integrity

The Hydrodynamic Test Facilities—both the east and west firing areas—at Site 300 played a crucial role in determining the final design criteria of all LLNL nuclear weapons in the U.S. stockpile between the years 1955 and 1992.

The east area firing facilities at Site 300—Buildings 802A, 812A, and 845A—are of historic interest for the period 1955–1982 for their hydrodynamic testing activities in support of LLNL nuclear weapons design and nuclear weapons testing.

However, Buildings 802A, 812A, and 845A—no longer possess historic integrity for the period of their historic significance.

Building 802A is no longer used as a firing facility. Most of its equipment has been removed and it is currently being used for storage. Building 802A is an empty concrete bunker and no longer reflects the work of historic significance that was done there.

Building 812A is no longer used as a firing facility. The linac and the oscilloscopes that replaced it are no longer in the bunker. Currently, the firing table is being used for experiments with a three-inch air gun. Building 812A no longer reflects the work of historic significance that was done there.

Building 845A is no longer used as a firing facility. It is being used to dispose of explosive waste from the HE Process area. Building 845A is essentially an empty concrete and corrugated-metal bunker that no longer reflects the work of historic significance that was done there.

The west area firing facilities at Site 300—Buildings 850 and 851A—are of historic interest for their hydrodynamic testing activities in support of LLNL nuclear weapons design and nuclear testing. The periods of significance for 850 and 851A are 1958–1992 and 1960–1992, respectively.

The west firing area does possess integrity for the period of its historic significance. Furthermore, it is eligible for National Register consideration as a historic district. Building 850 and 851A acted together as the locus of hydrodynamic testing for Site 300 during the Cold War. Furthermore, Buildings 850 and 851A still represent the hydrodynamic testing activities that occurred there from 1958 to 1992 and 1960 to 1992, respectively. The period of historic significance for district consideration is 1960–1992.

Building 850 is no longer in use as a diagnostic bunker but it still represents its original mission via its design and remaining equipment. Coupled with Building 851, it represents the hydrodynamic testing process involved in LLNL weapons design work. The control room and oscilloscopes are largely intact. The design of the bunker includes camera ports and cable ports that represent the diagnostics housed in this structure, while the firing pad is intact. Additionally, although housed in Building 867, LLNL still possesses the original Cold War era streak cameras used in this facility. The firing table also looks much as it did during its period of historic significance.

Building 851A also still possesses integrity for the period of its historic significance. The linac installed in 1960 is intact and used for much the same purpose as it was during the Cold War. Non-fissionable nuclear weapons components and materials are still tested there for the Stockpile Stewardship Program. Building 851A looks and feels much as it did during the Cold War era, when it played an integral role in LLNL's design of nuclear weapons.

9.20.5 Recommendation

The west area Hydrodynamic Test Facilities, consisting of Buildings 850 and 851A, are eligible for National Register consideration as a historic district.

The west area Hydrodynamic Test Facilities were designed and built as a unit and the locus of hydrodynamic testing shifted to the west firing area after 1960. Hydrodynamic testing was a critical element in the process of LLNL nuclear weapon design. The west area Hydrodynamic Test Facilities represent this work.

Buildings and structures under fifty years of age are generally not considered eligible for the National Register. The west area Hydrodynamic Facilities of Site 300 will not be fifty years of age until 2010.

However, under Criteria Consideration G, properties under fifty years of age can be considered eligible to the National Register if it can be demonstrated that they are of exceptional significance.

The Cold War has been recognized as a period of exceptional significance within U.S. and world history. Additionally, hydrodynamic testing was a critical element in the process of nuclear weapons design. The west area Hydrodynamic Facilities physically represent this aspect of the design and testing of all LLNL nuclear weapons in both the historic and enduring stockpile. Therefore, it is of exceptional historic significance as defined within the LLNL Cold War preservation themes Nuclear Weapons Design (subtheme Weapons Design) and Nuclear Weapons Testing (subtheme HE Testing).

**9.21 World War II Properties:
Buildings 212, 213, 216, 217, 218,
219, 314, 315, 316, 318, 319, 404,
405, 412, 415, 419, 511, 514, 516,
and 517**

9.21.1 Description

The WWII properties at LLNL are located on the main site north of East Avenue and south of First Street and to the east and west of Southgate Drive. The WWII properties were constructed between 1942 and 1944 as part of the Livermore NAS, which originally included fifty-five structures.

Twenty WWII properties remain of the original NAS Livermore buildings. These buildings (referred to by their current names and designations) are:

- Building 212, Accelerators
- Building 213, Physics and Advanced Technologies Office
- Building 216, Computations
- Building 217, Computations
- Building 218, Computations
- Building 219, the University of California Institutes
- Building 314, Financial Office
- Building 315, Financial Office
- Building 316, Department of Energy Office
- Building 318, Pool Changing Room Facility
- Building 319, University Relations Program/Planetary and Physical Sciences
- Building 404, Battery Shop/Warehouse
- Building 405, Plant Engineering/Industrial Electronics
- Building 412, Hot Cells
- Building 415, Science Education Offices/Employee Center
- Building 419, Material Process Handling Facility
- Building 511, Plant Engineering Crafts Shop
- Building 514, Liquid Waste Treatment Facility
- Building 516, Permits and Real Property
- Building 517, Electrical Utility Offices.

During WWII, the missions of NAS Livermore were to train navy pilots and to support the war in the Pacific. NAS Livermore also tested, to a limited extent, new navy flight techniques and equipment.

In 1950, Ernest O. Lawrence, the director of the University of California Radiation Laboratory (UCRL), in collaboration with California Research and Development Corporation (CR&D), a subsidiary of Standard Oil Company, acquired buildings at NAS Livermore for a research project sponsored by the AEC. CR&D established Livermore Research Laboratory at the NAS Livermore site and built an accelerator, the Material Test Accelerator (MTA), to produce fissionable materials. A few of the WWII properties were used by CR&D for research, but the majority of the buildings they used functioned as support structures or offices.

In 1952, UCRL took over NAS Livermore from CR&D, and it became LLNL, a second nuclear weapons design laboratory. WWII properties were used by LLNL primarily as offices for administrative and program personnel, shops, and support structures. A few, notably Buildings 212 and 412, were used for nuclear weapons and other research programs.

Today, most of the WWII buildings are used by LLNL as administrative offices or as support facilities. Buildings 212 and 412 have been decommissioned and are no longer in active use. Building 412 is slated for demolition.

In the following discussion, the WWII properties are grouped according to their original function, as follows:

B-1 H-type Navy Barracks

- *Buildings 216, 217, 218, 314, and 315*

H-plan Classroom

- *Buildings 219 and 319*

WAVES Residence

- *Building 316*

Drill Hall

- *Building 212*

Warehouses

- *Buildings 404, 405, 516, and 517*

Industrial

- *Buildings 412, 419, 511, and 514*

Miscellaneous

- *Buildings 213, 318, and 415*

9.21.2 Mission History

The WWII properties have two primary periods of historic context—WWII and the Cold War.

WWII Mission History

NAS Livermore had two primary missions during WWII—training naval pilots and providing respite for operational units. During its first mission, from May 1942 until October 1944, NAS Livermore operated as a training base for naval aviators. Naval cadets spent eleven to fourteen weeks at NAS Livermore receiving flight instruction

before leaving for more advanced flight training at other naval installations. As the need for newly trained pilots decreased near the end of the war, naval training programs began to close. The training program at NAS Livermore closed in October 1944.

From November 1944 until the end of the war, NAS Livermore provided support and respite for operational units of the Twelfth Naval District. During this time period, navy pilots serving in the Pacific theatre used NAS Livermore as a stop to rest and recuperate before returning to active duty.

From November 1944 through December 1945, NAS Livermore also operated, in a limited capacity, as a testing base for navy equipment. One of the new navy flight procedures tested at NAS Livermore was the ground-controlled approach. A pilot would fly blindfolded (with a co-pilot for safety during testing activities) and land via the instructions of the tower operator.

The navy also tested Jet-Assisted-Take-Off (JATO) bottles at NAS Livermore. A JATO bottle blasted a fighter plane 200 feet into the air within seconds from as little as a fifty-foot airstrip. NAS Livermore also had the opportunity to test some of the first jet engines introduced during the war.

Buildings 216, 217, 218, 314, and 315 H-Type Navy Barracks

During WWII, these buildings served as barracks or sleeping quarters, for navy cadets, officers, flight instructors, and other enlisted navy male personnel for NAS Livermore.

Buildings 219 and 319***H-Plan Classroom***

Both of these structures served as classrooms for the navy flight training school. Cadets trained ten hours a day, logging time both in the air and in ground school.

Building 316***WAVES Residence***

During WWII, Building 316 served as the enlisted barracks, or sleeping quarters, for Women Appointed for Voluntary Emergency Service (WAVES). WAVES at NAS Livermore trained cadets on the Link Trainer, a simulated flight machine. They also served as support staff in various capacities.

