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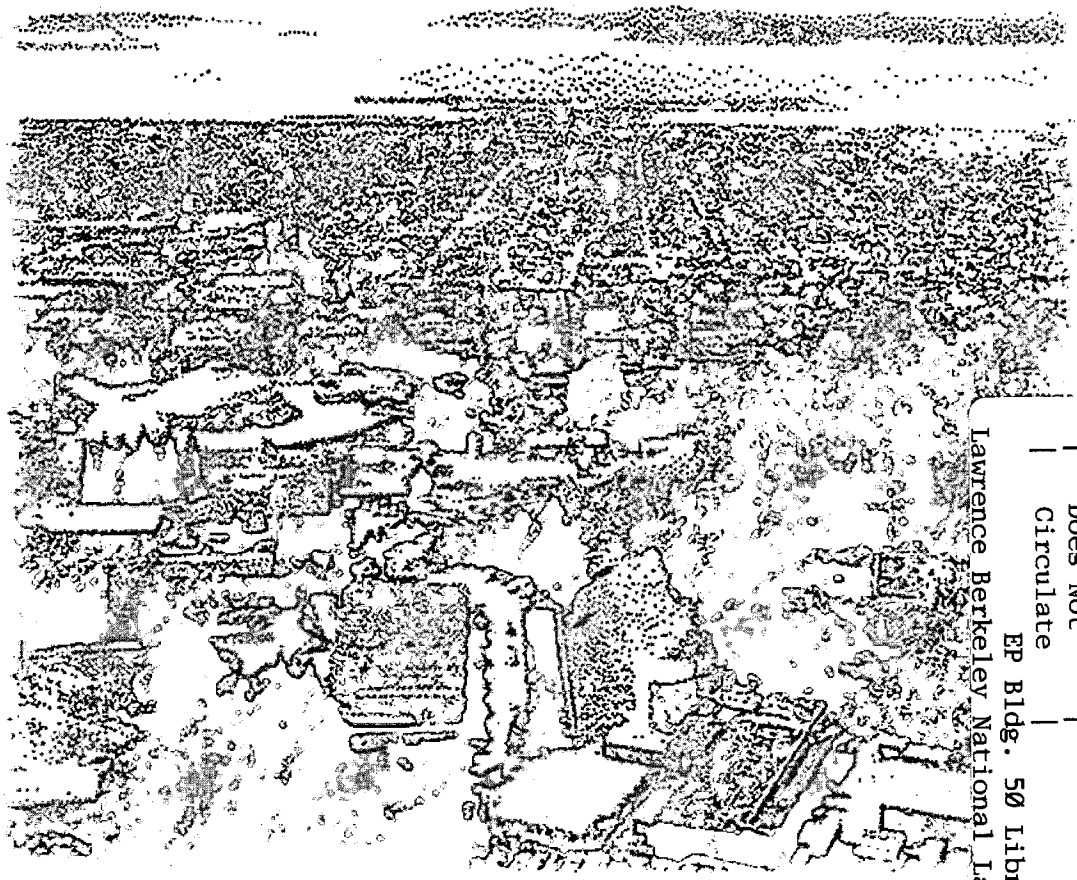
Ernest Orlando Lawrence Berkeley National Laboratory

Institutional Plan

FY 1998 – FY 2002

August 1997



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ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

INSTITUTIONAL PLAN

FY 1998 – FY 2002

August 1997

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PREFACE

The FY 1998 Institutional Plan provides an overview of the Ernest Orlando Lawrence Berkeley National Laboratory (Berkeley Lab) mission, strategic plan, initiatives, and the resource requirements to fulfill its role in support of national needs in fundamental science and technology, energy resources, and environmental quality. This year, to advance the Department of Energy's direction in defining the Integrated Laboratory System, the Berkeley Lab Institutional Plan has been significantly restructured to emphasize the strategic elements of the Laboratory's planning efforts.

The Institutional Plan is a management report that supports the Department of Energy's mission and programs and is an element of Department of Energy's strategic management planning activities, developed through an annual planning process. The plan supports the Government Performance and Results Act of 1993 and is a complement to the performance-based contract between the Department of Energy and the Regents of the University of California. It identifies technical and administrative directions in the context of the national energy policy and research needs and the Department of Energy's program planning initiatives. Preparation of the plan is coordinated by the Office of Planning and Communications from information contributed by the Laboratory's scientific and support divisions.

