INEEL/EXT-97-01021
(Revision 1)

The Idaho National Environmental and Engineering Laboratory
A Historical Context and Assessment
Narrative and Inventory

Prepared for
U.S. Department of Energy Idaho Operations Office

by

The Arrowrock Group, Inc.
Boise, Idaho
Contract K97-557098

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TABLE OF CONTENTS

Table of Contents, continued

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THE ARROWROCK GROUP, INC.

The Arrowrock Group, Inc., is a historical consulting firm based in Boise, Idaho. Organized in 1991, the Group consists of four partners, each of whom are historians qualified to conduct historical surveys performed pursuant to Sections 106 and 110 of the National Historic Preservation Act of 1966 (as amended).

Under the direction of the Department of Energy's Idaho Operations Office (NE-ID, formerly known as DOE-ID), Lockheed Martin Idaho Technologies Company (LMITCO) contracted the Arrowrock Group, Inc., on April 4, 1997, to research and write a context report on the history of INEEL, to assess the significance and National Register eligibility of INEEL buildings and structures then under DOE-ID jurisdiction, and to make recommendations for future historic preservation activities that will ensure compliance with historic preservation laws.

The Arrowrock Group submitted a draft of this work on September 25, 1997, to Julie Braun of the LMITCO Cultural Resources Department, technical manager for the contract. Representatives of DOE-ID, LIMITCO, and the Idaho State Historic Preservation Office reviewed the draft and suggested several revisions. Upon incorporation of these revisions, Arrowrock sent the report to the Cultural Resources Department in 1998.

In 2003, the Cultural Resources Department, under the management of Bechtel BWXT Idaho, Inc., requested that the report be revised once more, this time to account for significant changes and developments that have taken place at INEEL since 1998 and to update the extant building inventory and historic preservation recommendations.

INTRODUCTION

The Origin of this Study

When summarizing the achievements of the National Reactor Testing Station (NRTS), the Department of Energy (DOE) sometimes notes that 52 nuclear reactors operated at the site, pointing out that this was the largest concentration of such machines ever assembled in one place anywhere in the world. The reactors occupied the site of a former United States Naval Proving Ground (NPG). Most of those reactors served in experiments and tests that have long since been decommissioned or dismantled. Since then, the NRTS has seen changes in its mission and several name changes--to Idaho National Engineering Laboratory (INEL) in 1974, to Idaho National Engineering and Environmental Laboratory (INEEL) in 1997, and to Idaho National Laboratory (INEEL) in 2003. Yet there remains a residual pride in the memory of those 52 reactors.[1]

The last reactor built at the site was the Loss-of-Fluid Test Reactor (LOFT), conceived in 1963 and operated for the first time in 1972. As of this report, the Advanced Test Reactor (ATR), the ATR Critical Facility (ATRCF), and Argonne West's Neutron Radiography Reactor (NRAD) are the only three reactors routinely operating. Others are decommissioned, inactive, or awaiting dismantlement. Clearly, the mission to test and operate experimental reactors has drastically declined.

In 2003, the mission of INEEL appears to reach in two directions. A future-oriented research direction is to "enhance energy security through leadership in nuclear science, engineering, and technology development."[2] The mission is far broader than the laboratory's past concentration on nuclear reactors and their safe operation, but will include the development of Generation IV reactors.[3]

The second direction reflects the past. The activities at the INEEL site since its inception in 1949 have left buildings, structures, hazards, and wastes of various kinds

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[1] A recent example is Lockheed Martin Idaho Technologies Company, *Comprehensive Land Use Plan*, 1996, page 10.

[2] INEEL, *Strategic Plan* (Idaho Falls: INEEL, 2003), p. 4.

[3] INEEL, *Institutional Plan, FY 2002-2006*, p. 68-69. The characteristics of Generation IV reactors are: proliferation-resistant, decreased waste, improved economics, and improved safety.

which may pose a range of threats to environmental and human safety. Eliminating them may involve decontamination, decommissioning, inactivation, remediation, removal, transport, processing, re-use, or some other disposition.

A "cleanup" mandate has existed since at least 1969, but DOE has recently articulated a goal to "accelerate" the cleanup in order to reduce overhead costs and, presumably, risks to the environment and the public.[4]

The INEEL cleanup has been planned largely without reference to the historic significance of targeted buildings, structures, and objects. Nevertheless, INEEL is obliged by federal laws to consider the historic significance of properties being altered or dismantled. Section 106 of the National Historic Preservation Act of 1966 (as amended) requires DOE to consider the impacts their activities will have on historic properties and to allow the Advisory Council on Historic Preservation (ACHP) to comment when such activities will cause adverse impacts. Section 110 requires DOE to establish an interpretation and preservation program to include identification, evaluation of historic significance, nomination to the National Register of Historic Places, and protection of its historic properties.[5]

In view of the conflict between two national-interest goals -- an accelerated "cleanup legacy" and preservation of the "historical legacy" of INEEL -- agreeing upon suitable methods to attain both goals is a somewhat urgent task.

This report is intended to do the following:

* Present a contextual history of the INEEL

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[4] Environmental regulation comes from National Environmental Policy Act of 1969 (NEPA); Resource Conservation and Restoration Act of 1976 (RCRA); Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA); and from numerous other laws, consent orders, and agreements. See also DOE *Ten Year Plan*, Environmental Management, August 8, 1996; and U.S. Environmental Protection Agency, Region 10; The State of Idaho, Department of Health and Welfare: and the U.S. Department of Energy, *Federal Facility Agreement and Consent Order in the Matter of the U.S. Department of Energy Idaho National Engineering Laboratory ("INEL")*, Administrative Docket No: 1088-06-29-120, 1991.

[5] In addition to the Act, see also "Regulations of the Advisory Council on Historic Preservation Governing the Section 106 Review Process," 36 CFR Part 800.

* Identify any periods of "exceptional significance" that might apply to the INEEL site as a whole
* Inventory each NE-ID building
* Assess the historic significance of each building
* Make general recommendations for historic preservation activities in keeping with DOE's Section 110 responsibilities.

The report is in two sections. The first contains the general recommendations, historic assessments, and context narratives. The second contains a photograph and inventory form for each extant building at the INEEL. The form contains information specific to each building, such as size, description, and relationship to a historic context.

Questions to be Answered

This report is intended to help answer four key questions. The first two are: Do the NPG and/or INEEL properties merit a place among the nation's historically significant properties? If so, what is the contextual basis for this assertion? The NRTS began operations in 1949. Many of its individual activity centers and buildings are less than fifty years old. Federal properties less than fifty years old typically are not eligible for listing on the National Register of Historic Places. However, they may still be eligible under Special Consideration G for "exceptional significance." The NPG is a World War II ordnance test site; its buildings are more than fifty years old. Therefore, it is eligible for consideration. The contracted work includes assessing its historical significance.[6]

The third question considers what actions DOE might take should the INEEL be deemed to house exceptionally significant historic assets. DOE is expected to propose a reasonable approach to interpreting and preserving its contribution to American history. DOE would develop such a proposal in consultation with the SHPO, ACHP, and other key stakeholders. Upon such consultation, plans will be legitimized through a Programmatic Agreement.

In the absence of a such a program to date, proposals

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[6] United States Department of the Interior, National Park Service, Interagency Resources Division, *National Register Bulletin, How to Complete the National Register Registration Form* (Washington, D.C.: U.S. Government Printing Office, 1991), p. 37.

to dismantle or alter a property were handled on a case-by-case basis, typically resulting in a "memorandum of agreement" regarding the documentation of the building. This system has evolved to a more systematic approach. The present inventory, context report, and the incorporation of architectural management planning as part of broader facilities planning efforts are part of this evolution.[7]

Typically, the mitigation option for an "exceptionally" important building was Historic American Building Survey/Historic American Engineering Record (HABS/HAER-level) documentation complete with narrative history and a photographic record (large-format negatives) of architectural and engineering drawings, historic, and pre-dismantlement photos. By the time the building faced dismantlement, the reactor, the instrumentation, or the experiment within the building -- the thing that had been so significant -- had been removed long before. Thus, HABS/HAER-level photos typically documented shells.[8]

In light of this, all parties realized that preserving the historic legacy of the INEEL might take forms other than (or in addition to) HABS/HAER reports. This report recommends several other such preservation activities that DOE should consider as part of a Programmatic Agreement.

The fourth question relates to management: How can the facility inventory forms in this report be used most effectively as management tools to guide the DOE and the SHPO to execute timely and appropriate preservation requirements? The INEEL is a large, functioning, dynamic facility. Historic preservation activities ought not be outpaced by environmental cleanup. In fact, preservation-in-place should be an available option. Early and timely information about historic significance and appropriate preservation should be incorporated in operational plans, appropriately funded, and scheduled in a timely and logical sequence. The standard Idaho State Historic Sites Inventory forms have been adapted with the needs of multiple users at the INEEL and the Idaho SHPO in mind.

In summary, this report proposes a historical context

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[7] Braun, Julie B., *INEEL Historic Architectural Properties Management Plan for U.S. Department of Energy, Idaho Operations Office* (Idaho Falls: Bechtel BWXT Idaho, LLC, Report No. INEEL/EXT-02-1338, Revision 0), p. 3.

[8] HAER reports were prepared for TAN 629, CPP 633, the ARVFS Bunker, and ARA I, II, III. See bibliography.

for the INEEL, recommends a general preservation program, and supplies a management tool to help with disposition decisions.

Method of Approach

Contract Requirements. During the six-month period in which the building survey and context study were undertaken (April-September 1997), the members of the study team confronted certain limiting conditions in executing the contracted work. First, for safety, security, or schedule reasons, the interior condition of most buildings could not be examined. The hundreds of buildings at INEEL would have made this impractical in any case given the six-month window for the survey. The contract limited the survey to "buildings," which at the INEEL are identified with 600 and 1600 numbers. This meant that "structures," which are identified by 700 or 1700 numbers, were not surveyed. The contracted work also excluded from inventory those properties managed by DOE's Pittsburgh and Chicago field offices. However, the context study was to include those properties -- the Naval Reactors Facility and Argonne West -- and their contributions to the overall history of the INEEL.

Secondary and Primary Literature. Secondary literature on military ordnance and atomic energy research is surprisingly skimpy when it comes to the NPG and the NRTS. Despite the INEEL's long-lasting impact on the state's economy, politics, and cultural life, Idaho and DOE histories (until 2000) neglect the INEEL.

To celebrate the 50th anniversary of the INEEL in 1999, DOE commissioned and published the first general history of the facility. This full-length, illustrated, and documented book, *Proving the Principle, A History of the Idaho National Engineering and Environmental Laboratory, 1949-1999*, by Susan M. Stacy, was researched and published after the 1998 version of this Context Report.[9] It is a welcome artifact of historic interpretation and preservation to the credit of the DOE and INEEL.

Two years of research, writing, and photo research went into *Proving the Principle*. The author was the project manager for the 1998 version of the Context Report and the

[9] Susan M. Stacy, *Proving the Principle, A History of the Idaho National Engineering and Environmental Laboratory, 1949-1999* (Idaho Falls: DOE, Idaho Operations Office, 2000).

editor for this revision. The book was a major addition to the secondary literature about the INEEL. With its illustrations, oral history sources, and more penetrating research on many topics than was available for the Context Report, it has substantially aided in the improvement of this revision to the Context Report. The INEEL has made it available on the Internet at www.inel.gov/provingtheprinciple/. For readers' convenience, a table that cross-references this report to appropriate chapters or pages of the book, is supplied at the end of this introduction.

The best source of national "context" for nuclear power continues to be Richard Hewlett's trilogy on the history of the Atomic Energy Commission (AEC). The second book of that series, *Atomic Shield*, provides an excellent basis for understanding the origins of the NRTS. But the third, which covers the Eisenhower years, abandons Idaho almost completely; its index, for example, contains only three entries for "reactor test station."[10]

A substantial body of literature discusses broad issues such as nuclear weapons proliferation, commercial reactor safety, and waste processing. Protest literature began to appear in the early 1970s, followed by defensive and "think tank" type literature. Little in this material pertains directly to the NRTS, although it helps define the historic themes that are relevant to the NRTS.[11]

To develop an INEEL-specific contextual chronology, we consulted INEEL's abundance of primary sources: building history profiles, technical reports, photographs, construction drawings, conference proceedings, and contractor brochures.

Organization. To organize the research into manageable units, we investigated each of the INEEL's major operating centers. Within the INEEL's nearly 890 square miles,

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[10] Richard Hewlett and Francis Duncan, *Atomic Shield, 1947-1952, Vol. II of a History of the United States Atomic Energy Commission* (Univ. Park, PA: The Pennsylvania State University Press, 1669); and Richard Hewlett, *Atoms for Peace and War, A History of the Atomic Energy Commission, Vol. III* (Berkeley: Univ. of California Press, 1989), pages 255, 352, and 422.

[11] "Protest" literature that chronicles the hazards of nuclear power typically mention the explosive SL-1 accident that killed three men at the NRTS in January 1961.

activities are concentrated at nine official "primary areas."[12] Each primary area is geographically separated from the others by many miles of sagebrush desert, and each has a history distinctly its own, albeit related to the whole. The study narrative reflects this organization, presenting area histories within a chronological framework.

The contracted assignment was to develop a context for the INEEL as a whole, not its parts. Of particular help in doing this was considering the time in which each reactor operated. Realizing that no new reactors (except LOFT) were built after 1970 was invaluable in developing a sitewide chronology, conceptualizing historical themes, and assessing historical significance.[13]

We developed a building typology to help assess each building. Although the NRTS is unique in the world, we still needed to ask, "What would you expect to find at a nuclear reactor test station?" The typology helped to connect a specific building with its historic context, and thus its significance. The typology provided a logical method for sorting out the relative importance, for example, of pumphouses for sanitary sewage systems and pumphouses for sending reactor coolant to a heat exchanger. The building typologies are located in the introduction to the inventory forms and photographs.

As we began this project, we expected to find a great deal of standardization among buildings. For example, we expected that all "guardhouses" might be so similar that, as a mitigation strategy, recording one guardhouse would amount to recording all guardhouses. This proved not to be the case, however. Guardhouses and other buildings were supplied by many different vendors at many different times. Even when they functioned similarly, they were not standardized.

Survey Forms. The inventory used Idaho SHPO's reconnaissance-level site survey form and modified it for this project. Michael "Bert" Bedeau, the Idaho SHPO manager of the National Register program in 1997-98, and other SHPO staff were very interested in the potential management usefulness of the inventory and provided considerable

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[12] Idaho Operations Office/DOE, *Comprehensive Facility & Land Use Plan*. Idaho Falls: INEL Report No. DOE/ID-10514, 1996.

[13] *Proving the Principle* contains an alphabetized list of reactors, with information on operating dates, when these were available.

encouragement and assistance. The modifications created new spaces on the form for data on the size of the building, its typology, and a recommendation for recordation. In 2003, the Idaho SHPO requested removal of the latter.

Recommendation Format. One of the issues considered in this report is an appropriate National Register format for the general recommendations. Should the whole INEEL be thought of as one historic district? Or should each individual primary area be considered on its own? If so, might some areas be significant and others not? Should this be thought of as a multiple property study?

An answer to these questions emerged after the building survey was completed. Officially, we examined buildings only, but it was impossible to ignore the other features and structures on the scene -- the World War II ordnance craters, the cooling towers, the bin sets, the evaporation ponds, the arrays of piping, the exhaust stacks, the waste pits, and the earthen shielding berms. Surrounding all of it was the windy expanse of dry sagebrush desert, with views of mountains, distant buttes, and an occasional antelope. Human enterprise in this specific desert environment made it possible to build nuclear submarine hulls, an airplane hangar (now used to shelter a tank armor factory), below-ground control bunkers for nuclear reactor experiments, an experimental farm, and all of the complex support systems these activities required. Evidence of the mutual impact of people on place and place on people was everywhere.

A format for historical significance comes from *National Register Bulletin 30, Guidelines for Evaluating and Documenting Rural Historic Landscapes.*[14] It seems unlikely that the Bulletin's authors contemplated a highly industrial nuclear testing station in a desert as a "rural" landscape. Nevertheless, their definition applied appropriately to INEEL and its history:

> For purposes of the National Register, a rural historic landscape is defined as a geographical area that historically has been used by people, or shaped or modified by human activity, occupancy, or intervention, and that possesses a significant concentration, linkage, or continuity of areas of land use, vegetation, building and structures, roads and

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[14] Linda Flint McClelland, et al. *National Register Bulletin 30, Guidelines for Evaluating and Documenting Rural Historic Landscapes.* (Washington, DC: U.S. Department of the Interior National Park Service, no date.)

waterways, and natural features.[15]

Additionally, the four "processes" and seven "components" of historic landscape analysis provide a way to organize present and future information about the INEEL's history. This report, while referencing all of these, documents in detail three of the processes: land use, large-scale patterns of spatial organization, and response to the natural environment. The inventory emphasizes the "building" and "cluster" components of this landscape. Future examinations of this landscape -- and the historical sites and structures within it -- are likely to document processes and components in more detail.[16]

Considering the INEEL as a historic landscape illuminates an extraordinary evolutionary connection between succeeding interventions by the federal government on this western desert. In four waves of experimentation, the nation has tried to extend the frontiers of science and engineering. First, it sought to irrigate the desert for agricultural settlement and production. Then it tested the performance of ordnance bunkers, ordnance, and explosives during World War II. Soon after, it created a "testing station" for dozens of nuclear reactor experiments and a chemical processing plant. Having contaminated a natural environment, the government's fourth wave of experiment seeks to remediate it. Future historians may name a fifth wave once they have had time to examine the meaning of the 21st Century mission to "enhance energy security."

The government itself recognized the mutual impact of human activity and the desert environment. In 1975 it declared the INEEL a National Environmental Research Park for the purpose of examining that impact scientifically.[17]

The "historic landscape" concept allows for a holistic interpretation of the built environment at INEEL. A given building is invariably part of a system of buildings -- a

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[15] *Bulletin 30*, p. 2.

[16] *Processes*: land uses and activities, patterns of spatial organization, response to the natural environment, cultural traditions; *components*: circulation networks; boundary demarcations; vegetation related to land use; buildings, structures and objects; clusters; archeological sites; small-scale elements. See *Bulletin 30*, p. 4-6.

[17] INEL, *Comprehensive Facility and Land Use Plan* (Idaho Falls: DOE/ID Report No. 10514, March 1996), p. 50.

complex of supportive and auxiliary functions that were situated where they were for highly specific reasons related to the environment, to the needs of an experiment, to human safety, or to government directives for economy. The recommendations for historic preservation and mitigation take this into account.

Period of Significance and SubThemes: Certain themes dominated INEEL history during discrete periods of time. This report refers to these periods as "contexts." Each context has a name, subthemes (in some cases), and begin/end dates. As will be discussed in more detail below and in the narrative report, the historical analysis concluded that the history of the INEEL site after 1942 falls into four "contexts." (Previous analysis by others has identified and named two "contexts" previous to these four. These are addressed briefly in the report.)

Evaluating the contexts for their historic significance was the key reason for this project. Upon this evaluation hangs the assessment of any given building constructed during that period of time. Of the four post-1942 contexts, two are assessed as historically significant: the "Ordnance Testing" and "Nuclear Reactor Testing" contexts, whose dates are 1942-1949 and 1949-1970 respectively. The last two contexts are "Multi-Program Research" and "Remediation of Waste." These two overlap conceptually to some extent, but they have the same dates: 1971-present. Neither is assessed as historically or "exceptionally" significant. The activities are still evolving and it is too soon to evaluate their importance.

The context period for Ordnance Testing involved two different wars, so it identifies SubThemes related to either World War II or the Vietnam War.

The many and varied activities related to Nuclear Reactor Testing are also categorized in SubThemes. These major national concepts help describe the vast history of the Age of Nuclear Technology in the United States.[18] The INEEL is very much a part of these national themes:

Nuclear reactor testing, experimentation, and development
Cold War weapons and military applications
Commercial reactor safety
Chemical Reprocessing (of spent fuel to recover

[18] The term "testing" in this report must not be understood as the detonation of nuclear weapons devices.

uranium)

The context periods for Multi-Program Research and Remediation of Waste have been given no SubThemes.

CROSS REFERENCE TABLE
The Context Report and Proving the Principle

Contexts 1 and 2	Ch. 1: Aviator's Cave
Context 3, Naval Proving Ground	Ch. 2: The Naval Proving Ground
Context 4: National context for reactor research	Ch. 3: Uranium Trail Leads to Idaho
Transition from NPC to AEC	Ch. 5: Inventing the Test Station
Argonne National Lab	Ch. 3: Uranium Trail Leads to Idaho
EBR-I reactor	Ch. 6: Fast Flux, p. 44-48 Ch. 8: Reactor Zoo, p. 64-66 Ch. 14: Imagining the Worst, p. 135-136 Ch. 17: Science in the Desert, p. 165 Ch. 20: A Question of Mission, p. 192
Test Reactor Area, MTR	Ch. 6: High Flux, p. 48-51 Ch. 8: Reactor Zoo, p. 66-69 Ch. 17: Science in the Desert, p. 162 Ch. 20: A Question of Mission, p. 194-196
Nautilus prototype	Ch. 6: Rickover Flux, p. 51-53 Ch. 8: Reactor Zoo, p. 69-73.
Test Reactor Area, ETR	Ch. 12: Reactors Beget Reactors Ch. 17: Science in the Desert, p. 160-
OMRE	Ch. 17: Science in the Desert, p. 163
Naval Reactors Facility	Ch. 10: Cores and Competencies
Idaho Chemical Processing Plant	Ch. 11: The Chem Plant Ch. 17: Science in the Desert, p. 169-172
Test Area North	Ch. 13: The Triumph of

	Political Gravity over Nuclear Flight Ch. 17: Science in the Desert, p. 164-165
Argonne's BORAX experiments	Ch. 14: Imagining the Worst, p. 128-133
SPERT experiments	Ch. 14: Imagining the Worst, p. 133-134
EBR-2 and Fuel Recycling	Ch. 14: Imagining the Worst, p. 136-137 Ch. 17: Science in the Desert, p. 165-166
Army Reactor Area	Ch. 15: The SL-1 Reactor Ch. 15: The Aftermath
Test Reactor Area, ATR	Ch. 17: Science in the Desert, p. 160-162
Dairy Farm	Ch. 17: Science in the Desert, p. 167-169
Argonne and LMFBR	Ch. 18: The Shaw Effect, p. 174-176 Ch. 19: ...And the Idaho Boost, p. 184-188 Ch. 23: The Endowment of Uranium, p. 231-232
Safety Test Program and LOFT reactor, PBF	Ch. 18: The Shaw Effect, p. 177-183 Ch. 23: The Endowment of Uranium, p. 222-226
Context V, and National Change of Attitude re nuclear power after 1970	Ch. 20: A Question of Mission Ch. 21: By the End of this Decade Ch. 23: The Endowment of Uranium, p. 231-32
Context V, Multi-Program Research	Ch. 22: Jumping the Fence
Context V, the IFR	Ch. 23: The Endowment of Uranium, p. 232-238
Context V, the SMC	Ch. 23: The Endowment of Uranium, p. 228
Context V, Chem Plant (INTEC)	Ch. 23: The Endowment of Uranium, p. 229

Context V, the IRC	Ch. 25: Mission: Future, p. 247-255
Context VI, Remediation of Waste	Ch. 9: Hot Stuff Ch. 20: A Question of Mission, p. 197-204 Ch. 21: By the End of this Decade Ch. 22: Jumping the Fence, p. 219-221 Ch. 24: The Uranium Trail Fades, p. 238-244 Ch. 25: Mission: Future, p. 244-247
Glossary of Terms	p. 307-312
List of INEEL reactors	p. 259-268

INVENTORY AND SURVEY RESULTS

The survey of buildings in the following INEEL site areas resulted in inventory forms for 468 buildings. This total may not match the number of inventory forms because some buildings joined together at one wall are regarded as two buildings, each with its own number. Some of these were described on one inventory form. Likewise, identical sets of buildings were described on one form.

* Sitewide (B)	21
Army Reactor Area (ARA)	1
Central Facilities Area (CFA)	71
Idaho Chemical Processing Plant (ICPP) (named INTEC since 1999)	138
Experimental Breeder Reactor-I (EBR-I)	2
Power Burst Facility (PER)	26
Test Area North (TAN)	76
Test Reactor Area (TRA)	87
Radioactive Waste Management Complex (WMF)	44
Howe Peak	1
East Butte	1

* "Sitewide" is a term used at the INEEL to describe areas outside the primary activity areas. This group includes guardhouses at INEEL entry stations, for example.

The oldest extant building dates from 1942. The newest were built in 2003. The distribution of buildings by decade is:

1942-1949:	12
1950-1960:	128
1961-1970:	49
1971-1980:	54
1981-1990:	127
1991-2000:	94
2001-2003:	4

The distribution of buildings by the assessment of their historical significance and within their appropriate (or earliest) historical context is:

Context III	Ordnance Testing:	12*
Context IV	Nuclear Reactor Testing:	175
Context V	Multi-Program Research	230
Context VI	Remediation of Waste:	51

Some Context III buildings are also associated with Contexts IV and V.

RECOMMENDATIONS

Summary Statement of Significance. The context narrative suggests the following conclusion regarding the significance of the INEEL: The INEEL was associated with events during the period between 1942 and 1970 that have made a significant contribution to the broad patterns of American history, particularly with respect to its association with World War II and, thereafter, with (nuclear) Science and Engineering. The facilities at the INEEL associated with these themes are of exceptional significance.

Section 106 Recommendations. The following recommendations are intended to assist NE-ID meet Section 106 and 110 responsibilities.

1. *Landmarks*. If a building has been identified as of "exceptional significance" and is of National Landmark potential, the recommendation is that it be preserved in place and maintained in appropriate condition for historic interpretation to the benefit of the public and future generations.

2. *Reactors*. Any building that housed a reactor or a significant process, such as the Materials Test Reactor, the Fuel Processing Building at the Chemical Processing Plant (INTEC), and Experimental Organic Cooled Reactor, for example; and was constructed during the historic period of significance or is exceptionally significant (ie, LOFT) should form the key property in a HABS/HAER study.

HABS/HAER documentation should record the key reactor building and the cluster of support facilities that surrounded and supported it. For example, a reactor building might have been supported by a stack, ventilator building, coolant water process buildings, cooling tower, hot shop, and others. A HABS/HAER report provides a useful way to bring together the abundant historical documentation scattered about the INEEL: construction progress, aerial, and interior photographs; architectural, engineering, and process drawings; and reports. While HABS/HAER reports are not required to be "definitive" histories, they are opportunities to build *dossiers* on facilities that will be useful to future researchers.

HABS/HAER reports should be undertaken for all landmark properties and associated programs and support structures.

3. *Reactor Support*. If a building that was an intimate

component of a reactor or process complex (fuel element storage, plug storage, heat exchanger, cooling tower, hot shop, for example), it should be photographed with large-format archivally processed black/white film. The photographs should be preserved along with historic photographs and drawings. When a HABS/HAER report is undertaken for the key building in the complex, these photographs and other documents will become part of it. This procedure should allow the objectives of cleanup and preservation to progress together.

4. *Reactor Support Auxiliary*. If a building was a contributing feature of a historic complex, but not immediately essential to the experiment (sewer pumphouse, cafeteria, bunkhouse, warehouse), its contribution to the complex would be best captured in historic photographs collected as part of a broader HABS/HAER study.

5. *Reassessment*. Buildings should, in general, be allowed to reach fifty years of age before their importance in American history is assumed. However, buildings of lesser age may reasonably be re-assessed for their potential as "exceptionally" significant properties from time to time.

Section 110 Recommendations. In the early 1990s, a dispute erupted between the National Park Service and the National Aeronautics and Space Administration over the disposition of twenty-five Man in Space properties. Subsequently, the Advisory Council on Historic Preservation produced a report entitled *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities*.[19] Without a doubt, the INEEL is a highly scientific facility where scientific boundaries were moved forward. And without a doubt, the demands of continuing operations sometimes conflict with the goal of preserving and conveying to the public its historic legacy.

The *Balancing* report reminded everyone that the object of historic preservation is to connect the citizens of the country to their heritage. The preparation of HABS/HAER reports alone (followed by dismantlement) is hardly likely to reach the potential audience of interest. The Council listed several suggestions and invited scientific agencies to be innovative.

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[19] Advisory Council on Historic Preservation, *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities* (Washington, D.C.: ACHP, 1991).

We recommend that DOE embark on a proactive program of historic preservation and interpretation. This program should be encased in a Programmatic Agreement, with identified milestones and funding provided. The following activities should be included.

1. National Historic Landmarks. The scope of this study did not include a detailed evaluation of potential candidates for National Historic Landmarks. Such analysis should be undertaken and needs to include an assessment of the proposed landmark's integrity and should be done with cognizance of other nuclear-research-related landmarks in the country. At the INEEL, only the Experimental Breeder Reactor I (EBR-I) has been named a National Historic Landmark.

The American Nuclear Society (ANS) conducts a landmark program to recognize facilities of significance to the history of nuclear science. It has awarded its "Landmark Award" to several INEEL sites: to EBR-I, Experimental Breeder Reactor II, the Old Waste Calcining Facility, the nuclear submarine prototype S1W, Special Power Excursion Reactor Tests I-IV (SPERT I-IV), and Materials Test Reactor (MTR). These facilities and the Engineering Test Reactor (ETR), the Aircraft Nuclear Propulsion Program (ANP), and the Loss-of-Fluid Test (LOFT) should also be evaluated for National Historic Landmark status.

A significant feature of INEEL history is its singular nature as a nuclear "proving ground" and the wide-ranging activities that took place here. Any landmark program should be flexible enough to commemorate not only individual buildings (as was done at EBR-I) but the testing station as a whole.

2. HABS/HAER Reports. A systematic program of HABS/HAER reports should be undertaken for the following areas or facilities:

U.S. Naval Proving Ground (1942-1949)
Test Reactor Area (TRA)
SPERT I-IV and the Power Burst Facility (PBF)
Idaho Chemical Processing Plant (ICPP, INTEC)
Experimental Organic Cooled Reactor (EOCR)
Naval Ship Reactors
Argonne National Laboratory West (ANL-West)
ANP/LOFT (to supplement HAER No. ID-32-A, TAN Hangar)

The reports should center upon a key area, experiment, or process. All auxiliary buildings, structures, and artifacts should be included. Auxiliary buildings should not be the center of any HABS/HAER reports.

The buildings at the INEEL are frequently less interesting than the activities they housed. HABS/HAER reports should be regarded as an opportunity to mine the INEEL archives for historic photos documenting the processes and experiments that took place within the buildings as well as their special construction and architecture. The nature of scientific research was to recycle buildings and equipment, so historic photographs should be used to preserve the legacy of that work. Archival aerial photographs and technical reports also can help document the interaction between science and the landscape.

Pursuant to Section 106 of the National Historic Preservation Act, HAER reports have been completed for the following: ANP Hangar (TAN-629), the Advanced Reentry Vehicle Fuzing System (ARVFS) Bunker, the Old Waste Calcining Facility (ICPP-633), and Army Reactor Areas I, -II, -III, and -IV.

3. Preservation of Archival Material. The INEEL Photo Lab maintains a collection of an estimated one million negatives. Original engineering drawings may be available. The INEEL Technical Library houses the reports and journals in which scientific findings were published. Motion picture films and videotapes also exist on the INEEL site. All of this material can not all be preserved via a HABS/HAER report, but together they are irreplaceable documents recording the history of the INEEL.

Some of this material has been discarded after it has served the technical needs of scientific researchers. However, we recommend that the material be considered an archival collection with great historical value, and that it be preserved, managed, stored, and used accordingly.

4. Preservation of Artifacts. We recommend that a group of scientists and engineers form a committee to consider what artifacts, structures, and objects will help preserve and convey the historic legacy of scientific research to future generations. Such articles should be preserved for use in a museum or special (permanent) exhibits. Examples might include control panels, robots, unique fabrications (like the dolly that transferred HTRE experiments to their test site and back), shielded locomotive, instrumentation, older and newer generations of analytical equipment, cadmium rabbits, grappling tools, friskers, (unirradiated) fuel elements, metal-toed boots, dosimeter badges and detection equipment, transport casks, straddle carriers, and scale models of facilities.

Upon identification, such objects should systematically be collected, stored, and protected until they are permanently installed in a museum, exhibit, or otherwise preserved.

5. Exhibits. Having preserved artifacts, the next issue is to consider the setting in which they might best contribute to the larger understanding of the INEEL: In an expanded museum near EBR-I? In connection with another landmark-status reactor building? Perhaps in the Experimental Organic Cooled Reactor that was built but never went critical? Perhaps a combination museum/surround-sound theater in Idaho Falls would provide a better opportunity, or when appropriate, interactive traveling exhibits that could visit school science classes and similar locations.

6. Oral Histories. Present and retired INEEL employees are the most compelling source of information (sometimes the only source) about "why we did this," or what it was like "to be there." For every $200,000 budgeted for the remediation of a site or dismantlement of a building, an amount (such as .5 percent) could be placed in a fund for an Oral History program. The money would finance a professional program of travel, interview, recordation, and transcription of a wide range of INEEL workers.

7. Written Histories. The research conducted for HABS/HAER reports should be used in other formats to help interpret INEEL history to various audiences. Possibly HABS/HAER reports should be published in quantity and distributed to public libraries. Commemorative books for special occasions could exploit the photographic archive to help tell the story of science, of research, atomic power, of nuclear engineering, or of environmental impacts. Fellowships might be financed to invite and encourage historians to use the archival resources at the site for research projects. The book *Proving the Principle* should be made available for the general public. Additional books interpreting INEEL history could be commissioned.

8. Re-use, an Alternative to Dismantlement of Historic Buildings: Although present DOE priorities are to reduce costs associated with maintaining idle resources, it is recommended that alternatives to dismantlement be considered in the case of historic buildings. Re-use, postponement of dismantlement, or stabilization and closing might extend the life of a facility and make it available for future mission needs or historic interpretation to future generations.

One possible strategy to preserve a historic structure is to re-use it without destroying its historic integrity. This strategy should be applied discriminately at INEEL. Scientists designing the next experiment are notorious for "re-using" everything from vacant buildings to materials and tools that someone else abandoned. In some cases, re-use will preserve a historic structure; in others, re-use obliterates the interior features that made a building historically interesting.

One example of re-use that preserved a historically significant building is at Test Area North, where a tank armor manufacturing plant was erected under the barrel-vaulted ceiling of an airplane hangar designed to house a nuclear-powered jet airplane. The shape and size of the hangar were unaffected by the new use (although repairs to the leaky roof threatened to change its appearance). Inside, the armor plant left in place the one feature that related to the hangar -- a lead brick docking structure intended for the airplane.

More typically, re-use occurs when the rectangular shell of a building is gutted of its former laboratory configuration and equipment, de-contaminated, and re-occupied by another type of activity altogether. All trace of the historically significant activity is gone, while the building shell lives on, meaningless for any historical interpretation except "It used to be in this building." Re-use of this type occurred at the Army Reactors Area where the shell of a (swimming-pool-type) reactor building was cleaned up and re-used for offices.

Historic re-use is sometimes uniquely interesting. For example, the ammo-storage bunkers built at the Naval Proving Ground (Central Facilities Area) were built before nuclear fallout had made its appearance on Earth. When later radiologists sought a place with low background radiation for their laboratories, they selected these bunkers and adapted them.

The challenge for historic preservation is to evaluate the relationship between an architectural envelope and the activities occurring inside. The architecture of a hangar or a domed reactor building relates to the purpose of the experiment for which it was designed. A standard rectangular building intended as an economical shelter from the weather carries far less meaning. Failing to distinguish between the two situations can result in misplaced preservation priorities.

Re-using an empty building shell in the name of "historic preservation" is pointless. Future generations would be better served if artifacts, scale models, measuring devices, films, photographs, oral interviews, histories, and documents related to the experiments are preserved and interpreted for public access.

Summary of Building Recommendations.

The table below summarizes the status suggested for 433 buildings inventoried at the INEEL. All buildings constructed between 1942 and 1970 are eligible for consideration to the National Register of Historic Places.

Area	No. of bldgs	Eligible for Nat Reg
Site	23	5
CFA	74	39
ICPP (INTEC)	130	23
EBR-I	2	2 *
PER	22	12
RWMC	48	0
TAN	58	27
TRA	76	59

* EBR-1 is a National Historic Landmark and is regulated according to 36 CFR Part 65.

HISTORIC CONTEXTS AND CHRONOLOGY
A Summary Assessment of Significance

The body of knowledge accumulated about the 890 square-mile geographic landscape area known as the Idaho National Laboratory in Southeast Idaho can be organized into six (slightly overlapping) contextual periods. This report does not assess the significance of context periods preceding 1942, but they are summarized here for the reader's convenience.

I.	Prehistoric/Protohistoric	15,000 B.P. to 1805 A.D.
II.	EuroAmerican Contact and Settlement	1805 to 1942
III.	Ordnance Testing	
	A.World War II: U.S. Naval Proving Ground	1942 to 1949
	B. Vietnam War	1968 to 1970
IV.	Nuclear Reactor Testing	1949 to 1970
V.	Multi-Program Research	1971 to pres
IV.	Remediation of Nuclear Waste	1971 to pres

Context I: Prehistoric/Protohistoric: 15,000 B.P. to 1805 A.D.

Archaeological investigation on and near the borders of the INEEL has indicated the presence of early peoples at hunting sites and shelters as long ago as 12,000 years. The lava plain was populated by mastodons, giant bison, camels, and saber-toothed tigers, all of which attracted hunters. Water, small animals, useful plants, minerals, and obsidian for spear points also drew people to the area.

From about 8,000 years ago, small bands of people crossed over the land in an annual cycle, gathering plant resources in season and traveling between stone quarries, fishing areas, and other supply areas. Archaeologists continue to gather information about early human life in the area, noting rock paintings, animal and human bones, occupational sites, and the changing styles of projectile points. This lengthy context period is further subdivided into a more detailed chronology dividing the period into Early (15,000-7500 B.P.), Middle (7400-1300 B.P.), Late (1300-150 B.P.), and Protohistoric (300-150 B.P.). The latter period was characterized by the presence of European trade goods and the introduction of horses.

A summary description of this context period and a comprehensive bibliography can be found in *Idaho National Engineering Laboratory Management Plan for Cultural Resources* (Final Draft) by Suzanne J. Miller.[20]

Context II: EuroAmerican Contact and Settlement: 1805-1942

The period of EuroAmerican contact in Idaho is generally considered to begin in 1805 with the Lewis and Clark Expedition. The first EuroAmericans to have entered the INEEL territory most likely were French-Canadian trappers and other explorers, perhaps around 1820. U.S. Army Captain B.L.E. Bonneville traversed the area in 1832-33 and referred to it as the "plain of the Three Buttes."[21] Explorers and trappers in the vicinity of the INEEL would have met Shoshone and Bannock peoples gathering plants or hunting.

Large numbers of emigrants followed the Oregon Trail through Idaho beginning in the 1840s. A shortcut known as Goodale's Cutoff was established in the early 1850s; its traces are still visible in the southwestern corner of the INEEL. Later this trail was used when cowboys drove great herds of cattle across the plain from Idaho, Washington, and Oregon to Wyoming. Sheep drives replaced cattle in the 1880s.[22]

Two stagecoach lines crossed the area near Twin Buttes, near the southern boundary of what became the INEEL. Transportation became more reliable through the area after freighters began serving miners in the mountain camps north and west of the INEEL. Cattlemen established ranches along the Little Lost River and Birch Creek in the early 1880s. Homesteaders settled in the Big Lost River area in the late 1870s and began the daunting task of farming arid lands.

The federal government became involved in the effort to irrigate arid lands when Congress passed the Carey Act in

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[20] The report, published by INEL Lockheed Idaho Technologies Company, was prepared in July 1995 as Report No. DOE/ID-10361.

[21] Washington Irving, *Adventures of Captain Bonneville* (Portland, Oregon: Binfords and Mort, no date, Klickitat Edition), p. 110.

[22] See Miller, p. 2-19 for a map of historic trails crossing the INEEL.

1894, followed by the Reclamation Act in 1902. These laws provided land and financing for water storage and distribution projects. This federal action might be said to constitute its first "test" in reshaping the landscape at the INEEL. The Big Lost River Irrigation Project included two large tracts of land, one in the south-central portion of the present INEEL. This experiment in settlement and irrigation ultimately failed. The engineers miscalculated the available water and had a poor understanding of the soils and porous basalt layers that underlay their reservoirs and canals. Settlers drifted away in the 1920s, having failed to find "salvation from the application of science and engineering expertise" for their project, leaving the land once more very sparsely populated, and having brought no large town to the environs of the INEEL.[23]

Considerable historical research has illuminated this context period and provided benchmark dates that mark a more detailed chronology. Historic themes include early exploration and discovery, trapping and trading, the Oregon Trail, mining, cattle and sheep drives, transportation, EuroAmerican/Native American relations, settlement, irrigation, and ranching.[24]

Context III: Ordnance Testing: 1942-1949 and 1968-1970

This context is divided into two periods. The first related to World War II, extending from 1942 to 1949. When the Navy established an ordnance plant in Pocatello, Idaho, to manufacture, repair, and assemble components for large naval guns, it required a place to proof-fire the gun components.

The isolation of the site and its sparse human population made it suitable for the Navy's purposes. The land was arid, flat, and mostly in the public domain. The Navy built a residential and proof area at the site and conducted proof operations and explosives experiments during and after the war. A history of this "test" period is contained in Chapter 2 of *Proving the Principle.*

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[23] Hugh Lovin, "Footnote to History: `The Reservoir Would Not Hold Water,'" *Idaho Yesterdays* (Spring 1980), p. 14. Lovin's remarks referred to the Blaine County Irrigation Project, which lies northeast of Howe in Butte County.

[24] These themes are introduced in Miller, p. 2-18 to 2-21, and supported by an excellent bibliography.

When the Atomic Energy Commission (AEC) selected the site for its National Reactor Test Station (NRTS), the Navy buildings remained, but Navy personnel departed. The practice of explosives experimentation ended. However, during the Vietnam War, the site was again used for U.S. Navy ordnance experiments and related target practice. Gun mounts were aimed away from new buildings and targeted towards the Big Southern Butte.

The present study begins with this context period and supplies a summary narrative historic overview. It relates to the national historic context of World War II: the Home Front, the U.S. Navy, gunnery, ordnance manufacture and testing, and explosives research. As one of the few sites of its type, this report has identified the World War II ordnance testing context as historically significant.

Context IV: Nuclear Reactor Testing: 1949-1970

The AEC selected the site for its reactor test station for reasons similar to those that had attracted the Navy -- isolation and safety. In order to prevent exposing large populations of people to the possible consequences of an accidental release of radiation, it established a test station that could be used by any of several national laboratories to construct experiments and test new reactor concepts. Of equal importance was its supply of underground water. Landscape features such as wind patterns, average temperatures, and subsurface layers of lava rock became important in siting and operational decisions.

The AEC concept for managing the testing station was to supply a series of central services, so that the laboratories or other contractors could set up their tests as economically and expeditiously as possible. The existing Navy buildings were used as a central supply and administrative area. To this core, additional buildings were added as the NRTS grew. NRTS managers situated the reactor experiments at specified safety distances from the central area and from each other.[25]

The three main objectives of the AEC nuclear reactor

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[25] John Horan, former director of Health Physics at INEL, understood that a rough "rule of thumb" of about five miles guided the separation of reactors from populated areas and each other. These were revised after the development of the Shippingport reactor in Pennsylvania. Interview with author, July 29, 1997.

program were: to develop a supply of nuclear materials for national defense, to develop knowledge about nuclear reactor concepts, and to establish safe operating parameters for reactor safety and human health. As has been well documented by Richard Hewlett and the other authors of *Atomic Shield* and *Atoms for Peace and War*, the Cold War and the race for nuclear weapons supremacy between the United States and the Soviet Union consumed substantial AEC energies and resources. Significant weapons system development took place at the NRTS, particularly by the Navy and Air Force. The Army likewise was active at the site, not in pursuit of a weapons system, but of a nuclear alternative to diesel generators and fuel supply lines for field bases.

Despite the heavy investment in military activities, other AEC program goals were in abundant evidence at the site. Several experimental reactor concepts were tested, the first being EBR-I. Other concepts tested included gas-cooled reactors (as part of the Army's program), an advanced breeder reactor, and organic moderated reactors.

Reactor safety experiments also began early at the site with the Boiling Water Reactor Experiments (BORAX) and Special Power Excursion Reactor Test Program (SPERT). Environmental monitoring was an early and continuous activity. The program included an experimental farm and the regular monitoring of soil, groundwater, and waste streams.

In the 1940s and 1950s, the AEC thought that uranium, the raw material for reactor fuel, was a relatively scarce element on the earth. It therefore had to husband its supply with great care. Test reactors and plutonium-producing reactors used highly enriched uranium fuel that lost its reactivity in a reactor over a period of 17 to 18 days of operation, leaving 80 percent or more of the fuel unfissioned. This situation dictated the practice of recovering uranium from spent reactor fuel. At the NRTS the Chemical Processing Plant recovered uranium from the test reactors on the site and from fuel shipped from many other places.

After reviewing the history of each of the "primary areas" at the INEEL, the authors of this report have concluded that all of its early activities with nuclear reactor experiments fell into one of the following historic SubThemes:

* Cold War weapons and military applications
* Nuclear reactor testing, experimentation, and development
* Commercial reactor safety (environmental and human)

* Chemical Reprocessing (of spent fuel)

The narratives in this study are therefore identified according to these themes. A new Atomic Energy Act was passed in 1954 to permit (among other purposes) the commercial use of nuclear material. After 1954, nuclear reactor testing was a growing enterprise.

Beginning in 1971, the thematic continuity of "nuclear reactor testing" began to break down. By that time, most of the 52 reactors had been built, served their experimental purpose, and been dismantled or destroyed. In the case of military experimentation, the Army program had taken place from 1957 to 1965; further research was canceled at that time. The Air Force project to build a nuclear-powered turbo-jet bomber had been canceled by President John F. Kennedy in 1961. The Navy's drive to create a nuclear-powered fleet of submarines and surface ships, on the other hand, had already succeeded. While research continued on how to improve the payoff for using nuclear reactors in ships (such as fitting large ships with two or more reactors), the thrust of the Navy mission shifted to the enhancement of proven concepts and to the training of sailors to operate nuclear-powered ships.

After 1970 the AEC's reactor development program of experimenting with new or advanced reactor concepts no longer involved the construction of new reactors at the NRTS. The AEC placed its faith in the development of a major breeder reactor to be built at Clinch River, Tennessee, a project that ultimately failed.

The only new reactor to appear at the NRTS (other than the placement of new cores in existing reactor facilities) after 1970 was connected with the Loss-of-Fluid Test (LOFT) program. This important reactor safety program originated in the early 1960s. A commercial nuclear power industry was growing fast, and great interest focused on the safety of scaled-up power reactors. One of the worst accidents that was imagined was for a large reactor to experience a loss of coolant fluid to its core, heat up, and melt down. After several redefinitions of the "loss of fluid" problem and redirection of the program, the LOFT reactor reached its first criticality late in 1972.

Without doubt, the "nuclear reactor testing" context at the NRTS is of national significance in American nuclear history. Hewlett, in *Atomic Shield*, shows that the decision to establish the NRTS helped break a certain AEC malaise and get the reactor program off the ground. The NRTS was the only place in the world of its kind, and the tests conducted there were of consequence in the evolution both of weapons programs (ie, nuclear-powered submarines and bombers) and of the commercial atomic industry. The narratives that follow will examine these contributions in more detail.

Equally without doubt, this era is of great historical significance to the State of Idaho. Soon after its establishment, the NRTS was the single largest employer in the state and remained so until very recent years. The federal investment in personnel and physical plant has been substantial. People from all over the country entered Idaho and changed it permanently.

It was easy to define the beginning date of the NRTS's historical significance (for the purpose of this report) as 1949, but defining its end date was more challenging. Reactor research continues at the INEEL to the present day; a few reactors continue to run. Given the fact that the historic mission of the site was to perform reactor tests, this study chose the year in which this mission was no longer on an upward trajectory, but rather moving downward. Based on evidence from within the INEEL and from the national scene, that break occurred between 1970 and 1971.

The evidence from within INEEL is summarized by considering the operating years of the NRTS reactors. With one important exception (LOFT), no new reactors appeared at the site after 1970. In 1970 the Materials Test Reactor shut down; significantly, this was after a failed attempt by commercial and academic interests to finance continued nuclear research there.

The nation as a whole was beginning a turn away from further nuclear research and the potential of nuclear energy. The many complex reasons for this were becoming evident in 1971:

The National Environmental Policy Act of 1969 (NEPA) had been signed by President Richard Nixon on the first day of 1970. The Environmental Movement -- a perception by American citizens that hazardous contamination of air, soil, and water must be reversed and prevented -- had reached this first major legislative watershed. In its wake came other laws that affected how government, business, and industry would operate. In 1971, a federal court ruled that the AEC must abide by the rules of NEPA. Nuclear energy fell into the net of the environmental movement.