Building 212***Drill Hall***

Building 212 served as an assembly area and drill hall for NAS Livermore during WWII. It also had office space and recreational facilities for both officers and enlisted naval personnel.

Buildings 404, 405, 516, and 517***Warehouses***

These buildings served as support structures for NAS Livermore during WWII. They were warehouses. Building 404 served as cold storage for storing all foodstuffs—meat, fish, vegetables, and dairy. Building 405 housed supplies. Building 516 stored clothing and flight gear. Building 517 was also used for dry-goods storage.

Buildings 412, 419, 511, and 514***Industrial***

These buildings functioned as maintenance facilities for the airplanes of NAS Livermore during the war. Building 412

served as an aircraft inspection and repair hangar. Building 419 housed the Paint and Dope Shop. Building 511 was an airplane repair and overhaul hangar. It also housed a parachute shop, wing shop, and woodworking shop. Building 514 was built specifically to house jet engine research.

Buildings 213, 318, and 415***Miscellaneous Structures***

These buildings were primarily used for administrative functions or as support structures. Building 213 was the Chief Petty Officers' Club. Building 318 was the Swimming Pool. Building 415 was the Administration Building, which housed the Officer of the Day's office, the personnel office, office of administrative records, and the legal officer.

WWII Period of Historic Significance

From May 1942 to October 1944, NAS Livermore functioned as a Primary Flight Training Center, the first phase of training for naval aviators. NAS Livermore trained 4,000 naval pilots over a two-year period in basic flying skills. Graduates of NAS Livermore went on to receive additional training at Intermediate and Operational Training Centers before being assigned to a naval unit and shipping out to the Pacific or Atlantic.

Naval air power during WWII played a decisive role in the U.S. military victory in both the Atlantic and Pacific theatres. Naval aviators provided protection and support for amphibious operations, escorted merchant ships to their destination, and detected and destroyed enemy submarines and ships.

NAS Livermore performed a vital service to the U.S. Navy, providing the first phase of training for naval aviators destined for service in the Pacific or Atlantic theaters.

Therefore, buildings associated with the training of naval aviators at NAS Livermore are of historic interest for the time period May 1942–October 1944. The following seven structures are associated with the training of NAS Livermore naval pilots: Buildings 219 and 319, H-Plan Classrooms; Building 212, Drill Hall; Building 412, Aircraft Inspection/Repair Hangar; Building 511, Airplane Repair/Overhaul; and Building 415, Administration Building; and Building 318, Swimming Pool. These structures were associated with the training of pilots or the command and operation of NAS Livermore's Primary Flight Training Center. Therefore, they are of historic interest within the historic context of WWII and the established LLNL preservation theme of Naval Pilot Training.

From November 1944 to December 1945, NAS Livermore provided direct support of the U.S. war effort in the Pacific. During this period NAS Livermore functioned as an operational base for naval pilots from the Twelfth Naval District, providing respite for carrier crews before they returned to the Pacific. NAS Livermore performed an important and essential service in the U.S. navy through support of naval carrier crews, which were an important factor in the decisive U.S. military victory in WWII.

Therefore, WWII buildings associated with the housing and servicing of naval carrier crews at NAS Livermore are of historic interest for the time period November 1944–December 1945. The following ten structures

are associated with the respite of naval pilots: Buildings 216, 217, 218, 314, and 315, H-Type Navy Barracks; Building 212, Drill Hall; Building 412, Aircraft/Inspection Shop; Building 511, Airplane Repair/Overhaul; Building 213, Chief Petty Officers' Club; and Building 318, Swimming Pool. These structures are associated with the rest and recuperation of naval pilots or the overall command and operation of NAS Livermore as an operational base for the Twelfth Naval District. Therefore, these buildings are of historic interest within the historic context of WWII and the established LLNL preservation theme of Support of the U.S. War Effort.

From November 1944 to December 1945, NAS Livermore also, to a limited degree, tested new flight techniques and equipment. In particular, the research conducted on JATO bottles and jet engines represents historically interesting work.

After the British successfully demonstrated one of the first jet engines in 1941, airplane manufacturers in the United States began developing jet-propelled airplane engines. In March 1943, Westinghouse, under the sponsorship of the Navy Bureau of Aeronautics, produced the first successful U.S. jet engine. Soon afterward, research and development of jet engines blossomed in the United States.⁷⁰⁸

Research and testing of new equipment provided critical technical support to the U.S. war effort. In particular, the development of JATO bottles and jet engines lent the navy an edge in flight technology.

⁷⁰⁸ Otis E. Lancaster, ed., *Jet Propulsion Engines* (Princeton: Princeton University Press, 1959), 30–36.

Building 514, Jet Engine Research, is the building associated with the testing and research of JATO bottles and jet engines. Therefore, this building is of historic interest within the historic context of WWII and the established LLNL preservation theme of Support of the U.S. War Effort. The period of significance for these activities is November 1944 to December 1945.

Buildings 404, 405, 419, 516, and 517 were warehouses or shops serving as support structures for NAS Livermore. They are of no historic interest within the LLNL WWII context and preservation themes.

Cold War Mission History

NAS Livermore was decommissioned on December 31, 1946. From 1947 to 1949 the Alameda Board of Supervisors leased the NAS Livermore facilities for the Livermore Public School system as additional classroom space.

In 1950, CR&D, in collaboration with Ernest O. Lawrence from UCRL, took over NAS Livermore to develop a particle accelerator, the MTA, which would produce fissionable material for the U.S. nuclear weapons program.

In 1952, UCRL took over the CR&D lease, and opened the former NAS as the Livermore branch of UCRL. The Livermore branch of UCRL, now LLNL, opened as a second nuclear weapons design laboratory to compete with LANL in development of hydrogen bombs (or thermonuclear weapons). In addition to nuclear weapons design, LLNL's original mission included providing diagnostic measurements for weapons tests, developing controlled thermonuclear reactions for power sources, and basic physics research.

For the most part, former NAS Livermore properties were used by CR&D and then LLNL as offices, shops, storage, and administrative support structures.

Building 216, 217, 218, 314, and 315 H-Type Navy Barracks

The barracks were not used immediately in the early 1950s. However, by the mid-to-late 1950s they were transformed into office space for administrative and programmatic use.

Building 216 is an office building. From the mid-1950s to 1980, it housed engineering and physics offices. It also housed Project Pluto personnel during the early 1960s. From the 1980s to 1990 it housed the Defense Nuclear Agency. From the 1990s until the present it has contained part of Computation.

Building 217 is also an office building. It initially housed the administrative staff for Engineering. From the early 1960s through the 1970s, it was the offices of Mechanical Engineering. In 1980, it housed accounting, classification, and education services. In the 1990s, it housed classification and administration information systems. It currently houses part of Computation.

Building 218 provided offices for various programs. In the mid-1950s, it housed the offices for apparatus engineering. In the 1960s, it contained the offices of Neutronics, Nuclear Physics, and Engineering. In the 1970s, it housed physics and engineering. From the 1980s on, it has housed Computation.

Building 314 initially housed the AEC's offices at the site. In the 1960s, it served as administrative offices for LLNL. In the 1970s, it housed the support staff for the engineering and physics program. From the 1980s, it has contained the finance department.

Building 315 housed the offices of the Project Sherwood staff from the 1950s through the 1980s. It also housed offices for physics and engineering during the 1960s and 1970s. From the 1990s on, it has housed part of the finance department.

Buildings 219 and 319 H-Plan Classroom

The old WWII classrooms were also converted to administrative offices.

Building 219 initially housed health physics offices in the 1950s. In the 1960s it housed classified document review, administrative offices, and the Defense Atomic Support Agency. In the 1970s, it was administrative offices. In the 1980s, it housed earth sciences and the news bureau. In 1990, public affairs and community relations moved in. It currently houses the University of California institutes.

Building 319 housed personnel, purchasing, general services and other administrative offices from the 1950s through 1980. In the 1980s, it housed career development services. Since the 1990s it has housed the planetary and geophysical sciences. Currently, the university relations program has offices there as well.

Building 316 WAVES Residence

Building 316 housed graphic arts from the 1950s until the 1980s. During the

1980s, beam research had its offices there. Currently, it houses DOE's site offices.

Building 212 Drill Hall

Building 212 was one of the few WWII properties used for laboratory research during the Cold War.

In 1950, CR&D moved into the NAS Livermore facilities and briefly used the Drill Hall for experiments in the MTA project.

In 1952, LLNL took over the NAS Livermore facilities. The Drill Hall was immediately renovated into laboratory space. Building 212 housed the earliest magnetic mirror machines in Project Sherwood—Toy Top I, Table Top I, and Cucumber I—until the fusion research program moved into Building 431 in 1954.