In 1971 President Richard Nixon articulated the nation's first National Energy Policy. He made it clear that the AEC's broad inquiry into many different reactor concepts had come to an end. He singled out one reactor type for further research--the breeder reactor. Nixon said that breeder reactors were "our best hope today for meeting the nation's growing demand for economical, clean energy..." But also in 1971 the fuel in the Enrico Fermi breeder reactor, a demonstration project jointly developed by commercial interests and the AEC near Detroit, Michigan, became depleted. The facility soon closed and the reactor never ran again.

In 1971 the price of energy, which had been declining throughout most of the century, leveled off and began to rise. In 1971 the AEC, which had up to this year always estimated an energy future in which nuclear power provided a growing share of electricity, revised its forecast downward for the first time.

The decline of nuclear reactor research continued into the 1970s. In 1971 the estimated cost of the Clinch River breeder reactor rose dramatically. The project was to be a partnership between the AEC and private utility companies. The contract among these parties came together in 1971, but the utility companies lacked confidence in it. They demanded that the federal government pay for any cost overruns that might be incurred. Congress agreed to this the next year, but the project failed to thrive.

In 1972, at West Valley, New York, where the AEC had encouraged and subsidized the establishment of a commercial reprocessing plant to handle spent fuel from commercial power reactors, the plant shut down after failing to make a profit for each of its six years of existence. The private market had failed to establish an essential element of the nuclear power industry -- the processing of spent fuel.

In October 1973 the oil producing nations of the Middle East embargoed the shipment of oil to the United States. Some people thought this might be an opportunity to cast nuclear technology as the path to American energy independence. But the public responded to rising energy prices by reducing its demand. Utility companies now had proof that American demand for energy was elastic in the face of rising prices. The cost of bringing new power plants on line continued to rise, and utility companies began to fear the possible consequences of such rising costs.

In 1974 the AEC was reorganized into two agencies, the Nuclear Regulatory Commission (NRC) to regulate the nuclear industry and the Energy Research and Development Administration (ERDA) to formulate energy policy. All orders placed for nuclear power plants after 1974 were subsequently canceled.

And so it went. In 1979 an accident at the nuclear power plant located at Three Mile Island, Pennsylvania, and the publicity which followed, convinced large numbers of citizens that nuclear power was not worth the risk. A constituency fearful of nuclear weapons proliferation successfully challenged the old idea that the uranium and plutonium in spent fuel should be recovered and recycled. Congress finally killed the funding for the Clinch River breeder reactor in 1983. Another major physics research project, a Supercolliding Superconductor, was canceled in 1993 not long after it went under construction. The death of the Superconductor, while not a reactor research project, symbolized the lack of national interest in expensive physics research.

In conclusion, the flow of national historical events had begun to turn away from nuclear reactor research by 1970 -- with profound impacts on the INEEL. Its mission had to change. The historically significant "nuclear reactor testing" context ended in 1970.

Context V: Multi-Program Research: 1971-Present

Research continued after 1970, but it was clearly research of a different type than before. It was broad-based, going far afield from nuclear physics and nuclear chemistry into realms such as cosmology, genetic information coding, the geosphere, geothermal energy, ecosystem processes, mathematics, computing, and medicine. INEEL developed clients well beyond the Department of Energy.

Trying to conceptualize the post-1970 period brings into relief the National Register policy that history be allowed to unwrap itself for fifty years before historians jump to conclusions. This investigation has not found sufficient evidence to characterize the post-1970 context as "exceptionally significant."

Of all the post-1970 research at the NRTS, LOFT-related activities are more closely related to what had gone on before 1970. Therefore, LOFT buildings were inventoried as part of the "nuclear reactor research" context.

Context VI: Remediation of Waste: 1970-Present

The "cleanup" phase of the Nuclear Age carries the weight of a contextual period all its own. The Department of

Energy has been charged -- through legislation, judicial order, and internal commitment -- to remediate the Cold War "legacy" of contamination and waste left by nuclear weapons and reactor development. Resource expenditures at the INEEL in the 1990s were dominated by the prevention of waste, the cleanup of waste sites created in the past, and research into better ways of handling waste, eliminating waste, reducing waste, transporting waste, and transforming waste from one form into another. The name chosen for this context is "Remediation of Waste." (This name distinguishes remedial activity from the management, handling, and disposition of waste that was a normal part of operations at the INEEL since its establishment in 1949.)

The year 1970 is offered as the beginning of this period. Nationally, it was the first year of NEPA and the chain of events that followed. At the NRTS, 1970 was the year that NRTS decided to store nuclear waste from Rocky Flats, Colorado, above ground at the Radioactive Waste Management Complex (RWMC), the new name for the old NRTS "Burial Ground." This sparked another series of events leading to heavy federal investment in the remediation of the pits and trenches of the old burial ground and the construction of the first buildings at the RWMC in 1974.[26]

All of the buildings at the RWMC were identified as part of this context. Several buildings at other INEEL activity areas were likewise identified. Certain waste research facilities overlap the previous context, but the inventory disposition makes little difference. It is premature to regard either context as historically significant, so the association of a facility with either context has no impact on the preservation recommendations.

[26] It should be noted that the volume of waste at INEEL is a small percentage of the total "legacy" of waste in the United States. The remediation of waste at the Hanford and Savannah River facilities is likely to outweigh the activities at INL in scale, scope, and historical impact. See Chapter 3, "Waste," in Department of Energy, *Linking Legacies* (Washington, D.C.: Office of Environmental Management, 1997), p. 31-71. For example, the INEEL holds only three percent of the total volume of high-level nuclear waste.

CONTEXT III: ORDNANCE TESTING, 1942-1949, 1968-1970

SubTheme: *World War II*
INEEL Area: Navy Proving Ground/Central Facilities

Introduction: World War II Arrives in the Idaho Desert

Before World War II, the arid lands between Arco and Idaho Falls were used primarily for grazing. Earlier in the century, local irrigation companies had promised settlers water from the Big Lost River, but they failed to deliver it. Disappointed homesteaders relinquished their lands. A few traces of human habitation and enterprise remained on the landscape -- the banks of abandoned canals, foundations of former homes and farm buildings, and a few non-native plantings. A new demand for these isolated lands, most of them still in the public domain, arose when the United States entered World War II.

When Nazi Germany invaded Austria in 1938, the U.S. Congress authorized the U.S. Navy to expand its ship and aircraft strength. The Navy built large air bases on the east and west coasts and on the islands of Hawaii and Guam. The Navy also strengthened its support facilities, especially for the West Coast bases, where these were minimally adequate. After Japan attacked the U.S. fleet and air bases at Pearl Harbor, the pace quickened dramatically as the country went to war. The Navy searched everywhere for new locations to accommodate further expansion. Because of wartime shortages of materials and manpower, construction rules specified that new buildings should be basic and strictly functional, without elaboration or unnecessary enhancements. Substitutes were to be sought for scarce materials.[1]

As the war in the Pacific intensified, so did the demand for military support of all kinds: training, ordnance and ordnance testing, gun repair, and research related to safety. The coastal cities had supplied all the facilities and labor that they could, so the Navy looked inland for suitable locations. Congress appropriated funds, and Navy projects were established in several western states. The Sixth Supplemental National Defense

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[1] United States, *Building the Navy's Bases in World War II: History of the Bureau of Yards and Docks and the Civil Engineer. Corps, 1940-1946*, Vol. 1 (Government Printing Office: Washington, D.C., 1947), p. 1-13. Hereafter cited as "*Building the Navy's Bases.*"

Appropriation Act of 1942 placed two facilities in Idaho. One was a large personnel training base, Farragut Naval Training Center, at Lake Pend Oreille in north Idaho. The other was the Naval Ordnance Plant at Pocatello, established on April 1, 1942.[2]

The Pocatello Naval Ordnance Plant

The mission of the Pocatello plant was to manufacture, repair, and assemble large-caliber naval guns, mounts, and related equipment required for the Navy's Pacific battleships. A key activity was the relining of major-caliber battleship guns sent to the plant after repeated firings in battle had worn out the rifling in the guns.

The Pocatello site met all the selection criteria. It consisted of 211 acres located three miles north of the town. It was inland and east of the coastal mountain ranges, so it was both isolated and secure. The area contained a plentiful labor supply and space for expansion. The land was marginal for farming and, therefore, less expensive than other potential sites. Ample water was available. Most important, the site was situated near one of the largest Union Pacific railroad terminals in the United States. A transcontinental highway also passed through Pocatello. The plant could easily take delivery of steel, chemicals, ordnance, personnel, and battleship guns shipped from the West Coast.[3]

The plant, built by the Idaho-based Morrison-Knudsen Company, contained large and small gun shops, ordnance storehouses, personnel quarters, machine and proof shops and accessory buildings. While spacious, the Pocatello site lacked one necessary asset: a location nearby to proof-fire the relined guns before declaring them ready to return to the coast and remounting on battleships. The Navy first considered a site near Tabor, Idaho, about forty miles northwest of Pocatello but found the land too uneven and access limited.

The Navy looked further north toward the Arco Desert and found an ideal site. The land was flat, arid, and sparsely

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[2] *Building the Navy's Bases*, p. 16-44; 351.

[3] *Building the Navy's Bases*, p. 341; see also Julie B. Braun, *Lockheed Idaho Technologies Company Internal Report, INEL Historic Building Inventory Survey, Phase I* (Idaho Falls: Sept. 1995), p. 29-30. Hereafter cited as "Braun, *Inventory Phase 1*."

populated. A few acres were in private hands, but most of the land was in the public domain. The Navy appropriated about 271 square miles, configured up to nine miles wide and thirty-six miles long at its extreme dimensions. A branch of the Union Pacific Railroad passed near the southern edge of the site on its way from Pocatello to the towns of Arco and Mackay. By building a short spur line, the rails could carry the guns and other traffic between Pocatello and the proving ground -- a distance of about sixty-five miles. The Morrison-Knudsen Company built all the buildings at the site. J.A. Terteling Company, another Idaho construction company, did subcontract work there and at the Pocatello plant. The proving ground was finished by August 1943.[4]

The Arco Naval Proving Grounds (NPG): 1942-1949

The Arco Naval Proving Grounds facilities were divided into two areas: the Proof Area and the Residential Area. The Proof Area was the business end of the site, equipped to test-fire the guns relined or manufactured at the Pocatello plant, noting their accuracy and consistency. Later during the war the spacious expanse of the desert was the scene of additional missions -- bombing target practice, research on the safe design of explosives storage cells, and miscellaneous research on new forms of explosives.

The buildings and structures in the fenced and guarded eighty-five-acre Proof Area included a bank of ten gun emplacements, a concussion wall, control tower, an office building east of the control tower, the tool room and oil storage tanks west of the control tower, a nearby restroom, five munitions magazines, two electric substations, guardhouse, pumphouse, and two temporary buildings. Railroad trackage supported the movement of guns and equipment around the area. Most of the structures were constructed of reinforced concrete to withstand blast and vibration from proof testing and potential munitions explosions.

The concussion wall, 315 feet long, 15 1/2 feet high, and 8

[4] Information on M-K and Terteling companies from "Appendix B," *Interim Ordnance Cleanup Program Record Search Report for the Interim Action to Clean Up Unexploded Ordnance Locations at the Idaho National Engineering Laboratory* (Idaho Falls: Wyle Laboratories, Scientific Services and Systems Group, Norco, California, for Scientech, Inc., January, 1993). Hereafter cited as "*Scientech Report*."

feet thick, was reinforced with double rebar placed in a close eight-inch grid. The railroad siding near the gun emplacements was equipped with a 250-ton gantry crane to remove guns arriving from Pocatello. A gun ready to be proofed was positioned on one of the ten emplacements, loaded with a charge, and fired northward. Test operators located within the building behind the concussion wall could observe the firing through narrow window slits. Downrange, spotters were positioned at observation towers and in communication with the control tower. Aided by rows of marked concrete monuments across the desert, they triangulated the location of impact and recorded the performance of the gun.[5]

Munitions magazines, also located near railroad trackage, were constructed completely of reinforced concrete. They either had earthen berms on the side walls or were built below-ground with berms covering the entire building except for the entrance.

The Residential Area supported the Navy, Marine, and civilian personnel who lived and worked at the site -- including Women Ordnance Workers, or "WOWs." It contained civilian and officers' houses, associated garages, enlisted personnel barracks, (patrol) dog kennels, a warehouse, commissary, paint house, water tower, deep wells, sanitary sewers, fences, and electrical distribution lines. In 1944 a combination garage, fire station, and locomotive shed was added. On twice-weekly movie nights, the residents moved the locomotive outside, set up a movie projector, and settled down on rows of benches to enjoy the show.[6]

The Residential Area was divided into two complexes, separated by the railroad spur coming in from the Union Pacific branch. The civilian complex was on the south side and consisted of single-family dwellings. They were situated close to one another in an oval, with a circular roadway located on the outer edge and driveways leading to each house. The homes were wood frame, probably of prefabricated materials, and had lawns and fenced gardens.[7]

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[5] Margaret and Orville Larsen, interview with Susan M. Stacy, March 19, 1999. For a fuller account of life and operations at the Naval Proving Ground, see Chapter 2, "The Naval Proving Ground," in Stacy, *Proving the Principle*.

[6] Stan Coloff, "The High and Dry Navy: World War II," *Philtron* (October 1965), p. 3; Stacy, *Proving the Principle*, p. 11, 12. Hereafter cited as "Coloff."

[7] A 1951 photograph shows most of these buildings: INEEL negative number 02974.

The officers' houses and the Marine barracks were on the north side of the spur tracks. These buildings were sided with brick veneer and had shutters around the windows. The lawns were landscaped with substantial plantings of trees and shrubs. The base commander's residence (later known as CFA-607) had its own matching garage. The barracks was of similar construction and housed approximately twenty Marines. Among other duties, the Marines -- and their dogs -- patrolled the site perimeter. The kennels were near the barracks.[8]

Within a very short time, the Navy had shaped the desert landscape to accommodate its mission. A road system, water lines, sewer lines, electrical and telephone lines, and the railroad track united the Residential and Proof areas. The Navy named the main roads Lincoln Boulevard, Farragut Avenue, and Portland Avenue -- names that continue in use today. The railroad siding and village was (and still is) called Scoville after John H. Scoville, the Officer in Charge of Construction at the Pocatello plant and the proving ground.

Research and Testing Programs at Arco NPG: 1942-1949

Although a small facility, the Arco NPG was one of only six specialized facilities conducting ordnance experiments during World War II. One of the largest ammunition depots in the United States already existed at Hawthorne, Nevada, but no testing was performed there. Each ordnance testing facility specialized in various types of ordnance. The White Oak, Maryland, site tested underwater mines. At Stump Neck, Maryland, powder testing was the emphasis. The Montauk, New York, site specialized in torpedoes. In 1943 (after the Pocatello plant was constructed) a rocket ordnance test station was established in the Mojave Desert at Inyokern, California. In 1944 the Shumaker, Arkansas, site began large-scale production of rockets.[9]

At Arco, the specialty, but not the only one, was the proof firing of the Navy's 16-inch ship guns. In addition, proof-testing was done on lesser-caliber anti-aircraft guns, aiming them high into the air. Between 1942 and 1945, the Arco NPG test fired 1,650 gun barrels, large and small.[10]

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[8] Coloff, p. 3.

[9] *Building the Navy's Bases,* p. 339-340, 351-354.

[10] Braun, *Inventory Phase 1,* p. 31-32; and *Scientech Report,*

The Navy permitted certain U.S. Army activities at the site. Bomb groups and fighter squadrons training at the Pocatello Army Air Base used two areas of the proving ground to practice day and night high-altitude bombing techniques. B-24 Liberator bombers dropped 100-pound sand-filled bombs equipped with black powder spotting charges. The pilots aimed at wooden pyramid targets.[11]

Other areas were used for safety-related detonation research. The Joint Army/Navy Ammunition Storage Board authorized demolition tests to determine safe distances between high explosive munitions magazines. The research questions concerned how best to store explosive shells and cartridges in transit and at docks and depots. Army chemists built test storage cells and bunkers in the desert, packed them with TNT to simulate an actual storage facility, and ignited nearby "accidental" charges. The tests helped the scientists combine concrete barriers with air gaps in designs that would help protect the contents of nearby ammo cells. A test conducted in 1945 exploded 250,000 pounds of TNT stored in an igloo-type storage bunker, incidentally creating a crater fifteen feet deep and a noise heard all the way to Salt Lake City.[12]

Smokeless powder tests were conducted in 1944 and 1945. The tests helped determine whether confinement in a standard reinforced concrete magazine would cause the powder in them to explode, rather than burn. One of the concrete bunkers located near the concussion wall stored the powder in quantities of 500,000 pounds until it was tested.

The researchers tested new types of illuminated projectiles (also called "star shells") and white phosphorus projectiles to determine detonation characteristics. Mass detonation of projectiles took place in 1945. The ammunition was shipped to the Arco site from the depot at Hawthorne, Nevada.

After World War II ended, explosives research continued at the proving grounds. Varying quantities of conventional

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p. 2-6, 2-7.

[11] One area was located five miles northwest of INL's Radioactive Waste Management Complex; the other, centered on today's Highway 20 between East Butte and the site of Argonne West. See *Scientech Report*, Reference 96, p. 2-74, 6-7.

[12] See *Scientech Report*, Table 2-1, p. 207.

explosives were used on numerous structures and materials. The tests continue to advance the safety standards for storing large quantities of explosive materials. The largest powder explosion of the time took place at the site on August 29, 1945. Similar tests continued into 1946.[13]

By 1947, gun proofing activities at the site had significantly diminished. The proving ground absorbed new functions. After the war, naval vessels were decommissioned, and various equipment from the ships were sent inland for repair and storage. Pocatello received much of that material, and some of the abundance -- nets, floats, mooring rings, buoys -- went for temporary storage to the proving ground awaiting sandblasting and repainting. The NPG was designated a depot stockpiling surplus manganese for the U.S. Treasury.

The research that continued went along at a slower pace than before and no longer in connection with the gun plant in Pocatello. Some 1948 and 1949 research was classified, the details generally unknown today. "Project Marsh" may have been an effort to develop countermeasures for guided missiles. "Project Elsie" may have tested 16-inch shells made with depleted uranium.[14]

The Atomic Energy Commission Acquires the NPG, 1949

Congress created the Atomic Energy Commission (AEC) in 1946 to develop nuclear energy for peaceful purposes under civilian authority. After evaluating several locations, the AEC selected the Arco NPG in 1949 as the site for a nuclear reactor testing station. The Navy reluctantly gave up the proving ground and its buildings to the AEC.[15]

The houses, warehouse, rail trackage, and the accompanying infrastructure of the Residential and Proof areas became very useful to the AEC as it began to build the country's first and only National Reactor Testing Station (NRTS). This area became

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[13] *Scientech Report*, p. 59-71.

[14] *Scientech Report*, p. 72-73.

[15] Richard Hewlett and Frances Duncan, *Atomic Shield, 1947-1952: Volume II of a History of the United States Atomic Energy Commission* (University Park: Pennsylvania State University Press, 1969), p. 210.

the nucleus of what later became known as the Central Facilities Area (CFA). Houses became offices and ad hoc laboratories, storage areas continued to serve construction contractors, and new buildings quickly enlarged the site.

The gun emplacements and concussion wall outlived their function. These assets were not reused, but left in place.

SubTheme: *Vietnam War*
INEEL Area: Navy Proving Ground/Central Facilities

Vietnam War Ordnance Testing

The Vietnam War revitalized several mothballed ordnance facilities across the United States. The Pocatello Naval Ordnance Plant resumed its work relining 16-inch guns for the *USS New Jersey* -- a battleship sent for special duty in Vietnam. The guns were reworked to extend their range. The Navy used the ship to clear (from off-shore) 200-yard-diameter landing zones in Vietnam's heavily canopied jungles.[16]

In 1968 a new Naval Ordnance Test Facility (NOTF) was constructed at the NRTS. Because nuclear reactors and their associated buildings and structures now occupied the old bombing and gun ranges, the original swath of desert north of CFA could not be used. Guns would have to point south. The Navy built a new gun emplacement northeast of Experimental Breeder Reactor-I, along with a new access road, railroad spur, firing pit, pivot point, concussion wall, and equipment shelter. It moved the NPG gantry crane from its original location to NOTF, where it once more unloaded heavy guns for proof testing. The target was the northern flank of Big Southern Butte.[17]

Proof-firing at the NRTS ceased in 1970, before the end of the war. The Indian Head Ordnance Station in Maryland expanded and took over this role for the *USS New Jersey* and other major battleships.

Most NOTF structures have since been removed from the site except for one gun emplacement and parts of the concussion wall.

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[16] Norman Friedman, *The Naval Institute Guide to World Naval Weapons Systems, 1991/92* (Annapolis, Maryland: United States Naval Institute, 1991), p. 457.

[17] Stacy, *Proving the Principle*, p. 17.

These are now ruins. The gantry crane returned to its original location at the Central Facilities Area. Impact craters from NOTF gun proofing are still visible on Southern Butte's north-facing flank.[18]

Extant NPG Buildings

Several Arco NPG buildings and structures are extant. The Proof Area retains railroad trackage, parts of the bank of gun emplacements, the concussion wall and the operations building directly behind it, at least one ammo storage bunker, a pumphouse, and the gantry crane.

In the Residential Area, the civilian houses were removed to make way for new requirements of the CFA as the NRTS grew and expanded. Several examples of the red-brick Navy personnel housing remain, including the Marine barracks, officers' quarters, the commanding officer's house, and a garage. Lincoln, Farragut, and Portland roads continue in use.

Significance of the NPG and Recommendations

As one of six specialized ordnance facilities that conducted research and experiments during World War II, the NPG was a fairly rare military feature on the Home Front. Victory in the Pacific theater relied partly on the performance of battleship guns. The NPG was the terminus of an elaborate logistical system that began with the guns on ships like *USS Missouri* and *USS Wisconsin*. After repeated combat firing wore out the rifling, the guns were shipped to the coast, sent by rail overland to Pocatello, relined, sent to the proving ground, test-fired, and scored for accuracy. The guns then returned to action the way they had come and entered battle once more. Aside from being a tribute to the logistical excellence of the U.S. military, the NPG's association with the great battleships of the war and with military research are important national historic themes.

The NPG is one of very few sites in Idaho that might interpret for future generations what the state contributed to American victory in the Pacific during World War II. Likewise, it

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[18] Braun, *Inventory Phase 1*, 37; INEEL photos 68-1808, 68-2408, 68-2412, and 68-2866 at the INEEL Photo Archive; Brandon Loomis, "Blast Site--INEL Officials 'Cleaning Up' Land Mines," Idaho Falls *Post Register*, from clipping file with no date.

retains a few remnants of a unique "village" of civilians and military personnel arranged for domestic life amidst the firing of battleship guns, bombing practice, and the detonation of vast stores of TNT.

The NPG also provided the core setting for the present-day INEEL. Infrastructure such as roads and rail sidings influenced the location of later facilities. Beyond the proofing and residential centers, the NPG had altered the desert landscape. Explosives tests and gun firings had produced impact craters and left a variety of ruins on the desert floor -- piles of shattered concrete and twisted metal, bomb shells and even unexploded projectiles. The latter was sometimes observed being "initiated by desert heat," a hazardous legacy that remained unattended until many decades later.[19]

In 1992 INEEL contracted with Wyle Laboratories of Norco, California, to clear the desert of explosive debris and scrap metal. Since then, over 1,500 explosive ordnance items have been destroyed and 120,000 pounds of scrap metal cleaned up.[20]

For its many thematic associations, the World War II "Ordnance Testing" context is assessed as historically significant. A HABS/HAER-level document ought to gather together archival resources such as historic photographs, plans, oral histories, military correspondence and research reports. Material published as Chapter 2 in *Proving the Principle* is an additional source of interpretation and context that could supplement the HABS/HAER report and be reprinted for public distribution.

Historic preservation planning at INEEL should preserve the Proof Area in place, aiming to protect it from further decay or destruction. Plans for the Residential Area should continue to reuse and preserve the NPG-era buildings.

The role of ordnance testing at NOTF for the Vietnam War was considerably less important to the prosecution of that war than the previous testing during World War II. Likewise, the impact of this activity on the course of Idaho history was relatively minor. The equipment shelter is not extant. Unless the remaining ruins have retrospective value in interpreting WW II activities, they are not assessed as historically or exceptionally significant in the Vietnam War era of "Ordnance Testing."

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[19] *Scientech Report*, Reference 92.

[20] *Scientech Report*, see also Loomis, cited in Note 18 above.

CONTEXT IV: NUCLEAR REACTOR TESTING: 1949-1970

Preliminary Review of Nuclear Reactors

The work of "nuclear reactor testing" is best begun with a short introduction to nuclear reactors and related subjects mentioned frequently in this report. Nuclear reactors have several features in common: core, reflector, control elements (ie, rods), coolants,

Core: The core is that part of the reactor consisting of the fuel and control elements, a coolant, and the vessel containing these. The design is such to sustain a chain reaction. Neutrons are less likely to split another atom if they travel at their natural rate of speed, which is in the range of millions of miles per hour. To slow them down, the fissionable fuel, such as uranium, is surrounded by a substance that slows, or **moderates,** the neutrons. Some materials do this well, but others absorb the neutrons, taking them out of play as promoters of the chain reaction.

Reflector: Surrounding the core (of many reactors) is a reflector. One of the challenges in reactor design is to prevent the neutrons from escaping the core and becoming useless to the chain reaction. A single fission event of a uranium atom will produce, on average, about 2.5 neutrons. Each of these are capable of fissioning another atom. If the neutrons escape from the core, they will not be available to continue splitting the uranium atoms. Reflectors bounce the neutrons back into the core of the reactor.

Control Elements: One objective of reactor design is to control the chain reaction at the will of the operator -- to control the rate at which neutrons are produced within the core and thus the rate at which the chain reaction proceeds. Control elements are made of materials that absorb neutrons and slow down the reactivity of the fuel. The elements often are in the shape of rods. Operators move one or more control rods into the midst of the fuel where they absorb the neutrons in just the quantity required by the operator to reduce reactivity or shut down completely.

Heat and Coolants: The supreme reason for requiring perfect control over a chain reaction arises from the fact that every fission of an atom produces a unit of heat. The fissions can occur so fast and in such quantity that the heat can melt the fuel, the moderator, and the container vessel surrounding it. Reactor designers, therefore, must arrange for some reliable method of carrying off the heat.

In the case of reactors intended to generate electricity, the heat is the useful part of the reaction. The coolant carries away the core heat and transfers it to a secondary coolant, which then provides the motive force (ie, steam) to power the turbines of the generation machinery. In many reactors, the coolant can serve a dual function as a moderator.

Reactor "concepts." Reactors can be configured in many possible arrangements and use a variety of materials in any part of its architecture. For example, the coolant can be water, a liquid metal, or gas. A reactor performs differently -- and the engineering is very different -- depending on the type of coolant (or fuel, or moderator, etc). The literature of nuclear reactors refers to a particular combination of nuclear features as a "concept." Each combination performs quite unlike the other choices, so each "concept" must be studied to discover its characteristics, its advantages for any given purpose, and its disadvantages.

"Excursions" and "Transients." As scientists began their post-war research into reactor concepts, they needed to find out just what the safe operating limits of reactors were. For example, how much heat could build up before a fuel element or its cladding would melt? Many of the safety tests conducted at NRTS dealt with "excursions" and "transients," names used to refer to extreme power levels and heat build-up. For various reasons (such as imperfectly manufactured fuel elements, the behavior of the coolant, failed cladding materials, or some other anomaly) the power level in a reactor can rise sharply and unexpectedly. This can produce dangerous quantities of heat. Much of the early testing and research at INL sought to discover the safe operating limits of reactors and the materials of which they were made. It also was important to study how the design of reactor components could eliminate or reduce the occurrence of such episodes, how to predict reactor behavior under various conditions, and how to use instrumentation and safety systems to prevent accidents.

SubTheme: *Reactor Testing, Experimentation, and Development*
INEEL Area: Central Facilities

CFA Site Transitions from the Navy to the AEC: 1950-1954

The AEC "inventors" of the reactor testing station decided that the reactor experiments would take place at locations assigned to the sponsor and selected according to safety and other criteria administered by AEC management. The AEC would then supply support services -- such as security, laundry, warehousing, dosimeter and health services, fire prevention and suppression, transportation to and from Idaho Falls -- to all sponsors from a centralized location.

The NPG complex became that location, equipping the AEC with ready-made buildings, roads, rail spur, yards, security perimeters, electricity, and water from which to launch the rest of the enterprise.

While the transfer of ownership from the Navy to the AEC was still in process, the AEC began evaluating the water supply, building a well for the first reactor experiment, and improving the existing Navy roads and trails. Soon the foundation for the Experimental Breeder Reactor (EBR-I) was under construction. The AEC added new rail spurs and expanded the Scoville electric substation to serve potential reactor sites.

When it came to construction standards and policies, AEC policies were similar to those that governed the armed forces. Shaped by similar congressional mandates and budgets, the AEC required functional and standardized design, ease of construction, safety practices, and careful programmatic and fiscal accounting. Adapting NPG buildings for new uses rather than dismantling them was one way to save funds.[1]

Thus NPG dwellings and other buildings were the first home to for the testing station's many central functions. Some of the houses became construction contractor offices. Site engineers made use of the established military grid used by the Navy to define its territory and adapted it to the new requirements of the testing station.

The red-brick officer's residences, garages, and Marine barracks became offices, lunch rooms and security control centers (CFA-606, -632, and -607 respectively). The Navy bunkhouse (CFA-613) continued to be used as a bunkhouse. One

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[1] United States Department of Energy, *National Register of Historic Places Multiple-Property Documentation Form, Historic, Archaeological and Traditional Cultural Properties of the Hanford Site, Washington* (Richland, Washington: US DOE, February 1997), p. 6.10; see also "Engineering Aspects of the National Reactor Testing Station" (US Atomic Energy Commission, Idaho Operations Office, October 1951), p. 13. Hereafter cited as "Engineering Aspects."

residence (CFA-603) was converted into a dispensary. Despite the changes in use, engineers worked carefully to blend new additions and changes with the old.[2]

Buildings in the Proof Area also were recycled for NRTS missions. In the 1950s site engineers remodeled and joined together several extant buildings near the concussion wall and control tower. These structures were originally assigned individual numbers, such as the oil shed (646) and office (684). A portion of this remodel was a new instrument laboratory, numbered CFA-633, and a new locomotive shed (no longer extant, built in 1951.) By 1987 all of the buildings attached to the old battery wall had been renumbered as CFA-633, and the old 646 and 684 numbers were reassigned to other storage buildings at the CFA. The control tower was logically converted into a fire lookout. The old NPG boiler room (CFA-650), located near the battery wall, required few renovations and continued in use until the 1990s.

Over the years the Navy munitions bunkers were used to store hazardous materials. Their heavy-duty concrete construction and berms provided the same protection from chemical explosions as from munitions explosions. One of the bunkers became the Dosimetry Calibrations Laboratory (CFA-638) in 1969, providing appropriate shielding from background radiation. The NPG locomotive shed and fire station, located south of the old Marine barracks (CFA-606), were converted into craft shops (CFA-654, no longer extant).

The NRTS landlords often pointed proudly to their adaptation and reuse of existing buildings for central services as a mark of their cost-saving efforts. They avoided duplication of basic services and preserved resources better directed to the far more costly requirements for nuclear reactor experiments.[3]

Building contractors patterned new NRTS buildings after established military and industrial designs. Such designs were unembellished and functional, based on engineered building plans with virtually no architectural influences. "Industrial Vernacular" a term later coined by industrial archaeologists and architectural historians, describes this type of architecture.[4] Some of the more permanent

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[2] Architectural drawings, Medical Dispensary Remodel (CFA-603), on file at EROB, INEEL, Idaho Falls, Idaho. See also Julie B. Braun, *LITCO Internal Report, INEL Historic Building Inventory Survey, Phase I* (Idaho Falls: INEL, September 1995).

[3] "Engineering Aspects," p. 13. See also Braun, p. 46.

[4] United States Department of Energy, *National Register of Historic Places Multiple-Property Documentation Form -*

structures, such as offices and early reactor buildings did reflect a few International-Style characteristics of the 1950s, and later Contemporary architecture. Most, however, were plain, box-like structures with flat roofs and concrete walls or corrugated metal siding. These building materials were easily available and relatively inexpensive. Good gravel for concrete existed on-site, and the AEC moved a batch plant from one site to another as needed. The railroad provided easy transport of portland cement, prefabricated metal siding, and framing to each site.[5]

New buildings at the CFA illustrated the site's new nuclear testing mission. Since employees were no longer living on-site (except during the earliest construction phase), none of the new buildings were houses. The domestic-scaled brick Minimal Traditional officers' quarters became a thing of the past. The emphasis was science, engineering, and industry, all of which called for purely functional and impersonal design.

The CFA warehouse (CFA-601) and fire station (CFA-666), built by AEC contractors in 1950 and 1951, set the pattern for the vernacular industrial design that became the norm at the NRTS. The warehouse was a concrete masonry or "pumice block" structure, with a built-up flat roof and concrete slab floor. The AEC's Division of Engineering and Construction designed the building, and regional contractors C.B. Lauch and Associates built it. The fire station, designed and constructed by the same group, used similar materials. A 1951 AEC Engineering Division report took pride in the low cost of these buildings while meeting AEC design requirements at the same time.[6] The cafeteria and bus station, the two buildings constructed specifically for site employees, followed the same functional and impersonal lines. Both were built of concrete block and exhibited no stylistic adornments.

Several smaller CFA support buildings were constructed of material other than concrete. In 1951 most of the pumphouses, storage buildings, generator buildings, and small repair shops were prefabricated structures of corrugated iron cladding on a steel frame. A few were constructed with wood or asbestos shingle siding, and only one of brick after 1950. The fire station generator building

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Historic, Archaeological and Traditional Cultural Properties of the Hanford Site, Washington (Richland, Washington: US DOE, February 1997), p. 6.9, 6.19, 6.25.

[5] Stacy, *Proving the Principle*, p. 38-40.

[6] "Engineering Aspects," p. 13.

(CFA-679) had brick masonry walls, a concrete foundation, and a flat, corrugated-iron sheet roof. The prefabricated metal building became the norm for most later support facilities on the NRTS. These buildings easily could be constructed, dismantled, or moved and recycled for another use. An example was the lead storage building (CFA-687), which was moved from the Idaho Chemical Processing Plant to the CFA in 1952. These structures were -- and still are -- representative of vernacular industrial architecture. Their use emphasizes the change in approach from the Navy to the AEC. Instead of building for permanence, the AEC preferred to erect prefabricated, temporary buildings. In later decades, rapidly changing technology and concerns about radioactive contamination at the nation's nuclear sites increased the AEC's interest in temporary structures.

CFA New Construction Slows Down: 1955-1970

In the 1960s, few buildings were constructed at the CFA. Most of them were storage buildings. Some reflected the changing concerns and issues of the nuclear industry (and its critics), particularly related to the handling of nuclear waste. One of the first radioactive-waste handling facilities at the NRTS was the "Hot" Laundry Facility (CFA-669). Built in 1950, the facility handled all contaminated protective clothing for the entire station. Initially, such low-level waste was regarded in the same light as conventional chemical, or even domestic, waste.

The design of the Laundry Facility reflected this thinking. Radioactively contaminated clothes were washed, and the waste water was carried by a separate sewer line to a trickling-filter sewage plant. The waste entered the same septic tank as other CFA effluent and went to an open drain field. This process had evidently been tested at Los Alamos in 1952 and was considered an effective way to handle low-level waste. Eventually, the hot laundry building, sludge lines, and drain field became thoroughly contaminated. The facility was decontaminated and decommissioned in 1981, when its boiler exploded. A new hot laundry facility (CFA-617) took its place, with its sewage lines going directly to a separate septic tank. The old hot laundry was dismantled in 1992.[7]

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[7] For early national perspective, see A.D. Mackintosh (Superintendent of New Facilities Design and Construction at Oak Ridge National Laboratory), "Architectural Problems in Atomic Labs," *Architectural Forum* (January 1952), p. 159. For CFA laundries, see the Idaho Operations Office, Engineering and Construction Division report by A. L. Biladeau, "Radioactive

As early as 1958, the NRTS reacted to growing national concerns over radioactive fallout from nuclear testing. Site engineers converted an old NPG locker room into a Health and Safety Laboratory (CFA-649) for studying radioactivity levels in area plants and animals. Cow's milk from area dairies, feral and domestic rabbits, wild antelope, and native plant species were studied under laboratory conditions. In 1960 these studies discovered a low level of Iodine-131 in milk from "environmental" cows on nearby farms. Internal reports attributed the rise to an unexplained "special test" conducted at the NRTS.[8]

In 1963, a new and expanded Radiation Environmental Laboratory was built, along with a new Technical Center Laboratory. A 1963 report from the Radiation lab indicated that there had also been an increase of Strontium-90 occurring in cow's milk.[9] Above-ground nuclear testing beyond the boundaries of the NRTS was one likely source of some spikes in Iodine-131 or Strontium-90 levels.[10] Growing calls for protecting the underlying aquifer from continued disposal of radioactive waste prompted NRTS scientists and site managers to voice their concerns to the AEC.

As the nation's attention grew more focused on environmental quality in the 1970s and 1980s, the role of CFA in environmental monitoring and general administration at INEEL eventually grew. As reactors closed down at the other activity centers on the site, reactor-support functions would diminish at the CFA.

SubThemes: *Reactor Testing, Experimentation, and Development*
and
Commercial Reactor Safety

Waste Removal in A Trickling Filter Sewage Plant," May 1953. See also the EG&G Idaho internal technical report by R.D. Browning, "TAN, TRA, and CFA Sewage Treatment Plant Study" (Operational and Capital Projects Engineering, January 1989).

[8] NRTS internal report, "Environmental Monitoring Data for the National Reactor Testing Station, Calendar Year 1959 and 1st Quarter of 1960," p. 1; see also report for Calendar Year 1963.

[9] NRTS internal report, "Environmental Monitoring Data for the National Reactor Testing Station, Calendar Year 1963."

[10] "Environmental Monitoring Report No. 17; Third and Fourth Quarter and Annual Summary, 1965," (Idaho Falls: AEC Idaho Operations Health and Safety Division, NRTS; 1965), p. 1-2.

INEEL Areas: EBR-I, Argonne National Laboratory West

Argonne National Laboratory: An Introduction

The origin of the Argonne National Laboratory places into a national context the purpose of the National Reactor Testing Station.[11]

On December 2, 1942, in the basement of Stagg Field at the University of Chicago, Enrico Fermi and a team of researchers conducted the experiment that produced the world's first self-sustained nuclear chain reaction. The Chicago Pile-1 (CP-1) experiment was part of the Manhattan Project, the government's secret effort to produce an atomic weapon. The scientists who conducted the experiment were members of the Metallurgical Laboratory ("Met Lab"), one of several secret research facilities involved in the bomb project.

The secret project responded to political and scientific events in Europe in the 1930s after Otto Hahn and Fritz Strassman discovered nuclear fission. Physicists world-wide understood that controlled nuclear fission could provide a nearly unlimited source of energy. It could also be designed for bombs with unimaginably powerful explosions. As Hitler advanced, scientists feared that German scientists might be first to discover how to control it for the production of bombs. Several of them petitioned President Franklin Roosevelt to support atomic energy research in the United States. By 1942 the Manhattan Project was underway.

The scientists working on CP-1 knew they would not be able to continue pile research in the basement of Stagg Field. Their assignment, once the chain reaction was achieved, was to experiment with uranium pile size and configuration, searching for the most effective pile design for plutonium production, (an activity that took place at Hanford, Washington). For improved safety, security, and working space, the Met Lab group moved in 1943 to the Argonne Forest Preserve, a site near Chicago. Enrico Fermi was named director of the new Argonne Laboratory.[12]

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[11] For additional background, see Stacy, *Proving the Principle*, Chapter 3, "The Uranium Trail Leads to Idaho," p. 18-27.

[12] Jack M. Holl, *Argonne National Laboratory, 1946-96* (University of Illinois Press, 1997), p. 22-23. Hereafter cited as "Holl, *Argonne*." After the war a larger site in Du Page County, Illinois, became the current location of Argonne National Laboratory.

Manhattan Project scientists had always discussed the future of nuclear research. Atomic science was new. It had potential for power production and other uses, but to advance these, further research was needed in materials, efficiency, operating methods, and safety.

The Manhattan Project laboratories were the likely centers for such research. In 1946, a committee formed by General Leslie Groves, head of the Manhattan Project, recommended distributing various research needs among the existing laboratories and a new one to be located in the Northeast. Argonne would pursue atomic pile, or reactor research. Walter H. Zinn became director after Enrico Fermi moved to Los Alamos.[13]

By August 1, 1946, when President Harry S. Truman signed the Atomic Energy Act, the newly named Argonne National Laboratory (ANL) was one month old. It would focus on two major AEC objectives: developing reactor concepts and the safety of commercial power plant reactors.

Establishing A Test Site for Nuclear Reactors: 1949-1951

One of Walter Zinn's earliest proposals was to design and construct an experimental "breeder" reactor, a reactor that would produce more fuel than it consumed. In those early days of nuclear research, scientists believe that uranium was a scarce resource. Only uranium could be used to fuel reactors, and less than one per cent of natural uranium is fissionable uranium-235 (U-235). A breeder reactor could make uranium scarcity a non-issue. In 1947 the AEC's General Advisory Committee listed the breeder reactor as one of its high-priority projects.

Zinn and others realized that reactor experiments were too dangerous to expose large population centers to possible accidents. The AEC Reactor Safeguards Committee recommended in 1949 that reactor experiments take place at a remote location. After a search for a suitable location, the AEC settled on Idaho's Navy Proving Ground and set out to transform it as a National Reactor Testing Station.[14]

Having settled this matter, the AEC was ready to

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[13] "Atomic pile" was the early term for a reactor, coined because the materials used in the chain reaction experiments were piled on top of each other. The word "reactor" came into use after World War II. Holl, *Argonne*, p. 7, 35-44.

[14] Stacy, *Proving the Principle*, p. 26-27.

execute its reactor-research priorities. Argonne became one of the first clients of the NRTS, responsible for Zinn's breeder reactor experiment, sometimes referred to by his colleagues as "Zinn's infernal pile."

Experimental Breeder Reactor-I (EBR-I)

The Experimental Breeder Reactor (EBR-I), the first reactor constructed at the NRTS, was located in the southwest corner of the site south of U.S. Highway 20/26). Zinn selected the location after a test well began to produce water. At the time, site engineers did not realize that the Snake River Plain aquifer underlaid nearly the entire NRTS site and could have supplied water just about anywhere.

Construction of EBR-I began early in 1950, although a local contractor had poured building foundations in the fall of 1949 to expedite the project. The reactor design, developed at Argonne, already had been approved by the AEC. The Austin Company of Cleveland, Ohio, was architect/engineer. The Bechtel Corporation of San Francisco was named construction contractor and took over construction in the spring of 1950.[15]

The multi-level building, completed in April 1951, was made of steel, brick, and concrete. A single building housed the reactor and control room, as well as utilities and the equipment used for handling, storing, and cleaning nuclear fuel elements. The building, 122 feet long by 77 feet wide, included a basement, main floor, and mezzanine level. It was fifty feet high, with subgrade areas thirty feet deep. The project cost $2,500,000.[16]

By January 1951, the building was ready for action. A team of nine scientists arrived at the NRTS from ANL to assemble the reactor. The reactor was expected to prove the validity of the breeding principle and demonstrate the use

[15] Richard G. Hewlett & Francis Duncan, *Atomic Shield, 1947-1952: Volume II of a History of the United States Atomic Energy Commission* (University Park, Penn.: Pennsylvania State University Press, 1969) p. 495-496; Holl, *Argonne*, p. 87; "Breeder Design Completed, Contractor Selected," *Nucleonics* (January 1950), p. 93.

[16] "Breeder Design Completed, Contractor Selected," *Nucleonics* (January 1950), p. 93.; and E.W. Kendall, D.K. Wang, *Decontamination and Decommissioning of the EBR-I Complex, Final Report* (Idaho Falls: Aerojet Nuclear Company Report ANCR-1242, July 1975), p. 7.

of liquid metal as a coolant. Unmoderated, the reactor was cooled by a eutectic potassium-sodium alloy, NaK. The reactor was small, with a core the size of a "regulation football." The creation of plutonium (breeding) was to occur in two "blankets" of uranium-238 (U-238) surrounding the core. The reactor was operated with twelve stainless-steel-jacketed U-238 control rods, eight of which also functioned as safety rods.[17]

Once the team had assembled the reactor and installed the fuel, it was time to bring the reactor to criticality. Walter Zinn arrived in May 1951 to begin criticality tests. Unfortunately the first test failed. More uranium fuel was needed. Finally, on August 24, the reactor went critical. Zinn's associate Harold Lichtenberger continued to run tests until late December.[18]

On December 20, 1951, energy generated by EBR-I lit four light bulbs in the reactor building -- the first time a nuclear plant had ever produced electricity. The next evening, the reactor provided electrical power for the entire reactor building. The Argonne team had demonstrated that nuclear power could be a source of electricity.[19]

Despite the historic lighting of the four light bulbs, electric power production was not EBR-I's primary mission. Later experiments with its original core (Mark I) and a later core (Mark II) went on to demonstrate the breeder principle: the reactor could produced as much fissionable material as it used. The AEC announced this landmark in June 1953, after core and blanket samples had been examined.[20]

EBR-I's success in breeding fuel also led to the construction of a commercial breeder reactor. In 1956, Detroit Edison began building the Enrico Fermi reactor at Lagoona Beach, Michigan, on Lake Michigan near Detroit.

Boiling Water Reactor Experiments (BORAX).

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[17] W.H. Zinn, "Basic Problems in Central-Station Nuclear Power," *Nucleonics* (September, 1952), p. 10-13; Robert L. Loftness, *Nuclear Power Plants: Design, Operating Experience, and Economics* (Princeton, New Jersey: D. Van Nostrand Company, Inc., 1964), p. 335. Hereafter cited as "Loftness, *Nuclear Power Plants*."

[18] "Critical" means that the reactor is able to achieve the nuclear chain reaction; "criticality" is the point at which the reactor is just capable of sustaining a chain reaction.

[19] Stacy, *Proving the Principle*, p. 64-66.

[20] Stacy, *Proving the Principle*, p. 135.

In 1952 Argonne scientist Samuel Untermeyer suggested that steam formation in the core of a light-water reactor during a power excursion (sudden rapid rise in the power level of a reactor) might shut down the reactor. He wondered if boiling water could be used as a reactor control mechanism.[21]

His theory was that boiling produced a negative coefficient; that is, as the temperature rises, reactivity decreases. Steam bubbles decrease the water's effectiveness as a moderator. As more bubbles are formed, the reactivity slows until the reactor shuts itself down. This theory was contrary to the widely accepted belief that steam bubbles in a reactor core would cause instability. Untermeyer presented his idea to Walter Zinn, who supported a series of experiments with boiling water reactors (BORAX) at the NRTS. The first experiments in the BORAX series began in the summer of 1953.[22]

BORAX-I was an open-top boiling water reactor located about a half mile northwest of EBR-1. No building was constructed to contain the reactor. The core was placed in a ten-foot diameter shield tank surrounded by a shield of soil piled ten feet deep and layered at a 45-degree angle. Access to the reactor was from an exterior stairway and platform. During the experiments, personnel were in a control trailer located outside the immediate area.

Arrington Construction built the facility in May 1953. The first in a series of more than 200 experiments began immediately. BORAX-I demonstrated that boiling-water reactors of the same or similar design would shut down if the power were suddenly increased. During the experiments clouds of steam and streams of water shot up from the reactor core as high as fifty feet. R.O. Haroldsen, who was present for the experiments, said that when the BORAX-I experiments were running, motorists on the highway could

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[21] "Light water" is ordinary water (H_2O). As a moderator, it slows down fast-moving neutrons and helps maintain the chain reaction. It also absorbs some neutrons, so light-water reactors require enriched uranium, which has more neutrons than natural uranium. Reactors that use "heavy" water (D_2O), which does not absorb neutrons, can operate with natural uranium. See Richard Wolfson, *Nuclear Choices* (Cambridge: MIT, 1991), p. 155-160.

[22] Holl, *Argonne*, p. 118; Andrew W. Kramer, *Understanding the Nuclear Reactor* (Barrington, Illinois: Technical Publishing Co., 1970), p. 37, 70.

observe the steam and water shooting out of the top of the reactor and reported that the Arco Desert had produced a new Old Faithful.[23]

The last BORAX-I experiment took place in July 1954. It was designed to push the reactor to its limits, that is, to destroy it. On July 22, a crowd of scientists and AEC officials gathered to observe. When the crew in the control trailer quickly removed the excursion rod, the sudden change caused a tremendous steam explosion. Although the reactor runaway was planned -- all BORAX-I experiments involved a runaway reactor -- the explosion was something of a surprise. Debris, including reactor rods, plywood sheets, and dirt, shot high into the air. The guests and a number of workers were told to take shelter while a cloud containing small amounts of radioactivity passed over the site.

The results of the final experiment were regarded as inconclusive, but BORAX-I demonstrated that boiling water in the reactor core did not cause instability. A later series of experiments with boiling water reactors (the SPERT tests, discussed later in this report) included modifications of the reactor design to safeguard against excursions.[24]

The BORAX-I reactor debris was buried in place -- entombed. The uncontaminated control equipment was salvaged for use in a later series of BORAX experiments. In the fall of 1954 a site a short distance from BORAX-I was selected as the location for the remaining BORAX experiments.

The early BORAX experiments contributed to the design of Argonne's Experimental Boiling Water Reactor (EBWR), the country's first power production pilot plant. EBWR, which operated at the Argonne site in Illinois from 1956 to 1967, successfully supplied power for the national laboratory in 1966.[25]

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[23] J.R. Dietrich and D.C. Laymans, *Transient and Steady State Characteristics of a Boiling Reactor: The Borax Experiments, 1953*, ANL-5211, February 1954; Holl, *Argonne*, p. 118; Ben Plastino, *Coming of Age: Idaho Falls and the Idaho National Engineering Laboratory, 1949-1990* (Idaho Falls: Margaret Plastino, 1998), p. 64.

[24] Holl, *Argonne*, p. 199-121; Loftness, *Nuclear Power Plants*, p. 156-158; Richard L. Doan, "Two Decades of Reactor Safety Evaluation," Memorial lecture in honor of Dr. C. Rogers McCullough, prepared for delivery at the Winter Meeting of the American Nuclear Society (Washington, D.C.: November 15-18, 1970), p. 5.

[25] Argonne National Laboratory, *Frontiers, Research*

The later experiments in the BORAX series (BORAX-II through BORAX-V) were housed in a prefabricated corrugated metal reactor building erected in late 1954 by the Morrison-Knudsen Company a short distance from the site of BORAX-I. A turbine generator brought in for experiments with power production was placed in a separate building, also made of prefabricated corrugated metal.[26]

BORAX-II and BORAX-IV (1954-1955 and 1956-1958 respectively) tested various core combinations and fuel elements. The BORAX-III series, operated in 1955, tested the reactor's power production capabilities. For these, researchers installed the turbine generator for the experiments. According to R.J. Haroldsen, the team scrounged up an old "wet steam" turbine at an abandoned mining site in New Mexico to use for the power production tests. On July 17, 1955, BORAX-III was patched into the Utah Power & Light power grid. For two hours (11 p.m. to 1 a.m.) BORAX-III produced power for the town of Arco, part of the CFA, and the BORAX reactor complex. Although the power to Arco from BORAX-III was discontinued after the first brief run, BORAX-III continued to supply power for the BORAX complex and the CFA whenever it was running. It ceased operating later in 1955.[27]

BORAX-V, the final experiment in the BORAX series, operated from 1962 to 1964. Although BORAX-V was housed in the same reactor building as the earlier experiments, the structure and the reactor both were modified. The original reactor vessel was buried in place, covered with a deep layer of sand, and capped with concrete. A new reactor vessel was placed in a new addition to the reactor building.

Highlights, 1946-1996 (ANL 1996), p. 16; Loftness, *Nuclear Power Plants*, p. 167-213.

[26] The two buildings and associated support structures (including a redwood cooling tower and a guardhouse) were located in an area about .75 mile north of EBR-I. A control trailer was located about one-half mile from the BORAX area for BORAX II-IV. A control building was built outside the EBR-I complex for BORAX-V. D.L. Smith, *Decontamination and Decommissioning Plan for the BORAX-V Facility*. (Idaho Falls: EG&G Idaho, Inc., Nov. 1988).

[27] Glenn R. Rodman, *Final Report of the Decontamination and Dismantlement of the BORAX-V Facility Reactor Building* (Idaho Falls: INEL, Inactive Sites Dept., Lockheed Martin Idaho Technologies Company, INEL-96/0325, May 1997), p. 1-2; Loftness, *Nuclear Power Plants*, p. 2-4; Holl, *Argonne*, p. 139; Plastino, p. 64.

The purpose of BORAX-V was to demonstrate the feasibility of producing integral superheated steam in a reactor facility. "Integral" means that the boiling water and the superheated ("dry") steam are produced in the same core. It was thought that superheated steam would prove more efficient and economical than a simple boiling water reactor system. BORAX-V went critical on February 9, 1962, and produced its first superheated steam on October 1963. During the course of experiments, BORAX-V tested the safety and effectiveness of superheated steam. The tests also examined safety problems related to damaged or corrupted fuel elements. At the end of a number of successful runs, BORAX-V was placed on stand-by in late 1964.[28]

The BORAX experiments helped persuade the AEC that the deliberate inducement of power excursions and the deliberate withdrawal of coolant to a reactor could be tested under controlled conditions without disaster. Many more followed BORAX. Such tests yielded valuable safety information which, at a time when the modeling capability of computers was long into the future, could be acquired no other way. They established for the NRTS a unique and primary role in the development of safe nuclear power reactors. BORAX proved the principle enabling pressurized water reactors to be further developed.[29]

The Argonne-West Facility Grows: 1955-1965

In addition to the landmark event of BORAX-III lighting the town of Arco, the year 1955 also brought a milestone of another sort to Argonne's Idaho Division.[30] In November, EBR-I experienced an unintentional core meltdown -- the first such accident in a nuclear reactor. Walter Zinn viewed the accident as a source of important information about fuel rod configuration and operating procedures, but the AEC's failure to publicize the accident gave rise to questions

[28] Rodman, p. 2; Loftness, *Nuclear Power Plants*, p. 217-218.

[29] Stacy, *Proving the Principle*, p. 132.

[30] The name "ANL-West" did not come into usage until later. According to Richard Lindsay, ANL-West Public Information Officer, "Idaho Division" and "Idaho Branch Administration" were used to describe different activities, and the similarity of the names caused confusion. He believes that ANL-West was used unofficially to describe all of the operations and may have been made an official name when the headquarters lab was reorganized.

about reactor safety and the credibility of the AEC.[31]

Nevertheless, Argonne expanded its facilities at the NRTS. A second breeder reactor, EBR-II, was proposed by Walter Zinn and approved by the AEC in 1954. Based on experimental results and operating experience with EBR-I, EBR-II would be an intermediate-sized reactor, capable of producing twenty megawatts of electricity. Design of EBR-II began in 1955 and construction began late in 1957.

Zinn located the new complex at "Site 16," on the eastern edge of the NRTS site, a location nearest to Idaho Falls. It soon was known as Argonne-West or ANL-West. Argonne planned to operate EBR-II for several years and knew that there would be frequent visits from scientists based in Chicago. Time saved in driving to and from Idaho Falls, after flying in from Chicago, was the most important factor in the site selection.[32]

Although Argonne was poised to lead the nuclear industry in the development of breeder reactors, differences of opinion between AEC and Argonne somewhat stunted Argonne's role in the development of major test reactors. In 1965, the AEC canceled Argonne's Fast Reactor Test Facility that had been approved in 1962. To the dismay of Argonne supporters, the AEC went on to build the Fast Flux Test Facility at Hanford, Washington. When the AEC decided to focus its resources on a breeder concept known as the Liquid Metal Fast Breeder Reactor (LMFBR), Argonne's assignment was to do safety research in its support, using EBR-II and its other facilities for that purpose.

EBR-I after 1955.

After EBR-I's accidental melt-down, Argonne examined the reactor core and found that its fuel elements had bowed in the high temperatures. The materials and design had not allowed for heat expansion. When a new core (Mark III) was installed in 1957, design modifications included zirconium spacers in the fuel elements, cluster-mounted control rods, and clamping of the inner core assembly. The modifications prevented unwanted mechanical movement within the assembly, which was seen as the cause of the meltdown. Thus, the accident contributed to the accumulation of knowledge about the safe design of nuclear reactors.

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[31] Stacy, *Proving the Principle*, p. 135-136.

[32] Richard Lindsay, public information officer, ANL-West, Personal communication with Elizabeth Jacox, Sept. 2, 1997.

Five years later, in 1962, a new core (Mark IV) was installed, loaded with plutonium fuel elements, the first plutonium fuel elements used in a power reactor. EBR-I operated successfully with the Mark IV core until it was shut down in 1964.[33]

Argonne West Reactors 1955-1970

Zero Power Reactor III (ZPR-III). The Argonne-West complex expanded steadily with the addition of several new reactors and their support facilities. Activities originally located at the site of EBR-1 gradually migrated to the new complex.

Reactor development depended partly upon tests in "critical assemblies," which are low power or zero power reactors (ZPRs) that allow the chain reaction to occur without a significant accumulation of heat or hazard. Using zero power reactors, experiments were conducted with various configurations of fuel to help test critical size, operating, and control features of a new or proposed reactor design.[34] ZPR-III was built near EBR-1 in 1955 to test core designs for EBR-II. It also tested designs for EBR-I's MARK-III core and for the Enrico Fermi Reactor.[35]

ZPR-III's critical assembly consisted of two tables mounted on a platform, one table movable, the other fixed. Drawers or trays for fissionable materials allowed the reactor to be loaded manually with different fuel configurations. The reactor was brought to criticality by moving the two halves together.[36]

Argonne eventually built two additional critical assemblies at its Illinois site to ease the demand on ZPR-III, but ZPR-III remained in operation until 1970 when it was replaced by the Zero Power Plutonium Reactor (ZPPR) a

[33] Loftness, *Nuclear Power Plants*, p. 339; Kendall & Wang, p. 7; "EBR-II since 1964," unpublished ms., historical files, INEEL Cultural Resources Office.

[34] ZPR-I, designed and built by Argonne in 1950, provided basic physics studies for the Navy's S1W submarine prototype reactor. ZPR-II was built to help test reactor designs for Du Pont's proposed reactor at Savannah River, South Carolina in 1951.

[35] Holl, *Argonne*, p. 149.

[36] J.K. Long et al, *Hazard Evaluation Report on the Fast Reactor Zero Power Experiment (ZPR-III)* (ANL Report, October 1969), p. 11-17.

larger, more versatile critical assembly at the Argonne-West site near EBR-II. In 1975, the ZPR-III critical assembly was decontaminated, dismantled, and moved to the EBR-I building for display. The ZPR-III containment building was decontaminated and dismantled.

Argonne Fast Source Reactor (AFSR). The AFSR, a low power, fast spectrum reactor, achieved criticality October 29, 1959. Associated with instrumentation tests for EBR-II, AFSR was originally located in a metal building southeast of ZPR-III. In 1965, AFSR was moved to the new Zero Power Plutonium Reactor Facility at Argonne-West, where it was used for instrumentation and operation tests until the late 1970s.[37]

Transient Reactor Test Facility (TREAT). In 1958, construction began on the Transient Reactor Test Facility (TREAT). A project of Argonne's Fast Reactor Safety Program, TREAT had a similar purpose as the BORAX tests, but for breeder-type reactors. TREAT was designed to test the behavior of various fuels and structural materials in breeder reactors under extreme or "transient" conditions.

The Teller Construction Company of Portland, Oregon, built the TREAT reactor and control buildings. Located just less than a mile northwest of EBR-II, it is built of aluminum-sided steel with a high bay and service wing. The reactor and associated instrument and utility areas are on the main floor. The basement is an equipment storage area and also contains the subreactor room, where control rod drive mechanisms are located. The control building, located approximately a half mile northwest of EBR-II, is a one-story concrete block structure. In 1982, the building was enlarged to accommodate larger reactor components and fuel elements.[38]

TREAT performed safety tests on samples of nuclear fuel. The reactor was graphite-moderated and air-cooled, using uranium oxide fuel. The reactor was designed to allow simulations of severe accidents, including meltdown or fuel element vaporization, without damage to the reactor. Slots

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[37] Personal communication from Richard Lindsay, September 12, 1997; *Thumbnail Sketch* 1965; Harry Lawroski, "Zero Power Plutonium Reactor Facility," *Nuclear News* (February 1968), p. 47. See also Appendix A in *Proving the Principle* for estimated dates of operation of AFSR, p. 260.

[38] G.A. Freund et al, *Design Summary Report on the Transient Reactor Test Facility (TREAT)* (Argonne National Laboratory, June 1960, ANL-6034).

through the core allowed for a camera to record events taking place in the test hole during the excursion. Beginning in 1960, tests of fuel element designs for EBR-II were run in TREAT.[39]

Experimental Breeder Reactor II (EBR-II). After EBR-I had validated the idea that a breeder reactor could produce nuclear fuel, Argonne developed a design proposal for a second breeder reactor, EBR-II. EBR-II would serve as a prototype for commercial breeder reactors, but it was also designed to test and develop fuel reprocessing systems. EBR-II had a notable new feature: the reactor was submerged in a pool of sodium during operation.

Next door was a fuel reprocessing plant, at which spent reactor fuel would be removed from the reactor, sent through the reprocessing cycle, and returned to the reactor. Construction of the basic components of the EBR-II began in 1958 and the reactor was completed at Argonne-West in 1961. The architect/engineer for the project was the H.K. Ferguson Company of Cleveland, Ohio.[40]

The EBR-II complex includes four closely related facilities: reactor, power plant, sodium-boiler plant, and the Fuel Cycle Facility. The reactor building is a dome-shaped structure of one-inch-thick stainless steel, identified as "a gas tight containment shell" built to withstand an explosion the equivalent of 300 pounds of dynamite. The building houses the reactor facility, the primary sodium cooling system, and support systems. Because of the potential danger of explosion when sodium and water mix, there is no water system in the reactor plant.

Early in 1962, before the sodium coolant was added to the system, the reactor was brought to "dry criticality," and a number of tests were run at low power to provide comparison data for later experiments with the coolant present. Following the dry critical tests, the sodium coolant was added to the system in 1963. EBR-II achieved "wet" criticality in November 1963. The reactor operated at less-than-full power until 1969. Its spent fuel was reprocessed for the first time in 1964. EBR-II produced electricity for the first time in 1964. The reactor produced all of the power used at ANL-West and had power left over, so it supplied the NRTS as well. Argonne-West was able to "sell" power to Idaho Power, saving the AEC more than a million dollars each year.

[39] Stacy, *Proving the Principle*, p. 136.
[40] *Frontiers*, p. 16; "EBR-II since 1964."

EBR-II's original design objectives -- to demonstrate the feasibility of a central-station fast breeder reactor and on-site fuel reprocessing -- were met by 1965. In a new phase of experimentation, the reactor was used as an irradiation facility to produce study samples for use in design of new reactors. Thousands of fuel elements, reactor components, and other reactor materials were irradiated and tested in EBR-II.

Zero Power Plutonium Reactor (ZPPR). In 1965 Argonne requested funding for the Zero Power Plutonium Reactor (ZPPR), a facility for testing fast reactor plutonium cores. The design of ZPPR allowed testing large core volumes (up to 5,000 liters), much larger than the facility at ZPR-III. The $3 million dollar request was granted and in August 1966, construction of the facility began. The reactor and ancillary systems were designed by Argonne, the structure was designed and built by Mason-Hanger Silas-Mason Company.[41]

The ZPPR facility consists of an earth and gravel containment mound and a support building. The support building houses the control room, staff offices, and the Argonne Fast Source Reactor. The ZPPR, a split table critical assembly similar to ZPR-III, but much larger, is housed within the containment mound. The 2,000-square-foot roof of the cell is a sand-and-gravel filter which varies from 16 to 21 feet in depth. A bank of 28 HEPA (high efficiency particulate air) filters backs up the sand-and-gravel roof to prevent the escape of airborne particles. Inside the mound, the reactor assembly was originally 10 feet x 10 feet x 8 feet, but was later expanded to 14 feet x 14 feet x 10 feet.

The work of the ZPPR was to carry out safety tests of reactor cores for fast breeder reactors. Some of the work that had been conducted in earlier, smaller critical assemblies was confirmed with additional testing in the ZPPR.[42]

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[41] Holl, *Argonne*, p. 269, mentions that ZPPR was the forty-sixth reactor built at the NRTS and was one of twenty-two in operation in 1969.

[42] Lawroski, "Zero Power Plutonium Reactor Facility," *Nuclear News* (Feb 1968); "Zero Power -- But Large Purpose," *Nuclear News* (January 1970; "ZPPR -- Zero Power Plutonium Reactor," Argonne National Lab brochure, no date; "Contributions of the Zero Power Plutonium Reactor (ZPPR) to the LMFBR Program," anon, no date.

Fuel Cycle Facility (FCF)

EBR-II was the first nuclear reactor with on-site fuel reprocessing incorporated into its design. The exterior of the building is concrete block and steel. Inside are two hot cells where the fuel elements from EBR-II were disassembled, reprocessed, and reassembled for use in the reactor.

The fuel elements were highly radioactive, so all work was done by remote control. Operating personnel worked behind heavy shielding. The hot cell walls were of concrete five feet thick. Materials were handled with bridge cranes, mechanical manipulators, and master-slave manipulators. One hot cell was doughnut-shaped and contained argon gas instead of air. This shape allowed workers access to the cell from work stations around the perimeter of the cell or from the center. The argon atmosphere was necessary to avoid problems when sodium or other reactive elements were present in the fuel elements. The atmosphere of the second, rectangular cell, was air. In the original facility, the argon cell was used to disassemble fuel elements, the air cell, to fabricate the recycled elements.[43]

Argonne-West and the Breeder Concept 1965-1970

Argonne National Laboratory's national role in reactor development shifted its emphasis in the 1960s, and the shift affected ANL-West. By 1960, fully half of ANL's budget and staff were devoted to reactor development. ANL expected to work on the fledgling breeder reactor program throughout the 1960s, or "a full ten years," as the AEC told the Joint Committee on Atomic Energy in 1960. The optimistic projections were that the breeder concept could create as much fuel as its original supply in five to ten years of operation. (It takes time for the new fuel to accumulate in the blankets surrounding the reactor core.) EBR-II and its Fuel Cycle Facility were operating in 1964, putting the projections to the test.

ANL had several proposals for development of reactor concepts other than the breeder and sought AEC funding to pursue them, but change was in the air. In 1965, with the appointment of Milton Shaw as the AEC's director of reactor development, the AEC decided to adopt the Liquid Metal Fast Breeder Reactor (LMFBR) as its top priority for commercial reactor development. The LMFBR was to be a demonstration

[43] D.C. Hesson, et al., ANL-6605; ANL-West brochure, "Hot Fuel Examination Facility," 1974).

reactor, operated on a larger scale than reactors operated up to that time. ANL was obliged to focus exclusively on the LMFBR. "Scaling up" the technology of EBR-II for commercial operation brought new problems of design, engineering, and safety controls. In 1971 President Richard Nixon confirmed the AEC's direction and called for construction of a commercial demonstration Liquid Metal Breeder Reactor by 1980.[44]

EBR-II and the ZPPR became the centers for LMFBR research. EBR-II, which by then had met its original objective of demonstrating the feasibility of a central-station breeder reactor and an on-site fuel reprocessing system auxiliary to it, became an irradiation facility, used to test fuels and materials. It produced study samples used in the design of new reactors. EBR-II irradiated thousands of fuel elements, reactor components, and other materials. The ZPPR, the largest critical assembly facility in the world, helped develop and test core mock-ups for commercial breeders. Information derived from the testing conducted in EBR-II and ZPPR provided the basis for design of the Fast Flux Test Facility (FFTF), the next step on the ladder to a demonstrator for a commercial LMFBR.[45]

The LMFBR program led to a reorganization of ANL's reactor development staff, construction of new facilities, and funneling of funds into the LMFBR program. Argonne-West grew substantially, and by 1967, the facility employed 275 people.[46]

Fuel Cycle Facility Modified as Hot Fuel Examination Facility

Argonne renamed its Fuel Cycle Facility several times as its mission shifted over the years. By 1968 the original studies planned for the facility had been successfully completed. More than 400 fuel sub-assemblies, containing

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[44] Holl, *Argonne*, p. 230-235, 265-270, 272; "The Future Role of the Atomic Energy Commission Laboratories, a Report to the Joint Committee on Atomic Energy," (Washington: Atomic Energy Commission, January 1960), Vol. 1, Analysis and Conclusions, Section five, p. 80; Vol. 2, Supplementary Materials, p. 21.

[45] Glenn T. Seaborg and Justin L. Bloom, "Fast Breeder Reactors," (*Scientific American*, Vol. 223, No. 5), p. 19-20.

[46] Holl, *Argonne*, p. 273-277; "Employee Distribution by Work Location and Residence," February 1967, in vertical file, subject: Idaho National Engineering Laboratory, Idaho State Historical Society, Library and Archives, Boise.

more than 35,000 individual fuel elements, had been prepared for EBR-II.

The FCF was modified, renamed the Hot Fuel Examination Facility (HFEF), and dedicated by Idaho Congressman Orval Hansen on July 5, 1972. The HFEF was a hot cell capable of examining large irradiated specimens, part of the research for the Liquid Metal Fast Breeder Reactor program. The HFEF contained two shielded cells, one with an air atmosphere, and one with an argon atmosphere for reprocessing fuel elements. The walls of the cells are four feet thick, and the cells are 70 feet long, 33 feet high, and 30 feet wide. Work in the HFEF was done entirely by remote control, using master-slave manipulators and other automated or semi-automated equipment. Maintenance of the equipment is also remote-controlled and the design has been successful for more than twenty years.

Specimens brought to the HFEF were examined using either non-destructive or destructive techniques. If a specimen was to be returned for further testing, non-destructive examination such as photography, weighing, measuring, and gamma-ray spectroscopy recorded information for comparison after further testing. When a specimen arrived for destructive, or final, examination, samples were cut and prepared for a smaller HFEF hot cell or sent to the Analytical Laboratory.[47]

Expansion of the facility in 1975 brought another name change. The FCF was modified and its name changed to Hot Fuel Examination Facility-North (HFEF-N) in 1975 when the Hot Fuel Examination Facility-South was built. HFEF-N handled and examined irradiated specimens from EBR-II, TREAT, and other facilities.[48]

Argonne-West Significance

The cluster of reactors and support facilities at ANL-West have played a historically significant role in the history of nuclear reactor research in the United States.

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[47] "Fuel," *Nuclear News* (August 1972); ANL brochure "Hot Fuel Examination Facility," 1974; "Hot Fuel Examination Facility (HFEF)," ANL web site, June, 1997.

[48] When the Integral Fast Reactor (IFR) program took shape in the 1980s, HFEF-N was modified and renamed Fuel Cycle Facility. In 1994, the facility's name became Fuel Conditioning Facility, its mission to treat spent EBR-II fuel prior to planned disposal at a geologic waste repository.

Argonne National Laboratory was the country's first national laboratory; its Idaho Division was an integral part of its operation. Argonne was a leader and innovator in the AEC's breeder reactor development program.

The silver containment dome of EBR-II dominates the ANL-West complex. The reactor produced electrical power for ANL-West for thirty years, demonstrating the feasibility of a liquid metal reactor as a central power plant. Power production was so successful that EBR-II became the first co-generator in the State of Idaho. Also, it was the first reactor in the country to employ on-site fuel reprocessing, a function that operated successfully for six years of operation at the FCF.

Argonne's BORAX reactors provided the basic information leading to the design and construction of the Experimental Boiling Water Reactor (EBWR), the country's first nuclear power production pilot plant. BORAX-I proved that under extreme conditions the boiling water would shut the reactor down before heat could melt the fuel plates. BORAX-III was the first nuclear reactor to provide electricity to an American town (Arco, Idaho). The BORAX experiments laid the groundwork for SPERT, the next series of BWR safety tests. Private industry moved ahead with construction of the Vallecitos Boiling Water Reactor (California, 1957); the Bodega Bay Reactor (California, 1964), and the Pathfinder Reactor (North Dakota, 1964), all building on the experience and data gathered in the BORAX experiments. In short, the BORAX tests were a necessary precursor to the establishment of a commercial nuclear power industry that could operate within known safety parameters. All of the buildings associated with BORAX experiments have been demolished.

EBR-I has a unique historical importance. It was the first reactor built at the newly established NRTS. By the time it was decommissioned in 1964, the small reactor had been the first nuclear reactor in the world to produce usable electrical power, the first to employ a liquid metal as a coolant, the first to produce more fuel than it consumed, the first power-producing reactor to use plutonium fuel, and the first to experience a meltdown of the core. EBR-I provided basic information about nuclear reactors and power production.

As noted earlier, the National Park Service designated EBR-1 as a National Historic Landmark in August 1966 in ceremonies that included President Lyndon B. Johnson and AEC Chairman Glenn T. Seaborg. EBR-I was placed on the National Register of Historic Places in 1975, recognized as a

National Historic Engineering Landmark by the American Society of Mechanical Engineers in 1979, and named a Historic Landmark by the American Nuclear Society in 1994. The only original buildings remaining at the EBR-I site are the reactor building and the guardhouse.

SubTheme: *Reactor Testing, Experimentation, and Development*
INEEL Area: Test Reactor Area

Establishment of the Test Reactor Area: 1944-1954

After World War II, nuclear scientists hoped to apply nuclear knowledge for peaceful purposes. They understood how to apply a chain reaction to an explosive weapon, but very little about the best way to design reactors and reactor fuel for electrical power generation, propulsion, or other useful purposes. The list of unknowns was exceedingly long.

Even though physicists could design reactors that would generate enough heat to produce steam and generate electricity, engineers had yet to perfect the pipes, valves, fittings, and instruments that would keep the coolant moving, exchange its heat, and maintain the fuel at a constant and safe temperature. The limiting factor in the size or power level of a nuclear reactor is the ability of the coolant to carry away heat. [49]

At that time, chemists and engineers did not know much about how various materials would react in a nuclear environment. They didn't know the best materials to use for power reactors. They didn't know if their computations predicting how something would work were accurate. They didn't know how long metal, rubber, glass, and other fabrication materials would last under the constant bombardment of radiation. They didn't know how long a fuel element itself would last under the impact of radiation. Would a material react differently depending on whether the neutron was fast or slow? How? Would the fuel element change shape or lose strength? How? Bow inward? Bow outward? Crumble? Crack?

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[49] Samuel Glasstone, *Sourcebook on Atomic Energy, 3rd edition* (Princeton, N.J.: D. Van Norstrand Company, Inc., 1967), p. 562-566.

They didn't know how certain materials would perform as absorbers or reflectors of neutrons. They didn't know how serious a problem it might be if some materials had impurities in their manufacture or were of uneven quality. They didn't know the best shape for the fuel -- rods? plates? curved? straight? They didn't know the best material to clad the fuel and hold it in position in the reactor core. For coolant piping, they didn't know what alloys of aluminum and steel would resist the corrosion caused by fission particles and extremely high temperatures. Of all the elements in the periodic table, they knew "cross sections" for only a few of them. (A cross section is the probability that neutrons at a given speed and temperature would strike the element's atoms.) Indeed, they didn't even know what materials would absorb neutrons or scatter them. Yet this knowledge was essential to designing reactors.[50]

In addition to everything else they didn't know, they had few safety procedures, standard practices, or efficient operating routines. Until they answered all these questions and hundreds more like them, nuclear scientists could not fulfill their hopes for the safe and peaceful use of atomic energy.

A Materials Testing Reactor

The scientists needed a reactor that could function as a kind of "mother reactor" to facilitate the design of other reactors. They needed to research how different temperature, pressure, and coolant conditions would affect various kinds of fuel assemblies. The reactor would be designed explicitly to test materials by exposing them to a high flow (flux) of neutrons and gamma radiation. In addition to solving these "urgent and practical" problems, they needed a reactor that could produce radioactive isotopes in sufficient quantity for medical treatment and experiments.[51]

Scientists needed to accumulate information quickly, considering the AEC's interest in developing the use of nuclear energy for power generation. A testing reactor could subject a material to the equivalent of months or years of radiation exposure in a much shorter period of time, simulating the expected period of time the material might be exposed to radiation in a power reactor.

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[50] *1965 Thumbnail Sketch*, p. 16.

[51] Phillips Petroleum, *The Materials Testing Reactor* (New York: United Nations, a reprint from Chapter 3, *Research Reactors*, presented to delegates at the International Conference on Peaceful Uses of the Atom, August 1955), p. 160-163. Hereafter referred to as *The MTR*.

The Progress of the MTR

As early as 1944, scientists at the Clinton Laboratory at Oak Ridge began designing what they called a "high flux" or "reactor development reactor," the Materials Testing Reactor, or simply the MTR. Just to design it required experimentation, and the Clinton Lab built small low-power assemblies to conduct such experiments.

In 1946 the Clinton Lab proposed that the AEC build a test reactor and a companion chemical processing plant to recover uranium from the reactor's spent fuel. The AEC agreed and assigned the Kellex Corporation to design it. By 1947, the project "was well advanced."[52] Naturally, the scientists at Oak Ridge expected that this reactor would be built there. But the AEC decided in 1948 to centralize its reactor development program at Argonne National Laboratory near Chicago and build it there. Overcoming intense disappointment ("[Argonne] stole all our reactors," was the bitter sentiment),[53] they cooperated with a five-member steering committee whose task it was to manage the final design and construction of the MTR.[54]

In the end, Argonne did not house the MTR either. The AEC's Reactor Safeguards Committee decided that the proposed power level of 30 megawatts was too high to risk operating near the four million people living in the Chicago area. Argonne's director, Walter Zinn, felt that the proposed chemical plant ought not to be near such dense population either. The MTR and the Idaho Chemical Processing Plant (ICPP) became two of the first four projects built at the new NRTS in Idaho.[55]

Because the Idaho site was not yet organized, the steering committee completed the design of the reactor and its associated support facilities, created a site plan, approved construction drawings, and began procuring materials and supplies. Blaw-Knox

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[52] John R. Buck and Carl F. Leyse, eds., *The Materials Testing Reactor Project Handbook* (Lemont, Illinois, and Oak Ridge, Tennessee: Argonne National Laboratory and Oak Ridge National Laboratory, 1951), p. 37. Hereafter referred to as *MTR Handbook*.

[53] *Atomic Shield*, p. 126. The other Clinton Laboratory reactor to be relocated was a Navy submarine reactor.

[54] Its members were S. McLain, chairman; M.M. Mann, ORNL; J.R. Huffman, ANL; W.H. Zinn, ANL; A.M. Weinberg, ORNL. *MTR Handbook*, p. 28.

[55] See *Atomic Shield*, p. 185.

was chosen the architect/engineer in July 1949, and preliminary plans were ready a few months later.[56]

While Blaw-Knox was at work, Kellex constructed a full-scale mock-up of the reactor at Oak Ridge. Its main purpose was to perfect the hydraulic performance of coolant and air circulation systems without the reactor producing neutrons. After initial simulations, the mockup operated on real fuel and ran as a low-power reactor, going critical for the first time on February 4, 1950.[57]

That same month, the AEC chose the Fluor Corporation to construct the MTR complex in Idaho. Fluor broke ground in May, and in July the AEC's Idaho Operations Office took the project over from the steering committee.[58] Construction proceeded somewhat unevenly, sometimes getting ahead of blueprints. Progress was interrupted further by an unusually cold winter in 1950-51.[59]

Siting the MTR

The AEC Safeguards Committee required that two concentric zones surround any reactor site. The near zone would be a controlled-access area where an accident could pose severe danger. The radius of this area was determined by a formula based on the reactor's power level. The second zone would be a "hazard area" to be determined by a combination of reactor type, meteorology, hydrology, and seismology. Danger within this zone would be much smaller; nevertheless, it should contain only a limited population.

In addition, an informal practice appears to have evolved during the Manhattan Project of siting reactors no closer than five miles from one another when this was feasible. John Horan, who arrived at the NRTS in 1952 and later served as director of Health Physics, said in an interview that this practice may explain why the MTR was located about five miles from the CFA and why the Navy's propulsion reactor was subsequently located five miles beyond the MTR.[60]

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[56] *MTR Handbook*, p. 38.

[57] *The MTR*, p. 210. The MTR was a tank reactor with a steel lid over the top. It was water-cooled, beryllium reflected, and used aluminum-clad fuel plates.

[58] *MTR Handbook*, p. 43.

[59] *Atomic Shield*, p. 496.

[60] John Horan, in telephone interview with Susan Stacy, July

The civil engineers surveying for a specific location for the MTR wanted to build on solid lava rock. They noticed that as the distance increased from the gravel creekbed of the Big Lost River, the depth to bedrock decreased. Therefore, knowing the depth of the MTR basement, they simply placed the building at a point where the gravel overburden matched the basement depth. They cleared the gravel and anchored the building to the lava. Horan said these engineers "bragged for years" about how this strategy saved the considerable costs of building footings or blasting through lava rock. They employed the same procedure in siting the ICPP and the Navy's first reactor. At the time, less was understood than today about the boundaries of the river's flood plain, so the legacy of the siting strategy is a location that requires vigilance with respect to potential floods.[61]

The MTR steering committee liked the terrain around the selected site. Because one of the proposed experiments would project a neutron beam a quarter of a mile from the MTR, the committee wanted a site that was flat for at least that distance around the reactor. The site also provided access to water and had natural drainage for retention basins. Finally, a convenient site for the Chem Plant -- at the right elevation above bedrock -- was available about one and a half miles away and would not be downwind of prevailing winds from the MTR.

The principle of isolation applied to all future NRTS reactor experiments (if not always at five-mile increments), so the NRTS's characteristic land-use pattern of widely distributed clusters of buildings established itself from the beginning. The MTR, the ICPP, the Navy propulsion project, and the Experimental Breeder Reactor (EBR-1) each settled in its own "desert island," connected to the CFA by roads and utility lines.

Designing the MTR Complex--Taking Account of its Natural Setting

Within the rectangular MTR complex, buildings and their future expansions were oriented with respect to predominant winds, which came from the southwest during the daytime. This dictated the location for the exhaust stack on the east side of the compound. And the stack had to be high. Contaminated air had to be discharged high enough to disperse and dilute over a large uninhabited area. For security reasons, it had no aircraft warning lights.[62]

29, 1997.

[61] John Horan, July 29, 1997.

[62] *MTR Reactor*, p. 352.

One of the major features of the MTR was its "canal," an underwater facility for storing spent fuel until it could be sent to the Chem Plant and processed to recover its uranium. The below-grade canal projected 87 1/2 feet from the east side of the main reactor building. The canal was built 25 feet longer than called for in the original plan because during 1951 the managers were not sure that the Chem Plant would be operational in time to take delivery of MTR's first several months' accumulation of spent fuel. The extra length would accommodate extra fuel.[63] The ceiling of the canal tunnel, made of reinforced concrete, was slightly below ground level. The road that passed over the canal was reinforced to support the heavy trucks and crane used to lift the transport casks. The unloading hatch was at an offset widened portion of the road located where traffic had the least impact on loading operations.

The MTR's auxiliary buildings were oriented to each other for the shortest feasible extensions of piping, air ducts, wiring, fencing, roads, and walkways.[64] The entire complex was surrounded by a barbed-wire perimeter fence with the parking lot outside. Just inside the fence was a 10-foot wide patrol road. The reactor building and other buildings containing radiation hazards were further fenced within an "exclusion" area.

Thus, by intentional design, the buildings in the most intimate association with reactor operations in the exclusion area were the reactor building, its laboratory wing, the storage canal, the hot cell building, plug storage building, process water building, fan house and stack. A 150,000 gallon water reservoir also was in the area.

On the upwind side were the pumps and wells, storage tanks, substation, demineralizing building, emergency diesel generator, steam plant, cooling tower, warehouses, administration and service building, and canteen. Downwind and outside the perimeter fence were the sewage plant and evaporation ponds.

The MTR Goes Critical

The Korean War began in June 1950. The AEC's peaceful intentions for the MTR had to yield to the demands of national defense. The MTR could help speed the development of plutonium-producing reactors for weapons and propulsion reactors for Navy submarines.[65] In fact, during 1950, the study groups working at

[63] *MTR Handbook*, p. 287.

[64] *MTR Handbook*, p. 356.

[65] *Atomic Shield*, p. 419.

Argonne considered how the MTR could be modified to produce plutonium should this be necessary. The Chem Plant, originally intended to reprocess only MTR fuel, also was recruited for defense. Design changes enabled it to process U-235 fuel slugs used at Hanford's tritium-production reactors, Naval reactor fuel, and later the fuel for the Air Force's turbojet experiments.[66]

At the end of 1950, after considering 34 candidates, the AEC contracted with Phillips Petroleum Company to operate the MTR, partly because it wanted physicist Richard L. Doan, director of research at Phillips (and who had previously been loaned to the Manhattan Project) to be the manager. Doan brought with him 42 other Phillips specialists.[67] The group spent several months at Oak Ridge training in nuclear physics, health and safety, and reactor operation and management. There they practiced operating Oak Ridge's High Flux Training Facility, the new name for the MTR mock-up.

The MTR went critical for the first time on March 31, 1952, with Fred McMillan, the reactor manager, at the controls. Operators carefully increased its power, making adjustments as needed, until it reached its full power operation of 30,000 kilowatts. On August 5, 1952, the MTR opened for business as the first test reactor in the world designed to test components for future reactors.[68]

MTR Work

The MTR was an instant hit. Like Sun Valley, another Idaho landmark, the MTR became so essential and so famous that nuclear literature at the time often dropped references to its country and state. MTR test loops were busy irradiating proposed fuels for the Navy's *Nautilus* and other reactor prototypes, for the proposed nuclear-powered bomber, and for reactors at the AEC's Savannah River weapons plant. It developed non-destructive techniques for the Chem Plant to assay the uranium in fuel

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[66] *Atomic Shield*, p. 496, 499.

[67] *Atomic Shield*, p. 496. See also Phillips Petroleum, *Phillips, The First 66 Years* (Bartlesville, OK: PPCo, 1983), p. 140. Other Phillips employees who moved to Idaho with Doan were Alene Carter, fuel tester; Hugh Burton, physicist; Harry Markee, safety specialist; Ed Fast, physicist. See also Rich Bolton, "Fast Enters Retirement at same well-known pace," *INEL News* (Sept 7, 1993), p. 5.

[68] *Atomic Shield*, p. 515. See also "INEL Pioneers set high standards," *INEL News* (March 19, 1991), p. 4.

assemblies that were to be dissolved. It irradiated thousands of materials.[69]

One example will illustrate how the MTR was instrumental in the design of nearly every reactor later built in the country. Sylvania Electric Products Company wished to manufacture fuel slugs for the AEC. Using two different techniques, Sylvania fabricated eighteen fuel slugs made of natural uranium. MTR operators subjected them to prolonged high flux exposure -- and observed both types gradually change their shape and size, increasing in diameter and decreasing in length.[70] Findings such as these were of critical importance in safe reactor operations. If fuel slugs were spaced too close together in a reactor and expanded, they could choke off the flow of coolant, cause a hot spot, melt the fuel, damage the reactor, and cause a serious accident.

By the time the MTR shut down for the last time in 1970, it had performed more than 15,000 different irradiation experiments, and its operators had disseminated the findings to a large community of nuclear scientists.

The Test Reactor Mission Grows

As the steering committee had anticipated, the MTR site expanded. A Hot Cell Building (TRA-632) went into use in the summer of 1954. Here, operators, while shielded safely behind thick concrete walls and special viewing windows, could handle, photograph, mill, measure, and weigh radioactive samples using remotely operated manipulators.

The AEC authorized a Reactivity Measurement Facility (RMF) in February 1954. This was a small (very low power) reactor located in the east end of the MTR canal, where water was its moderator, reflector, and shield. It complemented the MTR in that it had a high sensitivity to subtle changes in reactivity, unlike the MTR. The author of the proposal suggested that the small facility would function as a "detector," whereas the large MTR functioned as a "source" of neutrons. The two functions could not be maximized in the same reactor. The RMF enabled studies of reactivity changes in hafnium, zirconium, and other fuel materials as a function of their total irradiation -- without having to transport the experiment to some other more distant

[69] J.R. Huffman, *MTR Technical Quarterly Report, First Quarter 1954* (Idaho Falls: PPCo Report IDO-16181), p. 5-13.

[70] J.R. Huffman, *MTR Technical Quarterly Report, Second Quarter, 1954* (Idaho Falls: PPCo Report No. IDO-16191), p. 17; and Huffman's *Third Quarter 1954 Report*, PPCo No. IDO-209, p. 12.

facility on the NRTS site.[71]

Demand for space in the MTR grew to such an extent that merely expanding its adjunct facilities was not enough to satisfy it. By the end of 1954, the scientists were making preliminary calculations for a new, larger, more convenient, and higher power test reactor.

In 1954 the United States was entering a new phase of its atomic energy program. Congress passed a new Atomic Energy Act, superseding the old act of 1946. Due largely to the successful research program carried out at the MTR and other AEC facilities, the time had arrived for private enterprise to become more involved in the development of a nuclear power industry. Up to this point, private ownership of atomic facilities had been forbidden. The new law provided for private licensing of reactors and nuclear fuel. Further, it allowed industry scientists access to information that heretofore had been classified.[72]

TRA Programs Expand: 1955-1970

The pace of activity at the NRTS in general picked up markedly in 1955. National defense made continued demands on the MTR. The Korean War had ended, but the Cold War competition for weapons supremacy between the United States and the Soviet Union was an escalating pressure at the Test Reactor Area (TRA).

New activity centers had sprouted up at the NRTS. One was Test Area North, site of General Electric's turbojet experiments for the U.S. Air Force, where the first Heat Transfer Reactor Experiment went critical on November 4, 1955. Another was the SPERT program, a series of experiments begun in 1955 that examined the safety and stability of water moderated reactor systems when their power levels increased unexpectedly.

The MTR played a role in most of the new experiments. For SPERT I, for example, the Argonne experimenters predicted what would happen when power levels rose as high as 2400 megawatts. When the results of the actual test were other than expected, the

[71] W.E. Nyer, et al. *Proposal for a Reactivity Measurement Facility at the MTR* (Idaho Falls: Phillips Petroleum Report No. ID)-16108), p. 6-8. Reactivity is a measure of the departure of a nuclear reactor from criticality. The measure is either positive or negative and indicates whether neutron density will rise or fall over time. An RMF is also called a "critical facility."

[72] Public Law 83-703 was enacted by the 83rd Congress, 2nd session, and signed into law by President Eisenhower August 30, 1954.

MTR helped determine why the calculated prediction was in poor agreement with that obtained in the experiment.[73]

To accommodate a growing demand for gamma irradiation experiments by commercial interests, the AEC's Idaho Operations Office designed a gamma irradiation facility (TRA-641). Because of the classified military work conducted at MTR, commercial scientists without security clearance could not be admitted to the MTR exclusion area. However, to provide them access to gamma radiation for tests, the Gamma Irradiation Facility was located outside the security fence.

The Gamma Facility opened in 1955. The facility took advantage of the MTR's spent fuel, a valuable research asset. After removal from the MTR core, it radiated gamma rays, a penetrating form of energy (and hazardous to human health.) Very active when first removed from the reactor, the gamma source would gradually decay. An experimenter could specify the degree of "freshness" required for a given test.[74]

Fuel was transported to the facility from the MTR in 26,000-pound fuel-element carriers made of lead, steel, concrete, and water. Once the fuel was in the facility's 6-foot wide storage canal and shielded by 16 feet of water, operators maneuvered the elements into cadmium boxes and positioned them at safe distances from the adjacent elements (to prevent an accidental chain reaction). Packages containing the materials to be tested were wrapped in water-tight containers and dipped into the canal at a selected distance from the fuel element. Depending on the length of time the material was to be exposed, packaging could be a plastic bag, a can, or a special container with a corrosion-resistant coating.

Experimenters paid non-profit rates (40 cents per million roentgens plus shipping; $10 minimum charge) to be scheduled on a first-come, first-served basis. They subjected nearly everything imaginable to gamma radiation -- potatoes, meat, plastics, heat-sensitive pharmaceuticals, diamonds -- anything for which there was a hope that irradiation would improve it, make it last longer, or increase its value. At any given time, the canal contained forty to fifty fuel elements.[75]

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[73] IDO-16259, p. 13.

[74] J.R. Huffman, *MTR Technical Branch Quarterly Report for First Quarter, 1955* (Idaho Falls: PPCo Report No. IDO-16229), p. 24.

[75] *Gamma Irradiation Facility, A Fact Sheet*, no author, p. 3-5. Pamphlet found attached to the 1957 version of *Thumbnail Sketch*.

In September 1955, the MTR reached a milestone when Phillips increased the power level in the reactor to 40 megawatts. Higher levels permitted more rapid irradiation of materials and thus increased the speed at which an experiment could deliver results.[76]

Phillips' quarterly technical reports detail a constant barrage of research problems and questions. From the Chem Plant: Will it be safe to put 250 kilograms of two-percent enriched slugs into C Cell's 30-inch dissolver? From a reactor development program: Will these fuel pellets made of aluminum-uranium alloy melt under irradiation? From the medical community: Can thulium-170 be used as a source for radiography? Do impurities in the thulium produce undesirable effects? From the Bureau of Mines: Will neutron and gamma radiation improve the coking characteristics of Sewickly coal? From SPERT: What's the best way to design SPERT III so it will operate at temperatures of 650 degrees? From fuel manufacturers: Congress is allowing the U.S. to sell 20 percent enriched fuel to foreign interests. How will it perform in a high flux reactor?[77]

And, because the MTR itself was an experiment, Phillips conducted tests on how the reactor's own components were holding up. Had the fast flux of neutrons caused any structural weakness in the materials within the core area? Using its findings on this and other accumulated experience, Phillips designed the next test reactor.[78]

The Engineering Test Reactor (ETR)

By 1957, higher neutron fluxes than what the MTR could provide were in demand all over the country. Higher fluxes meant that an experiment could be carried out in a shorter period of time. Lower fluxes, such as those provided in the MTR low flux graphite zone, were no longer in demand except as a "mine" for isotope production.

In addition, test requirements were growing more sophisticated. Using MTR beam holes involved complicated and time-consuming handling problems. Also, in situations where it was important to have a uniform rate of flux, it was hard to supply this to the sample. Many experiments needed more room in

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[76] IDO-16254, p. 6.

[77] See series of Phillips Technical Branch quarterly reports for 1955 through 1957.

[78] IDO-16297, p. 5.

order to be in the proper test environment and not impact the MTR operation. Phillips designed the Engineering Test Reactor to solve these problems. It provided large spaces in the highest flux zone in the core. Further, the flux was uniform along the entire 36-inch length of the fuel elements.[79]

After the AEC approved Phillips' conceptual design, it hired Kaiser Engineers to design and build the ETR. Kaiser had General Electric design the reactor core and its controls. From design to completion, the project took two years. The reactor was a standard tank design except that its control rods were driven through the core from below the reactor, not from above. This left the area above the reactor available for experimentation.[80]

Siting the ETR

Phillips situated the airtight ETR building about 420 feet south of the MTR (center to center) so that it could share the MTR's auxiliary facilities while positioning its cooling towers to the east. Here it would be convenient to the MTR's operational centers (such as the Hot Cell, Hot Plug Storage, and Reactor Services Building) and yet be free of the facilities and services associated solely with MTR operations. Many of the shared facilities -- raw water, electrical and steam distribution, fuel oil, sewer, standby power, waste disposal -- then were extended or enlarged. This arrangement still left space available for even further expansion of both ETR and MTR facilities.[81]

The single most critical design driver for the reactor building was the size of the reactor vessel. When that was determined in October 1955, the rest of the planning continued. (The vessel is 35 feet long, with a diameter ranging between twelve and eight feet. It had to withstand a pressure of 250 pounds per square inch at a temperature of 200 degrees F.) Building height had to account for the bridge crane that would

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[79] "Test Reactors--The Larger View," *Nucleonics* (March 1957), p. 55.

[80] Philip D. Bush, "ETR: More Space for Radiation Tests," *Nucleonics* (March 1957), p. 41-42. The extra depth required for the control rods meant that a portion of the foundation had to be blasted through lava rock. See also R.M. Jones, *An Engineering Test Reactor for the MTR Site (A Preliminary Study)* (Idaho Falls: Phillips Petroleum Report No. IDO-16197, 1954), p. 7.

[81] R.M. Jones, *An Engineering Test Reactor for the MTR Site (A Preliminary Study* (Idaho Falls: Phillips Petroleum Report No. IDO-16197, 1954), p. 7.

manipulate and place the vessel.[82]

Other design features of the complex were based on experience with the MTR. The MTR had provided insufficient office space for both visitors and resident technical personnel. Desks cluttered the reactor floor, balconies, and any free space near the experimental equipment. To address this, three-level "lean-to" extensions were added to the ETR building on the east and west sides to prevent similar frustrations. Partitioning of the reactor floor was avoided, leaving the entire area free for experimental equipment.[83]

Because the reactor would operate at a power level of 175 megawatts, it generated considerably more heat than the MTR. The primary coolant loop contained demineralized water. To keep it from boiling, it had to be kept pressurized. Pressure was maintained by pumping the water through the core and withdrawing it at a rate that would maintain the desired pressure. A secondary loop discharged the heat to the atmosphere. Exhaust gases were filtered and vented to a new stack. Because the coolant accumulated radionuclides, the pipes between the reactor building and the heat exchanger building were shrouded with concrete shielding.