From 1954 until 1987, Building 212 housed accelerator research in support of the nuclear weapons program. In 1954, the 90-inch cyclotron and the 0.5-MeV Cockcroft-Walton Accelerator were moved into Building 212. Each of these instruments was housed in a forty-foot concrete pit surrounded by a blockhouse. The cyclotron was a "flexible source of protons, deuterons, alpha particles, and monoenergetic neutrons."⁷⁰⁹ The accelerator was used as a source of 14-MeV neutrons. Both the 90-inch cyclotron and the Cockcroft-Walton Accelerator were used to make time-of-flight and neutron cross-section measurements for the nuclear weapons design and testing programs at LLNL.

⁷⁰⁹ *Status Report: Fiscal Year 1958*, 125.

In 1964, the Physics Department replaced the Cockcroft-Walton accelerator with a newer model. A concrete testing cell was added to the east end of Building 212, adding approximately 630 gross square feet of space to the original structure. High Voltage Engineering Corporation of Massachusetts built and designed the new accelerator. It was used for “neutron experiments and the production of X-ray and proton initiated nuclear reactions” for the weapons program.⁷¹⁰

In 1968, the 90-inch cyclotron was removed and two machines installed in its place. Cyclotron Corporation designed an 80-cm, three sector, isochronous cyclotron with both an external negative ion source and an internal positive ion source. High Voltage Engineering designed the Van de Graaff electrostatic accelerator. These machines could be used separately or in a combination called the cyclograaff mode. This mode was used for neutron scattering experiments and nuclear structure studies.⁷¹¹ These machines were used in support of the weapons program until 1987.

Building 212 was a large structure and therefore housed many programs not directly related to its primary mission of accelerator research for the weapons program. In the 1970s and 1980s, a variety of unrelated programs used space in Building 212, including the Rotating Target Neutron Source (RTNS), the Two-Stage Light Gas Gun, the Flash Light Source Facility, the

High-Energy X-ray Calibration Spectrometer, the EBIT, the Vacuum Coating Facility, and the Phase R Dye Laser.⁷¹²

Buildings 404, 405, 516, and 517

Warehouses

Most of these buildings continued to serve as warehouses over the years, although some came to house support services or, more recently, offices.

Building 404 was used as a warehouse from the early 1950s through the mid-1980s. It stored petroleum and industrial gases. More recently, it was renovated to accommodate electronic support services, including fire and radiological alarm systems.

Building 405 was also used as a warehouse from the early 1950s through the mid-1980s. It stored batteries and Freon. In the 1980s, it became an audio intercom repair shop. It also housed security alarm systems. Currently, it houses Plant Engineering’s industrial electronics activities.

Building 516 was initially used for electronics maintenance. In the 1960s it housed Project Plowshare offices. In the 1970s and 1980s it was used as a temporary laboratory and shop. Currently, it contains the offices of real property, design files, and permits.

Building 517 was initially used for electronics maintenance. In the 1960s, it served as a temporary laboratory. From 1970 to the mid-1980s, it was used as a warehouse. It was renovated and now houses the electrical utility offices and land surveyors’ offices.

⁷¹⁰ “Preliminary Proposal for the Concrete Shielding Cell for New Cockcroft-Walton Accelerator,” January 1964, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1964, Folder Major Instruments, LBNL Archives.

⁷¹¹ “The LLL Cyclograaff,” Building 212 Binders, Volume 1, Building 490 Files, LLNL.

⁷¹² “Operational Safety Procedures,” Building 212 Binders, Volumes 17–18, Building 490 Files, LLNL.

Buildings 412, 419, 511, and 514 Industrial

With the exception of Building 412, these buildings continue to serve as shops or support services. Building 412, one of the airplane repair hangars, was converted for use in many of the Laboratory's research programs.

Building 412 was previously assessed for National Register eligibility.⁷¹³ This report concurs with the previous finding of ineligibility.⁷¹⁴ Building 412 performed routine support functions for LLNL programs. However, a brief summary of its mission history follows.

In 1950, CR&D renovated Building 412, adding a wing of hot cells for use in the MTA project. In 1960, LLNL used the hot cells for metallurgical and radiochemical research in support of Project Pluto, a project to develop a nuclear reactor-powered ramjet engine. From 1965 to 1968, the cells were used for research for the Space Reactor Program. The nuclear testing program also used the hot cells from the 1960s until 1981 to analyze radioactive

materials from test shots. The main section of the building was converted into laboratories for the Biomedical Sciences and Environmental Sciences Division. This included work by the Marshall Island Group, which monitored radioactive fallout in the Pacific Islands as part of Project Plowshare, the program to develop nuclear devices for excavation, mining, and other peaceful uses.⁷¹⁵

Building 419 was also assessed previously for National Register eligibility.⁷¹⁶ This report concurs with the previous finding of ineligibility. From the 1950s until 1975, Building 419 housed an assay laboratory for the Health Physics Department. From 1975 to 1991, the building housed Toxic Waste Control, now called the Radioactive and Hazardous Waste Management Division, which treated and disposed of hazardous and mixed waste. Building 419 also decontaminated radioactive equipment and parts for various LLNL programs. The building served in a support capacity to LLNL during the Cold War.

Building 511 has housed the Plant Engineering Craft Shops since LLNL opened in 1952. The Crafts Shops include: a machine shop, pipe shop, plumbing, air conditioning, electrical shop, welding, sheet metal shop, and carpentry shop. Today, Building 511 also houses personnel offices, budget offices, computer support, engineering offices, and architectural services.

Building 514 housed the site laundry in the early 1950s. Since 1960, it has been a liquid waste disposal facility.

⁷¹³ David Harvey, *Determination of National Register of Historic Places Eligibility Building 412* (Livermore: Lawrence Livermore National Laboratory, 2001).

⁷¹⁴ Although this report generally concurs with that by Harvey, there are some areas of difference. This assessment agrees with the determination regarding the hot cells. The hot cells performed routine radiological and metallurgical assessments for Project Pluto and the nuclear testing program. However, this report disagrees with the conclusion that the biomedical research conducted in the building by the Marshall Island Group is of historic interest. LLNL's biomedical program performed routine biomedical research and no medical breakthroughs of note occurred there during the Cold War. Please see Section 6.4.4 Subtheme: Biomedical Research in the historic context portion of this report for more discussion of biomedical research at LLNL. However, this is a minor point of disagreement, as the building no longer possesses integrity for its radiological monitoring work in the Marshall Islands and would therefore be ineligible anyway.

⁷¹⁵ Harvey, *Determination of National Register of Historic Places Eligibility Building 412*.

⁷¹⁶ David Harvey, *Determination of National Register of Historic Places Eligibility Building 419*, draft (Lawrence Livermore National Laboratory, 2002).

Buildings 213, 318, and 415 Miscellaneous Structures

Building 213 served as a dormitory until the 1970s. In 1976, it was converted into offices for the support staff of the Physics Department. Currently, it continues to house the support staff of the Physics and Advanced Technology Directorate.

Building 318 is the swimming pool and change facility. This was built in 1942 with the other WWII properties. It was built in support of pilot training and fitness. It is still in use as a recreational facility today.

Building 415 housed security from 1957 through the 1990s. In recent years, it has been renovated to accommodate the Science Education offices and provide exercise facilities for employees.

Cold War Period of Significance

For the most part, the WWII properties at LLNL have been renovated for use as offices, shops, or support structures. As such, Buildings 213, 216, 217, 218, 219, 314, 315, 316, 318, 319, 412, 415, 419, 511, and 514 are of no historic interest within the LLNL Cold War context and established preservation themes.

The exception is Building 212, which housed work of importance to the nuclear weapons design program and Project Sherwood.

From 1952 to 1954, Building 212 housed Project Sherwood. The earliest magnetic mirror machines were developed and housed in Building 212—Toy Top I, Table Top I, and Cucumber I.

Cucumber I demonstrated the feasibility of the magnetic mirror concept, which is considered one of the first breakthroughs

in fusion research.⁷¹⁷ Therefore, Building 212 is of historic interest within the Cold War context and established LLNL preservation theme of Non-Weapons Research, subtheme Energy Research. The period of historic significance for this activity is 1952–1954.

From 1954 to 1987, Building 212 housed accelerator research in support of the LLNL nuclear weapons design and testing programs. The 90-inch cyclotron (1954–1968), the Cockcroft-Walton accelerator (1954–1964), the new Cockcroft-Walton accelerator (1964–1987), the 80-cm cyclotron (1968–1987), and the Van de Graaff electrostatic accelerator (1968–1987) conducted neutron experiments for the weapons program. Accelerator research provided time-of-flight and nuclear cross-section measurements—both of which were notable contributions to the LLNL nuclear weapons design program. Therefore, Building 212 is of historic interest for its neutron experiments in support of LLNL weapons design and testing within the context of the Cold War arms race and the preservation themes of Nuclear Weapons Design (subtheme Weapons Design) and Nuclear Weapons Testing (subtheme Nuclear Testing). The period of historic significance is 1954–1957.