ETR Work

The typical life of a fuel element was eighteen days, in which time about 27 percent of the uranium fissioned. Like the MTR, the ETR required a water-filled canal where spent fuel elements could cool down before transport elsewhere.[84] ETR operators, like their colleagues at MTR, where the cycle also was 18 days, lived a cyclical lifestyle, taking three days to unload and refuel the reactor. Using remote manipulators, an operator could lift a fuel assembly part way up the side of the tank, tilt it, and slide it through an opening and down a chute. The element "flopped" into the 18-foot deep canal, where technicians used grappling poles to guide the element to a resting place on a rack. Here, the fuel sat for several months to cool off, its radioactive constituents continuing to decay. With the help of a 30-ton crane, it would be maneuvered into a special shielded

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[82] R.H. Dempsey, "ETR: Core and Facilities," *Nucleonics* (March 1957), p. 54; and Kaiser Engineers, *Engineering Test Reactor Project, Part I*

[83] R.M. Jones, *An Engineering Test Reactor for the MTR Site (A Preliminary Study)* (Idaho Falls: Phillips Petroleum Report No. IDO-16197, 1954).

[84] Bush, p. 41-56. See also *1965 Thumbnail Sketch*, p. 15.

transport cask, called a "coffin," and shipped down the road to the Gamma Facility or the Chem Plant to recover the valuable U-235 still remaining in the fuel element.[85]

The ETR went critical for the first time at its full power level of 175 megawatts on April 19, 1957; the ETR Critical Facility (ETRC), on May 20, 1957.[86] This low-power reactor did the same for ETR as the MTR's Critical Facility. In order to run the reactor safely and efficiently, operators had to know how the experiments would affect power distribution, whether the reactivity effects of experiments would impact the reactor or generate potential hazards. This information had to be available before each new cycle was begun. It used fuel and control rods like the ETR's and had the same type of beryllium-beryllium oxide reflector.[87]

The ETR mission was to evaluate proposed reactor fuels, coolants, and moderators. It was designed especially to simulate environments like those expected in civilian nuclear power reactors. ETR had more test space and more flexibility than the MTR. Over 20 percent of the head volume over the vessel was filled with test voids -- like a "large cake of swiss cheese," as one writer put it.[88]

During its lifetime, the ETR had less on-stream time than the MTR because its experiments were more elaborate and required more time to plan, pre-test, and install. They were more expensive, too. Various test "sponsors" invested over $17 million to adapt 18 of the test loops for their experiments.[89] Fabricating the tests required the services of welders, pipe fitters, heavy equipment operators, carpenters, mechanics, and many other specialists. These craft specialties explain the numerous shop buildings erected at the TRA complex and at the CFA to support these activities.

Demand for test space kept growing, calling for more than the MTR and ETR could supply. Use of space was prioritized and allocated by the Washington Irradiation Board. Military and AEC

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[85] R.H. Dempsey, "ETR: Core and Facilities," *Nucleonics* (March 1957), p. 54.

[86] R.L. Doan, "MTR-ETR Operating Experience," *Nuclear Science and Engineering* (January 1962), p. 23.

[87] *1965 Thumbnail Sketch*, p. 15.

[88] Bush, p. 43.

[89] Doan, p. 24.

priorities came first. After that, the rule was "first come, first served." If private test space were available elsewhere, the Board rejected commercial requests for irradiations in the ETR.[90] Nevertheless, ETR customers included research and educational institutions, and the civilian power industry.

Advance Test Reactor (ATR)

Even before the ETR went critical for the first time, the AEC had been requesting studies for an "advanced" general purpose test reactor, one that would supply the AEC's needs long into the future.[91] In addition, high demand from the Naval Reactors Program continued to press the capacity of the MTR and ETR test reactors. A new reactor, while planned for multiple purposes, would specifically meet the long term needs of the Naval Reactors program, with many of its test loops reserved for Navy work.[92]

Phillips prepared the conceptual design, combining its MTR and ETR operating experience with ideas from physicists at laboratories all over the country. One of the "advanced" features of the ATR was its ability to test several samples in the reactor at the same time, but exposing each one to different absolute flux levels. And flux levels were intense. The MTR designers had been reluctant to place test materials within the reactor core; but the ETR had a fuel grid that permitted just that. The ATR went further. With its "serpentine" or clover-leaf arrangement of fuel, a test material could receive a level of exposure in a few weeks, instead of years of equivalent exposure in the ETR. To accommodate varying power levels in its seven test loops, the ATR required an extremely sophisticated control system. A built-in computer -- an innovation at TRA -- reported continuously on reactor conditions.[93]

The AEC announced in October 1960 that Ebasco Services would be the architect/engineer, with Babcock & Wilcox preparing the nuclear core of the reactor. The reactor would operate at 250 megawatts, nearly 1.5 times the power level of the ETR -- and the

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[90] Doan, p. 32. See also *1965 Thumbnail Sketch*, p. 13.

[91] See J.R. Huffman, W.P. Connor, G.H. Hanson, "Advanced Testing Reactors," (Idaho Falls: Phillips Petroleum Company Report No. IDO-16353, May 28, 1956.)

[92] D.R. deBoisblank, "The Advanced Test Reactor--ATR Final Conceptual Design," (Idaho Falls: Phillips Petroleum Company Report No. IDO-16667, 1961), p. 11-12.

[93] *Advanced Test Reactor*, pamphlet, undated (Idaho Falls: Idaho Nuclear Corporation), p. 3.

highest operating power level of any test reactor in the world. In addition to the special Navy program loops, it would have a gas test loop, a pressurized water test loop, and sodium-cooled test loops for fast and thermal reactors. Although it considered other sites for the project, the AEC chose the NRTS for practical reasons: the Navy program already was established there; having the three test reactors operated as a single complex would be efficient and economical; Phillips was a highly competent operator; and the NRTS was the least limiting AEC site with respect to safety.[94]

Siting and Building the ATR

With Idaho Governor Robert Smylie attending the groundbreaking ceremony on November 6, 1961, the ATR became the largest single construction project ever undertaken in the state of Idaho, eclipsing the earlier record-holder, Mountain Home Air Force Base.[95] The Fluor Corporation built the project, situating the ATR building about 200 yards northwest of the MTR. A cooling tower, critical facility, metallurgical research facility, labs, and other structures supported the new reactor.[96]

The ATR complex opened up a new TRA quadrangle northwest of the MTR-ETR area. The site plan repeated earlier patterns of compact placement of support buildings around the reactor, although the large reactor building, with a first floor area of 27,000 square feet, enclosed several functions: the reactor and working area, the Advanced Test Reactor Critical Facility (to determine in advance the nuclear experiments to be programmed), decontamination room, office area, experimental labs, health physics labs, tool rooms, and heating/ventilating equipment. A common canal served for the critical facility reactor, for fuel element storage, for conducting irradiations, and for transferring fuel from one work area to another without using transport casks.[97]

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[94] Letter to Clinton P. Anderson, chairman JCAE from office of the General Manager, AEC. No date, 1960. Idaho Historical Society, US Senator Henry Dworshak Papers, Mss 84, Box 112, File "AEC-Miscellaneous."

[95] "Idaho Rites Start Record Atom Job," newsclip with no date, *Post-Register*, p. 1, 12. Found in Idaho Historical Society, Senator Henry Dworshak Papers, Mss 84, Box 124, File "AEC--Idaho Plant (1961)."

[96] AEC announcement, October 25, 1960; Idaho Historical Society, Senator Henry Dworshak Papers, Mss 84, Box 112, File "AEC Miscellaneous." See also *1965 Thumbnail Sketch*, p. 15-17.

[97] The ATR Critical Facility went critical for the first time

Other buildings in the complex included a shielded process water building immediately north of the reactor building with an enclosed driveway connecting it to the reactor building. This building contained the piping and controls for a heat exchanger, transferring heat from the primary to secondary coolant. A utility building containing diesel generators and demineralized water equipment was located east of the process water building. Laboratories and engineering space were housed in a one-story building east of the reactor.

After years of delay caused by the failure of heat exchangers, valves, emergency pumps, and instrumentation cables, Fluor completed the reactor in 1967. It began operating at zero power on July 2, 1967. On August 16, 1969, it operated at full power for the first time. Nuclear experiments began on Christmas Day. By this time, Phillips no longer was the TRA contractor; Idaho Nuclear Corporation had assumed control in 1966.[98] The ATR has continued routine operation since then.

ATR Work

The ATR routine was similar to that of the MTR and ETR. At the end of seventeen days operating at full power, about 15 percent of the U-235 in the core was consumed. The reactor shut down for refueling, to change experiments, and make other modifications. To conserve time during the shut-down interval, the crews of engineers, welders, electricians, and health physicists operated around the clock in three shifts.[99]

Compared to the long line of customers clamoring for the MTR and ETR in their early years, the clients of the ATR shrank to a small group. The major user was the Navy, which had grown its *Nautilus* submarine into a huge nuclear fleet consisting of submarines and surface ships in many classes and sizes. ATR analysis of Navy fuel led to continuous improvements in extending the operational life of a ship's fuel. The civilian power programs and the national space program also were looking to advance the science of fuel systems and materials. They, too, made use of ATR test loops.[100]

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on May 19, 1964.

[98] "Advanced Test Reactor Now Running at Full Power," *Nuclear News* (October 1969), p. 17.

[99] *1965 Thumbnail Sketch*, p. 15.

[100] *1965 Thumbnail Sketch*, p. 15.

MTR Retires in 1970--Reluctantly

In 1968, the AEC announced it would shut down the MTR in 1970. In response, other interests tried to develop commercial possibilities, hoping to keep the venerable MTR operating. The State of Idaho had formed an Idaho Nuclear Energy Commission in 1967 to promote nuclear applications in agriculture, mining, lumbering, and other fields. In 1969 a Western Interstate Nuclear Compact formed to promote nuclear commerce and trade in all the western states. These two groups tried to continue the life of the MTR as a "Western Beam Research Reactor." The problem was funding.

The Associated Western Universities proposed that the AEC finance some fifty research projects at the MTR, but the AEC was unwilling or unable to fund the proposal. The National Science Foundation considered the MTR as a possible "National Neutron Center of Interdisciplinary Studies," but concluded in 1972 that high-flux neutron beam capability would be cheaper at its Brookhaven, New York, or Oak Ridge laboratories than at the MTR.[101] Efforts to find a private buyer or renter for the MTR also failed.

For a brief period in 1970, all three test reactors at TRA operated at the same time. The last MTR experiment was called the Phoenix, in which the reactor was loaded with plutonium fuel. The test verified that this particular mix of isotopes would create more fuel than it consumed -- thus vindicating its name "rising from the ashes." Officially, the MTR's last day of operation was April 23, 1970.

But later in the year, the State of Idaho appealed for two days of operation in order to irradiate samples of pheasant and other wildlife. The Idaho Department of Fish and Game had recently discovered mercury in pheasant flesh and needed information quickly as to the potential extent of this problem. At the time, some farmers used grain fungicides containing methyl mercury. If mercury poisoning were widespread, the Department of Fish and Game would have to cancel the forthcoming hunting season. The NRTS obliged the state and loaded up the reactor with about a thousand samples of fowl and fish from several locations, irradiating them for about two days in August 1970.[102] That was

[101] "Annual Report of the Idaho Nuclear Energy Commission, Report No. 6, 1972," (Boise: INEC, 1973), p. 14-15.

[102] "INEL Programs set high safety standards," *INEL News* (March 19, 1993), p. 4. See also *Annual Report of the Idaho Nuclear Energy Commission, No. 4, 1970*, p. 6; Darrell W. Brock, "Application for Funding for a Proposed Study of Mercury Poisoning in Idaho," May 28, 1970, copy in Senator Len B. Jordan Papers,

the MTR's final service; it was decommissioned in 1974.

Significance of the MTR, ETR, and ATR

Because the MTR was the first multipurpose test reactor in the world, it moved the boundaries of nuclear knowledge constantly outward. Providing the world's most intense neutron flux available, the MTR performed its tests in relatively short times and produced radioisotopes of higher specific activity than any other reactor.

It accomplished its test mission safely. It logged 125,000 operating hours, sometimes with 600 samples loaded at a time. It conducted more than 19,000 irradiations in 800 different programs. The AEC had sponsored most of them, but many commercial clients had been served as well. In addition, MTR had accommodated ten major Air Force experiments, fifty major Navy experiments, and several for the Army.[103]

Among its peaceful services, the MTR had supplied hospitals with irradiated Cobalt-60 and other radionuclides, evaluated the economics of hydrazine rocket fuel, measured the properties of known trans-uranic elements and helped discover new ones. MTR spent fuel provided gamma radiation to countless samples of food -- testing the possibility that irradiation might extend the shelf life of food without refrigeration -- and thousands of other substances.

MTR was the first reactor ever to use Plutonium-239 fuel at power levels up to 30 megawatts, demonstrating that a reactor fueled with plutonium could be satisfactorily controlled.[104] Phillips physicist Deslonde deBoisblank announced this achievement at the Geneva Atoms for Peace Conference in 1958.[105]

In its early years, MTR experiments contributed to the design and improvement of all commercial pressurized water reactors in the United States and many beyond its borders. Later, it contributed to the Yankee and Dresden power reactors at Rowe, Massachusetts, and Morris, Illinois, respectively; to the organic reactor; to the liquid metal fuel reactor; and to the homogenous

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Boise State University, Box 174, File 32.

[103] *1961 Thumbnail Sketch*, p. 23-25; *1973 Thumbnail Sketch*, p. 7.

[104] *1959 Thumbnail Sketch*, p. 22.

[105] AEC Press release, September 11, 1958; IHS, Mss 84, Box 83, File "AEC--Idaho Plant."

fuel reactor.[106]

Behind the MTR were the people who managed, operated, maintained, and improved it. Quite simply, everything they did was new. The accomplishments of the pioneering machine were nothing less than the accomplishments of the human pioneers who devoted themselves to its success.

After all of the "firsts" accumulated by the MTR, the two reactors that followed it had a hard act to follow. Each, however, represented the most advanced designs in the world at the time for test reactors and were major landmarks in the history of test reactors. The ETR and ATR were significant and essential partners in the safe operation and success of the American nuclear fleet -- and in the development of the commercial power industry and the space program. In addition, they incorporated highly advanced and unique designs unlikely to have been replicated anywhere else in the world. When the fortunes of the commercial reactor industry began to decline in the 1970s, their role in scientific innovation also declined. Much of the ATR's work involved the analysis and improvement of performance rather than expanding the universe of knowledge.

The closure of the MTR -- and, most particularly, its failure to find either a commercial or institutional champion -- signaled the beginning of a different era in nuclear research at the NRTS. Until that time, NRTS research reactors had slaked an urgent thirst for nuclear knowledge. Its mission to "mother" other reactors had succeeded, but the nation was changing its mind about nuclear power. The role of nuclear research in the development of "atoms for peace" began what now appears to be a 26-year decline.

SubTheme: *Reactor Testing, Experimentation, and Development*
INEEL Area: Organic Moderated Reactor Experiment

The Organic Moderated Reactor Experiment (OMRE): 1957-1963

Among the many experimental reactor concepts that the AEC tested was a reactor that would use a liquid hydrocarbon as a coolant and a moderator. It contracted Atomics International -- which had conceived the concept -- to develop the reactor at the NRTS. From 1957 to 1963 the Organic Moderated Reactor Experiment (OMRE) was in operation. OMRE was notable as the first

[106] Dresden was the first large-scale privately owned boiling water nuclear power station to go into operation (in 1959) in the United States; Yankee soon followed as the first pressurized water power reactor (in 1960).

experimental reactor constructed at the NRTS with partial funding by private industry.[107]

Most reactor concepts at the time used water -- either light or heavy, pressurized or boiling -- as a coolant. During the late 1950s scientists began to consider materials other than water for use as coolants in reactors. Water has the disadvantage of becoming corrosive at the high temperatures to which it is subjected in the reactor. It was necessary to use stainless steel or zirconium alloys to clad the fuel elements over which the heat-removing water passed. The advantage of organic substances over water is their low vapor pressure and low corrosion effects. Initial studies and experiments at the MTR inspired scientists to try the concept of an organic fluid.[108]

The OMRE complex consisted of a 4,300 square-foot steel process and control building, a large airblast heat exchanger, a storage area, an auxiliary heat exchanger, a pipe gallery, several underground tanks, and extensive piping and electrical systems.[109] The complex was located east of the CFA (in the south central section of the NRTS) about halfway between the CFA and the Army Reactors Area.

The organic material used for OMRE was called Santo-wax-R, a mixture of terphenyl and diphenyl isomers.[110] This mixture is solid at room temperature, but becomes liquid when exposed to high temperatures. Experiments simulated the conditions of heat transfer, temperature, and coolant flow which would exist in a power reactor. The reactor went critical for the first time on September 17, 1957. OMRE operated at full-power beginning in February of 1958.[111] A second core went critical for the first time on May 9, 1959.

One consequence of the OMRE experiments was the construction at Piqua, Ohio, of the first organic-cooled and moderated nuclear power plant. It went critical in 1963[112]. This plant, built for a

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[107] *Thumbnail Sketch,* November 1958, p. 23.

[108] *Thumbnail Sketch,* November 1958, p. 23.

[109] Robert E. Hine, *Contamination and Decommissioning of the Organic Moderated Reactor Experiment Facility,* EGG-2059 (Idaho Falls: EG&G Idaho, Inc., September, 1980), p. 2.

[110] Terphenyl and diphenyl are hydrocarbons. Those known as polyphenyls were considered for reactor use.

[111] *Thumbnail Sketch,* November 1958, p. 23.

[112] The Piqua, Ohio, plant was part of the second round of

municipally owned utility company, operated until 1966. It shut down when organic matter built up in the reactor core, making it difficult to maintain and operate.[113]

The OMRE experiment was phased out in 1963 after its tests had established the feasibility of operating this type of reactor -- provided that the organic coolant-moderator be kept clean. The reactor was shut down, and the nuclear fuel and reactor vessel internal piping were removed. The facility remained in deactivated condition until 1977.[114]

Experimental Organic Cooled Reactor Extends OMRE Studies

The Experimental Organic Cooled Reactor (EOCR), built adjacent to the OMRE, was designed to advance the OMRE studies. It was viewed as a link between the early OMRE experiments and an economically viable power reactor. "Scaling up" the concept to a commercial size required more advanced experiments. The OMRE had been built at a (relatively low) cost of $1,800,000 and was insufficiently sophisticated to perform such advanced experiments, so the EOCR was planned to advance the concept.

The EOCR was designed by the Fluor Corporation and Atomics International. It provided five large in-pile experimental loops (facilities in the reactor that allowed for the test irradiation of various materials) that would be used to advance the coolant and fuel-element technology for the concept.[115] The facility consisted of a reactor building (STF-601), storage tanks, and pump houses -- all of which went under construction in 1961. The reactor building was the only large building in the complex, the others being pumphouses and other auxiliary buildings. The portion of the building below grade was constructed of reinforced concrete and the portion above grade was built of pumice block covered with corrugated sheet metal.

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demonstrations associated with the Power Reactor Development Program initiated by the AEC to invite industry to develop and finance power reactors.

113 One source that describes the Piqua, Ohio, plant is *Controlled Nuclear Chain Reaction: The First 50 Years* (La Grange Park, Illinois: American Nuclear Society,1992), p. 41; see also numerous editions of *Thumbnail Sketch*.

114 Robert E. Hine, *Contamination and Decommissioning of the Organic Moderated Reactor Experiment Facility OMRE* EGG-2059 (Idaho Falls: EG&G Idaho Report EGG-2095, 1980), p. 2.

115 W.E. Nyer and J.H. Rainwater, *Experimental Organic Cooled Reactor Conceptual Design* (Idaho Falls: Report IDO-16570, December 1959), p. 7.

Construction on the facility was ninety percent complete when the AEC canceled the organic coolant program in December 1962. It had concluded that the concept was not likely to improve significantly the performance of nuclear power plants beyond that already achieved by other reactor concepts. Thus, this reactor never was completed and never went critical.

OMRE and EOCR after 1963

Following the demise of the Organic Reactor Program in 1962 both the OMRE and the EOCR were placed in standby status. In 1977 workers proceeded to decontaminate and dismantle the OMRE and all of its support buildings. This was the first such dismantlement at the INEEL and therefore constituted a learning experience for everyone involved in the procedure. Even in its dismantlement, the OMRE was used for experimental purposes.

The D&D (decontamination and dismantlement) process took two years and ended in September 1979. There were two major objectives to the D&D at OMRE. One was to remove the entire facility by disposing of all contaminated articles and the second was to determine what techniques, procedures and special tools should be developed for other D&D projects.[116] Both objectives were met and demonstrated the need for further research into special tools, decontamination of soils, and ways to meet acceptable standards preventing the release of radioactive materials.

The EOCR, still in standby status, in 1963 was considered for conversion to a water-cooled and -moderated reactor. But this did not occur; the equipment and parts that had been ordered were used elsewhere. During 1978 and 1979 a portion of the building was used as office space auxiliary to the D&D of the OMRE. The facility then was used as a training facility for the security force at the INEEL. The vicinity was equipped for target practice and other security training procedures.

All of the structures at the EOCR site have been demolished. The organic-cooled reactor concept was a significant symbol of the AEC reactor program despite its status as a concept that ended up as "a path not chosen" for commercial development. Pursuant to a Memorandum of Agreement with the Idaho SHPO, photographs were taken of the buildings prior to demoliton in anticipation of HABS/HAER recordation.

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[116] Robert E. Hine, *Contamination and Decommissioning of the Organic Moderated Reactor Experiment Facility OMRE* EGG-2059 (Idaho Falls: EG&G Idaho Report EGG-2095, 1980), p. 3.

SubTheme: *Cold War Weapons and Military Applications*
INEEL Area: Naval Reactors Facility (NRF)

The Navy's Quest for Nuclear Propulsion: 1939-1948

The Navy's dream of nuclear power for propulsion predated both the existence of the AEC and the entrance of the United States into World War II. As early as 1939, the Naval Research Laboratory became involved in budding atomic research, and thereafter participated in the Manhattan Project. Navy research, shared with the Army, led to the production of Uranium-235, which the Manhattan Project used for the bomb dropped on Hiroshima.

After World War II, some Naval leaders, particularly Admiral Earle Mills of the Bureau of Ships, envisioned nuclear propulsion as the key to ocean-warfare supremacy. In 1946 Admiral Mills sent Navy researchers to Oak Ridge to learn the fundamentals of nuclear technology. Mills selected Captain Hyman Rickover, known for his excellent work on shipboard electrical problems, as senior officer. Rickover embarked on a career known for combining his formidable personality with the goal of developing nuclear propulsion.[117]

The Atomic Energy Act of 1946 and the formation of the AEC in 1947 obliged the Navy to work in close cooperation with the new civilian agency. Admiral Mills and Captain Rickover worked on procedures for cooperation between Navy and AEC staff. These arrangements stayed essentially the same for the next thirty years. The Navy focused more on engineering, while the AEC oversaw reactor research, initial design, and plant and shipboard safety. The Navy designed, built, and operated its ships. The AEC also received Navy funds for the naval features required on a shipboard plant. All land prototypes of the shipboard nuclear plants were funded by the AEC, with some supporting funds from the Navy. All actual shipboard plants were paid for by the Navy with the exception of the first two -- the submarines USS *Nautilus* and USS *Seawolf*.[118]

Several AEC national laboratories were responsible for developing various aspects of naval nuclear power. The Bettis Laboratory (operated by Westinghouse) near Pittsburgh, Pennsylvania, was chosen as the site for the design and development of a naval nuclear plant. Knolls Laboratory in

[117] Hewlett, *Atomic Shield*, p. 74-76.

[118] Francis Duncan, *Rickover and the Nuclear Navy* (Annapolis, Maryland: Naval Institute Press, 1990), 4. Hereafter cited as "Duncan, *Rickover*." See also Hewlett, *Atomic Shield*, p. 189.

Schenectady, New York, (operated by General Electric) was the site chosen for an intermediate naval reactor, with technical assistance supplied by the Argonne National Laboratory. Knolls engineers worked on the feasibility of a liquid-metal cooled reactor. Oak Ridge investigated the use of high-pressure, water-cooled reactors. A plant at Shippingport, Pennsylvania, was planned to demonstrate the feasibility of nuclear power for civilian use.

Submarines in the Desert: 1948-1955

After the AEC decided to build the NRTS, it determined that the Navy's water-cooled reactor prototype would be one of the first four projects built at the new testing station (the others being EBR-I, the MTR, and the Chemical Processing Plant). Argonne and Westinghouse designed and developed components for the reactor. The village of West Milton, New York, was chosen for the liquid metal-cooled reactor prototype, since it was close to the Schenectady laboratory. A small-submarine prototype plant was developed later at Windsor, Connecticut, in 1957.[119]

At the NRTS, Rust Engineering Company chose a site for the submarine thermal reactor about five miles north of the MTR site. In August 1950, F.H. McGraw & Company broke ground for the Submarine Thermal Reactor (STR, also referred to as the Mark I or the S1W Prototype -- S for submarine, 1 for first model, and W for the designer, Westinghouse). With this, Idaho's association with the Nuclear Navy officially began. NRTS Manager Leonard E. Johnston and his staff often clashed with Captain Rickover, who came out personally to oversee the construction plans and who missed few, if any, details. In the midst of the Korean conflict, the pressure was on both men to get the prototype operating by 1952.

The buildings at the Navy complex, which eventually became known as the Naval Reactors Facility (NRF), followed the same principles that guided the NPG and CFA: simplicity, ruggedness, and reliability. However simple the designs were, construction was often slow because the building blueprints were not ready on time. The reactor prototype was housed in a large steel building; inside was a full-scale section of a submarine hull surrounded by a 300,000-gallon tank of water. Following Rickover's insistence, the hull was identical to that of a regular Navy submarine, down to its "Battleship Gray" paint.[120]

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[119] Hewlett, *Atomic Shield*, p. 418-419; see also Duncan, *Rickover*, p. 5.

[120] Hewlett, *Atomic Shield*, p. 495-496; see also unpublished binder entitled "Naval Reactors Facility, 1994," on file at INEEL

By 1952, the Electric Boat Company, builder of USS *Nautilus* in Groton, Connecticut, had installed the main turbine, condenser, reduction gear, and other parts in the submarine's engine room. The pressure vessel was installed in the reactor compartment. In June of that year, President Harry Truman presided at keel-laying ceremonies for the *Nautilus*, destined to be the world's first nuclear-powered sea vessel. Meanwhile, during the hot Idaho summer of 1952, Westinghouse engineers worked two shifts, then eventually three shifts around the clock. They installed systems and began leak tests. Reactor control equipment and coolant pumps came from Pittsburgh's Bettis Laboratory in the autumn. By November 1952, the reactor prototype was complete except for its nuclear fuel and two heat exchangers.[121]

By March 1953, the S1W Prototype achieved criticality, the world's first criticality of a pressurized water reactor. On June 25, 1953, the S1W achieved full design power and immediately embarked on a successful 96-hour sustained run, simulating a submerged crossing of the Atlantic Ocean. Two years later the S1W sustained a 66-day, continuous full-power run. This run was equivalent to a submarine travelling at high speed twice around the world -- without having to stop and refuel. The S1W Prototype created two other "firsts" for the young nuclear industry and the Navy. It was the first use of highly enriched uranium as a fuel and the first use of zirconium alloy as a construction material in nuclear reactors.

The S1W Prototype was the model for the nuclear core of the submarine USS *Nautilus*, the first nuclear-powered submarine in the world. The *Nautilus* proved its capabilities in 1958 when it became the first vessel to travel under the North Pole ice cap. The success of this 1958 sea trial reflected glory on the S1W Prototype. Nautilus commander, Bill Anderson, sent the following telegram to NRF workers from the White House upon his triumphant return to Washington, D.C.:

> ... during *Nautilus*' North Pole submerged transit from Pacific to Atlantic the performance of our engineering plant exceeded all expectations. To the first manufacturer of naval nuclear propulsion our sincere thanks for providing the plant that made possible this first transpolar crossing.[122]

Cultural Resources Department.

[121] Hewlett, *Atomic Shield,* p. 515; "Naval Reactors Facility, 1994."

[122] The telegram is contained within the NRF "Historical

The S1W Prototype's early success was a prelude to the further development of naval reactor prototypes at the NRTS. A nuclear-powered aircraft carrier was in the design stage by 1952. The AEC and the Navy decided that Westinghouse would build the reactor and that the Newport News Shipbuilding and Drydock Company would develop the shipboard features. Westinghouse already had a good technical base for the project from its work on the reactor prototype in Idaho.

However, Rickover had to win over President Dwight D. Eisenhower and Congress, who were cutting budgets. The carrier was initially approved under President Truman in 1950, but was cut from the budget in 1953. The skyrocketing costs of nuclear ships (in all, the *Nautilus* program cost $65 million) caused both the Department of Defense and Congress to question their cost-effectiveness. But the Korean conflict gave Rickover, by this time an admiral, the opportunity to defend his request for a nuclear carrier. He was victorious in 1954, when funds for the nuclear carrier were reinstated and the USS *Enterprise* resulted, the first nuclear-powered surface ship. Years later, Rickover referred to this experience in a 1968 speech to Congress, where he fought against withdrawing funds for the nuclear carriers USS *South Carolina* and USS *Virginia*. To support his arguments, he cited the *Enterprise's* many accomplishments in the Vietnam conflict.[123]

New Prototypes, Personnel Training, and Spent Fuel: 1956-1969

On April 1, 1956, construction of the *Enterprise* prototype reactor began at the NRF. The ship itself was being erected in Newport News, Virginia. Two years later the Idaho reactor achieved criticality. Called the A1W (A for Aircraft Carrier, 1 for first model, and W for Westinghouse), the plant included two pressurized water reactors and associated steam equipment. Both reactors achieved full power in 1959. The NRF and the Bettis Laboratory used the A1W to test and develop different reactor materials. The information gained from A1W was used to design the C1W plant for the cruiser USS *Long Beach*, under construction in Quincy, Massachusetts. The A1W reactors continued in use after the carrier had been launched and were modified from May 1963 to November 1964 for a new surface-ship prototype. The A1W's new

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Scrapbook" for 1958.

[123] United States Congress, *Hearing before the Joint Commission on Atomic Energy Congress of the US eighty-ninth congress 2nd session on Naval Nuclear Propulsion Program, Jan. 26, 1966*, p. 3. See also Duncan, *Rickover*, p. 162-163.

core reached criticality in April of 1965.[124]

Having the submarine and aircraft carrier prototypes on the same site presented superb training opportunities. Rickover established an intensive nuclear training program in 1956 to support the growing inventory of nuclear-powered ships. Shipboard plant operators, specifically officers, first had to undergo six months of classroom instruction, then six months at a land prototype such as at the NRF. The prototypes gave the most realistic training possible because students learned their procedures and principles on operating reactors. If an officer passed this training, he was usually assigned to a nuclear ship and then undertook further study.

In a 1957 address to Congress, Rickover praised the Idaho training program: "The Arco Navy nuclear submarine training facility is most valuable... We have no better training facility in the Navy than we have there and it is absolutely essential for the future of nuclear power in the Navy that we train the people there...."[125] More than 12,500 Navy and civilian students received training at the S1W during its thirty-six years of operation. Approximately 14,500 were trained at A1W during its thirty-five-year life span.[126]

The next prototype built at the NRF was the S5G (S for submarine, 5 for fifth model, and G for General Electric), a natural-circulation reactor. In the natural circulation mode, coolant water flowed through the reactor by thermal circulation. The natural-circulation reactor was a quieter and simpler system because large coolant pumps were no longer needed. "Silent" running was a distinct advantage in stealth operations. In 1956, Bettis Laboratory had completed preliminary studies for a small, natural-circulation reactor. After further testing had been completed, Rickover pressured the AEC to build a prototype at the Idaho site. Again, the new facility would match shipboard conditions, but with a new addition -- the prototype would simulate the motion of an operating ship at sea. His main concern was whether the natural circulation reactor could function

[124] Duncan, *Ricknover*, p. 104-105; and "Naval Reactors Facility."

[125] United States Congress, *U.S. Congress, Joint Committee on Atomic Energy, Naval Reactor Program and Shippingport Reactor. 85th Congress, First Session, March 7 and April 12, 1957* (Washington, D.C.: USGPO, 1957), p. iii.

[126] Duncan, *Rickover*, p. 247-248; and "Naval Reactors Facility."

properly under those realistic circumstances.[127]

Rickover went to Congress in 1957 to ask for funding. He used strong Cold-War rhetoric to make his point. Growing Soviet naval strength gave impetus to his words:

> The efforts of the Naval Reactors Branch of the AEC...have given our Nation world leadership in the development of atomic power for naval propulsion....We believe that a fleet of nuclear powered underwater vessels capable of firing long-range missiles will ultimately decide the balance of world power and the maintenance of the peace.[128]

After Congress and the AEC approved funding for the prototype, Westinghouse, which was in charge of Bettis Laboratory, moved several key personnel from Bettis to work on the space program. Furious about this, Rickover persuaded the AEC to take the natural-circulation project away from Westinghouse and give it to General Electric's Knolls Laboratory. Thus, General Electric arrived at the NRF as a contractor at the NRTS.

Construction of the natural circulation submarine prototype plant began in September, 1961. Four years later it achieved criticality. In June 1966, the S5G completed a simulated cruise of 4,256 nautical miles from New London, Connecticut, to London, England. In November, the natural circulation system performed well under normal seagoing circumstances. The next year the test was performed for AEC officials. They were pleased with the results. The Navy began building ships using the natural circulation system. Rickover immediately sent 114 men to train at the S5G. The prototype continued operating for the next thirty years.[129]

Handling the Navy's Spent Fuel--The Expended Core Facility, 1957-1969

When the S1W Prototype commenced power operations in 1953, it had its own hot cell, a heavily shielded enclosure for remote handling of radioactive material, and water pit for examining its own spent nuclear fuel. Using remote handling methods, workers first placed the spent fuel assemblies into the water pit and then cut them apart using a special hack saw. Selected

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[127] Duncan, *Rickover*, p. 24.

[128] *Naval Reactor Program and Shippingport Reactor*, p. iii.

[129] Duncan, *Rickover*, p. 22-25; see also "Naval Reactors Facility."

subassemblies were moved into the hot cell for detailed examination and measurement. Of particular interest was the amount of distortion or other anomalies in the fuel as a result of its use. After this data had been gathered, the fuel components were loaded into casks for the short trip to the ICPP, where it was processed and its uranium recovered.

In 1957 a new set of hot cells and pools were built at the northwest perimeter of the NRF complex. Bettis Laboratory established design criteria for the Expended Core Facility (ECF). The engineer was Arthur G. McKee Company; and Paul Hardeman, Inc., the contractor. Its original dimensions were 340' x 190' with a 58' high bay down the center. The water pit, 34' x 50' under the high bay, dominated the center of the building. It was 30' deep at the fuel unloading area. Nine hot cells north of the water pit were connected to the pit by a transfer tunnel. Radiochemistry laboratories were north of the hot cells.

Railroad cars transported spent fuel from the other Navy facilities to the ECF. It arrived packaged in heavily shielded casks. The rail spur entered the high bay at the ECF's west end, into an area called the decontamination shop. The fuel was unloaded into the water pit, where it was separated from its structural material by a milling machine and core saw. From the pits, the fuel assemblies went to the hot cells for analysis.

Initially, the Navy sent about three fuel cores a year to the ECF; later, the shipments increased to five a year. The ECF also received irradiated materials from other NRTS facilities. Around 1960, MTR test specimens (plant materials, core structural materials, and naval reactor fuel) began going to the ECF for analysis. The specimens were first assembled at ECF, irradiated at the MTR (after 1970 at the ATR) at the Test Reactor Area, then sent back to the ECF for disassembly and examination. To handle these, the Navy built an additional hot cell and a water pit with a below-water-level observation room and a lead glass viewing window.

As the NRF developed additional prototypes, the workload at ECF grew. The number of ships in the Nuclear Navy also grew. With this growth, the ECF had to grow to keep pace -- eventually doubling in size from its original dimensions.[130]

The buildings at the NRF are managed by DOE-Pittsburgh, not

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[130] Information about the ECF came from Edgar L. Juell, "A Short History of the Expended Core Facility, (Idaho Falls: Naval Reactors Facility, 1990). See also "Naval Reactors Facility" and "Idaho Test Will Propel Huge Ship," *Idaho Falls Post-Register*, December 11, 1958.

DOE-Idaho. The scope of this report did not include a building inventory or assessment of historic significance. However, such an inventory and assessment was accomplished in 2000.[131]

It is clear that the NRF reactors, particularly the S1W Prototype, were of great significance in providing the United States with supremacy of the seas in the early decades of the Cold War. The three prototypes at the NRF are a major reason why the INEEL was of exceptional historical significance during the 1950s and 1960s. The primary mission of the NRF has been the research and development of nuclear propulsion plants. It should be noted that no new reactors were constructed at NRF after 1966, although new cores were inserted into the existing reactors.

SubTheme: *Weapons and Military Applications*
INEEL Area: Army Reactor Area (Auxiliary Reactor Area)

Origin of the Army Reactors Program: 1957-1965

The conventional method of supplying electricity to an isolated U.S. Army base or mobile field station was to transport a diesel generator to the site and operate a supply line to keep diesel fuel flowing from the nearest depot. Trucking or flying fuel to some bases, such as to Arctic locations where road access was impossible and flying was restricted, could be difficult, hazardous, and costly.

After World War II, the possibilities of atomic power tantalized the Army like it did the other military services. The allure was that a tiny handful of nuclear fuel might replace the logistical headache of fuel transport to remote locations. Or a nuclear power plant might be mobile, able to move with a field hospital or command center. Perhaps it could be portable, mounted on a barge and towable from one port to another as needed. Ideally, reactors could vary in capacity to serve a wide range of applications. They only needed to be small enough, light-weight enough, and cheap enough. The Army's nuclear power program aimed to meet these three challenges.

The Army organized an Office of Research and Development in 1951 to begin a nuclear research program. Its chief, General K.D.

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[131] Madeline Buckendorf, *A Historic Context of the Naval Reactors Facility: Including Historic Building Inventories and Assessments* (Idaho Falls: Prepared for the U.S. Department of Energy Pittsburgh Operations Office and Bechtel Bettis, Inc., by the Arrowrock Group, Inc., Boise, Idaho, November 2000).

Nichols, thought the Army's pursuit of small reactors might help to speed up the ultimate development of a commercial industry; he and others often used this argument as they sought support. The Army placed the Nuclear Development program under the supervision of the U.S. Army Corps of Engineers.[132]

Meeting initial resistance from the AEC staff, which desired to retain the initiative in developing a commercial industry, the Army gradually acquired allies in Alvin Weinberg, director of Oak Ridge National Laboratory; Admiral Lewis Strauss, an AEC Commissioner after July 1953; and the Joint Chiefs of Staff, who declared an official military "requirement" for a nuclear power plant in December of 1953. The AEC and the Army organized its first project, which the AEC approved for funding in July 1954.[133]

The Army's goal was to develop a family of three basic types of power plants. A *stationary* plant would be a permanent installation that could serve as a base in a remote area otherwise difficult to supply with fuel. It would not be designed for relocation elsewhere. A *portable* power plant would be pre-assembled for rapid erection in the field. A limited number of "packages" would make up the plant, each of which could fit in an air cargo transport or truck. The plant could be disassembled and then relocated to another site. A *mobile* power plant could move intact from one site to another without being broken down and reassembled at all -- possibly operate even while being moved.[134]

Further refining its goals, the Army selected operating ranges for its nuclear plants. A "low power" reactor would produce in the range of 100 to 1,000 kilowatts. "Medium power" reactors would supply from 1,000 to 10,000 kilowatts, and "high power" facilities could range between 10 megawatts to about 40 megawatts.[135]

The Army institutionalized these concepts in the names of its prototypes and experiments. Its first prototype, which went on line at Fort Belvoir, Virginia, thus carried the designation

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[132] Lawrence H. Suid, *The Army's Nuclear Power Program, The Evolution of a Support Agency* (New York: Glenwood Press, 1990), p. 3-8. This book is the most complete and useful source on the history of the Army nuclear program.

[133] Suid, p. 20-24.

[134] "The Army Reactor Program," *Nucleonics* (February 1959), p. 54; and John F. Hogerton, *The Atomic Energy Deskbook* (New York: Reinhold Publishing, 1963), p. 32.

[135] Hogerton, p. 32.

SM-1, a "Stationary Medium Power" reactor. Until it canceled its nuclear development program, the Army planned 17 different projects. Of these, seven went into service, seven others were designed, and three were experiments built at the NRTS in Idaho.[136]

The Army Comes to the National Reactor Testing Station

The Fort Belvoir reactor, within eighteen miles of The White House, was a pressurized water reactor, the same type that Admiral Hyman Rickover had installed in the USS *Nautilus* prototype. Although other reactor concepts promised to embody virtues of light weight and simplicity so eagerly sought by the Army, pressurized water technology was the proven state of the art at the time. The Army dedicated the reactor in April 1957. To symbolize its potential for both peaceful and military uses, the first electricity generated by the reactor was used to run a printing press and a radar antenna.[137]

Reactors cooled with pressurized water had several disadvantages, however. The coolant circulated in a primary loop through the reactor and exchanged heat with water in a secondary loop. The secondary loop transferred heat to a boiler, which produced steam to run a turbine/generator. The coolant piping, pumps, valves, controls, and instrumentation added considerable weight, bulk, and complexity to the total outfit.

The Army, therefore, set out to experiment with two alternatives. The first was a boiling water reactor. In this design, ordinary water boils as it passes through the hot reactor core. The steam generated here powers the turbine. The system eliminates the secondary loop and the heat exchanger equipment. The Army and AEC engaged Argonne National Laboratory to design a stationary reactor in the "low" power range that might be suitable for a remote location. It had the DEW Line (Defense Early Warning, later the Ballistic Missile Early Warning System) in mind, dozens of radar stations ringing the Arctic Circle on the watch for Soviet invasion. The Army wanted the plant small enough to haul on a 30-ton trailer. The prototype was named SL-1, and it was built on the NRTS at the Army Reactor Area (ARA).[138]

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[136] Hogerton, p. 33. Plants on the line were: SM-1 at Fort Belvoir; SM-1A at Fort Greeley, Alaska; PM-2A at Camp Century, Greenland; PM-1 at Sundance Air Force Base, Wyoming; PM-3A at McMurdo Sound, Antarctica; PL-3 at Byrd Station; and the *Sturgis*, a barge.

[137] Suid, p. 36-37.

[138] Suid, p. 82. For more technical detail on the SL-1 reactor,

The second alternative was a "gas-cooled" reactor, or GCRE. In this concept, a gas circulates in a closed loop through a water-moderated reactor to carry off the heat. The loop passes through a steam generator, which then runs the turbine. The system promised to be smaller and lighter than either of the other concepts. The Army hoped that ambient air might eventually be used as the coolant. The Army and AEC selected Aerojet-General Corporation to design it. As this would be the country's first gas-cooled reactor, testing had to determine its operating parameters and best fuel element design. Once that information was available, the plan was for Aerojet to build a prototype of a mobile low-power reactor -- the ML-1. Both of these alternatives and the ML-1 became clusters of activity at ARA.[139]

Siting the Army Reactor Area

The SL-1 was ready to be built first. In August 1955, the AEC chose Pioneer Services and Engineering Company of Chicago as the architect/engineer. Bid requests began to go out in 1956, including one to build the circular steel tank that would house the reactor.[140] Construction began in 1957 and was finished in July 1958.

By this time, the NRTS no longer was a *tabula rasa* upon which a contractor could pick and choose a construction spot at will. Reactors and tests dotted the terrain, and each new experiment had to meet siting criteria administered by a Site Selection Committee at the NRTS and approved by the AEC in Washington. The Committee knew from the outset that the Army program would consist of three experiments. (The first name for the site was Army Reactor Experiment Area; the word "experiment" later was dropped.) The site was placed a few miles west of Argonne West and five miles east of the Central Facilities Area.

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see "Army Reactor Program," *Nucleonics* (February 1969), p. 53-54 and insert.

[139] The GCRE was the eighth reactor type developed by the AEC Nuclear Reactor development program, selected for both military and civilian potential. US AEC press release, June 6, 1956; Papers of Senator Henry Dworshak, Idaho Historical Society, Mss 84, Box 55, File "AEC--Idaho Plant." Hereafter referred to as "Dworshak Papers."

[140] US AEC/Idaho Operations press release, December 11, 1956. Dworshak Papers, Box 55, File "AEC--Idaho Plant." The SL-1 was originally known as the Argonne Low Power Reactor, or ALPR.

The area was a master-planned four-cluster complex. The first cluster, ARA-I, was the administrative center. The three experiments were strung out along a connecting road and as close together as possible without compromising rules establishing minimum distances between reactors. The GCRE and SL-1 each required one mile; the ML-1, only a half a mile. (SL-1 was closer than one mile to the public highway, but it commenced before the one-mile rule was applied.) The four-cluster string was perpendicular to the direction of the most prevalent winds. This way, the risk of accidental releases from one reactor blowing over the other centers was reduced as much as possible.[141]

ARA-1 was the southern-most cluster of the four. It contained a hot cell building, a shop and maintenance building, guardhouse, pumphouse, hydraulic test power facility, and water and electrical utilities. Office trailers and a crew training building eventually were added. Its earliest buildings were constructed in 1959 and 1960.

SL-1, the first of the three projects, was next up the road at ARA-II. Completed in 1958, the site consisted of the cylindrical reactor building, a control room building with auxiliary equipment, and several small service buildings. The cylinder, made of quarter-inch thick steel plate, was part of the experiment. It was set on dummy piles to simulate construction methods used at DEW Line radar stations in permafrost. The reactor vessel, fuel storage well, and demineralizer for the water were in the lower part of the cylinder and shielded with gravel. Other equipment and shielding were in the upper two thirds of the building. The Army planned to use the SL-1 for training, so its operating contractor, Combustion Engineering, employed a military crew. Several earth berms were constructed at strategic places at the site. As at every other test area at the NRTS, a security fence and guard gate controlled entry.

The GCRE, at ARA-III was the next complex, ready for action in 1959. The reactor was in a rectangular building. Inside, the reactor operated within a sunken "swimming pool" filled with the moderating water. At the northern corner of the site stood a large tank for contaminated water, heavily bermed. The layout included a control and test building, a service building, a warehouse, gatehouse, petroleum storage, nitrogen storage tanks, and cooling tower along with fire protection, water, and sewer utilities. One of the buildings was a laboratory and fabrication

[141] Norman Engineering Co., *Master Plan Study for the Army Reactor Experimental Area* (Idaho Falls: Norman Engineering Report No. IDO-24033, 1959), Section II (no page numbers). The master plan also provided for other facilities that the Army never did build.

center related to the development of the next project down the line at ARA-IV, the ML-1 prototype.

The ML-1 reactor was assembled in Downey, California, put on an Army semi-trailer, and hauled to Idaho, where it arrived in February 1961.[142] The ML-I site (ARA-IV) was intended to simulate field conditions for training; therefore, it was relatively undeveloped. For example, water was trucked to the site from ARA-III.[143] The reactor control building was 500 feet away from the reactor, and only one or two other buildings were erected at the site. Most of the study work connected with ML-1 took place within GCRE buildings at ARA-III.

The Progress of the NRTS Experiments

SL-1 went critical for the first time on August 11, 1958, and produced electricity two months later on October 24. It was the first power plant reactor to use aluminum-clad fuel elements, which heretofore had been used only in test reactors like the MTR. It used a new alloy that overcame the low melting point of aluminum. After SL-1, aluminum alloys were used widely.

The GCRE, which went critical for the first time on February 23, 1960, tested two types of fuel elements, plate-type and then pin-type. The object was to find a fuel configuration that would have a long run before depletion. The pin-type promised to produce 300 to 500 kilowatts for a year without refueling. This design also reduced the shielding requirements for the reactor, which meant that the ML-1 prototype might meet the Army's goal of being transportable in four packages totaling no more than 38 tons.[144] The GCRE had frequent maintenance problems, and on April 6, 1961, the reactor was shut down for the last time because of a leak in some of its stainless steel piping. It was deactivated by July 1, 1962.

The Army then turned ARA-III to the support and testing of the ML-1 prototype reactor. The GCRE pool was converted to a dry pit with shielding on top to accommodate the ML-1. On September 21, 1962, ML-1 operated as a power plant for the first time in a short two-hour run, making history as the smallest nuclear power

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[142] AEC/Idaho Operations press release, February 11, 1961. Dworshak Papers, Box 122 B, File "AEC--Press Releases."

[143] IDO-24033, Section II.