9.21.3 Construction History

The Dinwiddie Construction Company broke ground for NAS Livermore on January 29, 1942. With the help of recruits from the Oakland Naval Reserve Air Base, the Dinwiddie Company completed construction in less than four months. NAS Livermore commenced operations in May 1942.

⁷¹⁷ Post, phone interview, 3 April 2003; and Hooper, phone interview, 3 April 2003.

Initial construction included three barracks, an administration building, dispensary, bachelor officers' quarters, subsistence building, auditorium, recreation building, and instruction center.

A second phase of construction added an operations and command building, a stores building, a garage and shop building, gas storage building, and a building for the heat and water supply.

Plans allowed for an aircraft inspections hangar, three additional barracks, and an addition to the subsistence building. Construction continued through 1944. At the war's end, NAS Livermore consisted of a total of fifty-five buildings. Twenty of those remain.

Buildings 216, 217, 218, 314, and 315—H-Type Navy Barracks

The barracks buildings were constructed between 1942 and 1943. They all had identical floor plans and construction. They were two-story structures built in the shape of an H. They were wood framed with pitched roofs and had drop wood siding or shiplap

on the exterior. There were double-hung wood sash windows along the length of the building on the north, south, east, and west elevations. The interiors housed dormitory-style bedrooms. Each building had a common area on the first floor. Figures 158, 159, 160, 161, and 162 are recent photographs of Buildings 216, 217, 218, 314, and 315, respectively.

Beginning in the 1950s, these barracks were continually upgraded for use as office space. A major change in these structures was the covering of the original wood shiplap with asbestos siding. The wooden windows have been replaced with new aluminum frames on most of the buildings. Other major structural changes include an addition to the south side of Building 216 in the 1970s, and the removal of one of the wings on Building 314 in the late 1950s.

Few original features remain in the interiors of these buildings. The second-floor hallway of Building 217 retains the original wainscoting. Building 218 has its original radiators. Figures 163 and 164 depict WWII-era wainscoting and a radiator, respectively.



Figure 158. Looking southwest at Building 216, east and north elevations, 2003.⁷¹⁸

⁷¹⁸ Building 216, exterior, LLNL photographer, 2003.



Figure 159. Looking southeast at Building 217, west and north elevations, 2003.⁷¹⁹

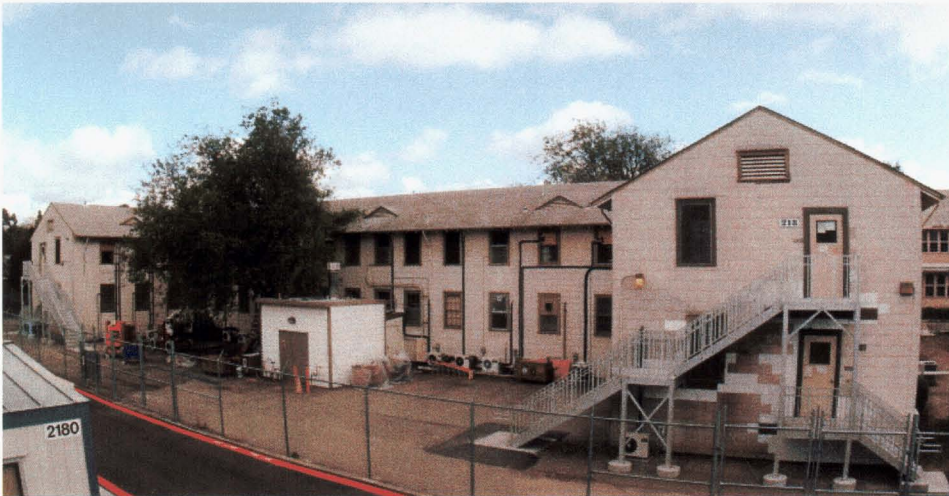


Figure 160. Looking south at Building 218, north elevation, 2003.⁷²⁰



Figure 161. Looking south at Building 314, north elevation, 2003.⁷²¹

⁷¹⁹ Building 217, exterior, LLNL photographer, 2003.

⁷²¹ Building 314, exterior, LLNL photographer, 2003.

⁷²⁰ Building 218, exterior, LLNL photographer Frank Nunez, 2003.



Figure 162. Looking south at Building 315, north elevation, 2003.⁷²²



Figure 163. WWII-era wainscoting, Building 217, 2003.⁷²³



Figure 164. WWII-era radiator, Building 218, 2003.⁷²⁴

⁷²² Building 315, exterior, LLNL photographer, 2003.

⁷²³ Building 217, wainscoting, LLNL photographer Frank Nunez, 2003.

⁷²⁴ Building 218, radiator, LLNL photographer Frank Nunez, 2003.

Buildings 219 and 319 H-Plan Classroom

In 1943, Blanchard and Maher, San Francisco architects, provided local design changes to the standard navy plans used to construct Building 219 and 319, the Instruction Buildings. They were two-story, H-shaped structures with pitched roofs. They were wood-framed and had drop wood siding on the exterior. They had double-hung wood

sash windows on both stories along the north, south, east, and west elevations.⁷²⁵ The first floor housed a large assembly room in the main wing, two classrooms separated by an office in the west wing, and a lecture room and locker room in the east wing.⁷²⁶ The second floor housed six classrooms, two in each wing.⁷²⁷ Figures 165 and 166 are recent photographs of Buildings 219 and 319.



Figure 165. Looking south at Building 219, north elevation, 2003.⁷²⁸



Figure 166. Looking south at Building 319, north elevation, 2003.⁷²⁹

⁷²⁵ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Instruction Building, Exterior Elevations," 1943, PLN43-219-004J; and "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Instruction Building, Elevations," 1943, PLN43-319-004J, PEL.

⁷²⁶ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Instruction Building, First Floor Plan," 1943, PLN43-219-002J, PEL; and "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif.,

Instruction Building, Second Floor Plan," 1943, PLN43-219-003J, PEL.

⁷²⁷ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Instruction Building, First Floor Plan," 1943, PLN43-319-002J; and "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Instruction Building, Second Floor Plan," PLN43-319-003J, PEL.

⁷²⁸ Building 219, exterior, LLNL photographer, 2003.

⁷²⁹ Building 319, exterior, LLNL photographer, 2003.

These buildings have been significantly modified over the years to accommodate office space for administrative and programmatic personnel. The interiors in these structures bear little resemblance to the original classroom design. They have been divided into smaller offices and conference rooms. The exteriors have been modified, like the barracks, by the replacement of the original wood siding with asbestos. Both of these buildings retain some original windows, although they are all scheduled to be replaced with aluminum frames in the near future.

Building 316 ***WAVES Residence***

The WAVES barracks building was built in 1943. It was built in a U-shape with a pitched roof. The exterior had wood drop siding and windows on the north, south, east, and

west elevations on both floors.⁷³⁰ The first floor housed a lounge in the center of the main wing flanked by bedrooms on the east and west wings.⁷³¹ The second floor housed bedrooms on both sides of the hall in all three wings.⁷³² Figure 167 is a recent photograph of Building 316.

Building 316 was first modified in 1955 and has been continuously upgraded since then. The exterior had the original wood siding replaced with asbestos in the 1950s. In 1957, a concrete vault used as storage for classified documents was added to the south elevation. Despite many modifications, Building 316 retains the fireplace in the original common area and the original wood window frames on the north and south elevations. Figure 168 depicts the original fireplace in the WAVES residence hall.



Figure 167. Looking north at Building 316, south elevation, 2003.⁷³³

⁷³⁰ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Bachelor Officers' Quarters, Elevations," PLN43-316-004J, 1943, PEL.

⁷³¹ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Bachelor Officers' Quarters, First Floor Plan," PLN43-316-002J, 1943, PEL.

⁷³² "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Bachelor Officers' Quarters, Second Floor Plan," PLN43-316-003J, 1943, PEL.

⁷³³ Building 316, exterior, LLNL photographer, 2003.



Figure 168. WWII-era fireplace, Building 316, 2003.⁷³⁴

Building 212 **Drill Hall**

Building 212 was built in 1943 as a Drill Hall for NAS Livermore. The Drill Hall was a rectangular wood-framed structure with cement-asbestos board exterior walls and hangar doors on the east and west elevations. Both the ground floor and mezzanine level had double-hung wood sash windows. The main building had a central assembly area forty-four feet high with freestanding laminated wood arches twenty-three and one-half feet apart. The central drill hall was flanked on the north and south sides by one-story wings for the armory, offices, showers, restrooms, and locker rooms. The main drill hall had five basketball courts with wood parquet flooring and a running track along the

mezzanine.⁷³⁵ Figures 169 and 170 are recent photographs of Building 212.

Shreve, Lamb, and Harmon of New York, the architects of the Empire State Building, designed the original blueprint for navy drill halls. However, local architects and builders usually modified these plans using regional materials and design features. The use of laminated freestanding wood arches rather than steel was an innovation in design incorporated by Shreve, Lamb, and Harmon. This design feature saved metals for more critical wartime use. The use of the laminated wood arches for drill halls was the most important contribution by the navy to building design during the war years.⁷³⁶

⁷³⁴ Building 316, fireplace, LLNL photographer Marcia Johnson, 2003.

⁷³⁵ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Drill Hall, Floor Plan and Elevations," 1943, PLN43-212-002J, PEL; and William Self Associates, *Documentation and Assessment of the History of the Lawrence Livermore National Laboratory Livermore Facility*, 29.

⁷³⁶ Garner, *World War II Temporary Military Buildings*, 52.



Figure 169. Looking southeast at Building 212, west elevation, 2003.⁷³⁷



Figure 170. Looking south at Building 212, north elevation, 2003.⁷³⁸

However, the laminated arches of Building 212 are not exceptional examples of this type of design or construction. These design features were used frequently by both the army and navy as well as civilian contractors. They were favored not only as an alternative to hard-to-obtain structural timber or steel but for their flexibility and adaptability. This type of design feature abounded in structures built during the

war, including the army's modification center in Vandalia, Ohio; hangars at NAS Lakehurst, New Jersey; a drill hall at Sampson Naval Training Station, Romulus, New York; a hangar at the Morristown Airport, New Jersey; a Northwest Airlines hangar in Fargo, North Dakota; and a gymnasium and Boeing Aircraft hangar in

⁷³⁷ Building 212, exterior west, LLNL photographer, 2003.

⁷³⁸ Building 212, exterior north, LLNL photographer, 2003.

Seattle, Washington.⁷³⁹ The use of freestanding laminated wood arches in Building 212 represents a design innovation developed in response to war-time exigencies. Yet it is not the only or the best-preserved example of its kind. Figure 171 depicts the laminated wood arches in Building 212.

In 1952, the Drill Hall was renovated for Project Sherwood laboratories. Several partition changes and additions were required to accommodate experimental programs in fusion research. Simultaneously, painting, plumbing, ventilation, heating, and electrical repairs and upgrades were undertaken.⁷⁴⁰

In 1954, the Drill Hall underwent major structural renovations when the 90-inch cyclotron and Cockcroft-Walton accelerator were installed. Each of these machines required a forty-foot deep pit and blockhouse. J. H. Fitzmaurice, Inc., designed and made the blockhouse out of 119 individual reinforced concrete blocks to provide shielding for the accelerators.⁷⁴¹ Figures 172 and 173 depict the blockhouse's east and west elevations.

At the time the cyclotron and Cockcroft-Walton were installed, the wood parquet floor of the Drill Hall was removed and the



Figure 171. Freestanding wood laminated arches, Building 212, 2003.⁷⁴²

⁷³⁹ Ibid.; "These War Buildings Were Significant," *Engineering News*, October 19, 1944, 118; "Wood Frame Hangar for Northwest Airlines," *Aviation* (April 1942), 163; and "Timber With a College Dream," *Engineering News Record*, March 8, 1945, 2.

⁷⁴⁰ Alton L. Wilson to J. J. Flaherty, letter, 25 November 1952, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1952, Folder Project Whitney, Site Buildings 153 Accelerators, LBNL Archives.

⁷⁴¹ C. L. Blue to San Francisco Operations Office, letter, 3 December 1952, Administrative Files Donald Cooksey, Lawrence Berkeley Laboratory, 1952, Folder Project Whitney, Site Buildings 153 Accelerators, LBNL Archives.

⁷⁴² Building 212, arches, Bart Sellick, 2003.

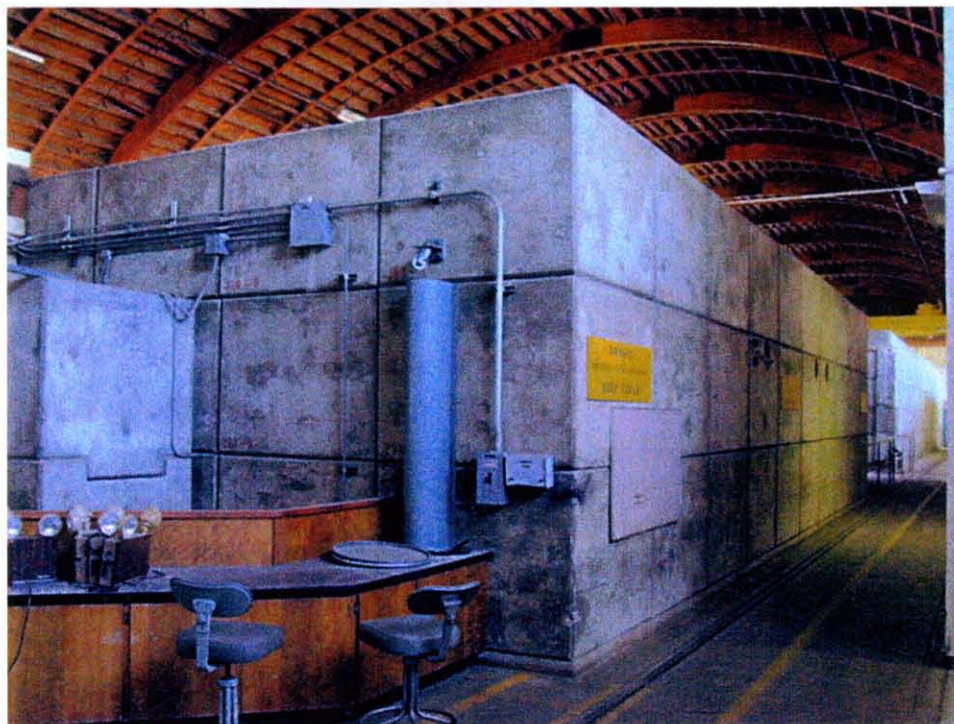


Figure 172. Cold War-era blockhouse, Building 212, east elevation, 2003.⁷⁴³

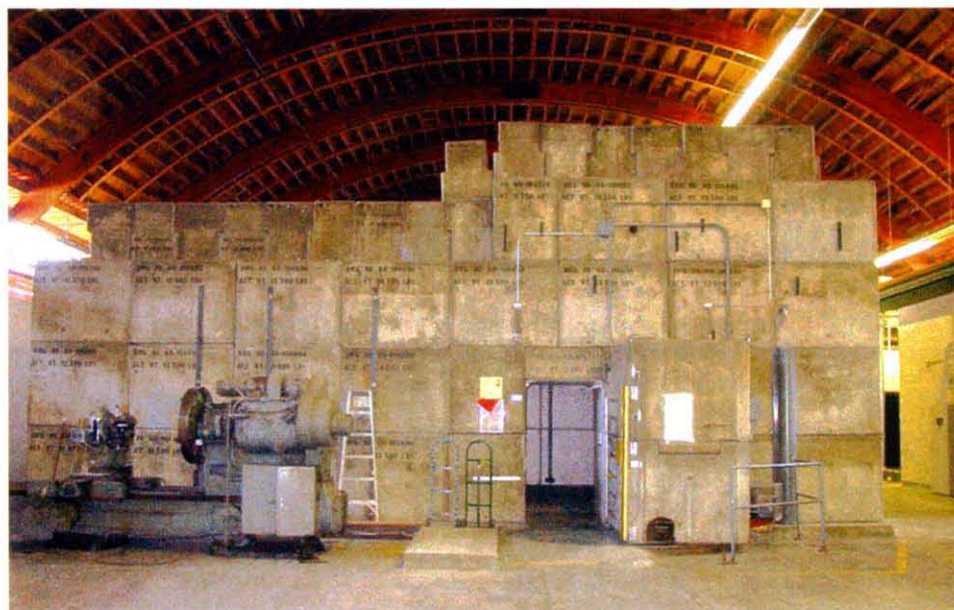


Figure 173. Cold War-era blockhouse, Building 212, west elevation, 2003.⁷⁴⁴

⁷⁴³ Building 212, blockhouse east, Bart Sellick, 2003.

⁷⁴⁴ Building 212, blockhouse west, Bart Sellick, 2003.

pits dug through the foundation. Figure 174 depicts the renovation required to transform Building 212 into a research laboratory.

In 1964, Falk and Booth, structural engineers, designed a 630-foot concrete addition to the east end of the building to accommodate the new Cockcroft-Walton accelerator.⁷⁴⁵

In 1969, the 90-inch cyclotron was removed and the 80-cm cyclotron and Van de Graaff accelerator were installed. Figure 175 depicts the remains of the Van de Graaff accelerator.

During the 1970s and 1980s, Building 212 continued to be modified in less extreme ways to accommodate various research programs.