[144] To James T. Ramey from Richard X. Donovan, November 21, 1960. Dworshak Papers, Box 112, File "AEC Idaho Plant." See also *Thumbnail Sketch*, April 1960, p. 17

plant on record to produce electricity. Also, it produced the highest core temperature of any previous reactor -- 1,225 degrees F. Furthermore, this was the first time a reactor was connected to a closed-cycle, gas-driven turbo-generator. It reached full-power operation on February 28, 1963.[145] During ML-1 tests, the operators trucked the reactor into a weather-sheltering metal building in the center of the ARA-IV area. The reactor control building was 500 feet away from the reactor just outside the perimeter fence. Evaluation, repair, and studies of the ML-1 took place within the GCRE buildings at ARA-III.[146]

The ML-1 proved to be disappointing, typically operating only a few days or hours before shutting down because of leaks, failed welds, or other problems. Only four days after it reached full power, a leak shut it down. It was out of action until spring 1964. After that, operations continued, but still with breakdowns. Radioactive releases were typical of ML-1; the experimenters realized that if it were to operate in the field, it would place its operators in danger. ML-1 tests ended in 1965.[147]

Meanwhile, in Washington, D.C., the Army Reactor Group had placed several prototype reactors on line in Greenland, Alaska, Wyoming, and Antarctica. Even though these had acquitted themselves well, the Group was having trouble persuading any of the services, including the Army, to order any of the plants. It appeared that the "life time" cost of a nuclear plant was lower than that of a conventional one, but the initial cost was far higher. When it came time actually to set a budget, the services opted for low first-cost alternatives. Economists suggested that this was false economy, but "balance the budget" pressures were more powerful.[148]

The SL-1 Accident

On January 3, 1961, the SL-1 had been shut down for maintenance since December 23, 1960. Three military crew members on an evening shift were preparing the reactor for another run. A

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145 Suid, p. 91.

146 See Photos from ARA HAER report: Nos. ID-33-D-96 through ID-33-D-102. These views show the ML-1 being moved from ARA-IV to ARA-III and set up for examination at in the GCRE pool.

147 Suid, p. 92-93.

148 "Economic Military Power Arrives, But Pentagon Hesitates," *Nucleonics* (April 1960), p. 27.

violent explosion occurred in the reactor vessel, killing all three men. This was the first -- and continues to be the only -- fatal accident in the history of American reactor operations.

The AEC immediately appointed an investigating committee to discover what had caused the accident. After interviewing hundreds of people, the committee never could say conclusively what had caused it. High levels of radioactivity in the building prohibited a detailed examination of its contents, although the technicians did manage to photograph parts of it remotely.

It seemed plausible that one of the crew had moved a control rod farther out of the reactor than was specified in the maintenance procedures. In four milliseconds, the reactor went critical, heated rapidly, and caused water in the core to flash to steam. The column of steam slammed into the lid of the pressure vessel, causing the entire vessel to jump from its foundation, shearing all of its piping connections and blowing shield plugs and shielding material from the top of the vessel. The men died from the impacts of the explosion rather than from the effects of nuclear radiation (although radiation in the reactor building was at lethal levels after the accident). Most of the radiation released from the reactor vessel by the explosion remained inside the building.[149]

The investigating committee identified many problems with the management of the SL-1 reactor. One of the worst, and possibly a contributing cause of the accident, was that the fuel elements had been allowed to deteriorate "to such an extent that a prudent operator would not have allowed operation of the reactor to continue without a thorough analysis and review, and subsequent appropriate corrective action."[150]

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[149] Many sources describe and discuss the SL-1 accident, among them "SL-1 Explosion Kills 3; Cause and Significance Still Unclear," *Nucleonics* (February 1961), p. 17-23; a series of press releases in Dworshak Papers, Box 122B, File "AEC-Idaho Press Releases;" "Summary of the SL-1 Reactor Incident at the National Reactor Testing Station in Idaho on January 3, 1961," prepared by the Staff of the JCAE, January 10, 1961, also in Dworshak Papers, Box 122B, File "AEC-Idaho Press Releases;" "SL-1 Accident, Findings of the Board of Investigation," published verbatim in *Nuclear News* (July 1961), p. 13-16. A videotape *The SL-1 Accident* produced by the NRTS Idaho Operations Office shows film of the recovery effort and the disposition of the reactor building. See also William McKeown, *Idaho Falls, The Untold Story of America's First Nuclear Accident* (Toronto: ECW Press, 2003).

[150] "Findings of the Board of Investigation," *Nuclear News* (July 1961), p. 13.

The AEC hired General Electric to evaluate options for disposal of the reactor building. The reactor core, vessel, and fuel went to the TAN Hot Shop for analysis. The rest of the lower-level radioactive debris and contaminated soil was placed in a "burial ground" about 1,600 feet from its original location. Two pits and a trench dug to bedrock accepted the waste. Backfill over the debris provided shielding, and an exclusion fence surrounded the burial zone. This on-site burial was considered a better approach than transporting the material sixteen miles on a public highway to the RWMC and risking public exposure.

The AEC decided that the cost of continuing to fund tests of boiling water reactors like SL-1 would not produce worthwhile benefits. It phased out the program and shelved it for possible future use. The Army felt that the concept had progressed "quite well," but it also stopped funding the concept.[151]

After decontamination, the ARA-II buildings were converted for use as offices. The NRTS contractor set up a welding shop to provide training and qualification testing for welders and braziers.

The accident may have aroused doubts in the minds of some about the Army's nuclear power plant program, but if so, the effects were not immediate. Editorials from nuclear industry publications such as *Nucleonics* said that accidents should be considered inevitable, but that the industry should do everything it could to protect its outstanding safety record to date. The AEC soon prohibited reactors that were controllable with only one control rod. The accident aroused protests from the local Oil, Chemical, and Atomic Workers International Union, which urged Congress to enact legislation to improve safety of nuclear workers. The Union also protested the lack of an isolation ward at the NRTS dispensary, lack of shielded lead caskets for burials, and lack of instruments available to read radiation levels higher than 500 roentgens.[152] Site managers agreed that it was ill-equipped to deal with high-radiation casualties, but also felt that their pre-planned emergency procedures had been carried out appropriately during the SL-1 accident.[153]

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[151] Suid, p. 87.

[152] To Senator Henry Dworshak from Donald E. Seifert and George Drazich for Local 2-652, May 11, 1961. Dworshak Papers, Box 122B, File "AEC--Idaho Plant."

[153] John R. Horan and C. Wayne Bills, "What Have We Learned? Health Physics at SL-1," *Nucleonics* (December 1961), p. 43-46.

Perhaps the long-term impact of the SL-1 accident is best measured by the frequency with which it was mentioned by anti-nuclear writers in the 1970s and 1980s. Books appeared containing lists of nuclear accidents, near-accidents, and mishaps, described in language aimed to outrage or frighten the reader. Sometimes the accounts of the SL-1 accident were quite inaccurate, but they helped alarm the public and inspire protests against nuclear power plants.[154]

The End of the Army Reactor Program

In view of the continuing difficulty finding missions for their small reactors -- and the continuing difficulty in keeping the ML-1 from breaking down -- the Army and the AEC concluded that the ML-1 program might eventually achieve its objectives, but that it would cost too much. Nuclear plants, particularly in the low-power end of the spectrum, could not compete with diesel plants: Using the Army's Antarctica reactor as an example, the initial cost of the nuclear plant was $6-7 million; for diesel, $350,000. A nuclear plant required a crew of 20 highly trained men; a diesel plant, six.

Partly behind the Army's reluctance to continue financing nuclear experiments was the country's growing involvement in the Vietnam War. The Department of Defense needed funds to prosecute the war. First the AEC and then the Army phased out the funding for the ML-1 development program by June 1966.[155] This action effectively ended the involvement of the NRTS in the Army's nuclear development program.

An Army Ad Hoc Study Group took up the question of the rest of its program in 1969. One of the participants summed up the situation by saying, "Nuclear power is a solution in search of a problem." Basically, no military requirements existed for nuclear power. In the end, the group decided that it was only in selected remote situations that nuclear systems were cost-competitive with conventional diesel plants, that experiments should stop, but that study groups could continue.[156]

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[154] See for example, Harvey Wasserman and Norman Solomon, *Killing Our Own, The Disaster of America's Experience with Atomic Radiation* (New York: Delacorte Press, 1982); John Fuller, *We Almost Lost Detroit* (New York: Reader's Digest Press, 1975); John May, *The Greenpeace Book of the Nuclear Age* (New York: Pantheon Books, 1989); Leslie J. Freeman, *Nuclear Witnesses: Insiders Speak Out* (New York: W.W. Norton and Co., 1981).

[155] Suid, p. 93.

[156] Suid, p. 103-105. The quotation comes from an individual,

However, the Chief of Engineers, Lt. Gen. Frederick J. Clarke, could see little reason even to continue study groups. He permitted existing plants to operate until major problems forced them to shut down. In 1971, the Army Engineer Reactor Group lost its name and became the Engineer Power Group. Soon this group was examining excess generators returning from Vietnam. The Army experiment with nuclear reactors was over.[157]

The ARA Complex at INEEL

All ARA buildings were dismantled in the 1990s except for the ML-1 Control Building at ARA-IV, which continues in use. As mitigation, the INEEL prepared a HAER report, HAER No. ID-33-D, which was approved and accepted by the National Park Service in 2001. The HAER report was required to document ARA-I, ARA-II, and ARA-III, but in the judgement of the author, the HAER would be more complete with documentation of ARA-IV as well. Thus, ARA-IV history, documentation, and photographs were included in the HAER report.

SubTheme: *Cold War Weapons and Military Applications*
INEEL Area: Advanced Reentry Vehicle Fuzing System Bunker

The Advanced Reentry Vehicle Fuzing System (ARVFS) facility was built at the NRTS for the U.S. Air Force to evaluate the impact of gamma radiation on certain packages of instruments related to the fuzing system of guided missile warheads. The facility consisted of a below-grade quonset hut covered with earth, a subsurface water tank open to the sky and built to shield spent fuel elements, and a support framework from which to suspend test packets over the gamma source. The bunker served as the control room during gamma exposures. The facility was on the east side of Lincoln Boulevard and northeast of the NRF.

During the mid-1960s, the American missile program was developing both offensive and defensive capabilities with respect to guided missiles. The ARVFS bunker and the gamma exposure of a fuzing system were a very small part of a major national priority to maintain weapons superiority over the Soviet Union.

After its initial use, the facility was used for a similar test in 1968 by health physicists at the NRTS to evaluate

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unnamed by Suid, who prepared a briefing for the Ad Hoc Study Group.

[157] Suid, p. 108.

computer-generated codes (which predicted gamma radiation exposure in certain situations) against an actual exposure. The test exposed dosimeter film.

Other opportunistic uses of the facility occurred thereafter. In 1980, fuel rod pellets were subjected to various kinds of charges, including a shaped charge, in the water storage tank at the facility. In 1974 four containers of contaminated NaK, previously stored at EBR-I, were moved to the bunker for safekeeping and isolation.

The ARVFS bunker site was decontaminated and dismantled in 1997. As mitigation for this potentially historic property, the Department of Energy contracted for a Historic American Engineering Record report on the facility.[158]

The ARVFS facility, which was of such short-term usefulness that neither electricity nor telephone were extended to the site, was a small part of the Arms Race. It represents one of a nearly infinite list of details executed to guarantee a weapon that would do the destructive work for which it had been designed.

SubTheme: *Cold War Weapons and Military Applications*
INEEL Area: Test Area North

Beginnings of the Aircraft Nuclear Propulsion Program: 1951

The idea for a nuclear-powered aircraft was envisioned before the end of World War II. Military advocates fought to have the idea given serious attention in the years after the war. The Aircraft Nuclear Propulsion (ANP) program -- as it would involve the NRTS -- began in 1951 when the Department of Defense decided that a nuclear-powered bomber was a military requirement. The concept for the weapon system was that a bomber would be able to remain aloft for at least five days, approach its target from any circuitous route, deliver the payload, evade enemy fire, and return home by any route desired.

When the AEC and the U.S. Air Force undertook the ANP program, they assigned the General Electric Company (GE) the task of developing a "direct cycle" heat exchange system for a turbojet aircraft. The NRTS opened up for GE a new site at the far northeastern end of the site -- Test Area North, or TAN. TAN

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[158] Susan M. Stacy, *Idaho National Engineering Laboratory, HAER NO. ID-32-B, Advanced Reentry Vehicle Fuzing System* (Idaho Falls: INEL Report INEL-97-00066, 1997.) The summary of ARVFS activities in this section are drawn from this HAER.

is about twenty-seven miles from the CFA.[159]

The Utah Construction Company broke ground for the first buildings at TAN in 1953. They were equipped and ready for serious experiments by Christmas of 1955. GE's objective was to set up a turbojet engine, connect it to a reactor, and prove that the heat from the reactor could propel the engine.

Major Facilities of the ANP Program

The project would require many support buildings in discrete activity areas. One of the first large buildings completed was the Assembly and Maintenance Building (A&M, or TAN-607). A sprawling one-story structure, it would be the place to construct, assemble, repair, and modify the experiment. The A&M contained a variety of fabrication shops and laboratories. The metallurgical lab contained X-ray machines for inspecting welds; the radioactive materials lab would examine spent fuel elements from the reactor and other radioactive samples. A Hot Shop, 52 feet wide by 160 feet long by 60 feet high, with its six-feet-thick shielded windows and master-slave manipulators, allowed for the remote handling of "industrial-scale work" and radioactive substances. A chemical lab handled other chemicals, and a photographic lab was available. "Cold" shops were equipped to repair jet engines, make and calibrate instrumentation, and assemble (prior to their initial test) the nuclear power plants that would be the subject of the experiments. This building was separated from administrative and other non-research functions by a 15-foot high earth embankment located atop a natural ridge formation.[160]

The ANP support facilities were connected to each other by shielded roadways, tunnels, and a four-track railroad that would allow safe transport of people and heavy equipment from one area to another.[161] GE built a unique shielded locomotive with the driver's cab surrounded by lead and water for the safety of the operator and passengers while transporting radioactively hot items.[162]

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[159] Stacy, *Proving the Principle*, p. 118-120.

[160] *APEX-15, ANPP Engineering Program Progress Report No. 15, March 1955* (Cincinnati, Ohio: GE ANPP Department, Atomic Products Division), p. 10; see also *Thumbnail Sketch* March 1959, p. 13.

[161] Susan M. Stacy, *Idaho National Engineering Laboratory, Test Area North, Hangar 629, HAER No. ID-32-A*, 1995, p. 22. Hereafter cited as "Stacy, *Hangar HAER*."

[162] *APEX-13, ANPP Engineering Program Report No. 13, September*

The Initial Engine Test (IET) facilities were located north of the A&M Building. When it was ready for a test, the reactor/engine assembly was moved to the "test pad" from the assembly area. Mounted on a dolly, the assembly could be moved in any weather enclosed in a moveable all-aluminum building. Because of the weight of the reactor assembly, the railroad tracks consisted of four rails. Operators conducted the test from a shielded underground Control and Equipment Building (TAN-620). When an experiment had been concluded and the reactor shut down, the locomotive hauled the assembly back to the A&M building for post-test examination and further study.[163]

The ANP Experiments

GE built three major "Heat Transfer Reactor Experiments" (HTREs). On December 30, 1955, HTRE-1 demonstrated that a nuclear reactor could be the exclusive source of power for an aircraft engine. This was the first time that heat from a nuclear power reaction operated a J-47 turbojet engine. The reactor generated heat, the heat was compressed and forced through the nozzle of the turbojet. In an aircraft, the nozzle exhaust would provide thrust. Measurements and additional tests continued through January 1957. The reactor/engine plant accumulated a total of 150.8 hours of operation.

In later experiments, engineers modified HTRE-1 so that they could test the impact of temperatures up to 2,800 degrees F. for sustained periods of time (and at even higher temperatures for shorter periods of time) on various materials within and near the reactor.[164]

The first two experiments had been built without regard to the space or arrangement limitations that would be relevant in the body of an airplane. The third experiment, HTRE-3, was built with the components arranged as they would be in an aircraft. Full nuclear power was achieved in 1959 and for the first time, an experiment ran two engines at the same time on nuclear power. In the course of these experiments, ANP research advanced scientific understanding of ceramics, alloys, and other materials subject to high heat.[165]

1954 (Cincinnati, Ohio: GE ANPP Department, Atomic Products Division), p. 10-11, 195.

[163] *Thumbnail Sketch* 1958, p. 14.

[164] Stacy, *Hangar HAER*, p. 46.

[165] Stacy, *Hangar HAER*, p. 46.

As the experiments progressed, GE built additional facilities at TAN. The Flight Engine Test facility was to house an anticipated airframe with typical crew compartments and aircraft control systems. The major structure was a hangar building (TAN-629) with a barrel-vaulted roof and open-span interior dimensions of 320 feet x 234 feet. Associated with the hangar was a shielded control building (TAN-630) and additional four-rail track leading into the hangar. The hangar was completed in 1959.[166]

The project required additional test reactors to perform a variety of studies. The Shield Test Pool Facility (SUSIE), which included the SUSIE reactor, was used to examine the problems associated with shielding a human crew on an aircraft with an operating nuclear reactor aboard. Engineers tested prototypes or mock-ups of various shielding materials and configurations. The facility was located some distance from the other TAN facilities and was known as the "swimming pool" because it had two water-filled compartments into which reactors could be submerged for the tests. Near the pool was a platform and gantry crane for "in air" tests. A control building served both the pool and the platform. Construction began in 1958 and was completed in 1959.[167]

Another support facility, the Low Power Test Facility (LPT), was located about one and one-fourth miles southeast of the A&M area and near the Shield Test Facility. Reactor assemblies were preliminarily tested here at "zero" or low power. Two low power reactors, the Hot Critical Experiment, and the Critical Experiment Tank were operated in the LPT in 1958, both associated with ANP research. Several buildings were constructed there including a single-story cinder block building (TAN-640) which contained two poured-concrete test cells. A wall five feet thick served as a shield between the cells and the rest of the facility. The walls between the cells were four feet thick, allowing personnel to work in one cell while the reactor was operating in the other.[168]

[166] Pursuant to a Memorandum of Agreement with the Idaho SHPO, the TAN Hangar was the subject of a HAER in 1995. This document includes further design details of the Flight Engine Test Facility. See Susan M. Stacy, *Idaho National Engineering Laboratory, Test Area North, Hangar 629, HAER No. ID-32-A.*

[167] *Thumbnail Sketch* March 1959, p. 14.

[168] R.E. Wood et al, *Operating Manual for the Low Power Test Facility* (Idaho Falls: General Electric Report DC 59-8-718, 1959), p. 6.

Although GE demonstrated the principle of nuclear-powered flight, one of its major disappointments was to find that the reactor could not heat the engine air to the desired high temperatures, a requirement for fast bomber speeds. A nuclear airplane might be able to fly, but if it could not sprint at rapid speeds to evade the enemy or manoeuver quickly, it could not serve as a military weapon.[169]

The End of the ANP Program: 1961

During the course of ANP experiments, the Department of Defense was simultaneously improving the technology of long-range guided missiles, another method of delivering a bomb to a far-away target. It proved to be more reliable and safer than a manned nuclear-powered bomber. In 1961 the new president, John F. Kennedy, was looking for funds to beef up the military's conventional forces and build the country's supply of Minuteman rockets and Polaris-firing submarines. He canceled the ANP program because, he said, "nearly fifteen years and about $1 billion have been devoted to the attempted development of a nuclear-powered aircraft; but the possibility a militarily useful aircraft in the foreseeable future is still very remote..." The ANP cut would save $35 million. Other military programs would, he felt, produce more tangible and immediate benefits.[170]

Following the cancellation of the program in 1961, which came as a shock and a surprise to the unprepared GE employees, the mission of TAN facilities changed considerably. The hangar and its control building were never beneficially used for an airplane, for example. But the hot shops, laboratories, fabrication and assembly shops could be turned to other demands and other programs. Many ANP facilities were altered and reused for purposes other than their original ones. Others remained vacant or underused for years. In 1970 a private industrial council based in Idaho Falls, interested in marketing the vacant spaces at NRTS, estimated that 20 vacant buildings with over 223,000 square feet of floor space were available -- most of them at TAN.[171]

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[169] Stacy, *Hangar HAER*, p. 46.

[170] "Kennedy Asks $2 Billion Defense Insurance Hike," and "A-Plane Work Halt Asked by JFK in Defense Message," *Idaho Daily Statesman*, March 29, 1961, p. 1 and p. 6 respectively.

[171] Dr. E. Fast, compiler, *Potentially Available Facilities at the National Reactor Testing Station* (Idaho Falls: Eastern Idaho Nuclear Industrial Council, February 1970), p. 14.

False Starts and New Programs at TAN in the 1960s

Another nuclear-technology program that had been underway in the United States during the 1950s was a program called Systems for Nuclear Auxiliary Power (SNAP). The object of this research was to devise a compact auxiliary power system for space vehicles and satellites. By the 1960s SNAP was a joint project of the AEC and the National Aeronautics and Space Administration (NASA).

Related to the SNAP program, the AEC prepared to conduct experiments with a Lithium Cooled Reactor (LCRE). The AEC envisioned a nuclear reactor that could power an electrical generator. It would have to be small and light-weight, but able to generate high power levels. The AEC contracted Pratt and Whitney (P&W) in 1962 to modify the TAN hangar building for the lithium-cooled-reactor concept. P&W already had done preliminary development of the concept.

P&W started on the modifications. The hangar building would house the experiment, while the hangar's control building, parts of the A&M building, the Health and Safety Building (TAN-607), and other buildings would house ancillary features of the project. But the work had barely begun before the AEC and NASA redirected the SNAP program, and the remodeling stopped abruptly.[172]

After the SL-1 reactor accident in January 1961, many TAN shops and laboratories were used in the analysis and clean-up that followed the accident. The AEC gave GE the contract to decontaminate and dispose of the debris, and GE used its many hot shops and laboratories for this work, glad to supply employment to at least a few of its ANP personnel.[173]

With its truncated staff, GE also took overflow work from some of the other contractors at the NRTS and did hot cell work for them. SUSIE was particularly popular. Now that the unique "swimming pool" was available to the rest of NRTS, it was in demand 24 hours a day all week long.[174]

GE operated the Fast Spectrum Refractory Metals Reactor, a low-power critical facility, in the LPT from March 1962 to 1968.

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[172] Stacy, *Hangar HAER*, p. 57.

[173] Stacy, *Hangar HAER*, p. 56.

[174] To Henry Dworshak from John W. Morfitt, GE Idaho Test Station, September 26, 1961; Dworshak Papers, Box 122 B, File: AEC Idaho Plant.

The main work of this reactor was to collect data for a proposed reactor concept called the 710 Reactor. This was another concept for developing a compact, high-temperature reactor for generating power in space. The reactor was to use tungsten and tantalum. The project was discontinued in 1969 when it was determined that existing non-nuclear technology could provide power needs in space.[175]

Also at the LPT, GE operated the 630-A Reactor Critical Experiment to explore the feasibility of an air-cooled, water-moderated system for nuclear-powered merchant ships. Further development was discontinued in December 1964 when decisions were made to lower the priority of the entire nuclear-powered merchant ship program.

Other experiments at TAN in the late 1960s were the Cavity Reactor Critical Experiment (CRCE) and Thermal Reactor Idaho Test Station (THRITS). Both of these were operated for the AEC by the Idaho Nuclear Corporation. The CRCE was installed in one cell of the LPT facility. It was a nuclear mock-up of a reactor having complete spatial separation of its low-fuel-density core and surrounding moderator -- a concept proposed by the NASA Lewis Research Laboratory for more efficient rocket propulsion. The THRITS experiment was housed in the second cell of the LPT and served as a thermal neutron source for several short-term tests.[176]

In May 1963 modifications were made to the Shield Test Pool Facility to house the Experimental Beryllium Oxide Reactor (EBOR). The project's objective was to develop the technology for using beryllium oxide as a neutron moderator in high-temperature, gas-cooled reactors. TAN-645 was built as the control and administration center, and TAN-646 was for the reactor building. While EBOR was under construction, progress was made elsewhere on developing graphite as a moderator, reducing the importance of developing an alternate moderator.

Following a now-familiar pattern, the AEC terminated the EBOR program in 1966 soon after it redirected its policy toward a much narrower scope of reactor research. Only those reactor concepts that held promise for economical (commercial) power production and were efficient users of nuclear materials were of interest to the AEC. (See discussion above relating to Argonne West and the breeder reactor.)[177]

[175] *Thumbnail Sketch* 1969, p. 38.

[176] For an illustration of the gas-core reactor concept, see p. 127 of Stacy, *Proving the Principle*.

[177] *Thumbnail Sketch* 1969, p. 37-38.

The ANP program represented the expenditure of about $1 billion across a period of fifteen years, a huge commitment of the national treasure in pursuit of weapons supremacy over the Soviet Union during the Cold War. The buildings and experiments at TAN represent a remarkable legacy of the Cold War, both nationally and in Idaho history. Although not all of the money was spent in Idaho, this was the place where engineers proved that nuclear-powered flight could be achieved. Some of the buildings and facilities were one-of-a-kind creations: the hangar building, the "swimming pool" reactor, the industrial sized hot shop.

Within the last decade, a number of TAN buildings have been decommissioned and dismantled. The Initial Engine Test Facility, with its test pad, exhaust stack, railroad turntable, guard house, utility support buildings, and control bunker have been demolished. An 1956 Administration Building was dismantled, and one of the maintenance and assembly buildings (TAN-615) has been demolished. Many other buildings are in "shutdown" status awaiting further mission or other disposition.

With the end of the Air Force program in 1961, the TAN buildings lost most of their functions with respect to the "Cold War and Military Applications," one of the four themes describing reactor research at the INEEL in the 1950s and 1960s. A few NASA-related programs came and went, but much of the work at TAN shifted to another theme entirely, that of supporting the growing commercial nuclear power industry by doing research that would improve "Commercial Reactor Safety."

SubTheme: *Commercial Reactor Safety*
INEEL Area: The SPERT/PBF Area

The AEC Reactor Safety Program: 1955-1962

With the Atomic Energy Act of 1954, Congress and the AEC aimed to encourage the development of a commercial nuclear power industry. Of great concern was the safe operation of future nuclear power plants. Clearly, reactors would be located near their markets in heavily populated areas.

In 1953 the AEC's Advisory Committee on Reactor Safeguards (ACRS) had formed from a merger of two safety groups: the Reactor Hazards Committee with members appointed by the AEC, and the Industrial Committee on Reactor Location Problems, whose members came from private industry. These groups concerned themselves with the location of reactors, their operational safety, radioactive fallout, and related issues.[178] The AEC and ACRS undertook safety research experiments on different reactor concepts. The incipient new private industry had a long way to go before reactor operations, even boiling water reactor operations then considered the most promising concept for commercial development, could be considered safe in locations other than isolated western deserts.

An early series of tests were the Special Power Excursion Reactor Tests (SPERT) that began in 1955. Originally conceived as a program to explore the operational limits of small study reactors used in university settings, the experiments moved on evaluate the safety limits of other types of reactors as well. Testing reactors to their point of destruction continued the tradition established uniquely at the NRTS with the earlier BORAX experiments.[179]

The SPERT experiments took place at a site built and operated by Phillips Petroleum Company about sixteen miles from the eastern NRTS boundary at a point where dominant winds would not carry radioactive materials across other activity areas at the NRTS in the event of a destructive reactor test. The site was a few miles northeast of the OMRE site and a few miles northwest of the Army's reactors.[180]

Research examined the safety requirements of containment buildings and the behavior dynamics of reactors should their power levels change rapidly.[181] A major objective was to postulate various kinds of "accidents" that could occur in a nuclear power plant, determine how the reactor would respond to them, and work out ways to control or prevent such accidents. Additional goals of the SPERT program were to design power plants with improved operational flexibility and at less cost.[182]

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[178] Richard Doan, "Two Decades of Reactor Safety Evaluation", Memorial Lecture in honor of Dr. C. Rogers McCullough prepared for delivery at the Winter Meeting of The American Nuclear Society in Washington, D.C. November 15-18, 1970.

[179] Stacy, *Proving the Principle*, p. 133-134.

[180] T.R. Wilson *An Engineering Description of the SPERT-1 Reactor Facility* (Idaho Falls: Report NO. IDO 16318), p. 8.

[181] *Special Power Excursion Reactor Tests* (Idaho Falls: Phillips Petroleum Company, no date) no page. Hereafter cited as "Phillips, *SPERT*."

[182] *Thumbnail Sketch* 1969, p. 31.

SPERT experiments began in 1955 and continued until 1970. A series of specially designed and instrumented reactors were deliberately operated beyond normal safety limits to answer the simple question, "What will happen?" The data that was gathered and analyzed throughout the period was used to help design commercial reactors.[183]

The SPERT Control Area

The purpose of SPERT was to find basic explanations for reactor behavior under runaway conditions. The SPERT complex was therefore arranged so that the reactors could be controlled from a safe distance. The control building was located half a mile from the reactors in a fenced area 250 feet x 250 feet. This area also included a supply of raw water.[184] The Control Building (later converted to a conference room in PER-601) housed the SPERT-I reactor controls, administrative offices, instrument and mechanical work areas, and dark room. It included sufficient expansion space for the controls and instruments of the SPERT reactors that would follow in later experiments.

The Terminal Building was about 2,800 feet from the Control Building. It housed the service facilities for the reactor, including necessary water and air equipment and a personnel decontamination and change room. It was located such that additional SPERT reactors could be built on an arc having a radius of about 400 feet from the building.

SPERT-1

The SPERT-I experiment was located 3,000 feet northwest of the control building and included two adjacent structures -- the Reactor Building and the Instrument Bunker, the latter being an earth-covered concrete structure that housed relays and other auxiliary equipment for the reactor. The two buildings were enclosed within a fenced area 150 feet x 150 feet. SPERT-I tested reactor transient behavior and performed safety studies on light-water moderated, enriched-fuel reactor systems. SPERT-I went into operation June 11, 1955. It was a simple reactor, consisting of the core in an open tank of water.[185]

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[183] Phillips, *SPERT*.

[184] *Thumbnail Sketch* 1962, p. 31.

[185] During the start of the Spert project, water-cooled and -moderated reactors were the most common type of reactor in the United States, and tests would be of immediate value to reactor designers.

A plate-type, enriched uranium-aluminum core was placed into the open vessel. The assembly had no provisions for heat removal or coolant circulation through the core. Total energy released during the anticipated lifetime of the facility was expected to be small, so no special biological shield was installed. The tank was four feet in diameter by ten feet high.[186]

The Reactor Building was a 24 feet x 18 feet galvanized iron structure which housed the reactor and associated equipment, electrical switchgear, and other auxiliary facilities. The structure was unimposing and built to afford the minimum required to protect personnel and equipment from extreme dust conditions and winter weather. The reactor vessel and tank were in a pit embedded in the floor. The pit had a drain and sump pump for automatic removal of waste water to a leaching pond outside the building. On the northwest side of the reactor pit, and also embedded in the building floor, were eighteen tubes used for the temporary storage of reactor fuel.

The Instrument Bunker was a 10 feet x 12 feet, earth-covered, concrete block structure. Openings for instrument and electrical leads entered the bunker from the Reactor and Control buildings. SPERT-I had two instrumentation systems, one for controlling the reactor and one for studying transients. Observers in the control room watched the reactor on closed-circuit television. The camera was mounted above the tank in the reactor building.[187]

The SPERT-I reactor could produce bursts of high-energy neutrons for very short time periods. The reactor successfully demonstrated in 1958 that a safety device called a reactor fuse was capable of preventing a reactor runaway. The fuse worked independently of the mechanical control system and shut down the reactor by rapidly injecting a neutron absorbing gas into a chamber located within the reactor whenever the power level rose at an excessive rate.[188]

The SPERT-I tests showed that the reactor typically shut down following a surge of power. But in some cases, instabilities were observed following the power peaks. These divergent oscillations would probably destroy the reactor despite its self-limiting characteristics if they were allowed to continue. Determining the precise causes of these oscillations in the face

[186] *Thumbnail Sketch* April 1958, p. 8.

[187] *Thumbnail Sketch* July 1962, p. 31.

[188] *Thumbnail Sketch* June 1961, p. 32-34.

of inherent shutdown tendencies in water reactors was one of the important research goals that justified the construction of additional reactors in the SPERT family. By 1960 SPERT-1 had been put through more than 1,000 tests using six different reactor cores.[189]

More complex SPERT reactors were under design and construction after 1958. Knowing this, researchers felt they could take greater risks with SPERT-I tests. Beginning in November 1962 SPERT-I was deliberately destroyed in a test that simulated an extreme reactor accident. SPERT-I was decommissioned in 1964. All but the outer vessel of the reactor, which had internal contamination, was dismantled. The SPERT-I site was then occupied by the Power Burst Facility.[190]

SPERT-III

Both SPERT-II and SPERT-III went under construction about the same time. But SPERT-III was ready for its initial criticality before SPERT-II. It consisted of a reactor vessel, a pressurizing tank, two primary coolant loops with pumps and heat exchangers. The reactor building consisted of the main section for the reactor and coolant systems and a wing for electrical switchgear, process controls, instrumentation, and other equipment. The main reactor building, a pumice-block structure, steel-girded, was 40 feet x 80 feet x 30 feet high. A ten-ton crane spanned the forty-feet width and served the entire length of the building. The reactor vessel was located below floor level in a pit centered twenty feet from the south wall. A process-equipment pit extended from the reactor pit to the north wall and was separated from the reactor pit by a concrete wall three feet thick.

The reactor was designed for versatility, allowing cores of different shapes and sizes to be placed in the vessel for investigation. To accommodate the different designs, the internal structure was easily removable and could be replaced by a structure that would accept a different core design. The reactor vessel and control rod drive could accommodate cores having a minimum active core height of 42 inches.[191]

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[189] "SPERT-2 Features Versatility," *Nucleonics* (June 1960), p. 120.

[190] *Site Characteristics, Volume II, Site Development Plan*, 1983.

[191] C.R. Montgomery, J.A. Norberg, and T.R. Wilson, *Summary of the Spert-I. -II. and-III Reactor Facilities* (Idaho Falls: AEC Report No. IDO-16418, November 1957), p. 25.

SPERT-III went critical on December 19, 1958, and continued to operate until the completion of its programmed operations in June of 1968. The first core in SPERT III was similar to some of the early SPERT-I cores, but the emphasis now was to vary the flow, temperature, and pressure of the coolant water in the reactor vessel to see what effect these had on excursions. The tests subjected plate-type fuels to a range of coolant temperatures and pressures, for example.

The results of the tests encouraged the nuclear power industry because they showed that operating a reactor under power-plant conditions did not significantly affect the self-shutdown of a reactor after an excursion. Beginning in 1965, SPERT-III tested another type of fuel, low-enriched uranium-oxide rods.[192]

SPERT-II

SPERT-II achieved criticality March 11, 1960. This pressurized water reactor had cost $4 million and featured removable fuel plates and variable coolant flow rate and direction. The system could use heavy or light water as a coolant. It had removable internal absorber shells so that the thickness of the reflector could be varied. SPERT-II tested various moderators and various core sizes.[193]

SPERT-II tested the behavior of heavy-water-moderated reactors, a reactor concept that was important in Canada and potentially important in the United States.[194] The tests also studied the effects of neutron lifetime on power excursions. The reactor went on standby status in October 1964 after completing its program in August 1964.

SPERT-IV

SPERT-IV was built partly because the tank of SPERT-I was

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[192] *Special Power Excursion Reactor Tests* (Idaho Falls: National Reactor Testing Station, 1965), p. 31.

[193] "Second SPERT Reactor in Idaho Goes Critical," *Idaho Daily Statesman*, March 13, 1960.

[194] Only one heavy water reactor was built as a part of the Power Demonstration Reactor Program (PWDR). The Carolina Virginia Tube Reactor (CVTR) used heavy water as a moderator and coolant and operated from 1964 to 1967.

too small for further investigations of instability phenomena. Construction of the facility was completed in October 1961; initial criticality was achieved on July 24, 1962.[195]

One of the important SPERT-IV activities involved the Capsule Driver Core (CDC), the testing of representative power reactor fuels to obtain information on the various mechanisms resulting in the destruction of reactor fuel. The information helped reactor designers provide safeguards needed to meet safety requirements. The CDC program at SPERT-IV ended in 1970.[196]

Significance of SPERT

SPERT reactors at the NRTS carried out the major portion of the AEC's reactor safety program during the early part of the 1960s. They provided the nuclear industry with information needed to design and operate boiling water, pressurized water, heavy water, and open pool reactors. The work was essential in establishing the commercial nuclear power industry in the United States (and Canada.) The contributions of the program to the evolution of nuclear technology are a major reason for the significance of the NRTS in American history.

SubTheme: *Commercial Reactor Safety*
INEEL Areas: The SPERT/PBF and TAN Areas

The AEC Launches the Safety Test Engineering Program: PBF and LOFT

To explain the distinction among the AEC's many series of safety tests, J.A. Lieberman, AEC Assistant Director for Nuclear Safety, once said that SPERT tests had investigated "why" a reactor would behave abnormally, while the Safety Test Engineering Program (STEP) tests at the Power Burst Facility and Loss-of Fluid Test facility would examine "what" would happen to a reactor in a full-scale accident.[197]

To find out "what" would happen, the experimenters originally conceived tests that would involve full-scale reactor

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[195] R.E. Heffner, et al, *SPERT-IV Facility* (Idaho Falls: Report No. IDO-16745, no date), p. 2.

[196] *Special Power Excursion Reactor Tests* (Idaho Falls: National Reactor Testing Station, 1965), p. 42-44.

[197] J.A. Lieberman quoted in "AEC Plans Reactor-Safety Engineering Test Programs," *Nucleonics* (February 1963), p. 19.

systems and accidents. STEP was planned as a two-phase program. One phase -- the PBF -- would involve oxide core destructive excursion tests to be conducted in an open tank and in a closed pressure vessel. SPERT I, south of TAN, would be modified for the this phase.

The other phase would consist of the LOFT project and take place at the Flight Engine Test facility (FET) at TAN. New facilities would be constructed and some existing facilities modified and adapted.[198] This phase would simulate loss-of-coolant (or loss-of-fluid) accidents, in which a coolant pipe would rupture. The test would deliberately initiate a rapid accumulation of heat in the reactor core and cause a subsequent release of fission products from the melting fuel. This accident was considered highly improbable to occur in a commercial reactor, but nevertheless it was posited as a worst-case accident and referred to as the "maximum credible accident."

The Power Burst Facility (PBF)

The PBF program advanced beyond the capabilities of the SPERT reactors. It was equipped to examine in great detail how fuel reacted under accident conditions. The reactor produced intense bursts of power capable of melting (and thus destroying) samples of fuel without damaging the rest of the assembly. A loop carrying pressurized water through the core of the PBF reactor permitted the testing of irradiated fuel samples containing highly radioactive fission products in a controlled environment.

The research and experiments conducted during these programs extended the information base upon which safety criteria, procedures, and regulations were developed. The PBF was scheduled for a series of forty tests.[199]

Construction of the PBF complex began near the old SPERT-I site on October 1965 and was completed in October 1970.[200] The single-story PBF Control Center building, made of pumice block, was located at the SPERT-I control area. The reactor console was in this building. The Reactor Building, about half a mile from the control building, was 119 feet x 82 feet and had two annex

[198] "Test Area North," *Nuclear News*, May 1969.

[199] *Power Burst Facility* (Idaho Falls: Prepared for the U.S. Department of Energy's, Idaho Operations Office by EG&G Idaho, Inc. no date).

[200] SPERT-I was decommissioned in 1964.

wings, a main reactor room, basement, and a sub-reactor room.[201]

The complex included a variety of support and auxiliary buildings, including a well house, substation, fabrication and development building, storage warehouses, emergency generator building, and others. Many of these buildings remain in use. Additional buildings were constructed in the PBF area after the PBF experiments ended and mission of the PBF area changed.

The PBF had an open-tank reactor vessel, a driver core region where the test fuel was located, and a loop coolant system. The loop coolant system provided temperatures and pressures typical of pressurized water reactors. The water in the open pool provided cooling. The main core, usually referred to as the driver core, was fueled with 18.5% enriched uranium-235 contained in approximately 2,400 fuel rods, grouped in assemblies containing 28 to 64 rods each.[202]

PBF achieved its first criticality on September 22, 1972. Subsequent experiments supplemented the tests carried out in the LOFT phase of the program. The Power Burst Facility shut down after completing it's mission. It is currently inactive.

Significance of the PBF

The PBF was a one-of-a-kind facility. It was the only reactor in the world where severe fuel rod burst tests were performed, where rapid power changes were performed on the order of milliseconds, and where loss-of-coolant accidents could be simulated within a special assembly that fit inside the main reactor core. Like the SPERT series, it advanced the safety of commercial power reactors.

Loss-of-Fluid Test (LOFT)

The Loss-of-Fluid Test was commissioned in 1962 when Congress authorized $19.4 million for the project.[203] The Phillips

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[201] A.A. Wasserman, et al, *Power-Burst Facility (PBF) Conceptual Design* (Idaho Falls: Phillips Petroleum Report No. PTR-590, no date).

[202] *Power Burst Facility* (Idaho Falls: EG&G), n.p.

[203] *A Historical Brief of the LOFT Project at the Idaho National Engineering Laboratory* (Idaho Falls: Aerojet Nuclear Company, December 1975), p.1. Hereafter cited as "*LOFT Historical Brief.*"

Petroleum Company was the major contractor when construction started in the fall of 1964. The original plan for LOFT was to study a single, full power, loss-of-coolant accident that would cause a full melt down of the reactor core. The concept for the test was the question: "What is the life of all the components of a commercial reactor and how good are they?" Components included the pumps, valves, pipes, conversions to power, and all the other gadgetry involved in a reactor. A fair test was thought to require a full-scale model of a commercial reactor using commercially available components, not the highly engineered and specialized components used by engineers doing research.

The experiment was scheduled for completion in 1967, but the project was redirected and changed several times because of debates in the nuclear industry about what kind of testing would be most useful and valuable. Eventually, it was decided that a test of safeguards intended to prevent a loss-of-coolant accident would be more valuable than a test of components, for which other testing techniques had arisen. Revising the test objective required time to modify the designs. By 1968, all construction had stopped in order to await redesign instructions. Frequent stop-starts caused by design lags, contractor problems, changes in management, the need for more funds from Congress, a labor strike, and other problems, occurred until the summer of 1976, when the facility was at last ready to have the core loaded into the reactor.[204]

LOFT employed a scaled-down model (50,000 thermal kilowatts, one-fiftieth the size of a commercial reactor) of a commercial power reactor. It was placed inside a steel-and-concrete containment building (TAN-650) located just east of the ANP's hangar control building (TAN-630). The experiment was mounted on the Mobile Test Assembly (MTA), a dolly pulled by a shielded locomotive over the four-track rails, so it could be shuttled between the containment building and the TAN Hot Shop for post-test analysis. (In actual practice, however, the LOFT reactor was not moved in and out of the building.) LOFT also required a service building, control and equipment building, large storage building, radioactive waste tank building, electrical equipment, water wells, a liquid waste disposal pond, and other support facilities.[205]

In conjunction with the revamped LOFT project, non-nuclear tests known as "semiscale" were underway elsewhere at TAN. The

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[204] See *LOFT Historical Brief.*

[205] For a full description of the planned LOFT site see *Preliminary Site Evaluation Report LOFT Facility* PTR-544, Phillips Petroleum Company, 1963.

semiscale apparatus consisted of a small reactor mock-up equipped with an emergency core cooling system (ECCS). (An ECCS was a system intended to flush coolant into a reactor core in the event that an accident interrupted the flow of the normal coolant.) Previous tests had suggested that water in the ECCS did not circulate as designed. Critics of the nuclear industry argued that the tests proved that emergency cooling systems would not work and that commercial reactors were at risk of releasing catastrophic amounts of radioactivity to the environment. The semiscale tests thus became part of the national debate over the safety of commercial nuclear power plants.[206]

Each LOFT experiment required time to construct and set up. The reactor vessel was installed on the MTA on November 6, 1972; the steam generator was set in place in December. In November 1973, the MTA moved into the LOFT containment vessel. During 1975, workers conducted functional testing of the LOFT systems. Non-nuclear large-break loss-of-coolant accidents (known as the L-1 series) took place from 1976 to 1978. At last, LOFT's first nuclear experiment began at the end of 1978 and continued into 1979 and 1982 as the L-2 series of nuclear large-break loss-of-coolant accidents.[207]

The containment building was a new domed building. Its substantial 200-ton doors were ready to withstand the force arising from a flash to steam when coolant was withdrawn from the reactor core. To begin the first simulation in December 1978 scientists opened a valve to imitate a "large break" in the cooling pipe. It was over in thirty minutes. The scientists learned that water flowed into the reactor vessel faster than it was expelled in the crucial first seconds after the "break," which kept the core cooler than they had expected.

Before a second test could be arranged the following May, an accident at a commercial nuclear power plant at Three Mile Island (TMI) in Pennsylvania caused a partial meltdown of the reactor core. LOFT scientists altered their work schedule and used their models (Semiscale) and computer programs to help determine how a potentially dangerous hydrogen bubble inside the TMI reactor could be dissipated. When the crisis was over, LOFT returned to its own test program, but as a result of TMI accelerated its study of "small breaks." The TMI experience had demonstrated that these, combined with the inappropriate intervention of human

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[206] U.S. Department of Energy, *Human Radiation Experiments: The Department of Energy Roadmap to the Story and the Records* (Washington, D.C.: Assistant Secretary to Environment, Safety and Health, February 1995), p. 96.

[207] *LOFT Historical Brief.*

operators, potentially could be as dangerous as larger coolant-flow breaks.[208]

In 1982 federal financing for the LOFT experiment ran out after thirty tests. An international consortium arranged to fund several more tests, including the last one in 1985, when scientists tried to simulate the TMI accident and melt the core. The test (numbered LP-FP-2) was performed with a specially insulated center fuel module that was the subject of the test. The main core was set up as a driver core, which created the desired experimental environment in a central fuel module. The center fuel module was the only portion of the core that simulated the "small-break" loss-of-coolant accident that occurred at TMI. The driver core of LOFT did not melt, nor did it experience conditions much different than normal operating conditions. The temperature rose to 4,000 degrees F., but the core did not melt. The safety system operated to flood the core and cool it off. After the analysis of this last experiment, the LOFT program ended in 1986.[209]

Significance of LOFT

The significance of the LOFT tests can hardly be overstated in the history of the nuclear power industry. A coincidence of historical timing linked the long-planned tests of reactor safety with the real-world accident at the TMI plant. The final LOFT tests validated the effectiveness of the safety systems that had been built into the TMI and other nuclear power plants.

The buildings associated most importantly with LOFT are the containment building (TAN-650) and the aluminum building (originally made to protect the ANP reactors from the weather) recycled as an entry into the containment building (TAN-624). The LOFT building should be preserved in place as an exceptionally significant part of American nuclear history.

SubTheme: *Commercial Reactor Safety*
INEEL Area: Experimental Dairy Farm

Studying the Effects of Radioactive Fallout: 1957-1970

[208] Bob Passaro, "TAN has Colorful, Secretive Past, to be mothballed by 2000," *Post Register*, May 15, 1994, p. H-12. The damaged core and tons of other contaminated waste from TMI was sent to the Site for analysis and study.

[209] Stacy, *Hangar HAER*, p. 62.

Not all nuclear research at the NRTS took place at reactors. With the growing frequency of the destructive types of tests done at SPERT, the Health and Safety Division of the AEC's Idaho Operations Office felt it would be wise to understand the potential health impacts of the radioactive releases that accompanied such tests. In the event of a large accidental release, the NRTS wished to be prepared with a plan of action aimed at protecting site employees and persons off-site and downwind of the release.[210]

The Health and Safety division initiated a program called Controlled Environmental Radioiodine Tests (CERT). Related issues and concerns included the potential impact of radioactive releases at nuclear power plants operating at normal conditions. At the time little was known about such effects. Even less was known about the impact of accidental releases. The CERT program used radioactive Iodine-131, one of the release products in destructive reactor tests, and gathered data on how it moved through the food chain in areas on and adjacent to the NRTS.

The Health and Safety Division already had previous experience during the early 1950s monitoring radioiodine in wildlife, natural vegetation, and on nearby farms and ranches. A number of studies had been made on the local jackrabbit population. In 1958 thyroid measurements were taken from two goats pastured near the Chemical Processing Plant (discussed below) for several days. The CERT program extended these studies, collecting its data under more controlled conditions.

The experiments involved releasing clouds of radioiodine over specific locations to answer certain questions. For example, the first tests examined what percentage of the radioiodine accumulated in the soil, grasses, and other vegetation and what percentage drifted off into the airshed. Then, when cows grazed on the grass, what percentage of the radioiodine was excreted and how much went into the cow's thyroid or milk. A final question involved determining what percentage of the material would end up in a human thyroid after drinking the cow's milk.[211]

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[210] Stacy, *Proving the Principle*, p. 167.