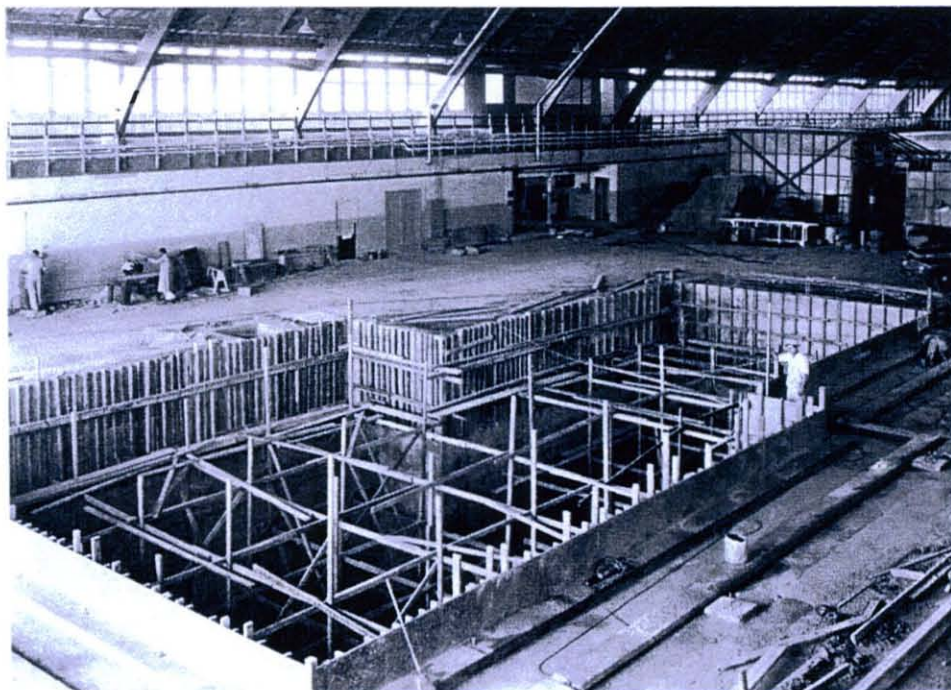


Figure 174. Renovation for 90-inch cyclotron and Cockcroft-Walton accelerator, Building 212, 1954.⁷⁴⁶

⁷⁴⁵ "Concrete Shielding Cell for New Cockcroft-Walton Accelerator For Building 153, Site Plan, Roof Plan, and Elevations," 1964, PLZ64-212-001JA, PEL.

⁷⁴⁶ Pit Construction for the 90-inch Cyclotron and Cockcroft-Walton Accelerator, 1954, Box 122, Folder 10732, LLNL Archives.



Figure 175. Remnants of Van de Graaff accelerator, Building 212, 2003.⁷⁴⁷

Buildings 404, 405, 516, and 517 Warehouses

In 1943, Blanchard and Maher provided local design changes to the standard navy plans for the construction of Building 404, the cold storage warehouse. It was a single-story structure with a very slightly pitched roof. It was wood-framed and had wood siding. There were two double-hung wood sash windows on the south elevation and three on the west elevation. The interior housed cold storage lockers for vegetables, fruits, smoked meats, fish, dairy products, and fresh meat. It also had a large space for dry storage and an office.⁷⁴⁸ Figure 176 is a recent photograph of Building 404.

⁷⁴⁷ Building 212, accelerator, Bart Sellick, 2003.

⁷⁴⁸ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Cold Storage Building, Plans, Elevations, and Sections," PLN43-404-001J, 1943, PEL.

The Building 404 interior was remodeled in recent years to house electronic support services. The exterior wood siding has also been replaced with asbestos siding.

Buildings 405, 516, and 517 had identical floor plans and construction. Built in 1943 as warehouses, they were single-story structures with a slightly pitched roof and a concrete foundation. They were wood-framed and had wood siding on the exterior walls. There were double-hung wood sash windows on the east, west, and south elevations. The north elevations had two large windows with multi-pane glass. The interiors contained five rooms for dry storage, including clothes and flight gear.⁷⁴⁹ Figures 177, 178, and 179 are recent photographs of Buildings 405, 516, and 517, respectively.

⁷⁴⁹ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Warehouse Building, Plans, Elevations, and Sections," PLN43-515-001J, 1943, PEL.



Figure 176. Looking southeast at Building 404, north and west elevations, 2003.⁷⁵⁰



Figure 177. Looking west at Building 405, east elevation, 2003.⁷⁵¹



Figure 178. Looking west at Building 516, east elevation, 2003.⁷⁵²

⁷⁵⁰ Building 404, exterior, LLNL photographer, 2003.

⁷⁵¹ Building 405, exterior, LLNL photographer, 2003.

⁷⁵² Building 516, exterior, LLNL photographer, 2003.

All three buildings have been modified over the years. The original wood siding has been overlain with vinyl cladding and some of the original wood-framed window sashes have been replaced with aluminum. The interiors have been transformed into offices for the most part.

***Buildings 412, 419, 511, and 514
Industrial***

In 1943, Blanchard and Maher provided local design changes to the standard navy

plans for the construction of Building 412. It was a large hangar-like structure with wood trusses. It was wood framed and had wood siding on the exterior walls. It had sliding doors on the east and west elevations and double-hung wood sash windows on the north and south elevations.⁷⁵³ The interior had two small offices in the northwest corner and a workspace on the north wall. The bulk of the space was a hangar for airplane storage.⁷⁵⁴ Figure 180 is a recent photograph of Building 412.

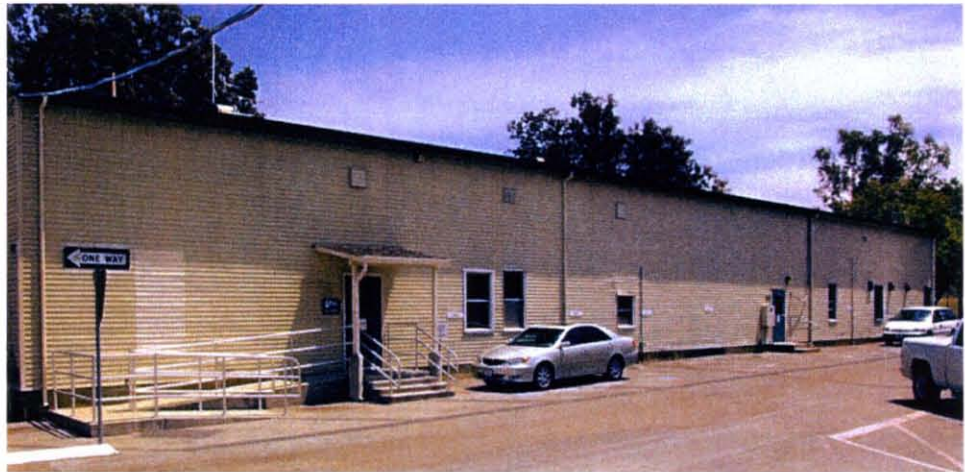


Figure 179. Looking east at Building 517, west elevation, 2003.⁷⁵⁵



Figure 180. Looking north at Building 412, south elevation, 2003.⁷⁵⁶

⁷⁵³ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Check Building #2, Elevations and Sections," PLN43-412-003J, 1943, PEL.

⁷⁵⁴ Ibid.

⁷⁵⁵ Building 517, exterior, LLNL photographer, 2003.

⁷⁵⁶ Building 412, exterior, LLNL photographer, 2003.

In 1950, CR&D designed a high-bay addition with hot cells for research connected to the particle accelerator. This added 8,607 gross square feet to the original structure.⁷⁵⁷

In the 1960s, the interior was also renovated to accommodate research laboratories for the biomedical program. A second floor of laboratories was added, as well as laboratory and office space on the first floor. Other major modifications to the building included covering the exterior with asbestos panels and removing the sliding door on the west elevation.⁷⁵⁸

In 1943, Blanchard and Maher provided local design changes to the standard navy plans for the construction of Building 419. It was a wood-and-steel-framed, windowless building with concrete exterior walls. The central portion of the building was a two-story structure flanked by two single-story

wings. Building 419 had a flat built-up roof, sliding doors on the north elevation, and double doors on the south elevation. The upper half of the main wing on the south, north, and west elevations had drop siding. The central section of the first floor had a dope spray booth and storage rooms for paint. Drying rooms were located on the first floor of the north and south wings. The second floor, in the center part of the building, had two blower rooms.⁷⁵⁹

In the 1950s the interior of the paint and dope shop were converted into assay laboratories for the health physics department. In 1970, an addition to accommodate a battery shop was built on the south end of the building.⁷⁶⁰ Additionally, the rooms were modified for use as decontamination facilities for the Radioactive and Hazardous Waste Management Division. Other modifications include the replacement of the wood siding on the upper



Figure 181. Building 419, exterior.⁷⁶¹

⁷⁵⁷ Harvey, *Determination of National Register of Historic Places Eligibility Building 412*, 7.

⁷⁵⁸ Ibid.

⁷⁵⁹ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Paint and Dope Shop, Foundation, Floor Plans, and Elevations," 1943, PLN43-419-001JA, PEL.

⁷⁶⁰ Harvey, *Determination of National Register of Historic Places Eligibility Building 419*, 6.

⁷⁶¹ Building 419, exterior, LLNL photographer Marcia Johnson.

half of the main wing with asbestos. Figure 181 is a recent photograph of Building 419.

In 1943, Blanchard and Maher provided local design changes to the standard navy plans for the construction of Building 511. It was a wood-framed hangar with a slightly pitched roof. It was a high-bay building with one-story wings on the east and west elevations. The west elevation wing had a saw-toothed roof to maximize light in the shops housed there. The east and west elevations had clerestory windows in both the main bay of the hangar and in the shop wings. There were sliding hangar doors on the north and south elevations.⁷⁶² Figure 182 is a recent photograph of Building 511.

The interior housed a main room for aircraft overhaul, an engine overhaul shop, cleaning and stripping shop, engine accessories shop, propeller shop, parachute shop, wood-

working shop, welding shop, tool room, and parts storeroom, carburetor room, and battery room. The mezzanine housed offices, locker rooms, restrooms, and records.⁷⁶³

Building 511 has been substantially altered over the years. The first floor has been divided into shops and offices. The high-bay interior was also modified to include a second floor of offices. In the 1960s, a corrugated-metal addition was put on the south end of the building. Other major modifications include the replacement of the original wood shiplap with asbestos siding, a metal skin façade added to the west elevation, and a stucco entryway added to the west side of the building. The saw-tooth roof of the shops remains on the east elevation, although the entire building is slated for a facelift that will cover many of the remaining clerestory windows on the east side.



Figure 182. Looking southwest at Building 511, east and north elevations, 2003.⁷⁶⁴

⁷⁶² "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Assembly and Repair Building, Elevations and Stair Details," PLN43-511-016J, 1943, PEL.

⁷⁶³ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Assembly and Repair Building, Plans, Door, and Finish Schedule," PLN43-511-015J, 1943, PEL.

⁷⁶⁴ Building 511, exterior, LLNL photographer Frank Nunez, 2003.

In 1944, the Bureau of Aeronautics designed Building 514. It was a concrete, H-shaped building with a test cell in the center flanked by two long rectangular test cells on the east and west elevations. The structure was windowless with soundproof baffles in the test cells and soundproof doors.⁷⁶⁵ Figure 183 is a recent photograph of Building 514.

Building 514 has been significantly remodeled since WWII. In the 1960s, retention tanks were added for the processing of liquid waste. In 1984, Increment 2 was added, filling in the H-shape of the building and making it a long rectangle. The west test cell has been renovated to accommodate offices. The exterior of the building has been stuccoed and a patio added.

Buildings 213, 318, and 415

Miscellaneous Structures

Building 213 was built in 1942 as the Petty Officer's Club. It was a square, single-story wood structure with a slightly pitched roof and windows on all four sides. The inside housed a large common room. In the 1950s it was converted into dormitories. In 1976, LLNL Plant Engineering converted it into eight offices and a large conference room.⁷⁶⁶ The exterior has the original wood-sash windows. However, the wood siding has been replaced with asbestos panels. Figure 184 is a recent photograph of Building 213.

Building 318 was built in 1942 as the swimming pool and locker rooms. The swimming pool was a fifty-meter, Olympic-size pool with a covered roof connecting it to



Figure 183. Looking northeast at Building 514, west and south elevations, 2003.⁷⁶⁷

⁷⁶⁵ "Navy Department, Bureau of Yards and Docks, U.S. Naval Air Station, Livermore, California, Two-Cell Engine Test Building, Plan, Elevations, and Sections," 1944, PLN44-514-002JB, PEL.

⁷⁶⁶ "Convert Building 213 to Office Space, Key Plan, Floor Plan, Section, Legend, and Notes," PLA76-213-001D, 1976, PEL.

⁷⁶⁷ Building 514, exterior, LLNL photographer, 2003.



Figure 184. Looking south at Building 213, north elevation, 2003.⁷⁶⁸

the locker room facilities. The original pool covering was wood framed with a slightly pitched roof, sliding doors, and windows.⁷⁶⁹ In 1966, the pool cover was removed and the roof of the locker room facilities was replaced with a mansard roof.⁷⁷⁰

In 1943, Blanchard and Maher provided local design changes to the standard navy plans for the construction of Building 415 as the Administration Building. It was a two-story, wood-framed structure with a single-story wing on the south elevation and a three-story tower. The building had wood drop siding, a flat roof, and double-hung wood sash windows along all sides on all three stories.⁷⁷¹ The first floor housed

the Officer of the Day's office, disbursement office, switchboard and telephones, and ten additional offices.⁷⁷² The second floor housed ten offices, the bindery, and a conference room. The third floor was the aerology room and had an exterior deck on the roof.⁷⁷³ Figure 185 is a recent photograph of Building 415.

Building 415 has been substantially altered over the years. The interior has been remodeled and upgraded to accommodate successive program needs. In recent years, fitness facilities were installed for employee recreation. Exterior modifications included covering the shiplap wood siding with asbestos siding.

⁷⁶⁸ Building 213, exterior, LLNL photographer, 2003.

⁷⁶⁹ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., 50 Meter Swimming Pool, Section and Toilet Details and Plumbing," 1942, PLN43-318-003JA, PEL.

⁷⁷⁰ "Building 145 Modification, Elevations, and Details," 1965, PLA65-318-140-JA, PEL.

⁷⁷¹ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Administration Building, Exterior Elevations, Sash, and Eave Details," 1943, PLN43-415-004J, PEL.

⁷⁷² "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Administration Building, First Floor Plan, Door, Window, and Finish Schedules," 1943, PLN43-414-002JB, PEL.

⁷⁷³ "Wagoner Field, Vicinity of Livermore, California, Additional Facilities, Naval Air Station Oakland, Calif., Administration Building, Second and Third Floor Plans, Deck Plan, Interior Elevations, and Miscellaneous Details," 1943, PLN43-415-003JC, PEL.



Figure 185. Looking east at Building 415, west elevation, 2003.⁷⁷⁴

9.21.4 Integrity

WWII Integrity

From May 1942-October 1944, Buildings 219 and 319, H-Plan Classrooms; Building 212, Drill Hall; Building 318, Swimming Pool; Building 412, Aircraft Inspection/Repair Hangar; Building 511, Airplane Repair/Overhaul; and Building 415, Administration Building were associated with the training of WWII naval pilots. Naval airpower was a decisive factor in U.S. military victories in both the Atlantic and the Pacific theatres of the war. Therefore, these buildings are of historic interest within the WWII context and the established LLNL preservation theme of Naval Pilot Training.

From November 1944-December 1945, Buildings 216, 217, 218, 314, and 315, H-Type Navy Barracks; Building 212, Drill Hall; Building 412, Aircraft/Inspection Shop; Building 511, Airplane Repair/Overhaul; Building 213, Chief Petty Officers' Club;

and Building 318, Swimming Pool were associated with the housing and servicing of naval carrier crews preparing for combat service in the Pacific theatre. NAS Livermore performed an important and essential service to the U.S. Navy in supporting naval carrier crews. Naval carrier crews were an important factor in the U.S. military victory in WWII. Therefore, these WWII buildings are of historic interest within the WWII context and established LLNL preservation theme of Support of the U.S. War Effort.

From November 1944-December 1945, Building 514, Jet Engine Research, was associated with the testing and research of JATO bottles and jet engines. Research and testing of new equipment provided critical technical support to the U.S. war effort. Therefore, this building is of historic interest within the historic context of WWII and the established LLNL preservation theme of Support of the U.S. War Effort.

⁷⁷⁴ Building 415, exterior, LLNL photographer Marcia Johnson, 2003.

The following list summarizes the WWII buildings of historic interest.

Buildings: 212, 412, and 511

Period of Significance: May 1942–December 1945

Preservation Themes: Naval Pilot Training and Support of the U.S. War Effort

Buildings: 219, 319, and 415

Period of Significance: May 1942–October 1944

Preservation Theme: Naval Pilot Training

Buildings: 213, 216, 217, 218, 314, 315, 318, and 514

Period of Significance: November 1944–December 1945

Preservation Theme: Support of the U.S. War Effort

However, none of these WWII buildings possesses integrity for the period of its historic significance.

All of the exteriors of these WWII properties have been notably modified through the removal of the original wood shiplap siding and its replacement with either asbestos panels or vinyl cladding. The double-hung wood sash windows on most of these WWII properties have also been replaced with aluminum frames or painted over.