[211] John R. Horan, editor. *Annual Report of the Health and Safety Division, Idaho Operations Office* (Idaho Falls: 1958), p. 95; D.F. Bunch, editor. *Controlled Environmental Radioiodine Tests, Progress Report Number Three* (Idaho Falls: Health and Safety Division, Idaho Operations Office, US AEC Report IDO-12063 1968), p. 2-4; *Human Radiation Experiments: Department of Energy Roadmap to the Story and The Records* (United States Department of Energy, Assistant Secretary for Environment, Safety and Health Report No. DOE/EH-0445, February 1995.)

To gather data on the human thyroid, the experiments had to involve volunteers who would drink the milk and then be measured for the iodine. The first experiment using cows and humans was conducted in May and June of 1963. Because permanent facilities were not yet available, CERT I took place on the "open range," an unirrigated section of land near the southern boundary of the NRTS. A temporary barn, corral, and control trailers were placed in the area on temporary foundations. Two pasture areas were established, one "hot," or radioiodine-contaminated and one "cold," where the cattle could be grazed prior to the experiment. Seven human volunteers drank the contaminated milk. Their thyroid activity was measured over a six-week period.[212]

The Experimental Dairy Farm, located about seven miles northeast of the ICPP, was built during the summer of 1963. The site was selected for its location relative to reactors and roads, water availability -- an adequate well already existed -- and because the land was unused and available. The farm was intended to duplicate regional farming methods. Facilities included a dairy barn, pumphouse, sprinkler system and corral. A twenty-seven acre pasture was established, and grass seed was planted.

The CERT experiments waited until the following September when the grass had matured. Six cattle were again grazed on the hot pasture following the release of radioiodine. Humans again participated in drinking contaminated milk. Related experiments measured thyroid activity following inhalation of I-131 by three people who sat in the pasture as the radioiodine cloud passed over it.[213]

Later experiments measured radioiodine deposits and dispersion under various weather conditions and in different seasons or times of day. In 1967 the experiments were modified to provide more detailed information. Stalls built in the barn allowed individual monitoring of each cow's water and feed. Careful measuring of feed and use of a "chopper" allowed more accurate measurement of iodine dosage than was possible when cattle grazed freely. These refinements reflected the growing

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[212] C.A. Hawley, et al, *Controlled Environmental Radioiodine Tests, National Reactor Testing Station* (Health and Safety Division, Idaho Operations Office, US AEC Report NO. IDO-12035, 1964), p. 2-10; C.A. Hawley, editor, *Controlled Environmental Radioiodine Tests at the National Reactor Testing Station, 1965 Progress Report* (Health and Safety Division, Idaho Operations Office, US AEC Report No. IDO-12047, February 1966) p. 2.

[213] Hawley, IDO-12047, p. 4-5.

sophistication of the investigation.[214]

The CERT program contributed to the worldwide efforts of scientists to learn more about the environmental effects of nuclear power plant operation. Previous studies at Hanford, Washington, and Oak Ridge, Tennessee, had provided some information about the dispersion of radioiodine, but the field and laboratory studies at the NRTS were more comprehensive. They provided data for computer models that predicted the transfer of iodine through the food chain to milk and subsequently as doses to human beings. The CERT study helped, in fact, to illuminate the key role of the food chain in the transfer of radioiodine and other substances. CERT data laid a basis for understanding the impacts of releases that might occur after an accidental release. CERT provided some of the most comprehensive and useful data available in the United States or anywhere else. The findings, in conjunction with data from other studies, helped scientists realize that the allowable releases of radioactive materials from nuclear power plants had to be reduced. CERT studies eventually led to regulatory changes reducing such discharges from light-water reactors.[215]

Two buildings related to CERT are extant, the barn (B16-603) and a pumphouse (B16-604). The barn has been converted for use as a storage building. They are a remnant of a frontier-like period in nuclear research when the impact of radionuclides on human health through the food chain and direct inhalation involved people and animals, helping to set parameters for future computer modeling, commercial reactor operations, and emergency planning.

[214] J.D. Zimbrick and P.G. Voilleque, editors, *Controlled Environmental Radioiodine Tests at the National Reactor Testing Station, Progress Report Number Four* (Health and Safety Division, Idaho Operations Office, US AEC Report NO. IDO-12065, January 1969), p. 2, 5.

[215] J. Newell Stannard, *Radioactivity and Health, A History* (Hanford, Washington: Pacific Northwest Laboratory, 1988), p. 1358.

SubTheme: *Chemical Reprocessing*
INEEL Area: Idaho Chemical Processing Plant

Establishment of the Chemical Processing Plant: 1949-1954

The Idaho Chemical Processing Plant (ICPP, or Chem Plant) was designed by the same group of physicists and chemists who had designed the MTR. As a companion facility for the MTR, it was equipped to receive the MTR's spent fuel elements and extract valuable U-235 from them. The spent fuel contained radioactive elements such as Strontium-90, Cesium-137, and other substances dangerous to human life. At the end of extraction process, the ICPP shipped the recovered U-235 to Oak Ridge, Tennessee, for further steps leading to the remanufacturing of fuel elements. The uranium was not a hazard, but the ICPP had to store or otherwise dispose of the dangerous materials left behind.[216]

The ICPP was one of the four original areas developed at the NRTS. Although its originators conceived it as an auxiliary to the MTR -- to recover the uranium in its highly enriched fuel -- its mission expanded to include processing of spent fuel from other sources. With the escalation of tensions between the United States and the Soviet Union, aggravated by the Korean War, the AEC shifted the majority of its resources to developing atomic weapons. The plutonium-producing reactors at Hanford, Washington, sent some of their spent fuel to Idaho.[217]

During normal operations, the MTR shut down every 17 days to remove its depleted fuel. By this time, less than a fourth of the U-235 had fissioned, leaving a substantial amount of U-235 in the fuel elements. Rather than discarding this costly material, it was possible to extract it from the aluminum cladding and other substances that had accumulated in the fuel in order to re-use it for new fuel elements.[218]

Establishing the Chem Plant required hiring and training its operators and then running "cold" operations with simulated waste to test the facility. After that, the first hot runs began processing spent Hanford fuel on February 16, 1953, with fewer than 100 employees.[219]

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[216] The ICPP was renamed Idaho Nuclear Technology and Engineering Center (INTEC) in 1999. This report will use the historic name.

[217] Stacy, *Proving the Principle*, p. 94-97.

[218] Stacy, *Proving the Principle*, p. 69.

[219] Stacy, *Proving the Principle*, p. 101.

The Modified PUREX Process

Uranium was extracted from the fuel elements in a multi-step chemical treatment process known as a modified PUREX (**P**lutonium and **UR**anium **EX**traction) process. (The PUREX process had been developed during the Manhattan Project.) The fuel was dissolved in a solution of nitric acid. This liquid then was "run" by steam-jet suction through three extraction processes or "cycles," in which chemical additives, catalysts, and mechanical actions produce a sequence of chemical reactions resulting in the separation of uranium from the other metals, acids, and fissionable products in the solution. "Waste" products -- solids, gases, and liquids -- accumulated upon completion of each cycle. The uranium product was then shipped to Oak Ridge, where it was further prepared for remanufacture into new fuel elements.[220]

Siting and Designing the ICPP

The ICPP was located to be convenient to the MTR and to the CFA. Initially consisting of 82 acres, the plant was located about three and a half miles north of the Central Facilities Area and on the east side of Lincoln Highway. The TRA is another mile and a half further northwest on the west side of the highway.

The Foster-Wheeler Company designed the plant. The Bechtel Corporation built it. The first operating contractor, American Cyanamid, managed construction, recruited and hired operating personnel, and developed the first operating manuals. On October 1, 1953, Phillips Petroleum Company took over the plant and continued managing it until 1966, the first in a series of five operating contractors.[221]

The plant buildings were contained mostly within the

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[220] For a more detailed description of the ICPP's modified PUREX process, see Brewer F. Boardman, *The ICPP (A Factsheet)* (Idaho Falls: Idaho Operations Office, 1957). For a general description of the plant and its operations, see R.B. Lemon and D.G. Reid, "Experience With a Direct Maintenance Radiochemical Processing Plant," *Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Volume 9* (New York: United Nations, 1956), p. 532-545.

[221] Succeeding operators were Idaho Nuclear Corporation, 1966-1971; Allied Chemical, 1971-1979; Exxon Nuclear Corporation, 1979-1984; Westinghouse Idaho Nuclear Corporation, 1984-1994; Lockheed Martin Idaho Corporation, 1994-present.

rectangular perimeter boundaries of a security fence. By no means did these consume the entire 82 acres; the designers planned for growth and expansion. Today the perimeter fence encloses 210 acres, and an additional 55 acres lie outside the fence.[222]

One way to identify the main features of the site is to follow a shipment of fuel as it arrived at the ICPP gate. The fuel arrived packed in heavily shielded transport casks carried in specially equipped carrier trucks or by rail. After passing through the main guard gate at the west side of the plant, the truck headed south about a third of a mile away to CPP-603, the Fuel Storage Facility, isolated from the main activity area for safety. The truck entered special bays for the transfer operation. Unloading of the fuel to one of two transfer basins was handled remotely. The fuel elements were placed in stainless steel buckets, suspended from overhead racks, and the whole apparatus placed in a water-filled basin. At least 15 feet of water was above the submerged fuel at all times. This water was recirculated and refreshed daily, the overflow going to a percolation pond just to the south of CPP-603 and on the outside of the perimeter fence. The Fuel Storage Facility had its own heating and air cleaning system and its own generator for emergency power supply. Water came from the main plant source, but was metered and filtered with separate equipment. The structural steel building was covered with Transite siding. Before arriving at the ICPP, the fuel typically had had at least 90 days of cooling time. Here it cooled off for another 120 days or more.

When the proper time had elapsed and the operators had accumulated sufficient fuel to "run" the extraction process at the Fuel Processing Complex (CPP-601), a "straddle carrier" transferred the fuel to the "head end" (south end) of CPP-601. The first step was to dump the fuel element into a vessel of nitric acid to dissolve it -- cladding, fuel, and all. From there it went via a complex system of piping from one process cell to another, each step producing various waste products. Each product in this waste stream required treatment before it could be released to the atmosphere or stored. All vessels and piping were sized (small) to prevent the accidental accumulation of a critical mass of fissionable fuel.

The process complex was designed for direct maintenance. This meant that during periodic shutdowns, workers could decontaminate work areas and perform maintenance tasks on the equipment. A minimum of moving parts made for simplicity, although essential items such as transfer jets, valves, and pumps

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222 "*Land Use Information*, www.inel.gov/resources/flup/icpp.html.

were installed in pairs, one being a spare. High-maintenance equipment was placed in crew-accessible lead-shielded cubicles outside the hot process cells. Cleaning solutions were sprayed into the cells, flushed out, and then entered by maintenance personnel via ladders.

The portion of the building above grade contained no uranium-processing equipment. It was constructed of steel framing and insulated with Transite siding. Chemicals added to the process feed were stored in tanks on this level.[223]

Waste products left the process building in underground pipes eastward to the Waste Treatment Complex, which included three main waste processing buildings and a tank farm. One of the buildings (CPP-604) housed the equipment necessary to recover Krypton-85 gas and generally reduce the volume of waste. Another (CPP-605) housed blowers which provided vacuum to process cells and exhausted filtered off-gases to the 250-feet tall main stack (CPP-708). The Complex recovered all of the nitrogen and oxygen needed at the ICPP and other parts of the NRTS site. Further east of the Waste Complex -- downwind of operations -- was the 250-foot stack.[224]

North of the Waste Treatment Complex is the Waste Tank Farm, constructed in 1953. Buried here were two 300,000-gallon stainless-steel tanks for storing high-level radioactive liquid wastes. Each was enclosed in a concrete vault and buried under ten feet of earth. One tank, which received the very "hot" first-cycle waste, was equipped with cooling coils; the other was not. A large empty area was left near these two tanks for future expansion. This restricted area contains structures housing instrumentation for monitoring the contents of the tanks.

The rest of the site was developed to complement and serve the main process. A laboratory and administrative building (CPP-602) adjoined the process building on the north. This building contained offices, cafeteria, health physics services, first-aid facilities, low-level and high-level laboratories, and a machine shop. A service building (CPP-606) at the north side of the laboratory housed the steam plant, electrical equipment, and ventilating equipment for the laboratory buildings. This too was built of structural steel and sided with Transite. Outside the

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[223] The progress of fuel to be reprocessed is extracted from "Chemical Processing of Reactor Fuel Elements at the Idaho Chemical Processing Plant," *Proceedings of the Geneva Conference* (New York: United Nations, 1955), reprint pages 14-23.

[224] R.D. Logan, *INEL Building Study, Idaho Chemical Processing Plant* (Idaho Falls: INEL Energy Management, 1990), p. 33-36.

perimeter fence on the northeast side was the sewage lagoon for sanitary wastes.[225]

As the ICPP was designed to be a "multi-purpose" plant, it was adapted from time to time to improve or perform specialized functions. One of them was the recovery of radioactive Barium from day-old MTR fuel. The L Cell in CPP-601 -- with extra thick concrete shielding -- contained centrifuges and other equipment related to this process and also to the handling of the off-gas byproducts. The researchers hoped to find a way to precipitate only the target element from a more complex solution. A Fuel Element Cutting Facility was attached to CPP-603 near the railroad siding to aid in the handling of fuel casks and fuel elements.[226]

The operation of the plant and its processes required substantial quantities of water. This was pumped from the Snake River Plain aquifer into two 500,000-gallon storage tanks at the north end of the site. As needed, water was demineralized or otherwise treated depending on its particular use.

The Role of the ICPP in the Cold War

As the Cold War and the arms race progressed, the United States poured its resources into weapons development, striving to assure its supremacy. Elsewhere in the country, the AEC's plutonium-production reactors were expanding. At the NRTS, all research missions bent to the compelling needs of national defense. From its original mission of reprocessing only MTR and Hanford fuel, the ICPP was adapted for more flexibility as a multiple-purpose processing plant. Eventually, it would process fuel from a wide variety of research, test, propulsion, and power reactors. In addition to aluminum clad fuels, it would dissolve fuels clad in zirconium, stainless steel, and other materials. It handled fuel from EBR-1, BORAX, and other experiments around the NRTS site.[227]

ICPP Adds New Processing Functions: 1955-1970

By the deliberate effort of Congress and the AEC, the supply

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225 "Chemical Processing of Reactor Fuel Elements at the Idaho Chemical Processing Plant," *Proceedings of the Geneva Conference* (New York: United Nations, 1955), reprint p. 19

226 *Thumbnail Sketch* 1956, p. 6.

227 *Thumbnail Sketch* November 1958, p. 15.

of spent fuel was destined to grow as a consequence of reactor development. Congress passed the Atomic Energy Act of 1954, and the AEC and Congress's Joint Committee on Atomic Energy did what they could to nurture a commercial atomic power industry. The US Navy launched the USS *Nautilus* submarine in the 1950s and then built a large fleet of ships propelled by nuclear reactors. Shippingport, an AEC demonstration reactor, went on line in Pennsylvania in 1957, the first large reactor to be built for civilian purposes. Research programs at the NRTS tested the safety limits of reactor fuels and core constructions. General Electric and Westinghouse scaled up the demonstration and began to sell reactors to electric utility companies. A commercial industry began to grow. Clearly, this success meant that spent fuel would need reprocessing.

With every processing run at CPP-601, a stream of high-level waste inevitably flowed into the stainless steel tanks at the ICPP tank farm. After the first one was filled, another was made ready, and then another. By 1960, 13 tanks populated the ICPP's tank farm. Nine 300,000-gallon vessels held aluminum-type wastes; the other four each held 30,000 gallons of zirconium and stainless steel. Awash in a million gallons of liquid were only ten gallons of radioactive material.[228]

Scientists knew that metal tanks could not serve as a long-term method for storing the waste. They regarded the life of a stainless steel tank to be no longer than 50 years because the acids from within or moisture from without would eventually corrode the metal. The hazard they wished to avoid was to have the radioactive liquid leak into surrounding soils and ground water. Far more than 50 years were required to sequester the waste -- several centuries would have to elapse before the process of radioactive decay could reduce the hazard potential significantly.[229]

Chemists in the AEC's national laboratories therefore launched investigations into "interim" and "ultimate" disposal of these wastes. One of the concepts for dealing with the growing volume of liquid waste was to transform it somehow into a dry

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[228] To Senator Henry Dworshak from John B. Huff, August 21, 1958; Senator Dworshak Papers, Box 83, File "AEC--Idaho Plant." Also, "Idaho Falls: Atoms in the Desert," *Chemical Engineering* (January 25, 1960), p. 5 (of reprint.)

[229] The half-life of Strontium-90 is 29 years; of Cesium-137, 30 years. A half-life is the time required for one-half of the atoms of a radioactive substance to disintegrate. The process is independent of temperature, pressure, or surrounding chemical conditions.

solid, eliminating the water. This meant designing a process that would concentrate radioactive substances into a dry form, leaving the water clean enough to discharge into the environment. This could be an "interim" step in storing the waste. The volume could be reduced and the hazard of corrosion and leakage minimized. It was also conceivable that the solid form might be rendered even more inert or stable using processes as yet unproven.

Scientists proposed several ideas for transforming liquid into an inert solid-carrier waste. A 1954 study from Brookhaven National Laboratory suggested that radioactive ions could be made to adsorb and fix upon montmorillonite clay. Other studies proposed fixation in ceramic glazes or "gelling" liquids above the sludges that form in the tanks. Various techniques for solidifying the waste included pot calcining, radiant heat-spray, and rotary-ball kilns. Some proposed to incorporate the wastes into low-melting salts and store the material in underground salt caverns equipped to remove heat. Another optimistic hope was that some breakthrough chemical means of decontaminating the radioactive constituents might be found. At Oak Ridge National Laboratory, workers were investigating the possibility of mixing waste with shale, limestone and soda ash and allowing decay heat to fix the material in a ceramic mass. Still other proposals sidestepped the problem altogether and proposed to discharge it into the oceans or outer space.[230]

The Waste Calcining Facility (WCF)

The first liquid-to-solid procedure that the AEC decided to fund for actual demonstration, however, was the "fluidized-bed calcination process," built at the ICPP. The development program began in 1955. Originally conceived by scientists at Argonne National Laboratory, the method was first tested using small-scale models and then built by Phillips Petroleum at the ICPP. The process not only solidified the waste, but the solid was granular, free-flowing, and easily handled by pneumatic transport techniques. Phillips engineers proposed early conceptual designs

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[230] See W.S. Ginnell, J.J. Martin, and L.P. Hatch, "Ultimate Disposal of Radioactive Wastes," *Nucleonics* (December, 1954), p. 14-18; "Outlook for Waste Disposal," *Nucleonics* (November 1957), p. 155-164; *The Waste Calcining Facility at the Idaho Chemical Processing Plant*, pamphlet, no date, no author, p. 2; Joseph A. Lieberman, "Treatment and Disposal of Fuel-Reprocessing Waste," *Nucleonics* (February 1958), p. 86; and J.I. Stevens, et al, *Preliminary Process Criteria and Designs for Waste Calcining Facilities at the Idaho Chemical Processing Plant* (Idaho Falls: Phillips Petroleum Company Report No. PTR-177, February 25, 1957), p. 5.

for the process in 1956.[231]

The concept of fluidized bed technology was not new. It had been applied in the petroleum, iron and steel, and limestone industries. As applied to liquid radioactive wastes at the WCF, it involved placing a bed of sand-like granular material at the bottom of a cylindrical vessel -- the calciner vessel. The grains are then heated to temperatures of 400 degrees C or more by a heat exchanger placed directly in the bed. A flow of hot air was introduced into the bed through fourteen holes at the bottom of the vessel and evenly distributed to the grains, placing the grains in motion, or "fluidizing" them. Liquid waste was fed as a fine mist into the vessel by pneumatic atomizing spray nozzles. In the hot environment, the water vaporized and the solids adhered to the small starter grains tumbling around in the fluidized bed. As the process continues, the solids knock against each other, causing particles to flake off and form the starter grains for the continuously sprayed liquid feed.

Congress appropriated funds in 1957 for the early phases of the WCF design. The AEC awarded a contract to Fluor Corporation to be architect/engineer for the project. In 1958, the AEC asked Fluor to complete and construct the system. The facility cost about $6 million. Fluor commenced construction in 1958 and completed the facility in 1961. Phillips took control of the building and began two years of "cold" trouble-shooting operations using simulated waste.[232] Hot operations began with the first run, called a "campaign," on December 23, 1963.

The WCF expanded the ICPP area to the east. The building (CPP-633) was placed southeast of the stack, where room still further east was available for the special tanks that would store the calcine. The building handled the entire process, receiving its fluid feed from underground piping extended from the main process building. The dry calcine -- called *alumina* -- exited the

[231] See C.E. Stevenson, et al, *Waste Calcination and Fission Product Recovery Facilities--ICPP, A Conceptual Design* (Idaho Falls: Phillips Petroleum Company Report PTR-106, August 2, 1956); and D.R. Evans, *Pilot Plant Studies with a Six-Inch Diameter Fluidized Bed Calciner* (Idaho Falls: Phillips Petroleum Company Report No. IDO-14539), p. 2.

[232] News release from Idaho Operations Office of the AEC, February 5, 1957; Senator Dworshak Papers, Box 74, File "Legislation--AEC--Idaho Releases." See also "Fluor Gets Contract to Complete Calcination System," *Nucleonics* (November 1958), p. 27; and L.T. Lakey, et al, *ICPP Waste Calcining Facility Safety Analysis Report* (Idaho Falls: Phillips Petroleum Company Report No. IDO-14620, 1963), p. ii-1.

facility propelled by pneumatic pressure to storage facilities called "bin sets" about a hundred feet east of the building.

Each bin set contained from three to seven vertically positioned stainless steel tanks. Partially above grade level, they were shielded by an earthen berm. On top of each bin set was an "instrument shack" and other devices designed to monitor the accumulation of waste heat and detect leaks or other problems. Seven bin sets have been constructed at the site. Experience with calcine led to modifications of the earliest bin set design. It was not known just what products in the solid might prove to have future value, so the storage containers were designed so that the calcine could be retrieved for some future purpose. All operations had to take place so that radioactive particles could not enter the air or water supply.[233]

The over-riding imperative guiding the design of any process dealing with hazardous radioactive waste is to protect workers from danger. The calcining building followed the same principles that had been implemented in the design of the Fuel Processing Complex (CPP-601). Process equipment was decontaminated using automated methods, and then maintained "directly" by crews. Radioactively hazardous areas were located below grade, while the non-radioactive service areas were on the ground floor.

The WCF building contained everything required for the calcining process except for the tanks that stored fuel oil and the bins that would store the calcined product. Filtered off-gases went up the main stack, and other wastes were sent through the calciner along with the fresh liquid feed.

The ICPP Operating Routine

With the calciner the ICPP had two major chemical processing operations underway. Phillips established a routine whereby the two processes alternated their "run" operations. While the main processor operated, a crew decontaminated and maintained the calciner. Likewise, when the calciner ran, the main processor was shut down for repair and cleaning. A traveler on Highway 20, just outside the NRTS site, could always tell when the calciner was operating because the stack exhausted an orange-yellow plume of nitric oxide gas, a byproduct of the calcine operation.

A range of laboratories complimented the site. In analytical laboratories, chemists routinely examined samples of solutions from various stages of chemical processing. They checked for uranium isotope content, acidity, and other parameters. To

[233] PTR-177, p. 7-8.

accommodate the type of analysis required, laboratories were "hot," "warm," or "cold," and designed accordingly. In addition, some laboratories were devoted to "wet" chemistry, examining primarily liquid solutions. Equipment such as mass spectrometers and x-ray devices sometimes required special enclosures or shielded cells.

Meanwhile, in the ICPP laboratories, chemists and engineers conducted tests and studies aimed at increasing the productivity and effectiveness of each process. One of the problems with the calciner, for example, was that the fluidized bed was heated by means of a circulating loop of NaK, a sodium-potassium eutectic alloy. Unplanned plant shutdowns frequently occurred because of leaks in the NaK piping. In 1970, in time for the calciner's fourth campaign, the NaK system was replaced by a direct combustion system. Engineers refitted the calciner vessel so that kerosene and oxygen could be sprayed into it. Nitrates from the waste feed would ignite it, placing the heat in intimate contact with the moving particles in the bed. This method supplied steady temperatures of 450 degrees C. Overall, the new system was less hazardous because hydrocarbon fuel piping was more reliable than NaK piping.[234]

Other improvements took place at the main process facility. Better headend equipment was installed for "cutting" fuel elements, reducing the amount of non-irradiated metal cladding dumped into the acid dissolver. A railroad track was built between the ICPP and the Naval Reactors Facility to facilitate the transfer of USS *Nautilus* and other fuels from that area.[235]

By 1959, the ICPP was engaged in a joint project with the United States Geological Service to monitor the aquifer downstream of the ICPP injection wells, into which the plant pumped low-level liquid wastes. Fifteen such wells sampled water downstream.

Failure of Commercial Processing

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[234] C.L. Bendixsen, *Safety Analysis Report for the Conceptual In-Bed Combustion System for the Waste Calcining Facility* (Idaho Falls: Idaho Nuclear Corporation Report No. CI-1119), p. 1, 27; and Bendixsen, *Safety Review Report for the In-Bed Combustion System for the Waste Calcining Facility* (Idaho Falls: Idaho Nuclear Corporation Report No. CI-1175, March 1970), p. 1-2. Nitrates in the waste feed interact with the kerosene to produce more benign nitrogen compounds.

[235] AEC-Idaho Operations Office Press Release, December 7, 1956, in Dworshak Papers, Box 55, File "AEC--Idaho Plant."

ICPP scientists also contributed to the government's effort to develop a fuel processing capability in the growing commercial nuclear power industry. The AEC hoped that private industry would handle fuel from civilian power reactors. In January of 1956, the NRTS sponsored a conference to which 600 representatives from industry were invited to learn more about the costs and problems involved in processing spent fuel.[236]

By 1960, government efforts to encourage a commercial fuel processing facility had failed to have the desired result. Therefore, the AEC reluctantly developed a plan for processing the spent fuel from civilian reactors. Because of the growing variety of fuel, it assigned certain kinds of fuel to each of its reprocessing plants and laid plans to expand the capabilities of the plants. To Idaho, it assigned highly enriched fuels, aluminum clad fuels from forty test reactors around the country, zircaloy-clad, and stainless steel-clad fuels.[237]

Then, still hoping private industry would take hold, it held off making the improvements. However, in June 1961, the AEC signed a contract to process highly enriched U-235 spent fuel from the Vallecitos Boiling Water Reactor in California, a commercial reactor owned and operated by Pacific Gas and Electric Company. The unburned fuel was worth $500 an ounce. In 1963, the ICPP began receiving rail shipments containing 90 percent enriched fuel from the R-2, a test reactor in Sweden.[238]

With an increasing number of reactors, more fuel was on the nations roads and railways traveling farther distances. (The

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[236] W.K. Davis to "Gentlemen," December 1, 1955, letter of announcement in Dworshak Papers, Box 55, File "AEC--Idaho Plant." See also Harold S. Vance, testimony before the JCAE, February 1958, p. 30-31. Copy in Dworshak Papers, Box 88, File "AEC--Committee Reports 1958."

[237] C.E. Stevenson, "How AEC Plans to Process Power Reactor Fuels," *Nucleonics* (February 1960), p. 72-73; and "Two Civilian-Fuel Reprocess Plants to Begin," *Nucleonics* (September 1959), p. 29. The AEC in 1959 began two projects to handle civilian fuels at Hanford and Oak Ridge. To these and a plant at Hanford, it assigned specific types or sources of fuel.

[238] "AEC Takes Two Steps to Encourage Private Industry," *Nucleonics* (May 1960), p. 27; "Fuels Reprocessing: Will Davison Build First Private Plant?" *Nucleonics* (December 1960), p. 23; and AEC Press Release, June 6, 1981, Dworshak Papers, Box 122B, File "AEC Press Releases;" and "US Fuel Back for Reprocessing," *Nucleonics* (August 1963), p. 49.

Swedish fuel took twelve days to arrive from the port of Savannah, Georgia.) Safety requirements for fuel shipping casks became more stringent. Casks became larger and heavier, requiring retrofitting of transport bays, docks, and cranes at the ICPP's Fuel Receiving Facility.[239]

Finally, as commercial power plants went on line all over the country during the 1960s, a private processing plant began operating at West Valley, New York. Although it was subsidized by the AEC, which had guaranteed West Valley a certain amount of fuel at a low price, the plant was not a success. It lost money in each of the six years it operated. The AEC shared with the operators its PUREX formulas, but the contractors were unable to operate the plant safely. The plant operated only until 1972.[240]

Meanwhile, the ICPP continued to adapt its process for new fuels. The main process building was modified in 1973 so it could process the stainless steel-clad elements from EBR-II. The graphite matrix fuels from Project Rover (an effort to use nuclear power to propel a rocket tested in Nevada) eventually came to Idaho, where a new head-end process had to be designed for those fuels.[241]

Peach Bottom Fuel Arrives at the ICPP

During the 1960s, the AEC encouraged the development of a reactor concept in which the coolant was a gas. It built an Experimental Gas-Cooled Reactor at Oak Ridge and then licensed a privately financed demonstration gas-cooled reactor at Peach Bottom, Pennsylvania. Spent fuel from these reactors had graphite cladding, which reacted unacceptably with water. It could not be stored in the underwater basins of the Fuel Storage Building (CPP-603).

Therefore, the ICPP added special dry storage facilities to its landscape. In 1971, the first Peach Bottom fuel was stored in 47 underground steel-lined vaults. Each was 3 feet in diameter, 20 feet deep, and topped with a heavy shielded concrete cover. Later, fuel arrived from the High Temperature Gas Cooled Reactor

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[239] "AEC to Adopt Rules for Shipping Spent Fuel," *Nucleonics* (November 1961), p. 46; "The First Foreign Shipment of Spent U.S.-Supplied Reactor Fuel Arrives in Savannah," *Nucleonics* (September 1963), p. 18-20.

[240] Walter C. Patterson, *The Plutonium Business and the Spread of the Bomb* (San Francisco: Sierra Club Books, 1984), p. 45-46.

[241] *Thumbnail Sketch* 1973, p. 13-15.

(HTGR) at Fort St. Vrain, Colorado. This fuel, and part of the Peach Bottom fuel, was placed in a special concrete building (constructed in 1975) attached to CPP-603. The building had manipulators and storage racks arranged so that an accidental criticality could not occur.[242]

With the arrival of Peach Bottom fuel in 1971, the role of the ICPP rounded itself out not only as the operator of two major processing activities, but also as the warehouser of a wide variety of fuels in both wet and dry conditions. And, of course, the plant contained eleven huge stainless steel tanks of liquid wastes and a gradually growing inventory of calcine bin sets. Thus established, the plant continued to refine its methods, replace aging facilities, and research methods of processing nuclear fuels and the waste it generated.

Significance of the ICPP

Waste Calcining Facility. The significance of the Waste Calcining Facility already has been acknowledged by the preparation of a HAER study. (The WCF was demolished in 1984.) The WCF was the first plant in the world to demonstrate successfully a practical method of transforming liquid high-level radioactive waste into a solid form. The process reduced the volume of the waste by a ratio of up to 10:1. The solid form was easier and safer to transport. The stability of the solid form reduced the likelihood that storage tanks would corrode, causing accidental releases into the environment (as has happened at Hanford and other DOE facilities). The storage containers for solids have a design life of 500 years, whereas the tanks holding the waste in its liquid form had a design life of only 50 years. Further, the process proved adaptable to a variety of chemicals deriving from different types of reprocessed fuels. The success of the WCF has meant a highly significant reduction in risk in managing high level liquid waste at the INEEL.

The quest for a workable calcining process at INEEL began early. Once operating, it continued reliably, and operated regularly. Partly because of it, the INEEL has no record of highly-radioactive liquid waste leaks into the soil or groundwater from tank leakage, a record not shared by the other AEC waste sites. Calcining constituted a significant reason for optimism in the pursuit by scientists of a safe nuclear-fuel cycle. Although the costs of development and operation of the calcining process were high, calcining may prove to have been the lowest-cost long-term choice because it has avoided the much higher cost of remediating serious leaks into the environment.

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242 *Thumbnail Sketch* 1973, p. 16.

Fuel Reprocessing Facility. The other major process of the ICPP is significant for the steady and successful recovery of spent uranium from reactor fuels. Although other facilities in the United States reprocessed spent fuel, the ICPP was equipped and modified to handle certain fuel types uniquely. The ICPP has been an integral part of the operations of the NRTS from its very beginning in 1949. Few of the other facilities at the NRTS could have operated as effectively as they did without the fuel reprocessing, fuel handling, and fuel and waste storage facilities at the ICPP.

CONTEXT V: MULTI-PROGRAM RESEARCH: 1971-PRESENT

SubTheme: *Reactor Testing, Experimentation, and Development*
INEEL Area: Central Facilities Area

CFA and Changing Missions: 1970s-Present

Political upheavals during the 1970s affected how government controlled the nuclear industry. The AEC was abolished, replaced briefly with the Energy Research and Development Administration (ERDA), and then by the Department of Energy (DOE) in 1977. The NRTS changed its name to Idaho National Engineering Laboratory (INEL) in 1974, emphasizing its status as a national laboratory.[1] New environmental laws, the energy crisis, and nuclear power plant accidents obliged the INEL to focus its resources on energy efficiency, nuclear waste cleanup and increased worker safety requirements.

EG&G became the primary Maintenance and Operations contractor of the INEL in 1976. Until about 1979, very little new construction had taken place at CFA -- a few additional storage facilities, utility buildings, and craft shops. Then the pace quickened. In 1979, a new High Bay Lab (CFA-686) and office buildings for Morrison-Knudsen and EG&G were constructed. The old hot laundry facility was remodeled to meet DOE standards for energy efficiency.

Similar changes occurred in the 1980s. New office buildings were needed to deal with health and safety issues: office buildings (CFA-612 and -614), and Hazardous Waste Storage Facility Field Offices (CFA-655). New multicraft shops replaced several outdated facilities.

By 1990 several CFA buildings were forty years old or more. The DOE site manager decided to dismantle many old structures and replace them with new ones. The quality of construction and the heavy-duty materials in the older structures created challenges for dismantlement teams. Those composed of reinforced concrete, especially the structures at the NPG Proof Area, were constructed with rebar that was typically doubled and crisscrossed. Asbestos insulation covered many old pipes and walls. Buried fuel tanks, contaminated water pipes, drainage pumps, and entire buildings required special handling. In the Proof Area, old naval ordnance had to be found and recovered.

Between 1990 and 1995, two new buildings appeared at

[1] Stacy, *Proving the Principle*, p. 217-218.

the CFA: the Core Storage Library (CFA-663), in which geological core samples were stored by the United States Geological Service; and a new office complex called Office #3 (CFA-615).

Beginning in 1995, after Lockheed Technologies became the consolidated contractor for the INEL, construction continued. Several old facilities were replaced and new ones constructed in connection with waste processing activities. Most were prefabricated metal structures. A new Transportation Complex (CFA-696), Medical Dispensary (CFA-1612), Fire Station, pumphouse and concrete-slab training facility (CFA-1611, -1603, -1606), and more offices (CFA-1608 through -1610) were completed. New chlorine injection facilities (CFA-1601) and waste water labs (CFA-1605) reflected the INEL's emphasis on environmental remediation. A Health Physics Instrument Laboratory (CFA-1618) was completed in 2002.[2]

Significance

As a centralized service center for contractors elsewhere at the INEEL, the CFA typically was not the scene of scientific discovery or historic breakthroughs in nuclear knowledge. Its labs, shops, transportation terminals, personnel services, storage warehouses, utility centers, and administrative offices all supported experiments elsewhere. As scientific inquiry shifted from nuclear reactor concepts and safety to waste remediation, CFA facilities shifted the burden of their support accordingly. Compelling demands by DOE to operate with energy efficiency and without excessive maintenance costs dictated that obsolete buildings be replaced.

Aside from changing missions, the extant buildings at CFA also reflect national trends in industrial vernacular architecture. When DOE mandated that all of its facilities reduce their energy consumption after the oil shortages of the early 1970s, vendors had to supply buildings that would meet new energy efficiency standards at costs low enough to win bids. Invariably this meant that pumice block, wood frame, and brick veneered buildings became a thing of the past. Prefabricated all-metal buildings tended to meet construction and energy conservation standards at lower costs.

Office buildings CFA-612 and CFA-614, built in the

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[2] Hollie Gilbert, "Building/Structure" Data Base, 2003 version.

1980s, are among the few buildings on the entire INEEL site to meld a defined architectural style (International and Contemporary) with the functional nature of industrial structures.

The blending of old NPG military structures in a setting with later nuclear-era buildings offers a rare opportunity to examine a landscape shaped by the federal government and its civilian contractors. The CFA exhibits the adaptation and reuse of military buildings and residences. The contrast between the Navy's approach to housing its employees on-site -- providing them with permanent housing, landscaping, and trees -- contrasts sharply with the AEC's determination not to house its employees on- or off-site and not to construct permanent buildings. Yet both the Navy and AEC were engaged in government-financed scientific experimentation and testing. Each created similar clustering of activity in this desert environment.

Because of the rarity of World War-II era military housing located in its original site, the extant NPG buildings are recommended for HABS/HAER-level documentation. These buildings are also historically significant because the NPG was one of only a few sites in the United States where military weapons research occurred and one of the few military sites of any kind in Idaho. They have survived adaptation and reuse in the nuclear era.

SubTheme: *Reactor Testing, Experimentation, and Development*
INEEL Area: Argonne National Laboratory West

The End of the Liquid Metal Fast Breeder Reactor (LMFBR)

As mentioned earlier in Context IV, the AEC altered its reactor development objectives radically around 1965. Instead of continuing research on many different reactor concepts, the AEC selected one concept for further development -- the LMFBR. This development tended to quench the start-up of new testing experiments at the NRTS in general, but some of the research on the LMFBR continued to involve Argonne West (ANL-West).

By 1970, LMFBR supporters felt ready to demonstrate the concept. They planned for the Clinch River Breeder Reactor (CRBR), to be located in Tennessee. It would be the joint effort of the AEC and a consortium of 700 private utility companies. The project would finally, it was hoped, prove the feasibility and safety of the LMFBR for commercial power production. The concept promised to breed plutonium fuel at a rate to double the initial fuel input in eight to ten years of operation. After years of debate and promotion, the federal government and the consortium companies committed funds for the project.[3]

The plan to build CRBR had developed despite the fact that Detroit Edison's small commercial breeder, the Enrico Fermi, shut down in 1972. The Fermi reactor had suffered a meltdown in 1966 when a metal plate below the core broke off and blocked the coolant flow. The reactor was repaired and continued operating until its fuel was depleted.

Other national forces, however, conspired to prevent the CRBR from being built, although site preparation was initiated in 1983. High demand for electrical power, which utility companies and the AEC had been predicting for years, did not materialize. Consumers responded to energy shortages in the early 1970s by reducing their use of electricity. Fossil fuels were not being depleted as quickly as had been predicted, and new sources of supply were discovered. Segments of the public began to worry that terrorists or "rogue states" might acquire plutonium for weapons. The 1979 accident at Three Mile Island -- and, many scientists believe, the inaccurate and incomplete way in which information about it was delivered to the public -- aroused fears among other citizens that nuclear power plants were unreasonably dangerous.[4]

In this atmosphere, critics of the Clinch River project became more vocal and organized. Even among those who supported nuclear power, there were questions as to whether it was the best demonstration plant. The reactor was based on early designs, and some scientists, including nuclear pioneer Walter Zinn, believed that the CRBR design was obsolete. In their view, the demonstration would be neither efficient nor cost effective. Design changes, regulatory compliance, and the passage of time all increased the costs of building the reactor. Although the funding for CRBR survived years of budget battles in Congress, private support weakened. In 1983, Congress canceled the funding.[5]

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[3] William Lanouette, "Dream Machine," *Atlantic Monthly* (April 1983), p. 48-52.

[4] See Stacy, *Proving the Principle*, chapters 23 and 24, "The Endowment of Uranium" and "The Uranium Trail Fades," for a synopsis of the impact of world events on the nuclear enterprise in Idaho, p. 222-243.

[5] "Breeder Program: Bethe Panel Calls for Reorientation," *Science* (182:1236), p. 1237; Lanouette, p. 46-52.

The Integral Fast Reactor Concept (IFR): 1984-1994

Research at ANL-West facilities contributed to the LMFBR program up until 1983, although ANL-West funding was not tied directly to the Clinch River project. The public's concerns about plutonium theft and, after the accident at Three Mile Island, power plant safety -- along with a universal concern for effective methods of handling nuclear waste -- inspired ANL to redirect its research goals.

Scientists and engineers at ANL had been considering a new breeder reactor concept named the Integral Fast Reactor (IFR). By 1984 the IFR had become ANL's new priority in reactor development, with tests and research centered at ANL-West. The project grew steadily. By 1994 employment levels at ANL-West reached a peak of about 850 people.[6]

Argonne was so interested in the IFR because it seemed to overcome many public concerns: its safety was derived from the operation of laws of nature, not the absence of human error; its fuel cycle reduced the volume of waste and the length of time it would be a hazard; and the nature of the residual plutonium was not in a form attractive for diversion to weapons. IFR proponents hoped to fulfill the early promise of nuclear energy for the peaceful and economic generation of electricity.[7]

The fuel for the IFR was a metallic fuel (in contrast to the ceramic fuel typically used in commercial reactors) with high thermal conductivity. The processing of spent fuel elements, which could be accomplished on-site without shipping the material to a processing plant, separated the unused fuel from most of the other waste, making the waste less highly radioactive than conventional spent fuel. Scientists hoped that the IFR, with this "closed" fuel cycle might ease public concerns about transporting nuclear fuels and wastes.[8]

Testing of the new fuel elements took place at ANL-West. The fuel, a combination of uranium, plutonium, and zirconium, appeared to perform more safely, economically, and efficiently than earlier designs. The fuel had greater

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[6] "Argonne Proposes `Proliferation-resistant' breeder," *Physics Today* (August 1984), p. 62; Holl, p. 446; Lindsay, personal communication, Sept. 16, 1997.

[7] Stacy, *Proving the Principle*, p. 232-237.

[8] At ANL-West, EBR-II and the Fuel Cycle Facility (FCF) were modified. The changes made power production, fuel reprocessing, and waste treatment possible at a single location. See Holl, p. 445-446.

thermal conductivity than earlier fuels and could transfer heat from the center of the reactor to the coolant more efficiently. This improved safety, because if heat should build up in the core, the fuel elements would expand, slowing the fission reaction, and resulting in a natural shut-down of the chain reaction.

The new "integral" fuel recycling process also added to efficiency and safety. It produced a conglomerate of plutonium, uranium, and other heavier-than-uranium elements that could be refabricated into new fuel elements in special hot cells located near the reactor. The ANL-West scientists believed this system could neutralize the threat of plutonium theft. Weapons production requires a supply of "pure" plutonium which could not be obtained from IFR fuel without additional reprocessing. Separating the plutonium from the highly radioactive mix would require heavy investment in very large facilities that would be difficult to hide.

In April 1986, the scientists at ANL-West loaded up the EBR-II reactor with IFR fuel and conducted a Loss of Flow Test and a Loss of Heat Sink Test to simulate a complete station blackout and a loss of ability to remove heat from the core. In both tests, no operator interventions or emergency safety systems were brought into action. The reactor shut itself down because of the natural laws of physics, not a set of human-engineered or human-operated safety procedures.[9]

Three weeks after ANL-West's 1986 tests, an explosion occurred at the Chernobyl nuclear power plant in the Soviet Union. The alarming accident released substantial radiation into the environment and reinforced the opponents of nuclear power plants who argued they were not safe. Despite the good news about IFR and its inherent safety features, ANL was unable to gain sufficient support for the studies that would allow for scaling up of the concept. President Bill Clinton and the U.S. Congress, responding to calls for budget reductions, eliminated all funding for nuclear reactor research in 1994. In that year, EBR-II was shut down after thirty years of operation.[10]

The EBR-II reactor is in the process of dismantlement. Its fuel was removed and its liquid sodium coolant has been

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[9] Stacy, *Proving the Principle*, p. 234-237.

[10] "Argonne Proposes `Proliferation-resistant' breeder," *Physics Today* (August 1984), p. 62; Holl, p. 450-456; Brandon Loomis, "End of an Era at Argonne, EBR-II Reactor Ends 30-year Run," (Idaho Falls) *Post Register*, Sept. 29, 2994, p. 1.

drained from the reactor vessel. In 2000, ANL-W began treating EBR-II's sodium-bonded spent fuel. The electrometallurgical process is expected to have applications for the treatment of the Fermi reactor fuel currently in storage at INEEL. Elsewhere on the ANL-W site, soils contaminated with Cesium-137 have been subject to experimental phyto-remediation efforts, in which specific plants take up the cesium in their root systems.[11]

SubTheme: *Reactor Testing, Experimentation, and Development*
INEEL Area: Test Reactor Area

The TRA Retrenches: 1971-Present

The AEC's focus on the LMFBR affected operations at the TRA. The Engineering Test Reactor (ETR) was designated as a key test vehicle for the breeder's safety program. In the spring of 1973, the Aerojet Nuclear Corporation, the TRA operating contractor at the time, began developing special sodium-cooled test loops for the breeder project. This conversion of the ETR reactor required a new closure to the top of the reactor vessel, a special helium coolant system, and a sodium handling system. Once the reactor was properly equipped, Argonne National Laboratory (ANL) would begin testing in mid-1974. The object of the tests would be to verify safety characteristics of the fuel and core design of the Clinch River breeder reactor.[12]

However, Clinch River became a very uncertain project even before Congress refused in 1983 to fund it further. DOE shut down ETR in December 1981. It never ran again and was placed on inactive standby in January 1982.

When the Cold War ended in 1990, the Navy's demands on the ATR declined. National motivation to keep the frontier of nuclear knowledge moving ahead weakened.

The operation of test reactors at TRA had not ended, however. The ATR and its critical facility reactor continued to serve research needs originating both on and off the site. In 1985, for example, the critical facility tested electronic components needed for decontamination work around the site. For off-site customers, the ATR has been a source of neutrons for measuring thermal cross sections of geological samples in uranium and oil exploration.[13] The

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[11] From a November 24, 2003, review of website http://www.inel. gov/facilities/anl-w-status.shtml.
[12] *Thumbnail Sketch* 1973, p. 9
[13] *Site Development Plan*, Volume 2, TRA.

U.S. Navy continues as a major ATR customer. In 1996, the isotope production mission was commercialized. The ATR continues to produce isotopes used by medical, industrial, and agricultural customers.[14]

The DOE is actively seeking new customers and missions for the Test Reactor Area, not only from within the United States, but all over the world. In 1999, the ATR was equipped with a new test feature, the Irradiation Test Vehicle, which is capable of accommodating fifteen separate tests at a time, speeding up research results for customers. The improvements are marketed to universities, among other research customers.[15]

In the meantime, DOE is ordering the decontamination and dismantling of unused TRA buildings to reduce maintenance expenses, remediate contaminated sites, and reduce the potential for further environmental hazards from occurring.

SubTheme: *Cold War Weapons and Military Applications*
INEEL Area: Auxiliary Reactor Area (Army Reactor Area)

The ARA sites after 1971

After the Army effort to create very small nuclear power generators collapsed in 1965, the NRTS contractor changed the name of the area to Auxiliary Reactor Area. The name was an apt indicator of the new mission of ARA buildings and facilities -- to provide technical support for other programs at the NRTS.[16]

At ARA-I, some of the buildings were remodeled to support various study programs taking place elsewhere on the site. A Plant Applications and Engineering Tests program was set up to ascertain the reliability, capability, and durability of safety system performance. Related work included taking fatigue measurements on irradiated materials, studying ways to extend fuel life of the Advanced Test Reactor, and analyzing component failures.[17]

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[14] "ATR Celebrates 30 years of testing," *Lockheed Star* (July 1, 1997), p. 1.

[15] Raymond V. Furstenau and S. Blaine Glover, "The Advanced Test Reactor Irradiation Facilities and Capabilities," found on November 24, 2003, at http://www.anes2002.org/proceedingcd/58Fur.pdf.

[16] *Site Characteristic* Idaho Falls: Idaho Operations, 1990), p. 14 of "Sitewide."

[17] *Site Characteristics*, p. 14 of "INEL Sitewide." Also,

The welding shop at ARA-II closed in 1987, and the rest of the complex remained idle until it was declared excess and prepared for dismantlement. In 1996 the Department of Energy, Environmental Protection Agency, and the State of Idaho agreed to improve the safety of the SL-1 burial ground by recontouring the site to direct water away from it and constructing an impermeable cap over it.[18]

After the Army deactivated the Gas Cooled Reactor Experiment and ML-1 tests in 1965, its buildings were likewise adapted for other uses. After the reactor was removed, the pipes were closed off, and the reactor pit was covered with concrete blocks. From 1966-1986, technicians used the building as a component and instrument lab to test and evaluate items used in reactor experiments elsewhere on the site. Such business was declining, however, and by 1987 this area too went idle.[19]

ARA-IV, the erstwhile home of the ML-1 reactor, was home for a short time to a small reactor sent from the DOE's Nevada Test Site, the Nuclear Effects Reactor, known as FRAN. This small reactor could supply bursts of high-intensity fast neutrons and gamma radiation. Its first criticality at the NRTS was August 28, 1968. Its mission was to test new detection instruments developed for reactor controls. But the program phased out, and the AEC sent the reactor to Lawrence Livermore Laboratory in 1970.

ARA-IV was renamed the Reactives Storage and Treatment Area (RSTA) in 1987. The purpose of RSTA was to provide a remote, safe location to store potentially reactive and explosive waste before shipping it off the INEL site or treating it further on-site. The activities carried on at RSTA site included detonation, open burning, and the chemical reaction of reactive and explosive waste. The cost of maintaining required operating permits for RSTA was high, and the amount of reactive waste diminished. INEL decided to close the site. The waste and the containers were characterized and classified as non-reactive and non-hazardous, and moved to an excess-materials storage yard at the CFA.

"Auxiliary Reactor Area," *Nuclear News* (May 1969), p. 60.

[18] Erik Simpson, "Agencies agree to cap reactor burial grounds," *INEL News* (February 6, 1996), p. 7. A similar treatment was agreed to for the BORAX-1 burial ground.

[19] Julie Braun, *Draft Historic Resource Management Plan for Historic Architectural Properties on the INEL* (Idaho Falls: US DOE, 1994), p. 71.

Decontamination and dismantling of the ARA clusters began in 1988. The DOE, the Idaho SHPO, and the NPS signed a Memorandum of Agreement to preserve the photographic and engineering record of the Army programs and prepare a HAER report. All ARA buildings except a small control building at ARA-IV have been dismantled. Because the HAER study documented the Army program, ARA buildings were not included in the inventory accompanying this report.[20]

SubTheme: *Cold War Weapons and Military Applications*
INEEL Area: Naval Reactors Facility

Maintaining the Status Quo: 1971-present

The 1970s and the 1980s marked the maturing of the NRF. New initiatives were much reduced, and most developmental work consisted of placing new cores in the existing reactors. In 1973, a prototype core for a two-reactor carrier was installed in the A1W plant and brought to power. In October 1984 the S5G Prototype completed end-of-life testing, and a new core containing a reused module from the submarine USS *Narwhal* was installed. It achieved criticality in 1986. Meanwhile, in 1973, the S1W prototype exceeded its originally estimated twenty-year design lifetime, and was still operating successfully.

In the 1970s, the Nuclear Navy was focusing its efforts on the improvement of submarine performance. The Navy was competing with Soviet nuclear submarines that were feared to be faster and deeper-diving than the Navy's. Admiral Rickover and Navy contractors were dealing with accusations of corruption and bribery in relation to defense contracts. The entire defense industry, in particular General Dynamics, was under attack for overspending and fraud.[21]

Throughout the 1970s, the workload at the ECF increased substantially. Additional hot cells with a transfer tunnel to the storage pools were constructed. By 1977, the first off-site reactor control rods were received for examination and repair. In 1979, the S1W demonstrated the feasibility of reusing all radioactive water, and discontinued discharging any radioactive liquids into the environment. By 1980, the

[20] "Memorandum of Agreement Among the United States Department of Energy, Idaho Field Office, the Idaho State Historical Preservation Office, and the Advisory Council on Historic Preservation," August 13, 1993.

[21] These issues were the subject of Patrick Tyler, *Running Critical, The Silent War, Rickover, and General Dynamics* (New York: Harper and Row, 1986).

ECF was sending liquid wastes to the ICPP for evaporation.

In 1981, the ECF expanded again with a fourth storage pool, this one designed to examine the reactor core from the Shippingport Power Station.[22] The ECF also continued receiving irradiated materials from TRA. Since 1957, approximately 3600 transfers have been made between ECF and TRA in shipping casks transported by exclusive-use truck.

International events soon affected the course of the Navy's reactor programs. Tensions began easing between the United States and the Soviet Union even before President George Bush declared the end of the Cold War in November 1990. Nuclear disarmament treaties reduced the buildup of a nuclear arsenal on both sides. The Navy no longer needed to maintain the vast nuclear fleet of surface ships and submarines that had been the legacy of the USS *Nautilus*. And consequently, it no longer needed to run the S1W Prototype to train operators of nuclear ships. On Oct. 17, 1989, the S1W concluded its last power operation. The prototype had operated for 36 years, longest of any nuclear reactor in the world at the time. The A1W shut down in 1994; the S5G, in 1995.

The three prototypes are presently inactive. The Navy's spent nuclear fuel shipments continue to arrive at the ECF, but an agreement with the State of Idaho has established milestones for final storage at an off-site repository. The involvement of the State of Idaho in the conduct of DOE affairs in Idaho has been a relatively new influence on the INEEL, arising out of concerns about the water quality of the Snake River Plain Aquifer and the indefinite plans of DOE for permanent disposal of nuclear waste.[23]

Historic Significance of the NRF

Idaho's NRF played an important role in establishing the "Nuclear Navy," allowing the United States to attain early naval supremacy in opposition to the Soviet Union during the Cold War. Careful engineering, testing, and training under the rigorous procedures laid out by Admiral Hyman Rickover gave the NRF and the U.S. Navy an excellent reputation for nuclear safety.

Several world "firsts" occurred at the NRF. The S1W

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[22] *Naval Reactors Facility, 1994.*

[23] United States Department of Energy, *INEL Comprehensive Facility and Land Use Plan* (Idaho Falls, Idaho: DOE/ID-10514, March 1996), p. 21-23.

prototype of the USS *Nautilus*, the first "atomic machine" was constructed there. As Westinghouse executive John Simpson observed, "This was the Kittyhawk of the Atomic Age."[24] Navy executives, including Admiral Rickover and USS *Nautilus* Commander William Anderson, credited NRF workers and on-site training of naval personnel for the success of the Navy's nuclear propulsion program. The site's initial success with the S1W prototype inspired the Navy to invest in further prototype projects in Idaho. These included the world's first nuclear aircraft carrier prototype (A1W), and the S5G, the first natural-circulation reactor. Both prototypes proved successful and helped the United States maintain its naval strength. These "firsts," it should be noted, all occurred before 1970.

SubTheme: *Military (and other) Applications*
INEEL Area: Test Area North

Specific Manufacturing Capability (SMC)

Even before the LOFT experiments ended in 1986, the buildings at TAN were modified for new uses. In 1983 the U.S. Army became one of INEEL's customers when it initiated a secret project using depleted uranium to manufacture a special armor for its M1-A1 Abrams tank. The project, named Specific Manufacturing Capability (SMC), was classified, so secret that many employees in the plant did not know the purpose of the work they were doing.

The project made use of the expansive space inside the old ANP hangar building, TAN-629. Essentially, the main manufacturing building was erected inside the hangar, hidden from possible overhead spy satellites. The project remained classified until 1990 when the Army made public the purpose of the program.[25] Numerous other TAN buildings support the SMC. The activity is notable as one of the few "production" activities at the INEEL (in contrast to "research and development.")

The Deactivation of TAN Activities and Facilities

A complete history of TAN would include a long list of general research customers, partly because of the presence of the TAN Hot Shop, still in use by various research

[24] John W. Simpson, *Nuclear Power from Undersea to Outer Space* (LaGrange Park, Ill.: American Nuclear Society), p. 53.

[25] Stacy, *Hangar HAER*, p. 63. See also Stacy, *Proving the Principle*, p. 228-229.

programs at the INEEL. The Hot Shop, in the group of buildings referred to as the Technical Support area of TAN, includes programs dealing with the Three Mile Island Unit 2 Core Offsite Examination Program, the Spent Fuel Program, and others.

The Spent Fuel Program concerns itself with the casks that transport spent fuel from one place to another. This research involves not just the casks, but the entire range of testing, security, manufacturing, and certifying transfer systems related to cask transport.

The damaged core from Three Mile Island was shipped to TAN between 1986 and 1990. TAN facilities received the wreckage, examined it, and prepared it for temporary storage. In a multi-year process that ended in 2001, the material was moved from TAN to a dry-storage facility at INTEC to await its next move to a national repository for spent fuel.

However, many TAN's facilities are no longer in use. The facilities at the ANP "Initial Engine Test Area" have been demolished. The buildings that were part of the LOFT program -- the Containment and Service Building, the Reactor Control and Equipment Building, and numerous auxiliary support buildings -- are shut down and facing deactivation. The buildings used in connection to the tank armor project will continue in use for the foreseeable future.

Part of the LOFT program included a Water Reactor Research Test Facility (WRRTF), a group of buildings that supported the tests occurring in the LOFT containment building. These buildings include the Thermal-Hydraulic Experimental Facility Assembly and Test Building (TAN-640, earlier known the Low Power Test (LPT) facility), its related Control Building (TAN-641), the Semiscale Control and Administrative Building (TAN-645), and the Semiscale Assembly and Test Building (TAN-646). The future of these buildings is uncertain.

Significance of TAN

The evolution of program uses at TAN exemplifies the flexible adaptation of DOE's nuclear research facilities from military uses to peaceful uses -- and back to military uses. After the failure and cancellation of the ANP program, the facilities were readily reincarnated for other research themes. Of all of them, the LOFT program and the contribution it made to reactor safety was perhaps the most important.

The LOFT reactor was the only reactor in the world that could repeatedly simulate different kinds of loss-of-coolant accidents that might occur in commercial power plants. The experiments conducted from 1978 to 1986 contributed to the safe operation of nuclear reactors all over the world. DOE, recognizing that the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD) had considerable experience in sponsoring international research programs, invited NEA to establish such a program with LOFT. In addition to the experiments already carried out, the program investigated more severe transients in which fuel disruption and release of fission products would occur. These experiments began in October of 1983. The OECD member countries participating were Austria, Finland, West Germany, Italy, Japan, Spain, Sweden, Switzerland, the United Kingdom, and the United States. In exchange for financial and technical collaboration, the OECD received valuable data on eight accident simulations, including reactor recovery to safe conditions. The experience of working closely together on post-test analysis forged enduring links among analysts in the member countries.

SubTheme: *Chemical Reprocessing*
INEEL Area: Chemical Processing Plant

The 1970s and 1980s: The Second Generation of ICPP Buildings

The decade of the 1970s began what the ICPP managers called a "facelift" of the plant. Safety standards for nuclear workers had become more stringent, as had standards for environmental protection. Decontaminating the process cells became more and more difficult -- a consequence of the fact that the main process and waste calcining buildings had been adapted to operate with chemical solutions that they had not been designed initially to handle. Aside from that, equipment simply was aging.

Design engineers addressed the ICPP's shortcomings by replacing and improving one system after another. New buildings appeared all over the campus. A new Waste Disposal Building, to wash and filter low-level gases and liquid wastes before release to the environment, was one of the first. An Atmospheric Protection System (CPP-649), a central filtering center that collected air and off-gases to preclude accidental releases, appeared in 1976.[26] Monitoring stations went up to detect and impound any waste water that

[26] *Thumbnail Sketch* 1973, p. 17.

became accidentally contaminated. Electrical distribution was revamped in a systematic upgrade. And a coal-fired steam generator plant went on line in 1984 to supply plant heat for the entire ICPP complex. Changes in waste management practices ended the use of wells for the injection of low-level radioactive liquid waste. Such liquid went instead to evaporation ponds. These new practices led to new monitoring stations housing new instrumentation and new pumps.

More significantly, four major new buildings replaced and modernized the original plant. The first to be replaced was the old Waste Calcining Facility (CPP-633). The old plant ended its ninth and last campaign in March 1981 after a run of nearly two years that had been interrupted several times by failing equipment. A new calciner had been under development and design since before 1975. It opened for its first hot run in September 1982. The building (CPP-659) had many features similar to the old one, but could process 3,000 gallons of feed per day, had better protection for workers and the environment, and could handle waste streams from a wide range of standard and exotic fuels. The building was placed northeast of the old calciner building between part of the tank farm and the oldest bin sets.

Next, the Fluorinel Dissolution Process (CPP-666) replaced the head-end portion of the original fuel reprocessing complex at CPP-601. Designed by the Ralph M. Parsons Company, it reversed the "direct maintenance" philosophy upon which the earlier process plants were based. The Fluorinel plant was to be operated and maintained by remote and computerized control. Under construction for four years, it was completed in 1984. The huge building -- its roof covers 2 3/4 acres -- integrated fuel storage with the dissolution process, meaning that fuel could be transferred underwater directly from its storage place to the process area without the use of transport casks. (At the time, site managers expected CPP-603, the original fuel storage complex, to be discontinued in the 1990s.)

The Fuel Storage Facility (FAST) contained six pools containing three million gallons of water. The pools, connected by transfer channels, were arranged in a north-south row. Within the pools were 2600 fuel storage positions. A cask-handling pool and two isolation pools were at the north end. To the east of the pools was the processing area, which contained a shielded process cell, operating galleries, and a chemical makeup area. Features such as shielded process cells, viewing windows, below-grade locations for process cells followed principles established in the earlier building. One of the building's innovative features was a plan to use decay heat (from the fission products in stored fuel) to heat the plant and other ICPP buildings in the future.[27]

The new plant began receiving fuel in 1984. Dissolution began in the spring of 1985. At the time, DOE expected the plant to pay back the cost of its construction ($200 million) within five years based on then-current values of enriched uranium and Krypton-85 gas.[28]

The third major improvement was a new laboratory, also designed by Ralph M. Parsons. The Remote Analytical Laboratory (CPP-684) joined the new processing and calcining facilities in 1986. Containing a hot cell, the lab examines and evaluates samples of highly radioactive waste. The samples arrive at the lab via a pneumatic transfer system similar to those used at drive-up bank windows. Compressed air moves the samples through an overhead pipe system connecting the laboratory to the new calciner and new processing buildings. Inside the laboratory, a small cart motivated by a magnetic drive system beneath the hot cell floor moves the samples from one manipulator station to another.[29]

The final phase of the upgrade began in 1988 with the commencement of the Fuel Processing Restoration project, which would completely replace the old uranium extraction plant, CPP-601, the original 1951 process building. This building was expected to take six to seven years before it was ready to start up in 1996.[30]

In accordance with President Ronald Reagan's determination to continue producing nuclear weapons, the Department of Energy decided to locate a Special Isotope Separation (SIS) process at the ICPP in 1989. The process was to accumulate Plutonium for nuclear weapons using lasers to separate isotopes from a metal vapor. The anticipated project brought a new wave of work to the area, opening up a new cluster of buildings at the north end of the ICPP. The SIS was never built, but the buildings remain.[31]

One of the legacies of the long Fluorinel and FAST construction periods was a substantial collection of

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[27] Logan, p. 205; and Westinghouse, *FDP Facts (Fluorinel Dissolution Process)* pamphlet (Idaho Falls: WINCO, 1986); and INEL, *FAST Facility at ICPP* (Idaho Falls: DOE/INEL, circa 1983), no page numbers.

[28] *FDP Facts.*

[29] Westinghouse, *RAL Facts* (Idaho Falls: WINCO, 1986).

[30] "40th Anniversary Package," p. 13.

[31] "40th Anniversary Package," p. 14.

construction- and contractor-related buildings -- offices, craft shops, warehouses, quality assurance labs, and waste accumulation structures. Temporary trailers and guard houses appeared on the scene, hauled to a useful (or available) place and parked on skids or bolted to concrete pads. Construction activity has been somewhat constant at the site, so these buildings have been re-used by the INEL manager or subsequent contractors. In the summer of 1997, a general clearance was underway. Several trailers were sent to the Arco School District for use at Arco High School.

Retrofitting and Remediation

The fuel processing and waste calcining equipment at the ICPP shut down in October 1989. Among the many laws, orders, and agreements pertaining to environmental protection was the Resource Conservation and Recovery Act of 1976 (RCRA). RCRA set forth standards for cleanup of hazardous waste sites and regulated the transport of hazardous wastes to prevent further contamination of the environment. It was now time for the vast kingdom of underground piping at the ICPP to be upgraded and retrofitted. The new standards specified that pipes carrying hazardous chemicals must be surrounded by a secondary containment -- a pipe surrounding the pipe that would catch the hazard should the primary pipe leak or break. Site workers took inventory and began years of work digging up and relaying pipes all over the plant.[32]

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, also known as "Superfund") provides mechanisms for the Environmental Protection Agency (EPA) to force agencies such as the DOE to clean up sites where accidents or usage have contaminated the soil or water. The State of Idaho passed a Hazardous Waste Management Act in 1983 which incorporated procedures and standards for dealing with asbestos and radioactive hazards.

The State of Idaho and the EPA pressed their interests, and the DOE itself issued various orders regarding the clean up of hazardous waste sites. On December 9, 1991, those three parties signed a Federal Facility Agreement and Consent Order, setting forth mutual goals on a wide range of activities. Since then the ICPP (and other areas of the INEEL) have cleaned up asbestos, petroleum product, heavy

[32] Kevin Richert, "Chem Plant closures will be indefinite, officials say," *Post-Register* (October 23, 1989).

metal, radionuclide, and other waste sites.[33]

The ICPP operators have undertaken a systematic survey and characterization of their site, identifying contaminated soils, buildings, and structures. After analyzing alternative approaches to the cleanup of a site, they undertake decontamination and dismantlement activities. In addition, obsolete or surplussed properties are being eliminated in accordance with DOE orders to reduce annual maintenance expenses at DOE laboratories.

The Cold War Ends -- The ICPP Acquires a New Mission and a New Name

After President George Bush declared the end of the Cold War in 1990, the Secretary of Energy ordered DOE facilities to terminate the recovery of uranium from spent fuel. The big new building under construction at the ICPP came to a halt, unfinished and suddenly irrelevant. And the State of Idaho -- after years of resisting the transport of nuclear waste and nuclear fuel into the state -- demanded that DOE perform a site-wide Environmental Impact Statement. The state filed for an injunction against any further receipt or storage of spent nuclear fuel until such an EIS was completed.

The conflict was resolved on October 16, 1995, with an agreement between DOE, the State of Idaho, and the U.S. Navy as to the future of fuel storage and management of liquid wastes at the INEL.[34] The agreement handed the ICPP a big job. It set forth compliance dates for calcining all of the remaining 1.7 million gallons of high-level liquid waste in the stainless steel tanks. In pursuit of this target, the New Waste Calcining Facility began a campaign during the summer of 1997 to calcine 287,000 gallons of non-sodium bearing waste, an effort that was completed in February 1998. The next goal is to calcine sodium-bearing waste, with

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[33] "INEL completes first 5 years of cleanup," *DOE This Month* (December 1996), p. 8.

[34] "Settlement Agreement between the State of Idaho, the Department of Energy, and Department of the Navy, October 16, 1995, to resolve issues in the action of Public Service Company of Colorado v. Governor Phil Batt [of Idaho]," No. CV91-0035-S. EJL (D.Id.) and US v. Batt, No. CV-01-0054-S-IJL (D.Id.) Section C.1 of the agreement says, "DOE shall remove all spent fuel, including naval spent fuel and Three Mile Island spent fuel from Idaho by January 1, 2035. Spent fuel being maintained for purposes of testing shall be excepted from removal, subject to the limitations [expressed elsewhere in the Agreement.]"

an end date expected by the end of 2012. When that task has been accomplished, the waste calcining process will likewise be irrelevant.[35]

The fuel left in wet storage when the 1992 order shut down the process must be relocated to dry storage facilities by December 2000. Fuels in the basins of CPP-603 and in CPP-666 must move to dry storage by the end of the year 2023. This meant another modification at CPP-603 to expand its capacity for dry storage of fuels then at the ICPP and also for the Three Mile Island fuels then stored at TAN.

The INEEL expects to receive a maximum of 575 shipments of Navy fuel between 1995-2035.[36] By that time, the federal government is expected to have a permanent waste repository for the country's stockpile of spent nuclear fuel.

With the evolution of a fuel storage mission, which features dry storage rather than storage shielded by water in pools or tanks, ICPP research has focused on new storage technologies and procedures, not new concepts for reprocessing spent fuel. Its engineers work on new technologies for waste management, better ways to store spent fuel, better ways to decontaminate and dismantle, and ways to scale up waste processing technologies to production-sized operations.

In 1999 the Chem Plant changed its name to Idaho Nuclear Technology and Engineering Center (INTEC). The mission of INTEC continues to focus on the technologies of receiving and storing spent fuel or calcining the waste still remaining at the plant.

Significance of Context V, Multi-Program Research

Much INEEL research since 1970 has not been related to nuclear reactors. Nor has it taken place on INEEL's desert site. After the MTR shut down in 1970, scientists looked for other projects. They found one at Raft River, Idaho, where they established the Raft River Pilot Plant, an investigation into geothermal energy.[37]

Other alternative energy explorations soon followed. Site scientists sought and found customers interested in a variety of research projects, including industrial energy

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[35] "INEEL restarts calcining liquid high-level waste," *LMITCO Star* (July 1, 1997).
[36] Section D.1.b. of Settlement Agreement.
[37] Stacy, *Proving the Principle*, p. 212-216.

conservation, the production of alcohol fuel, solar energy, and batteries for electric vehicles, and energy from biomass. INEEL became the DOE's lead laboratory for hydropower programs and helped the city of Idaho Falls install a low-head bulb-turbine system in the Snake River.[38]

Looking for new customers, helping private industry take advantage of government research ("technology transfer"), and diversifying research beyond nuclear questions -- these were new directions for INEEL. Most of these activities no longer required an isolated "test station" in the desert, although the desert continued to offer a practical laboratory for waste remediation research.

In 2002 the DOE declared that INEEL and ANL were to be its "lead laboratories" for nuclear energy research and development. At the same time, it began planning to "accelerate" the cleanup of and remediation of wastes at INEEL. Heretofore, INEEL has been managed from DOE's federal center in Washington, D.C., by its Division of Environmental Management (EM).

To better organize for new research initiatives (which may include the construction of a new reactor), DOE has begun to identify buildings that will be placed under the management of its Division of Nuclear Energy, Science, and Technology (NE). As of the date of this report, the final disposition of INEEL buildings under the purview of EM or NE is in progress. Many EM buildings will undoubtedly be slated for dismantlement or demolition. Some will be re-used.[39]

Context V, "Multi-Program Research" is, in general, a period that requires the passage of time -- at least fifty years -- before historians will discern how the historic patterns at work at the INEEL ought to be further described and characterized. Likewise, that time must pass before they should assess whether the buildings erected during this period are significant enough to qualify for preservation or recognition for their contributions to the broad scope of American history.

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[38] Stacy, *Proving the Principle*, p. 216.

[39] For an articulation of the new NE-related mission, see *INEEL, Strategic Plan*, January 2003.

CONTEXT VI: REMEDIATION OF WASTE: 1970-present

INEEL Area: Radioactive Waste Management Complex (RWMC)

Early Disposal Practices: 1952-1959

Environmental monitoring began at the NRTS before any radioactive material was even produced. In 1949 a one-year study documented natural background radiation. The study provided a starting point from which any radioactivity increase could be recognized and measured in air, water, cow's milk, soil, and animal flesh. With the beginning of NRTS operations, so did air and personnel monitoring. Quarterly or semi-annual reports were distributed to the Idaho Department of Health and the members of the Idaho Congressional delegation. In 1952 the United States Geological Survey reported a further base of useful information about the Snake River Plain Aquifer. This report expressed concern about potential contamination of the aquifer, but considered it a remote possibility.[1]

Among the many issues facing the youthful nuclear industry -- safety, industrial security, and reliable performance -- scientists also knew that the disposal of hazardous nuclear waste eventually would become a serious concern. In the 1950s, however, hazardous waste was not a ranking priority of the AEC. Each of the AEC's nuclear facilities made its own decisions about how to handle nuclear waste.[2] The AEC expected that by the time a commercial nuclear power industry had come into existence, further research and new technologies would have solved waste disposal problems.[3]

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1 B.C. Anderson et al, *A History of the Radioactive Waste Management Complex at the Idaho National Engineering Laboratory* (Idaho Falls: U.S. DOE Idaho Operations Office, Report PR-W-79-038, 1979), p. 21, 35, 101, 102. Hereafter referred to as "Anderson, *History of the RWMC*." Authors cite the U.S.G.S. report secondarily from sources such as an article by John Horan and Herman J. Paas, Jr., "Environmental Surveillance a the National Reactor Testing Station," *Health Physics* 12: 1039-1045 Pergamon Press, 1966; and a letter from Bruce L. Schmalz to F.M. Empson, "Information on Burial Ground," August 30, 1961.

2 Jack M. Holl, *Argonne National Laboratory, 1946-96* (Chicago: University of Illinois Press, 1997), p. 73.

3 For discussions of the AEC's early priorities, see, for example, see Michele Gerber, *On the Home Front: The Cold War Legacy of the Hanford Nuclear Site* (Lincoln: University of

As the Cold War escalated, the number of nuclear power plants and testing facilities nationwide increased. With this expansion came the generation of tons of radioactive waste and the growing dilemma of how to manage it. The NRTS expanded dramatically between 1950 and 1955. Radioactive waste came in the form of solids, liquids, and gases. Initially, some low-level liquid wastes were disposed of on-site at each reactor area via injection wells or settling ponds. The test reactors and ICPP released radioactive gases into the air, although releases were monitored and coordinated with favorable weather patterns so as to meet acceptable air-dilution levels.

The on-site airborne releases were relatively small compared to releases from weapons tests at the Nevada Test Site. The NRTS air monitors and other monitoring stations in Southern Idaho detected high amounts of airborne waste from the Nevada tests. One such test generated readings in Idaho so high that technicians attributed them to equipment error.[4]

Agricultural use of the land surrounding the NRTS site continued to grow. The 1950s advent of sprinkler irrigation and subsequent deep-well drilling made the desert surrounding the Site more attractive to farmers than it had been before. In addition, electricity was cheap. This caused the NRTS landlords concern, for they needed land as a safety buffer between the reactor complexes and local land use. In 1955, Congress authorized $1 million to purchase 140,000 acres north and east of the site. During this time, the AEC also made the level of "acceptable risk" for airborne releases eight times less stringent than it had been originally, so the acreage had the effect of adding additional protection. The purchase also included more area for expansion of the original waste burial grounds, which

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Nebraska Press, 1992); John Horan, George Wehmann, and Bruce L. Schmalz, "Experience in Site Selection at the National Reactor Testing Station, USA" (Idaho Falls: AEC, Health and Safety Division, 1962), hereafter referred to as "Horan, Wehmann, and Schmalz;" and Gerard H. Clarfield and William M. Wiecek, *Nuclear America: Military and Civilian Nuclear Power in the United States, 1940-1980* (New York: Harper and Row, 1984).

[4] Phillips Petroleum Co. Atomic Energy Division, internal report. *Survey of Fall-out of Radioactive Material in South and South-East Idaho Following the Las Vegas, Nevada Tests of October and November, 1951* (Prepared by the Site Survey Section of the Health Physics Division, NRTS, USAEC. January , 1952).

grew to 88 acres by 1957.[5]

In the late 1940s and early 1950s, the AEC thought that standard processes for domestic sewage treatment promised cost-effective radioactive waste treatment. In those early years, nuclear engineers and building designers viewed such low-level waste (composed of all radioactive waste not classified as high-level waste, transuranic waste, spent nuclear fuel, or natural uranium and thorium byproducts) in the same light as conventional chemical, or even domestic waste, particularly in dry climates.[6] The Hanford nuclear site used several separate sewer systems, for example, to carry plutonium-process wastes into drainage ditches and settling ponds. Increased radioactivity levels in these ditches and ponds led to Hanford's 1952 decision to phase out these ponds and use shallow trenches and subsurface rock "cribs."[7]

In 1952, NRTS engineers constructed a new sewage plant at the CFA. They used a "combination unit," also serving the "Hot Laundry" facility, which handled contaminated protective clothing. Although the Hot Laundry facility had a separate sewer line, it entered the same septic tank as the other CFA effluent and then went to the drain field. This process had evidently been tested at Los Alamos in 1952 and was considered an effective way to handle low-level waste. Eventually the sludge lines and drain field became contaminated.[8]

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[5] Anderson, *A History of RWMC*, p. 8. See also Horan, Wehmann, and Schmalz, p. 17-18.

[6] For example, see A.D. Mackintosh, "Architectural Problems in Atomic Labs," *Architectural Forum* (January 1952), p. 159-164; A.L. Biladeau, "Radioactive Waste Removal in a Trickling Filter Sewage Plant" (Idaho Falls: Idaho Operations Office of AEC, 1953); H.R. Zietlin, E.D. Arnold, and J.W. Ullmann (of Chemical Technology Division, Oak Ridge National Laboratory), "Economics of Waste Disposal" in *Manual on Nuclear Reactor Facilities* (New York: McGraw-Hill and *Nucleonics* Magazine, 1957), p. 101-103; and *INEL Comprehensive Facility and Land Use Plan* (Idaho Falls: DOE/ID-10514, 1996), p. 177.

[7] *National Register of Historic Places Multiple Property Documentation Form--Historic, Archaeological and Traditional Cultural Properties of the Hanford Site, Washington* (Richland, Washington: USDOE, February, 1997), Section 5, page 59. See also Gerber, *On the Home Front*.

[8] Idaho Operations Office, Engineering and Construction Division report by A. L. Biladeau, "Radioactive Waste Removal in A

Following the practice at other nuclear laboratories, the NRTS set aside a "Waste Burial Ground" for the disposal of contaminated wastes. The thirteen-acre site, isolated from the reactor facilities, was recommended by the U.S. Geological Survey. It had good surface drainage and clay sediments that would resist saturation.[9] On July 28, 1952, the first burial trench was opened, and low-level waste was placed in it. This waste consisted mainly of contaminated paper, laboratory glassware, filters, and metal pipe fittings. According to one 1953 internal report, liquid waste in sealed containers was also placed in the trench.[10] Between 1952 and 1957, nine more trenches were excavated to basalt bedrock. The trenches were enclosed with a barbed wire fence; metal tags marked the general location of the trenches. Low-level, site-generated waste was picked up twice a week, placed in sealed cardboard boxes, and randomly dumped into the trenches. Earth was placed over the boxes at the end of each week.[11] High-level waste also was dumped into trenches during this time. The material was contained in wooden boxes or 30-gallon garbage cans, shielded by a cask and lead open-top box container. These were immediately covered with earth.

Wastes from another AEC facility began arriving at the Burial Ground in March 1954. The Rocky Flats Fuel Fabricating Facility in Golden, Colorado, which manufactured trigger devices made of plutonium for nuclear warheads. The facility at Golden was small in size (four square miles), had a high water table, and was near a densely populated area. After studying the merits and economics of alternative sites, the AEC decided to ship the waste to the NRTS. Plutonium is a "transuranic" waste (TRU), an alpha-emitting

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Trickling Filter Sewage Plant," May 1953; and EG&G Idaho report by R. D. Browning, "TAN, TRA, and CFA Sewage Treatment Plant Study" (Operational and Capital Projects Engineering, January 1989).

[9] Anderson, *History of the RWMC*, p. 11, 21. See notes No. 1 and No. 19. Also see "History, Radioactive Waste Management Complex," *INEL Technical Site Information*, 1993.

[10] Anderson, *History of the RWMC*, p. 4, citing a report by P.T. Voegeli and Morris Deutsch, *Geology, Water Supply, and Waste Disposal at Sites 11 and 11A, Burial Ground D, and Vicinity* (Idaho Falls: NRTS ID)-22027, 1953).

[11] Anderson, *History of the RWMC*. [np] See also "History, Radioactive Waste Management Complex," *INEL Technical Site Information*, 1993.

element with a half-life greater than twenty years whose combined activity level is at least 100 nanocuries per gram of waste.[12] TRU waste can remain radioactive for hundreds of thousands of years. Rocky Flats shipped metal drums of TRU waste by rail to Idaho, where it was interspersed with NRTS waste in Trenches 1 through 10.[13]

In using shallow land burial methods, the NRTS followed practices used by most other AEC facilities. It was the main disposal method throughout the 1950s. Other methods included underground injection, sea burial, and large pit disposal.[14] In 1957 *Nucleonics* magazine published a series of articles on the economics of efficient waste disposal. One of them said, "One of the potentially attractive schemes for the ultimate disposal of radioactive waste is simply to pour the waste into pits." The pits should not be located near processing plants for geological reasons, and some transport might be required. The authors of the report considered the possible benefits of processing nuclear waste, writing, "It may be necessary or desirable to remove some fission products from the waste, particularly the long-lived activities, prior to ground disposal." AEC scientists and engineers predicted that by the year 2000 accumulated waste would be $3x10^{11}$ curies, with an estimated "permissible" disposal cost of anywhere from $.60 to $64 per gallon.[15]

Rocky Flats waste dramatically increased in 1957 due to a severe fire at the plant. Large quantities of bulky and contaminated fire debris was shipped to the NRTS. To accommodate this substantial new volume, the NRTS created a series of "pits" for disposal of this waste. Pit 1 opened on November 1, 1957. That year the AEC also produced formal disposal procedures for the NRTS. Solid waste was packaged in steel drums or large crates, stacked near the pits, and

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[12] U.S. Department of Energy, *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to Their Environmental Consequences* (Washington, D.C.: Office of Environmental Management, January 1997), p. 40. Hereafter referred to as "*Linking Legacies.*"

[13] Anderson, *History of the RWMC*, p. 16-21.

[14] *Linking Legacies*, p. 48.

[15] H.R. Zietlin, E.D. Arnold and J.W. Ullmann [Chemical Technology Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.], "Economics of Waste Disposal, *Manual on Nuclear Reactor Facilities* (New York: McGraw-Hill); and *Nucleonics* (1957), p. 101, 103-104.

then lowered into the pits by crane. Reporting and record-keeping on solid waste disposal was improved. The AEC further expanded and refined these requirements in 1959.[16]

Occasional flooding created problems at the Waste Burial Ground (later called the "Subsurface Disposal Area"). When the U.S. Geological Survey recommended the burial ground site in 1952, it had not predicted heavy cyclic floods. When the Big Lost River overflowed in 1958, site managers quickly arranged for a dam to divert water away from the burial ground. In 1962, two inches of rain fell on frozen ground, causing localized flooding. Some open trenches filled with water, allowing low-level waste barrels and boxes to float. A few boxes broke open, their contents of contaminated gloves and bottles to settle on lands near the burial grounds. These were retrieved and reburied. Diversion ditches and diking were constructed around the site, but intermittent flooding continued over the years.[17]

Interim Burial Ground: 1960-1963

As the number of AEC-licensed nuclear power plants increased, so did their waste. Utility companies hired from among several firms that packaged solid waste and buried it at sea. The cheaper cost of land burial caused the AEC to re-evaluate sea burial. In January 1960, the AEC announced plans to create regional interim burial grounds for commercial wastes. Until these were established, interim sites for storing wastes would be needed. In May, the AEC chose the Oak Ridge National Laboratory in Tennessee and Idaho's NRTS as the interim sites.[18] Two AEC-Idaho scientists, B.L. Schmalz and W.P. Gammill, wrote to the AEC stressing that the use of the NRTS as a burial ground be only a temporary measure. They indicated that a potential risk of water table contamination did exist and that the burial ground would soon be full. They recommended that the AEC investigate sites not overlying an aquifer. Combined with concerns about the Interim Burial Ground program, officials on and off the site questioned the wisdom of long-term storage of TRU waste at the NRTS.[19]

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[16] Anderson, *History of the RWMC*, p. 22-27. Anderson refers to the manual as an "AEC-ID Manual Chapter 0500-7."

[17] Anderson, *History of the RWMC*, p. 33.

[18] "West Coast Firm Attacks AEC Waste-Disposal Policy," *Nucleonics* (July 1960), p. 30; and "Luedecke Reaffirms AEC's Land Burial Waste Policy," *Nucleonics* (August 1960), p. 31.

[19] Horan, Wehmann, Schmalz, p. 17-18; see also Anderson's

As the AEC turned its attention to the issue, it required that Oak Ridge and the NRTS coordinate consistent procedures for land burial. No liquid waste was permitted, and fissionable material was closely supervised. Two major improvements in environmental monitoring were also implemented: increased subsurface monitoring by a system of ten monitoring holes around portions of the burial ground; and film badges placed around the perimeter to monitor direct radiation levels.

A special burial arrangement was made at a site outside of the official burial ground. An accident occurred at SL-1 in the Army Reactor Area (ARA) in January 1961, killing three men and damaging the reactor and much of the equipment in the reactor room. After a safety analysis indicated that it would be more hazardous to transport the debris to the burial ground than dispose of it closer to the site of the accident, a separate burial ground was opened about a quarter of a mile from the reactor. Some SL-1 materials were taken later to the interim burial ground and placed in Pit 1, which was reopened specifically for that purpose.[20]

The AEC closed the Oak Ridge and Idaho interim burial grounds in 1963, after commercial sites opened for business. Idaho continued to receive TRU waste from Rocky Flats because of its classified nature. That year also saw a step backwards from what later managers regarded as safe burial practices. A labor strike at the NRTS had created a limited work force. During the strike, workers dumped Rocky Flats waste randomly into the pits rather than stacking barrels in an upright and orderly way. This practice continued for seven years, long after the strike was settled, because site managers believed it minimized personnel radiation exposures. Rocky Flats waste sent to the NRTS after 1967 was dumped into Pits 9 and 10.[21]

Notes Nos. 1, 2, and 22.

[20] Anderson, *History of the RWMC,* p. 31-33.

[21] Anderson connects the 1963 labor strike with a change in practice from stacking to random dumping of waste containers from evidence in letters, memos, and personal communications. These are cited on p. 31 of his report; see Note Nos. 10, 27, and 28. See also an internal report from Frank G. Schwartz and Paul V. Strider, "Management of Pit 9--Highlights of Accomplishments and Lessons Learned to Date" (Idaho Falls, Idaho: U.S. DOE Idaho, 1997), p. 1; and "A Comprehensive Inventory of Radiological and Nonradiological Contaminants in Waste Buried in the Subsurface Disposal Area of the INEL RWMC During the Years 1952-1984" (Idaho

Increasing Environmental Concern, 1964-1970

Although environmental concerns at the Burial Ground already existed, these concerns were exacerbated by national and local events during the mid- and late-1960s. In the 1950s, the popular media had focused on fears of fallout and the "monsters" that might be engendered from radioactivity, not the practical problems of accumulating waste with radioactive half-lives. The national consciousness concerning environmental degradation on all fronts was raised by chemists, biologists, and other writers. Nevil Shute's grim 1957 novel *On the Beach* and Rachel Carson's *Silent Spring*, published in the 1960s, aroused public concerns about nuclear fallout and chemicals hazardous to the environment.

In 1960 and 1965, a National Academy of Sciences committee visited the NRTS and its waste burial ground. The committee felt that the ultimate leakage of plutonium waste was inevitable because the steel drums containing it would eventually corrode. Other minor incidents raised further concerns. In September 1966, two fires occurred in the waste burial ground, caused by alkali metal wastes inadvertently included with low-level waste. Further fires were prevented by compacting and immediately covering the barrels with earth. Another flood occurred in 1969, inundating the entire burial ground. Pits 9 and 10 were flooded, along with two trenches.[22]

Despite these problems, Pits 9 and 10 continued to receive mixed waste (low-level waste containing hazardous waste or PCBs) from Rocky Flats. In 1969, a 12,000-gallon metal tank filled with mixed waste from the Air Force was also placed in Pit 10.[23]

Falls, Idaho: EG&G Idaho, Inc., October 1993), p. 1-2 to 1-4.

[22] Anderson, discusses the report, but does not name it, citing a reference by John Horan in Note 32; see p. 35-39, 104. See also documents related to the report in the files of Idaho Governor Don Samuelson at Idaho State Historical Society, Box 50, File "Nuclear--1970." The *New York Times* reported that the AEC released a copy of the report to the *New York Times* in 1970. See clipping in file by Bob Smith, "AEC Scored on Storing Waste," March 7, 1970, no page number.

[23] Anderson, *History of the RWMC*, p. 38-41. See also D.H. Card, "History of Buried Transuranic Waste at INEL" (Idaho Falls, Idaho: EG&G Idaho, Inc., 1977), p. 23-31. Hereafter referred to as

By 1968, national concerns over water pollution resulted in the issuance of President Lyndon Johnson's Executive Order 11288, entitled "Prevention, Control and Abatement of Water Pollution by Federal Activities." The Federal Water Quality Administration surveyed the NRTS burial ground that year to determine if additional controls were needed to carry out this policy. Idaho Senator Frank Church also became concerned about Rocky Flats waste stored over the aquifer. He requested four federal agencies -- the U.S.G.S., Bureau of Radiological Health and U.S. Public Health Service, the Federal Water Pollution Control Administration, and the Bureau of Sport Fisheries and Wildlife -- to review the burial ground.[24]

In 1969, water samples taken from a subsurface monitoring hole after that spring's flood indicated that small amounts of Cesium-137 were present. The NRTS Health Services Laboratory conducted further investigations in 1969 and 1970 and found that some fission products and plutonium isotopes had leached into surrounding soil, probably because of the flood.[25] Although it was believed that these small amounts could not reach the aquifer, the finding stimulated operational changes. In December 1969, John Horan, Director of the Health and Safety Division of the Idaho Operations Office at the NRTS, wrote to the AEC recommending that burial of Rocky Flats waste be suspended during the winter months, and that plutonium-contaminated waste be segregated.[26]

Early Environmental Remediation and Cleanup: 1970-1979

In 1969 Congress passed the National Environmental Policy Act. In 1970 the AEC issued "Immediate Action Directive No. 011-21," regarding solid waste burial. This directive ordered segregation of high-level waste and storage to permit retrieval of contamination-free waste containers after periods of up to twenty years.[27]

"Card."

[24] Anderson, *History of the RWMC*, p. 35-36.

[25] Anderson, *History of the RWMC*, p. 41-42.

[26] Anderson, *History of the RWMC*, p. 37-38.

[27] Re the politics behind the federal environmental acts, see Mary Beth Norton, et. al., Vol. 2, *A People and a Nation* (Boston: Houghton Mifflin Company, 1986). See also Anderson, *History of the*

The NRTS gradually changed the way it stored different kinds of waste. Rocky Flats waste was carefully packed in drums and stacked once more, with Pit 11 reserved for this use. Waste contained in cardboard boxes was stored in Pit 10. Approximately 90 boxes were also placed in Pit 11, but they were stacked at the other end of the pit. Pit 11 was closed in October of 1970. That same year, TRU waste was still placed in Pit 12. The TRU waste consisted of sludge drums from Rocky Flats. The Idaho Operations Office decided not to bury any more Rocky Flats TRU waste in 1970 and began stacking it above ground. It expanded the waste management area to include 144 acres and closed Pit 12 closed in November.[28]

Until 1970, no buildings had been erected at the Waste Burial Ground and no waste had been stored above ground. In 1970, NRTS built a permanent above-ground facility, then called the Interim Transuranic Storage Area (now TSA). It consisted of a sloping asphalt pad 400 feet long, with a foot-high soil berm surrounding three sides. As the pad filled, individual cells were built and surrounded by firewall. The stacked waste was covered first with plywood, a nylon-reinforced polyvinyl, with soil two to three feet deep placed on top.[29]

To carry out the 1970 AEC decision to move TRU waste to above-ground storage, several studies on the waste's condition and cost of removal had to be performed first.[30] The studies, conducted in 1971, revealed varied conditions. Some drums were in good condition, while others were corroded and leaking. Buried plywood boxes and cardboard cartons were almost completely deteriorated. The NRTS assigned permanent equipment and personnel to the waste management site for the first time.

The Clean Water Act of 1972 stimulated further changes at the NRTS. A training program for operators and supervisors at the Waste Burial Ground was initiated in 1973, as was the first formal environmental surveillance plan.

RWMC, p. 42.

[28] Card, p. 31-33.

[29] Anderson, *History of the RWMC*, p. 44.

[30] Anderson, *History of the RWMC*, p. 42; see his Note No. 34, p. 104.

In March 1974, the AEC generated is own program, the "Formerly Utilized Sites Remedial Action Program." The NRTS (renamed Idaho National Engineering Laboratory (INEL) in August 1974) commenced drum retrieval operations, but only of those which were unbreached. Wooden and cardboard boxes were not retrieved because of their advanced state of deterioration. A total of 20,262 drums were repackaged and stored during the program.[31]

From 1975 to 1977, major changes in national oversight and regulation of the nuclear industry occurred. The AEC was abolished in 1974 upon objections that the agency was both regulator and regulated. The AEC's research and weapons production missions were given to the Energy Research and Development Administration (ERDA); its regulatory authority, to the Nuclear Regulatory Commission (NRC).[32]

In 1976, a new federal law was enacted to regulate hazardous waste disposal -- The Resource Conservation and Recovery Act (RCRA). At the INEL, further studies were conducted on uncontained TRU waste. Workers used an air support weather shield to retrieve the waste from Pit 2. Drums and boxes were badly deteriorated, but waste had not migrated into the surrounding soil.[33]

During the 1970s the first buildings were constructed at the Waste Burial Site, which was renamed the Radioactive Waste Management Complex (RWMC). The Radiation Analysis Laboratory (later called the RADCON field office, WMC-601), a metal building on a concrete slab, was placed at the site. A prefabricated metal building served as the Decontamination Facility (now called the RWMC High Bay, WMC-602). Of similar construction were the Pump House (WMF-603), and the Supervisor's Office (WMF-604, now called the Change House and Lunch Room Facility). These buildings later were termed the Administrative Area of RWMC. Permanent buildings were not built because the waste burial site was intended to be relatively temporary. Temporary buildings also were easier to dispose of if they became contaminated. Meanwhile, at a national level, ERDA requested funding in 1975 to evaluate and possibly develop a site in southeastern New Mexico for

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[31] Anderson, *History of the RWMC*, p. 55.

[32] Terence R. Fehner and Jack M. Holl, *Department of Energy, 1977-1994, A Summary History* (Washington, D.C.: U.S. Department of Energy History Division, DOE/HR-0098, 1994), p. 6, 17-20.

[33] Anderson, *History of the RWMC*, p. 59.

the permanent storage of TRU waste.[34]

In 1977 the Department of Energy (DOE) replaced ERDA as the cabinet-level federal agency in charge of the nuclear industry. Locally, changes were made in the way waste was stored at the INEL. Instead of trenches and pits, soil vaults were now used in what was now termed the Subsurface Disposal Area (SDA). Two cells in the Transuranic Storage Area (adjacent to the SDA) were then tested in 1978. This storage proved to be acceptable, especially after an air support weather shield was permanently placed over it.[35] In 1978, carbon steel vaults were placed in the Intermediate Level Transuranic Storage Facility (ILTSF). In later years, these proved to be corrosive. Further construction occurred at the RWMC in 1979. As part of continuing efforts to monitor waste, observation well houses (WMF 606-608) were built around the site. A heavy equipment storage shed (WMF-609) was constructed, again out of steel and metal, to house cranes and other large machines.[36]

The Era of CERCLA and Superfund: 1980-1989

In 1980, Congress passed the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), which established a "Superfund" to clean up the chemical waste sites that would be placed on a National Priority List for such cleanup. Some of the cleanup involved moving waste from one site to another. That same year, the Argonne National Laboratory (East) started sending its low-level waste to the INEL's RWMC site.

The Superfund effort lagged in 1981 under the Reagan Administration. Virtually no Congressional authorizations effected any change at the INEEL during the early 1980s. Only a guardhouse (WMF-611) was constructed at RWMC.[37]

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[34] R.D. Logan and D. Jacobson, Internal Technical Report, "INEL Building Study, Perimeter Area Buildings" (Idaho Falls, Idaho: EG&G Idaho, Inc., December 1990). Some construction dates in this report conflict slightly with 1993 and 1996 INEL Technical Site Information reports.

[35] Anderson, *History of the RWMC*, p. 54-59.

[36] Logan and Jacobson, (1990).

[37] "A Comprehensive Inventory, 1952-184" (October 1993), p. 1-4; "INEL Building Study" (1990).

In 1982 Congress passed the Nuclear Waste Policy Act. This law provided for the development of geologic repositories for high-level waste and spent nuclear fuel disposal. The act also established research, development, and demonstration programs regarding disposal of these particular wastes. On the heels of this act came the April 1983 *Leaf v. Hodel* decision, which subjected DOE to the 1976 RCRA requirements for handling hazardous waste disposal. Also during this time, the DOE had chosen Carlsbad, New Mexico, for a Waste Isolation Pilot Plant (WIPP) as its permanent TRU waste repository. After protracted controversy, WIPP opened, and the INEEL began shipping qualified waste for permanent storage in 1999.