Furthermore, the interiors of these WWII properties have been significantly altered over the years and no longer reflect the WWII period. Buildings used for administrative purposes in the post-war period (213, 216, 217, 218, 219, 314, 315, 319, and 415) have been constantly modified over the years to accommodate the ever-changing specifications and need for office space.

Buildings used for research or shop purposes in the post-war period have also been modified to accommodate laboratories and office space. The large open space used as a drill hall in Building 212 has been modified so that it no longer reflects its wartime purpose. The wood parquet floor of Building 212 has been removed and concrete pits dug through the foundation. Additional rooms have been added to the mezzanine and first floor to accommodate laboratories. The drill hall area has been transformed through the addition of concrete shielding blocks. The only feature of note remaining is the laminated arches, which are not sufficient to convey its historic role as a WWII drill hall.

Buildings 412 and 511 have added second floors for office space. Building 514 has been transformed from a shop for jet engine research into a waste-treatment facility. Retention tanks have been added, and the interior of the building has been transformed into office space.

Additionally, Buildings 212, 216, 412, 419, 511, and 514 have had additions that have substantially altered the original footprint or the original design of the building. Building 314 has had one of its wings removed, substantially decreasing the footprint of the structure.

Building 318 has had the original pitched roof replaced with a mansard roof and the covering over the pool removed.

Finally, WWII Buildings 212, 213, 216, 217, 218, 219, 314, 315, 318, 319, 412, 415, 511, and 514 no longer possess integrity within their environment. The WWII buildings of historic interest at LLNL were part of NAS

Livermore—an active facility during WWII. After WWII, NAS Livermore was decommissioned and became incorporated first into CR&D and then into LLNL. Both CR&D and later LLNL transformed the base runways into laboratory and office structures during the Cold War. NAS Livermore originally consisted of fifty-five structures. Of these, thirty-five buildings have been demolished and other buildings erected in their place. The result is that WWII buildings exist side by side with buildings of Cold War and more recent vintage. The remaining twenty WWII buildings no longer represent a cohesive naval air base. Instead, single WWII structures or small groups of structures exist amid the far more numerous Cold War buildings in the southeast and southwest portion of the site.

Cold War Integrity

For the most part, WWII properties remaining at LLNL are of no historic interest within the Cold War context and established preservation themes.

The exception is Building 212, which is of historic interest from 1952 to 1954 for its association with early Project Sherwood activities. It is also of historic interest from 1954 to 1987 for its association with accelerator research in support of the LLNL nuclear weapons program. However, Building 212 no longer possesses historic integrity for either of these periods of significance because the work was reliant on specific equipment.

Building 212 no longer possesses any of the early Project Sherwood magnetic mirror machines. Those machines were transferred to Building 431 in 1954, and have since been dismantled.

Nor does Building 212 possess enough accelerator equipment to represent the neutron experiments conducted for the weapons program from 1954 to 1987. The 90-inch cyclotron, 80-cm cyclotron, and both Cockcroft-Walton accelerators were removed from the building. The only remnants of accelerator research in Building 212 are the concrete shielding blocks over the pits, and pieces of the Van de Graaff accelerator in Room 159.

The concrete shielding blocks are indicative of numerous kinds of research at the Laboratory involving radioactivity and do not reveal the specific activities of historic interest that occurred here. Likewise, the remnants of the Van de Graaff are not sufficient to represent the historic research conducted in the building. Much less than the required eighty percent of the machine remains.

Therefore, despite being of historic interest for its association with Project Sherwood research from 1952 to 1954, and its associations with the LLNL nuclear weapons design and testing from 1954 to 1957, Building 212 no longer possesses integrity for either of these periods of historic interest.

9.21.5 Recommendation

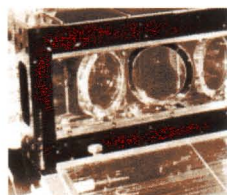
The WWII properties—Buildings 212, 213, 216, 217, 218, 219, 314, 315, 316, 318, 319, 404, 405, 412, 415, 419, 511, 516, and 517—do not qualify for National Register consideration under Criterion B, association with a historic figure; Criterion C, exceptional design or architectural significance; or Criterion D, potential to reveal information not found elsewhere. No person of historic note is associated with these buildings. The WWII buildings are military designs typical of

naval air bases of the period. They do not represent exceptional examples of this type of architecture. These WWII properties are not, nor will they be, a source of important historical information. The activities that occurred there are documented more fully in the written record. Furthermore, several U.S. naval air facilities in California are still intact and convey their association with significant historical events in WWII.

Of the twenty remaining WWII properties, fourteen buildings (212, 213, 216, 217, 218, 219, 314, 315, 318, 319, 412, 415, 511, and 514) do qualify for National Register

consideration under Criterion A, association with a historic event or pattern of events.

In this case the important pattern of events is the training of naval pilots and/or the support of the U.S. war effort in the Atlantic and Pacific theatres during WWII. The period of significance for these events is May 1942-December 1945. However, these WWII properties no longer possess integrity for their periods of significance. Therefore, Buildings 212, 213, 216, 217, 218, 219, 314, 315, 318, 319, 412, 415, 511, and 514 are not eligible for National Register consideration under Criterion A.



10. ACRONYMS

AEC	Atomic Energy Commission
AERL	AVCO Everett Research Laboratories
AGS	Alternating Gradient Synchrotron
ALICE	Adiabatic Low-Energy Injection and Capture Experiment
ARAC	Atmospheric Release Advisory Capability
ARC	Accelerator Research Center
ARCO	Applied Radiation Corporation
ASCI	Advanced Simulation and Computing Initiative
ATA	Advanced Test Accelerator
AVLIS	Atomic Vapor Laser Isotope Separation
CAA-WTS	Civil Aeronautics Authority War Training School
CDC	Control Data Company
CIAP	Climatic Impact Assessment Program
CR&D	California Research and Development Company
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DT	deuterium-tritium
DYNA3D	dynamics in three dimensions
EBIT	Electron Beam Ion Trap

ENIAC	Electronic Numerical Integrator and Computer
ERDA	Energy Research and Development Administration
ETA	Experimental Test Accelerator
FEL	Free Electron Laser
FXR	Flash X-Ray
GAC	General Advisory Committee
GOCO	Government-owned, contractor-operation
GPO	Government Printing Office
HABS/HAER	Historic American Buildings Survey/Historic American Engineering Record
HE	High explosive
HEAF	High Explosives Applications Facility
Helac	high explosive linear accelerator
ICBM	Intercontinental Ballistic Missile
ICF	Internal Confinement Fusion
IHE	Insensitive High Explosive
IRBM	Intermediate-Range Ballistic Missile
JATO	Jet-Associated-Take-Off
JCAE	Joint Committee on Atomic Energy
LANL	Los Alamos National Laboratory

LARC	Livermore Advanced Research Computer
LBNL	Lawrence Berkeley National Laboratory
Linac	linear accelerator
LIS	Laser Isotope Separation
LLNL	Lawrence Livermore National Laboratory
LOPO	Low Power Reactor
LPTR	Livermore Pool-Type Reactor
LTBT	Limited Test Ban Treaty
MACHO	Massive Compact Halo Objects
MFTF	Mirror Fusion Test Facility
MFTF-B	Mirror Fusion Test Facility Modification B
MIRV	Multiple Independently Targetable Re-entry Vehicle
MLC	Military Liaison Committee
MTA	Materials Test Accelerator
MTR	Materials Test Reactor
MTX	Microwave Tokamak Experiment
NAI	Non-Proliferation, Arms Control, and International Security
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration
NATC	Naval Air Training Center
NATO	North Atlantic Treaty Organization
NHPA	National Historic Preservation Act
NIF	National Ignition Facility
NLC	Military Liaison Committee
NNSA	National Nuclear Security Agency
NRL	Naval Research Laboratory
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory

PCMDI	Program for Climate Model Diagnosis and Intercomparison
PPG	Pacific Proving Grounds
RTNS	Rotating Target Neutron Source
SAGA	Sub-Critical Assembly Program
SCOTS	Secondarily Contained Tritium Systems
SDI	Strategic Defense Initiative
SHPO	State Historic Preservation Office
SLBM	Submarine-Launched Ballistic Missile
SNL	Sandia National Laboratories
SOM	Skidmore, Owings & Merrill
SSPX	Spheromak Physics Experiment
STACS	Special Tritium Area Cold Shop
START	Strategic Arms Reduction Treaty
SUBROC	submarine-launched rocket
TATB	Triamino-trinitrobenzene
TIRP	Tritium Inventory Removal Project
TMX	Tandem Mirror Experiment
UCRL	University of California Radiation Laboratory
U.N.	United Nations
U.S.	United States
USEC	United States Enrichment Corporation
USSR	United Soviet Socialist Republic
VERS	Vacuum Effluent Recovery System
WAVES	Women Appointed for Voluntary Emergency Services
WBNS	Water-Boiling Neutron Source Reactor
WWI	World War I
WWII	World War II



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