The need to qualify waste suited for WIPP storage led to plans for two waste disposal projects at the INEL. In 1984 the Stored Waste Examination Pilot Plant (SWEPP) opened. It provided operations capabilities for nondestructive examination and certification of TRU waste stored at the INEL. The RWMC's SWEPP facility was the first of its kind in the United States. Once the waste was certified at SWEPP, it was ready to be shipped to the New Mexico WIPP site. Waste which did not meet WIPP's waste acceptance criteria would be shipped to the proposed Process Experimental Pilot Plant (PREPP) for processing. PREPP, to be located at TAN, was planned as an experimental program to devise methods of processing wastes into acceptable forms. The proposed program would involve the shredding and incinerating of waste, then immobilizing it in concrete.[38]

SWEPP started operating in 1985. The SWEPP program generated another "first" for the INEL -- it was the first United States facility to perform nondestructive examination and certification of defense-generated TRU waste. However, the PREPP facility was never started, partly because of questions about the program's capabilities. DOE eventually decided to prepare transuranic wastes for shipment to a then-undecided national waste burial site elsewhere than at INEL. The emphasis at INEL shifted to preparation and packaging of the material for shipment. In 1988 and 1989, the TRUPACT II (transuranic waste package containers) loading station, work control trailers, and communications building were constructed at RWMC.

INEEL Area: SPERT/Power Burst Facility

[38] Video Script, "Processing Experimental Pilot Plant (PREPP)" (Idaho Falls, Idaho: EG&G Idaho, 1984).

New Mission for the Power Burst Facility (PBF)

In the 1980s SPERT/PBF took on a new research mission directed to waste management. In 1968 SPERT-III had been put in standby condition. In 1980 it was decontaminated, and its system components recovered. The process pit, reactor pit, dry storage houses, reactor head dock, main reactor floor, and the storage canal all were decontaminated. In 1982 it was renamed the Waste Experimental Reduction Facility (WERF) and converted to include an incinerator, melting furnace, compactor, and sizing shop where metallic waste was cut up and re-sized. WERF's mission was to reduce the volume of low-level radioactive waste and mixed waste before it was shipped to a disposal site.[39]

In 1985 the SPERT-I reactor, which had been located in a below-grade pit, was dismantled and the area returned to it's original state. In 1986 the SPERT-II Facility was renamed the Waste Engineering Development Facility (WEDF). It served as a place for investigating radioactive and mixed waste treatment technologies and processes. SPERT-IV also entered the waste management arena in 1986. It was renamed the Mixed Waste Storage Facility (MWSF) and modified to provide interim storage space for low-level mixed waste until the waste was dispatched to a more permanent waste site.[40]

The INEL's Post-Cold War Mission: 1990-1997

On December 9, 1991, the DOE Idaho Operations Office, Region 10 of the Environmental Protection Agency, and the Idaho Department of Health and Welfare signed the INEL Federal Facility Agreement and Consent Order. This document supplied all parties with a goal to restore the environment at the INEL and guidelines for a variety of cleanup activities. The sites to be cleaned up included those contaminated with asbestos, petroleum products, acids and bases, radionuclides, unexploded ordnance and explosive residues, PCBs, heavy metals and other hazardous wastes. It was hoped that INEL could be removed from the National Priorities List by 2006.

This legally binding document has provided numerous benchmarks and milestones in the remediation of hazardous

[39] *Comprehensive Facility and Land use Plan*. (Idaho Falls: Idaho National Engineering Laboratory, March 1996), p.157.

[40] *Comprehensive Facility and Land use Plan*, p.157.

residues of many kinds. Each facility complex in the desert was given a new label as a "Waste Area Group" or WAG. The resulting ten WAGs were then further inventoried as to their "Operable Units," or individual targets for clean up. WAG 10 covered the desert land beyond the fences of the Site's nine complexes. Under that name, the Navy's unexploded ordnance, chunks of TNT, and other debris were targeted for cleanup. Other projects involve the removal and treatment of organic vapors beneath the Radioactive Waste Management Complex, the excavation and treatment of buried mixed transuranic waste from Pit 9 and the treatment of contaminated groundwater from beneath TAN.[41]

The laboratory building to which many of the scientists who worked on waste cleanup reported was located in Idaho Falls. The Idaho Research Center (IRC), created in the 1980s during the national interest in fuel efficiency, expanded as INEL research efforts moved in directions such as fuel alcohol, the biological processing of ores, development of special metal alloys, and welding. For these types of work the INEL hired its first microbiologists and biochemists. When the INEL later faced its many complex cleanup challenges, the appropriate personnel and laboratory facilities were available. The desert, former site of explosives tests, nuclear experiments, industrial and nuclear waste disposals of many kinds, and myriad forms of contamination large and small, became the new laboratory for IRC scientists charged to remediate it all.[42]

The federal support of cleanup grew. During the 1990s, about sixty percent of the total INEL budget was for "Environmental Management," or cleanup. John Wilcynski, DOE manager during between 1994-1999, used to simplify INEL's path forward with the slogan, "Finish the sixty, and grow the forty," meaning that as the cleanup tasks were accomplished, the research mission of the laboratory could resume a larger share of the total effort.[43]

In 2003, DOE and its regulatory partners, the State of Idaho and the Environmental Protection Agency, were considering a cleanup schedule that would "accelerate" many of the target dates and deadlines to which they had previously agreed. This administrative thrust has the potential to accelerate the rate at which buildings and

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[41] *INEL Reporter* (November/December 1996), p. 1.

[42] Stacy, *Proving the Principle*, p. 247-249.

[43] Stacy, *Proving the Principle*, p. 253.

facilities -- many of them of historic significance -- are being decommissioned and dismantled. Even whole building clusters, which made up such a significant part of INEEL's historic "landscape," are proposed for complete erasure. The Army Reactors Area already has been eliminated in this fashion (although this was done prior to the "accelerated" schedule).

Significance of the Remediation of Waste Context

Though the history of the RWMC is relatively brief, the facility highlights a major turning point for the INEEL and the national nuclear industry. The early optimism engendered by nuclear energy's peaceful potential gradually became clouded by controversy about the disposition of waste and spent reactor fuel. In the 1970s the issues of burial, cleanup, and remediation of nuclear waste came to the national forefront. After the Cold War ended in 1990, interest (and funding) for nuclear science rapidly waned. The development of the RWMC and its constantly evolving technologies reflect this important shift in the history of INEEL and the national atomic energy program.

The INEL provided early experimental prototypes for nuclear waste remediation. The 1984 the Stored Waste Examination Pilot Plant (SWEPP) began operation at the INEL, the first United States facility of its kind to provide capabilities for nondestructive examination and certification of TRU waste. Whether this prototype will prove to have lasting historical significance or, indeed, whether the Remediation of Waste context itself, will survive the fifty-year benchmark for the National Register shall have to await the passage of time.

NOTES ON THE SITE SURVEY AND INVENTORY OF BUILDINGS

Purpose of Survey

The building survey and inventory provides a data base to support INEEL management plans and programmatic agreements. Its users will include INEEL Cultural Resources Department personnel, site property managers and planners, and the Idaho State Historic Preservation Office (SHPO). In addition to descriptive data, the forms supply information about a building's typology and its relationship to a historic context (if any). In some cases, the forms also recommend that the preservation of certain historically significant buildings be an element of future historic preservation management plans.

Previous Surveys

The staff of the INEEL Cultural Resource Department initiated surveys of the Central Facilities Area and the Test Reactor Area in 1995 and 1996 respectively. Using SHPO reconnaissance forms current at that time, the staff recorded buildings constructed before 1975 and photographed each building, taking two oblique views that showed four sides of the building.[1]

The Arrowrock Group, Inc., surveyed the rest of the buildings at the INEEL in 1997, except those at the Naval Reactors Facility (NRF) and Argonne West, and reformatted the earlier data onto the newly developed forms. The contractor for DOE/Pittsburgh Naval Reactors contracted separately with Arrowrock to complete an inventory of NRF buildings which was completed in 1998. The survey included black/white photographs. Argonne-West staff surveyed Argonne-West buildings in 1998, photographing the buildings using a digital format.[2]

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[1] Julie Braun, *LITCO Internal Report, Idaho National Laboratory Historic Building Inventory Survey, Phase I* (Idaho Falls: LITCO Report No. INEL-95-0498, 1995; and Julie Braun and Clayton Marler, *Idaho National Engineering Laboratory Historic Building Inventory Survey, Phase II* (Idaho Falls: Lockheed Martin Report No. INEL-96/0374).

[2] Hollie Gilbert, Fabulous Argonne Survey as yet with no title known to SS,

Photographs: Special Circumstances

The Idaho SHPO agreed in 1997 that the 1995 and 1996 photographs of the Central Facilities and Test Reactor areas were acceptably recent for the Arrowrock extension of the survey. Arrowrock continued the protocol of taking two oblique photographic views. Large or complex buildings required more than two views. For most buildings in the survey, this report represents each building with only one view. The remaining views are on file at the INEEL photograph laboratory in Idaho Falls.

Numerous "memoranda of agreement" have been negotiated between the Department of Energy and the Idaho SHPO since 1993 regarding mitigation for historic buildings that were to be altered or demolished. Pursuant to those, photographs were required and taken of the buildings in question and of one entire site activity complex, the Army Reactor Area (ARA). The ARA was documented in HAER-ID-32-D, completed in 2001. Only one extant building from ARA-IV has been inventoried.

During this survey, access to Howe Peak was not available. Howe Peak is a high-elevation site containing several communications facilities. It is located outside the boundary of the INEEL site, and access is restricted for security reasons. In spring and early summer 1997, the road was still covered with snow. Photographing Howe Peak buildings would have required leasing either a helicopter or four-wheel drive vehicle and securing appropriate clearance and escort. We suggest that inventory forms and photographs be supplied to SHPO as time allows to complete the inventory or if any of the buildings at Howe Peak are scheduled to be altered or dismantled.

Since the 1997 survey period, new buildings have been erected at the site. In no case are these buildings classifiable as "historic" or of "exceptional" historic interest. They have been inventoried and are now part of this updated report. Photographs of each are available in the *INEEL Comprehensive Facility and Landuse Plan*, which is routinely amended and updated.[3]

Exempt Buildings.

[3] United States Department of Energy, *INEEL Comprehensive Facility and Land Use Plan*. Idaho Falls: DOE/ID Report No. 10514, March 1996. The INEEL intranet address for this document is http://mceris.inel.gov.

Upon mutual agreement between INEEL and the Idaho SHPO, utility structures and mobile trailers have been exempted from survey and inventory. Therefore, such buildings are not included in this inventory.[4]

Content of the Inventory Forms

Property Data. This section includes the property name and the INEEL building number. The alphabetic prefix refers to a site complex: CFA for example, indicates Central Facilities Area. The numbers were assigned in sequence based on age. The first number was 601. When 600 numbers were exhausted at a given site, the next building was numbered 1601. Occasionally, numbers were re-issued to new buildings after an earlier building bearing that number had been dismantled. "Structures" are given 700 and 1700 numbers, except at Argonne-West, where buildings are assigned 700 numbers.

Historic Context. The general context for all INEEL properties, taken from the list of contexts in *National Register Bulletin 16 A*, is Science/Engineering. This phrase is followed by one of the three (sub)contexts discussed in this report: Nuclear Reactor Testing, Multi-Program Research, or Remediation of Waste.

National Register Recommendations. Historical research, summaries of which are presented in Part 1 of this report and supplemented by *Proving the Principle, A History of the Idaho National Engineering and Environmental Laboratory 1949-1999*, informed the historic assessment of buildings. An early hypothesis was that buildings were likely to be either uniquely related to a significant activity (such as a heat exchange system designed for a specific nuclear reactor and its coolant) or supportive of it, but not uniquely so (office building). Historic significance was expected, in most cases, to reside in the buildings containing a reactor experiment or main chemical process and its immediate auxiliaries.

This hypothesis was under constant review as the team visited each of the facility areas, walked the grounds with the INEEL photographer, and consulted technical and documentary sources. The hypothesis proved a good one, but

[4] See Julie Braun, *INEEL Historic Architectural Properties Management Plan for U.S. Department of Energy, Idaho Operations Office* (Idaho Falls: Bechtel BWXT Idaho, LLC, Report No. INEEL/EXT-02-1338, Revision O), p. 18, 95-96.

additional insight materialized. Although the facility areas are distinct, they have complex programmatic and physical interconnections such as roads, electric utilities, and communications. We observed the obvious impact that new missions and new conditions are having on each facility area.

Yet the site resembles its older historic self. Change is occurring well within the "cluster" arrangements established between 1949 and 1970. Except for some environmental monitoring and remediation activities, most activities are still confined within rectangular perimeter fences, secured by guard gates, and served with interior streets and pathways. Each area contains the usual mix of built objects: industrial buildings, structures, and the occasional artifact. Activities just outside the fences also take the same forms they always did: sewage lagoons, evaporation ponds, and laydown yards. At various locations elsewhere on the wide expanse of the desert, environmental research and monitoring stations dot the scene; their purpose has changed since the 1950s, but their presence creates a similar appearance. Observing these continuities strengthened our conviction that the most useful way to regard this site is as a historic landscape that continues its evolutionary process.

For this reason, the historians assessed every building in the survey as part of a "historic landscape," regardless of its construction date. The INEEL is a landscape that "historically has been used by people, or shaped or modified by human activity, occupancy, or intervention, and that possess a significant concentration, linkage, or continuity of areas of land use, vegetation, buildings and structures, roads and waterways, and natural features."[5] The continuity in this landscape is remarkable.

After considering the history of the site, we found that the "Ordnance Testing/World War II" and "Nuclear Reactor Testing" context are historically or "exceptionally" significant on both a national and state level. These contexts extend from 1942 through 1970. The protocol for acknowledging this on the inventory forms was to indicate that buildings of this period are "contributing in a potential district." If the building was one of the reactor or process buildings that was significant, it was additionally noted as "individually eligible." If an

[5] Linda Flint McClelland, et al, *National Register Bulletin 30, Guidelines for Evaluating and Documenting Rural Historic Landscapes* (Washington, D.C.: U.S. Department of the Interior, National Park Service, no date.), p. 1-2.

auxiliary building was associated with a reactor, it was identified as "contributing in a potential district."

Buildings erected in 1971 or later are noted as "not eligible" and/or "not contributing," with the exception of buildings that we consider of "exceptional significance."

It is expected that this information will support historic preservation plans aiming to preserve archival documentation, develop HABS/HAER-level recordation, and carry out other recommendations discussed in the introduction to this report.

Style, Plan, Materials, and Square Footage of Building. Most INEEL buildings are enclosures with no intentional style. The word "None" or "No style" indicates this. The "Plan" entry describes the shape of the building, approximate height, and roof style. This, when considered together with square footage can supply a rough image of the structure. The majority of INEEL buildings are rectangular, metal-clad, and metal-roofed.

Condition. Assessments of condition are taken from the *INEEL Comprehensive Facility and Land Use Plan* published by the INEEL in 1996 and as this document has been amended and updated.

Future Plans. This data represents the intentions of INEEL planners as stated in the 1996 Land Use Plan referenced just above, taking into account its subsequent updates.

Original Use, Current Use, and Historian's Type Classification. The typology provides a link between a specific building and the historic context. (See below for Typologies.) For example, a "pumphouse" constructed during the years of the "Nuclear Reactor Testing" context may be typed as a "Utility" if it is related to a water supply well. If it is related to the management of radioactive liquid waste, it will be typed "Waste Management." Both types are "contributing" features, but the utility pumphouse may be of substantially less historic interest.

Property Types

INEEL buildings fall into one of four context periods discussed in Part 1 of this report. For each context, one would expect to find certain types of properties. The continuity between "Nuclear Reactor Testing" and "Multi-Program Research" is such that the same typology holds for each. The Chemical Processing Plant (INTEC) does not contain nuclear reactors; however, its main processing buildings are of equivalent significance.

Some judgement must be exercised in assigning a building to a certain classification. Some overlap in the use of the terminology is natural. For example, some "storage" buildings may be directly associated with the operation of a reactor, as in the storage of plugs; other storage may be related to the warehousing of construction materials.

Property Types for Context III: Ordnance Testing

Testing facilities: Gun pit, concussion wall, bunker, target
Research: Laboratory
General administration: Office
Personnel services: Barracks, bunkhouse, residence, garage, cafeteria, dispensary
Auxiliary support: Fire suppression, storage/warehouse, maintenance/shops
Utilities: Water, heat, electricity, sewer
Transportation: Gantry crane, railroad tracks, roads
Communication
Security: Guard house, guard gates, fence, training range

Property Types for Contexts IV and V: Reactor Testing, Experimentation, and Development; and Multi-Program Research

Reactor/Test Experiment: Reactor building, reactor prototype, critical facility reactor
Reactor/Test Support: Laboratory; control room; coolant processing and handling; hot cell; fuel transfer; waste handling, storage, and processing; administration; shop fabrication, maintenance, repair; personnel services
Production: manufacturing facilities
General administration: Office
Personnel services: Cafeteria, dispensary, library, sleeping quarters
Auxiliary support: Training, health physics and safety labs, fire, suppression, emergency evacuation, badging
Utilities: Water, heating, electricity, sewer
Waste management and environmental monitoring: Monitoring stations, evaporation ponds, pumps, injection wells, instrument housing, meteorological stations, animal pens and barns
Transportation: Railroads, roads, bus depot, bus maintenance garage, bike paths/racks, helicopter

pads, scale house
Communication: Microwave relay, towers
Security: Guard houses, gates, fences, training ranges

Property Types for Chemical Processing Plant

Main Process Building: Chemical separation, calcining
Main Process Support: Fuel chopping, laboratory, hot shop, offices
Other types are similar to those in "Nuclear Reactor Testing."

Property Types for Context VI: Remediation of Waste

Waste Processing Facilities: Processing vaults and tunnels, pump houses, loading stations, hot cells, examination and certification stations, SWEPP, Pit 9 structure, pumphouses, storage
Decontamination Facilities: Hot laundry
Waste Venting facilities: Chlorine venting, propane vaporizer housing, SWEPP drum venting facility
Waste Monitoring Stations: Well houses, meteorological stations, field laboratory, soil percolation test stations, soil test grouting facility, core storage library, waste water laboratory
General administration: Offices
Personnel services: Change house, lunchroom
Auxiliary support: Warehouse, shop fabrication, maintenance, repair, equipment storage
Utilities: Water, heating, electricity, sewer
Security: Guard house, gates, fences
Transportation: Railroad stations, loading stations, shipping and receiving stations, helicopter facilities
Communication: Trailers, towers

Sources of Information

The following reports were particularly useful in providing data about construction dates, construction materials, and alterations. In cases where reports gave conflicting data, we used the data judged to be most reliable or consulted other sources. (To avoid duplication and undue lengthening of each form, these citations do not appear on each inventory form.)

Energy Management Surveys. After the Arab Oil Embargo of the United States in 1973, the Department of Energy mandated all of its facilities to reduce their level of energy usage by 25 percent within a specific number of years. At the INEEL this order resulted in the application of insulated siding on many cinder block buildings, construction of vestibules, weatherstripping, and the like.[6]

DOE issued a second order in 1985 to reduce energy usage an additional 10 percent by 1995. The Energy Management department researched, photographed, and inventoried each site building; prepared an energy audit; and made further recommendations. This information was published in the following reports.

T.L. Kinnaman, N.A. Rhodehouse, and D.M. Teel. *INEL Building Study, Test Reactor Area*. Idaho Falls: EG&G Report No. F&M-PM-88-015, 1988.

T.L. Kinnaman. *INEL Building Study, Test Area North*. Idaho Falls: EG&G Report No. F&M-PM-87-013, 1987.

R.D. Logan. *INEL Building Study, Idaho Chemical Processing Plant*. Idaho Falls: EG&G Report No. F&MD-PM-90-017, 1990.

R.D. Logan and C.E. Jacobson. *INEL Building Study, Perimeter Area Buildings*. Idaho Falls: EG&G, 1990.

D.M. Teel and T.L. Kinnaman. *INEL Building Study, Central Facilities Area*. Idaho Falls: EG&G, 1986.

Site Development Plans. DOE Order 4320.1B requires the preparation of Five Year Plan documents. These provided useful lists of buildings, site maps, and other information about the projected use or excessing of a building. We consulted a series of updates to these, beginning with versions originating in 1981.

Site Characteristics, Volume II, Site Development Plan. Idaho Falls: DOE ID, 1983 and later updates.

L.D. Smith, C.E. Jacobson, J.R. Cunningham. *Idaho National Engineering Laboratory Site Technical Information*. Idaho Falls: U.S. DOE Idaho Operations Office Report No. DOE/ID-10401, 1993.

Idaho National Engineering Laboratory. *Comprehensive Facility and Land Use Plan*. Idaho Falls: Report

[6] Dave Teel, Energy Management, in interview with Susan Stacy at Engineering Research Office Building, May 20, 1997.

No. DOE/ID-10514, 1996. The INEEL intranet address for this document is http://mceris.inel.gov.

Technical Reports. Technical reports available for some buildings describe construction design criteria. These typically explain the logic behind certain features of a building and provide insight as to its purpose.

IDAHO HISTORIC SITES INVENTORY: **INEEL HISTORICAL CONTEXT**
Idaho State Historic Preservation Office

This form documents a building at Idaho National Engineering and Environmental Laboratory. It assesses its eligibility for the National Register of Historic Places and includes other data pursuant to a Programmatic Agreement for INEEL.

PROPERTY DATA

*Property Name/Area/Bldg. Number ______ / ______ / ______
*USGS Map Reference ______
*Township ____ Range ____ Section ____, ____ 1/4 of ____ 1/4 of NE 1/4, Boise Meridian
UTM: zone ____ ______ easting ______ northing
*County Butte Acres ______ City 40 miles west of Idaho Falls *Address Idaho National Engineering and Environmental Laboratory
Historic Context Science/Engineering: ______
*Property Type: Building *Total # features ______
*Associated bldgs./structures ______
*Construction Date ______ Estimated Construction Period ______
Style ______ Plan ______
*Condition ______ *Moved: Yes ____ When ______
*Materials ______

*Original Use Govt./ ______ *Current Use Govt./ ______

NATIONAL REGISTER RECOMMENDATION: (check all that apply)

____ Individually eligible
____ Contributing in a potential district
____ Multiple property study
____ Significant person
____ Architectural/artistic values

____ Not eligible
____ Noncontributing
____ Historical significance
____ Historic landscape
____ Not evaluated

Comment ______
*Recorded by The Arrowrock Group, Inc. *Phone (208) 344-7371
*Address 1718 North 17th Street, Boise, Idaho 83702
*Project/Report Title Historic Context of INEEL, Toward a Programmatic Agreement
Survey Report # ______ Reconnaissance X Intensive ___ *Date Sept. 19, 1997

FIELD NOTES/ADDITIONAL INEEL INFORMATION

Other name(s) ______
Access restrictions due to contamination ___ yes
Square footage of building ______
Future plans ______
Historian's type classification ______

Additional comment page attached ___ yes

Other notes:

INVENTORY OF SURVEYED BUILDINGS, INEEL CONTEXT STUDY, 2003

Power Burst Facility Area

Building	Eligible for NR	Year blt	Context
PER 601	Yes	1955	NRT
PER 604	Yes	1955	NRT
PER 606	Yes	1956	NRT
PER 609	Yes	1957	NRT
PER 612	Yes	1959	NRT
PER 613	Yes	1960	NRT
PER 616	Yes	1967	NRT
PER 617	Yes	1962	NRT
PER 619	Yes	1955	NRT
PER 620	Yes	1966	NRT
PER 622	No	1990	Multi-Prog
PER 623	No	1991	Multi-Prog
PER 624	No	1974	Multi-Prog
PER 625	Yes	1966	NRT
PER 626	No	1972	Multi-Prog
PER 627	Yes	1966	NRT
PER 629	No	1981	Multi-Prog
PER 632	No	1980	Multi-Prog
PER 634	No	1983	Multi-Prog
PER 635	No	1981	Multi-Prog
PER 638	No	1995	Multi-Prog
PER 641	No	1993	Multi-Prog

Total Number of buildings: 22

Distribution by decade:

1950s6
1960s6
1970s2

Distribution by context:

NRT 12
Multi-Prog 10

1980s4
1990s4
2000s0

Central Facilities Area

Building	Eligible for NR	Year blt	Context
CFA 601	Yes	1950	NRT
CFA 602	Yes	1969	NRT
CFA 603*	No	1943	Ord WW2
CFA 604	No	1983	Multi-Prog
CFA 606	Yes	1942	Ord WW2
CFA 607	Yes	1942	Ord WW2
CFA 608	No	1984	Multi-Prog
CFA 609	No	1988	Multi-Prog
CFA 611	No	1991	Multi-Prog
CFA 612	No	1983	Multi-Prog
CFA 613	Yes	1943	Ord WW2
CFA 614	No	1986	Multi-Prog
CFA 615	No	1991	Multi-Prog
CFA 616	No	1983	Multi-Prog
CFA 617	No	1981	Waste
CFA 619	No	1989	Multi-Prog
CFA 621	No	1983	Multi-Prog
CFA 622	No	1984	Multi-Prog
CFA 623	No	1986	Multi-Prog
CFA 624	No	1986	Multi-Prog
CFA 625 A&B	No	1989	Waste
CFA 629	No	1979	Multi-Prog
CFA 632	Yes	1945	Ord WW2
CFA 633	Yes	1943	Ord WW2
CFA 635	Yes	1943	Ord WW2

Building	Eligible for NR	Year blt	Context
CFA 637	Yes	1943	Ord WW2
CFA 638	Yes	1943	Ord WW2
CFA 642	Yes	1943-49	Ord WW2
CFA 643	No	1977	Multi-Prog
CFA 646	Yes	1950	NRT
CFA 650	Yes	1943	Ord WW2
CFA 651	Yes	1943	Ord WW2
CFA 652	No	1979	Multi-Prog
CFA 660	Yes	1963	NRT
CFA 661	Yes	1963	NRT
CFA 662	Yes	1952	NRT
CFA 663	No	1990	Waste
CFA 664	Yes	1951	NRT
CFA 666	Yes	1951	NRT
CFA 667	Yes	1951	NRT
CFA 668	Yes	1951	NRT
CFA 671	Yes	1951	NRT
CFA 674	Yes	1952	NRT
CFA 676	Yes	1963	NRT
CFA 677	Yes	1951	NRT
CFA 678	Yes	1951	NRT
CFA 680	Yes	1951	NRT
CFA 684	Yes	1952	NRT
CFA 685	Yes	1952	NRT
CFA 686	No	1979	Multi-Prog
CFA 688	Yes	1963	NRT
CFA 689	Yes	1963	NRT
CFA 690	Yes	1963	NRT
CFA 692	Yes	1950	NRT

Building	Eligible for NR	Year blt	Context
CFA 693	Yes	1969	NRT
CFA 695	Yes	1966	NRT
CFA 696	No	1995	Multi-Prog
CFA 697	Yes	1960	NRT
CFA 698	Yes	1969	NRT
CFA 699	Yes	1969	NRT
CFA 1601	No	1995	Waste
CFA 1602	No	1990	Multi-Prog
CFA 1603	No	1995	Multi-Prog
CFA 1605	No	1995/96	Waste
CFA 1606	No	1995	Multi-Prog
CFA 1607	No	1995	Multi-Prog
CFA 1608	No	1995	Multi-Prog
CFA 1609	No	1995	Multi-Prog
CFA 1610	No	1995	Multi-Prog
CFA 1611	No	1996	Multi-Prog
CFA 1612	No	1996/97	Multi-Prog
CFA 1614	No	1997	Multi-Prog
CFA 1616	No	1997	Multi-Prog
CFA 1618	No	2000	Multi-Prog

* CFA 603 was altered after 1970 and is no longer eligible.

Total number of buildings: 74 (CFA-625 counted as one bldg.)

Distribution by decade:

1940s12
1950s15
1960s12
1970s 4
1980s13
1990s17
2000s 1

Distribution by Context:

Ord WW2 12
NRT 27
Multi-Prog 30
Waste 5

Sitewide Facilities

Building	Eligible for NR	Year blt	Context
B8-601	No	1984	Multi-Prog
B8-602	No	1986	Multi-Prog
B16-602	Yes	1958	NRT
B16-603	Yes	1964	NRT
B16-605	Yes	1956	NRT
B16-606	Yes	1963	NRT
B16-607	No	1982	Multi-Prog
B16-610	Yes	1960	NRT
B21-606	No	1984	Multi-Prog
B21-607	No	1988	Multi-Prog
B21-608	No	1989	Not identified
B21-609	No	1989	Not identified
B21-610	No	1989	Not identified
B21-611	No	1989	Not identified
B21-612	No	1994	Not identified
B21-620	No	1995	Not identified
B25-601	No	1995	Not identified
B27-601	No	1984	Multi-Prog
B27-602	No	1984	Multi-Prog
B27-603	No	1986	Multi-Prog
B27-604	No	1985	Multi-Prog
B27-605	No	1987	Multi-Prog
B27-606	No	2002	Not identified

Number of buildings: 23

Distribution by decade:

1950s 2
1960s 3
1970s 0
1980s14

Distribution by Context:

NRT 5
Multi-Prog 10
Not identified 8

1990s 3
2000s 1

Army Reactor Area

Building	Eligible for NR	Year blt	Context
ARA 617	Yes	1962	NRT

Number of buildings: 1

Experimental Breeder Reactor-1 Area

Building	Eligible for NR	Year blt	Context
EBR-601 *	Yes	1950	NRT
EBR-602	Yes	1950	NRT

Number of buildings: 2

* EBR-1 is a National Historic Landmark. It is managed in accordance with the requirements of the National Historic Landmarks program found at 36 CFR Part 65.

Test Reactor Area

Building	Eligible for NR	Year blt	Context
TRA 603 MTR	Yes	1952	NRT
TRA 604	Yes	1952	NRT
TRA 605	Yes	1952	NRT
TRA 607	Yes	1952	NRT
TRA 608	Yes	1952	NRT
TRA 609	Yes	1952	NRT
TRA 610	Yes	1952	NRT
TRA 611	Yes	1952	NRT
TRA 613	Yes	1952	NRT
TRA 614	Yes	1952	NRT
TRA 616	Yes	1952	NRT

Building	Eligible for NR	Year blt	Context
TRA 618	Yes	1952	NRT
TRA 620	Yes	1952	NRT
TRA 621	No	1982	Multi-Prog
TRA 622	Yes	1952	NRT
TRA 624	No	1981	Multi-Prog
TRA 625	No	1981	Multi-Prog
TRA 626	Yes	1952	NRT
TRA 628	No	1986	Multi-Prog
TRA 629	Yes	1956	NRT
TRA 630*	No	1952	NRT
TRA 632	Yes	1953	NRT
TRA 632A	Yes	1956	NRT
TRA 634	No	1982	Multi-Prog
TRA 635	Yes	1952	NRT
TRA 636	Yes	1952	NRT
TRA 637	No	1979	Multi-Prog
TRA 638	No	1979	Multi-Prog
TRA 640	No	1984	Multi-Prog
TRA 641	Yes	1955	NRT
TRA 642 ETR	Yes	1957	NRT
TRA 643	Yes	1957	NRT
TRA 644	Yes	1957	NRT
TRA 647	Yes	1957	NRT
TRA 648	Yes	1957	NRT
TRA 649	Yes	1966	NRT
TRA 651	Yes	1960	NRT
TRA 652	Yes	1966	NRT
TRA 653	Yes	1957	NRT
TRA 654	Yes	1959	NRT

Building	Eligible for NR	Year blt	Context
TRA 655	Yes	1957	NRT
TRA 656	Yes	1959	NRT
TRA 657	Yes	1952	NRT
TRA 658	No	1987	Multi-Prog
TRA 660 ARMF	Yes	1957	NRT
TRA 661	Yes	1962	NRT
TRA 662	Yes	1961	NRT
TRA 663	Yes	1957	NRT
TRA 664	Yes	1961	NRT
TRA 665	Yes	1962	NRT
TRA 666	Yes	1963	NRT
TRA 667	Yes	1964	NRT
TRA 668	Yes	1956	NRT
TRA 669	Yes	1968	NRT
TRA 670 ATR	Yes	1964	NRT
TRA 671	Yes	1971	NRT
TRA 673	Yes	1971	NRT
TRA 674	No	1984	Multi-Prog
TRA 675	No	1987	Multi-Prog
TRA 676	No	1989	Multi-Prog
TRA 677	No	1992	Multi-Prog
TRA 678	No	1991	Multi-Prog
TRA 679	No	1991	Multi-Prog
TRA 680	No	1991	Multi-Prog
TRA 681-686	No	1985	Multi-Prog
TRA 687	No	1995	Multi-Prog
TRA 688	No	2000	Multi-Prog
TRA 689	No	1997	Multi-Prog
TRA 690	No	1997	Multi-Prog

Building	Eligible for NR	Year blt	Context
TRA 691	No	1996	Multi-Prog
TRA 692	No	1996	Multi-Prog

Number of buildings: 71 + 5 = 76

Distribution by decades:

1950s43
1960s13
1970s 5
1980s12
1990s13

Distribution by context:

NRT 59
Multi-Prog 27

* TRA 630 has been substantially altered and no longer retains its historic feature.

Note: Building TRA 615 was built in 1970 and indicated for the NRT context. TRA 671 and 673 were built in 1971, but were assessed as part of the Nuclear Reactor Testing Context because of their close association with the Advanced Test Reactor.

Test Area North

Building	Eligible for NR	Year blt	Context
TAN 601	Yes	1956	NRT
TAN 603	Yes	1956	NRT
TAN 604	Yes	1956	NRT
TAN 605	Yes	1956	NRT
TAN 606	Yes	1956	NRT
TAN 607	Yes	1955	NRT
TAN 609	Yes	1956	NRT
TAN 616	Yes	1955	NRT
TAN 618	No	1987	Multi-Prog
TAN 624	Yes	1959	NRT
TAN 628	Yes	1958	NRT
TAN 629*	Yes	1958	NRT

Building	Eligible for NR	Year blt	Context
TAN 630	Yes	1959	NRT
TAN 631	Yes	1959	NRT
TAN 633	Yes	1958	NRT
TAN 636	Yes	1967	NRT
TAN 637	Yes	1958	NRT
TAN 640	Yes	1958	NRT
TAN 641	Yes	1958	NRT
TAN 642	Yes	1957	NRT
TAN 645	Yes	1960	NRT
TAN 646	Yes	1965	NRT
TAN 647	Yes	1965	NRT
TAN 648	Yes	1961	NRT
TAN 650	Yes	1960	NRT
TAN 651	Yes	1960 asm	NRT
TAN 653	No	1985	Multi-Prog
TAN 654	No	1986	Multi-Prog
TAN 655	No	1972	Multi-Prog
TAN 657	No	1971	Multi-Prog
TAN 658	Yes	1960s	NRT
TAN 662	No	1978	Multi-Prog
TAN 664	Yes	1954	NRT
TAN 665	No	1980	Multi-Prog
TAN 666	No	1980	Multi-Prog
TAN 667	No	1983	Multi-Prog
TAN 668	No	1985	Multi-Prog
TAN 671	No	1975	Multi-Prog
TAN 672	No	1979	Multi-Prog
TAN 675	No	1984	Multi-Prog
TAN 676	No	1985	Multi-Prog

Building	Eligible for NR	Year blt	Context
TAN 677	No	1974	Multi-Prog
TAN 678	No	1985	Multi-Prog
TAN 679	No	1986	Multi-Prog
TAN 680	No	1985	Multi-Prog
TAN 681	No	1985	Multi-Prog
TAN 682	No	1986	Multi-Prog
TAN 686	No	1987	Multi-Prog
TAN 687	No	1989	Multi-Prog
TAN 688	No	1986	Multi-Prog
TAN 690	No	1976	Multi-Prog
TAN 692	No	1988	Multi-Prog
TAN 693	No	1988	Multi-Prog
TAN 694	No	1987	Multi-Prog
TAN 695	No	1992	Multi-Prog
TAN 1601	No	1995	No context assigned
TAN 1611	No	2000	No context assigned
TAN 1613	No	2002	No context assigned

Number of buildings: 58

Distribution by decade:

1950s19
1960s 8
1970s 7
1980s20
1990s 2
2000s 2

Distribution by Context:

NRT 27
Multi-Prog 28
None assigned 3

* TAN Hangar 629 was the subject of HAER No. ID-33-A.

Chemical Processing Plant

Building	Eligible for NR	Year blt	Context
CPP 601	Yes	1953	NRT
CPP 602	Yes	1953	NRT
CPP 603	Yes	1952	NRT
CPP 604	Yes	1951	NRT
CPP 606	Yes	1950	NRT
CPP 608	Yes	1950	NRT
CPP 609	No	1982	Multi-Prog
CPP 615	No	1980	Multi-Prog
CPP 616	Yes	1953	NRT
CPP 617	Yes	1950s	NRT
CPP 618	No	1975	Multi-Prog
CPP 619	Yes	1955	NRT
CPP 620	Yes	1968	NRT
CPP 620 A	No	1989	Multi-Prog
CPP 622	No	1974	Multi-Prog
CPP 623	No	1974	Multi-Prog
CPP 626	No	1977	Multi-Prog
CPP 627	Yes	1955	NRT
CPP 628	Yes	1953	NRT
CPP 629	No	1985	Multi-Prog
CPP 630	Yes	1956	NRT
CPP 632	No	1974	Multi-Prog
CPP 634	Yes	1958	NRT
CPP 635	Yes	1957	NRT
CPP 636	Yes	1965	NRT
CPP 637	Yes	1958	NRT
CPP 638	Yes	1968	NRT
CPP 639	Yes	1958	NRT

Building	Eligible for NR	Year blt	Context
CPP 640	Yes	1961	NRT
CPP 644	No	1982	Multi-Prog
CPP 645	No	1977	Multi-Prog
CPP 646	Yes	1965	NRT
CPP 647	No	1970	Multi-Prog
CPP 648	No	1972	Multi-Prog
CPP 649	No	1976	Multi-Prog
CPP 651	Reassess	1974	Multi-Prog
CPP 652	No	1975	Multi-Prog
CPP 653	No	1975	Multi-Prog
CPP 654	No	1977	Multi-Prog
CPP 655	No	1974	Multi-Prog
CPP 656	No	1980	Multi-Prog
CPP 658	No	1975	Multi-Prog
CPP 659 NWCF	Reassess	1978	Multi-Prog
CPP 660	No	1978	Multi-Prog
CPP 661	No	1988	Multi-Prog
CPP 662	No	1976	Multi-Prog
CPP 663	No	1983	Multi-Prog
CPP 664	No	1974	Multi-Prog
CPP 665	No	1980	Multi-Prog
CPP 666 Flor	Reassess	1978	Multi-Prog
CPP 668	No	1984	Multi-Prog
CPP 671	No	1981	Multi-Prog
CPP 672	No	1981	Multi-Prog
CPP 673	No	1986	Multi-Prog
CPP 674	No	1984	Multi-Prog
CPP 675	No	1984	Multi-Prog
CPP 677	No	1984	Multi-Prog

Building	Eligible for NR	Year blt	Context
CPP 679	No	1983	Multi-Prog
CPP 682	No	1982	Multi-Prog
CPP 684 RAL	Reassess	1985	Multi-Prog
CPP 685	No	1981	Multi-Prog
CPP 687	No	1983	Multi-Prog
CPP 688	No	1983	Multi-Prog
CPP 689	No	1983	Multi-Prog
CPP 690	No	1983	Multi-Prog
CPP 691	Reassess	1993	Multi-Prog
CPP 692	No	1983	Multi-Prog
CPP 693	No	1980	Multi-Prog
CPP 694	No	1982	Multi-Prog
CPP 695	No	1984	Multi-Prog
CPP 696	No	1984	Multi-Prog
CPP 697	No	1986	Multi-Prog
CPP 698	No	1984	Multi-Prog
CPP 699	No	1985	Multi-Prog
CPP 1604	No	1986	Multi-Prog
CPP 1605	No	1986	Multi-Prog
CPP 1606	No	1986	Multi-Prog
CPP 1607	No	1985	Multi-Prog
CPP 1608	No	1987	Multi-Prog
CPP 1610	No	1985	Multi-Prog
CPP 1611	No	1985	Multi-Prog
CPP 1612	No	1985	Multi-Prog
CPP 1615	No	1990	Multi-Prog
CPP 1616	No	1986	Multi-Prog
CPP 1617	No	1986	Multi-Prog
CPP 1618	No	1990	Multi-Prog

Building	Eligible for NR	Year blt	Context
CPP 1619	No	1989	Multi-Prog
CPP 1630	No	1987	Multi-Prog
CPP 1631	No	1989	Multi-Prog
CPP 1634	No	1995	Multi-Prog
CPP 1635	No	1992	Multi-Prog
CPP 1636	No	1989	Multi-Prog
CPP 1637	No	1989	Multi-Prog
CPP 1638	No	1989	Multi-Prog
CPP 1642	No	1992	Multi-Prog
CPP 1643	No	1992	Multi-Prog
CPP 1644	No	1991	Multi-Prog
CPP 1646	No	1992	Multi-Prog
CPP 1647	No	1993	Multi-Prog
CPP 1649	No	1991	Multi-Prog
CPP 1650	No	1991	Multi-Prog
CPP 1651	No	1994	Multi-Prog
CPP 1653	No	1991	Multi-Prog
CPP 1656	No	1991	Multi-Prog
CPP 1659	No	1994	Multi-Prog
CPP 1662	No	1993	Multi-Prog
CPP 1663	No	1993	Multi-Prog
CPP 1666	No	1994	Multi-Prog
CPP 1671	No	1994	Multi-Prog
CPP 1672	No	1993	Multi-Prog
CPP 1673	No	1994	Multi-Prog
CPP 1674	No	1993	Multi-Prog
CPP 1676	No	1994	Multi-Prog
CPP 1677	No	1993	Multi-Prog
CPP 1678	No	1993	Multi-Prog

Building	Eligible for NR	Year blt	Context
CPP 1681	No	1994	Multi-Prog
CPP 1682	No	1994	Multi-Prog
CPP 1683	No	1996+	Multi-Prog
CPP 1684	No	2000	Multi-Prog
CPP 1686	No	2000	Multi-Prog
CPP 1689	No	2003	Multi-Prog
CPP T-1	Yes	1965	NRT
CPP T-2	No	1980	Multi-Prog
CPP T-3	No	1980	Multi-Prog
CPP T-5	Yes	1965	NRT
CPP TB-1	No	1980	Multi-Prog
CPP TB-3	No	1985	Multi-Prog
CPP TB-4	No	1984	Multi-Prog
CPP TB-5	No	1985	Multi-Prog
CPP TB-6	No	1981	Multi-Prog

Number of buildings: 130

Distribution by decade:

1950s16
1960s 7
1970s20
1980s55
1990s29
2000s 3

Distribution by context:

NRT 23
Multi-Prog 107

Note: The Bin Sets associated with Waste Calcining are as significant as the calciner and should be documented and made part of a HAER report. These structures could be added to the published HAER ID-32-C on the Old Waste Calciner or documented in a new HAER.

Radioactive Waste Management Complex

Building	Eligible for NR	Year blt	Context
WMF 601	No	1974	Waste
WMF 602	No	1974	Waste
WMF 603	No	1977	Waste
WMF 604	No	1977	Waste
WMF 605	No	1979	Waste
WMF 606	No	1979	Waste
WMF 607	No	1979	Waste
WMF 608	No	1979	Waste
WMF 609	No	1979	Waste
WMF 610	No	1983	Waste
WMF 611	No	1981	Waste
WMF 613	No	1986	Waste
WMF 614	No	1985	Waste
WMF 615	No	1986	Waste
WMF 617	No	1987	Waste
WMF 618	No	1988	Waste
WMF 619	No	1989	Waste
WMF 620	No	1988	Waste
WMF 621	No	1988	Waste
WMF 622	No	1985	Waste
WMF 624	No	1995	Waste
WMF 627	No	1997	Waste
WMF 628-634	No	1993	Waste
WMF 635	No	1995	Waste
WMF 636	No	1996	Waste
WMF 637	No	1995	Waste
WMF 639	No	1995	Waste
WMF 641	No	1990	Waste

Building	Eligible for NR	Year blt	Context
WMF 642	No	1990	Waste
WMF 643	No	1990	Waste
WMF 645	No	1991	Waste
WMF 646	No	1991	Waste
WMF 648	No	1992	Waste
WMF 649	No	1993	Waste
WMF 650	No	1993	Waste
WMF 653	No	1993	Waste
WMF 655	No	1995	Waste
WMF 656	No	1995	Waste
WMF 657	No	1990s	Waste
WMF 658	No	1995	Waste
WMF 660	No	1996	Waste
WMF Units A, B1, B2, C	No	1996	Waste

Number of buildings: 42 + 6 = 48

Distribution by decade:

1970s 9
1980s11
1990s28

Distribution by context:

Remediation of waste: 48

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ABBREVIATIONS AND ACRONYMS

A1W	Aircraft Carrier, 1st Model, Westinghouse-made
ACRS	Advisory Committee on Reactor Safeguards
AEC	Atomic Energy Commission
AFSR	Argonne Fast Source Reactor
ANL	Argonne National Laboratory
ANL-West	Argonne National Laboratory-West (Idaho office)
ANP	Aircraft Nuclear Propulsion Program (also ANPP)
ANS	American Nuclear Society
ARA	Army Reactors Area OR Auxiliary Reactor Area
ARBOR	Argonne Boiling Water Reactor
ARVFS	Advanced Reentry Vehicle Fuzing System
BORAX	Boiling Water Reactor Experiments
BWR	Boiling Water Reactor
C1W	Cruiser, 1st Model, Westinghouse-made (never built)
CDC	Capsule Driver Core
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERT	Controlled Environmental Radioiodine Tests
CFA	Central Facilities Area
CPP	Prefix for buildings at Idaho Chemical Processing Plant
CRCE	Cavity Reactor Critical Experiment
CUVTR	Carolina Virginia Tube Reactor
DOE	Department of Energy
EBOR	Experimental Beryllium Oxide Reactor
EBR-I	Experimental Breeder Reactor I
EBR-II	Experimental Breeder Reactor II
ECCS	Emergency Core Cooling System
ECF	Expended Core Facility
EOCR	Experimental Organic-Cooled Reactor
ERDA	Energy Research and Development Administration
ETR	Engineering Test Reactor
FAST	Fuel Storage Facility
FCF	Fuel Cycle Facility OR Fuel Conditioning Facility
FET	Flight Engine Test
FETF	Flight Engine Test Facility
FRAN	Nuclear Effects Reactor
GCRE	Gas-Cooled Reactor Experiment
HAER	Historic American Engineering Record
HFEF	Hot Fuel Examination Facility
HTRE	Heat Transfer Reactor Experiment

ICPP Idaho Chemical Processing Plant
IET Initial Engine Test
IFR Integral Fast Reactor
ILTSF Intermediate-Level Transuranic Storage Facility
INEEL Idaho National Engineering and Environmental Laboratory
INEL Idaho National Engineering Laboratory

LCRE Lithium-Cooled Reactor Experiment
LMFBR Liquid Metal Fast Breeder Reactor
LMITCO Lockheed Martin Idaho Technologies Company
LOFT Loss-of-Fluid Test Facility
LPTF Low Power Test Facility

MWSF Mixed Waste Storage Facility
MTA Mobile Test Assembly
MTR Materials Test Reactor

NASA National Aeronautics and Space Administration
NEPA National Environmental Policy Act of 1969
NHPA National Historic Preservation Act of 1966
NPG Naval Proving Ground
NPS National Park Service
NRAD Nuclear Radiography Reactor
NRC Nuclear Regulatory Commission
NRF Naval Reactors Facility
NRTS National Reactor Testing Station

OMRE Organic-Moderated Reactor Experiment

PBF Power Burst Facility
PREPP Processing Experimental Pilot Plant
PUREX Plutonium and Uranium Extraction
PWDR Power Demonstration Reactor

RADCON Radiation Control
RAL Remote Analytical Laboratory
RCRA Resource Conservation and Recovery Act of 1976
RSTA Reactives Storage and Treatment Area
RWMC Radioactive Waste Management Complex

S1W Submarine Thermal Reactor, 1st Model, Westinghouse
S5G Submarine, 5th Model, General Electric-made (Natural Circulation Reactor)
SHPO State Historic Preservation Office
SL-1 Stationary Low-Power Reactor, first model
SM-1 Stationary Medium Power Reactor, first model
SNAP Systems for Nuclear Auxiliary Power
SPERT Special Power Excursion Reactor Test
STEP Safety Test Engineering Program

SUSIEShield Test Pool Facility OR Shield Test Pool Facility Reactor
SWEPPStored Waste Examination Pilot Plant

TAG The Arrowrock Group, Inc.
TAN Test Area North
THRITS Thermal Reactor Idaho Test Station
TRA Test Reactor Area
TREATTransient Reactor Test Facility
TRUPACT Transuranic package containers OR Transuranic package transporter
TSA Transuranic Storage Area

WCF Waste Calcining Facility
WEDF Waste Engineering Development Facility
WERF Waste Experimental Reduction Facility
WIPP Waste Isolation Pilot Plant (in New Mexico)
WRRTFWater Reactor Research Test Facility
ZPPR Zero Power Plutonium Reactor
ZPR-III Zero Power Reactor-III