The Berkeley Lab FY 1998 Institutional Plan reflects and complements the Department of Energy's own Strategic Plan (working draft June, 1997), the Draft Energy Research Strategic Plan (1997), and the Strategic Laboratory Missions Plan Phase I (July 1996). The *Laboratory Missions and Core Competencies* section identifies the specific strengths of the Berkeley Lab that contribute to the DOE missions in general and the Integrated Laboratory System in particular. The *Laboratory Strategic Plan* section identifies the existing contributions of the Berkeley Lab's Core Business Areas, potential research trends and management implications, and long-range conditions that will influence the Laboratory. The *Initiatives* section describes some of the specific new research programs representing major long-term opportunities for the Department of Energy and the Laboratory. The *Operations Plan* section describes the strategic thinking in the areas of human resources; work force diversity; worker, public, environmental and asset protection programs; management practices; site and facility needs; and communications and trust. The *Resource Projections* are estimates of required budgetary authority for the Laboratory's research programs.

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I. DIRECTOR'S STATEMENT

As we plan for the future of the National Laboratory System, Berkeley Lab is advancing programs of scientific excellence and operating research facilities that move forward the frontiers of science and solve a spectrum of national problems. Berkeley Lab Vision 2000 continues as the framework for our strategic planning, to "distinguish ourselves as a premier DOE multiprogram national laboratory by performing research of the highest scientific quality." This year's planning advances DOE's Integrated Laboratory System and Strategic Missions Plan, placing key emphasis on the importance of the Laboratory's principal roles in computing, energy science, biological and environmental research, and high energy and nuclear physics.

Berkeley Lab performs forefront research within an institutional framework uncompromising in its management of safety, environmental protection, and operational policies. The Berkeley Lab's institutional distinction is based upon our University-based management and close working relations with campuses, government, and industry. We are committed to sound planning at national as well as local levels, with Strategic and Institutional Planning important to these efforts.

The Laboratory's competencies are serving the National Laboratory System in a new and integrated way: through the Fusion Energy Science Office, Joint Genome Institute, Large Hadron Collider and Relativistic Heavy Ion Collider programs, and the design and fabrication of National Spallation Neutron Source and of the Dual Axis Radiographic Hydrodynamic Test Facility, as examples. The integration of DOE's programs across Laboratory competencies is reflected in the initiatives highlighted in this year's plan, with strategic importance given to DOE's National Initiatives. These initiatives utilize the Laboratory's expertise to implement national and international long range plans. It is our vision that national laboratories work in partnership with DOE to develop consensus scientific roadmaps that further chart scientific directions, performance accomplishments, and Laboratory research roles.

Consistent with our principal roles for DOE, we are applying our fundamental capabilities in computational science of scale to address major scientific challenges, including fusion science, the fundamental properties of matter, combustion science, and structural biology. These computational capabilities are integral with the Laboratory's scientific divisions and focused through NERSC and the Energy Sciences Network (ESnet).

To meet the nation's need for a scientifically well-founded basis for a fusion energy supply, Berkeley Lab continues its role at the forefront of inertial confinement fusion science. To this end, we are defining, with the research community, the scientific questions that must be addressed for developing heavy-ion accelerators as fusion energy drivers. Understanding this science opens the prospect for efficient and reliable pellet ignition for civilian power production in the 21st century. The Lab's accomplishments and plans support the recommendations of the national Fusion Energy Science Advisory Committee.

The Advanced Light Source (ALS) has achieved dramatic new levels of scientific productivity through additional beamlines and extended operational hours made possible by the Scientific Facilities Initiative. Beamline service hours have doubled since 1996. New partnerships are under way with the semiconductor and pharmaceutical industries. The facility is now a collaboratory with remote interoperability for users. Environmental molecular sciences is a new field where an ALS beamline proposed by the scientific community could reveal at high resolution the distribution and chemical state of inorganic and organic materials in living samples.

Berkeley Lab as maintained its historic strengths in high-energy and nuclear physics, providing leadership for the B Factory at the Stanford Linear Accelerator Center (SLAC) and the STAR detector at the Relativistic Heavy-Ion Collider (RHIC). The Laboratory is helping to design and fabricate key detector and accelerator systems at the Large Hadron Collider in Europe. The 88-Inch Cyclotron successfully developed the Gammasphere, providing a first-ever glimpse into transition states of unstable nuclei, new magnetic nuclear rotations, and new superdeformed nuclei. The Laboratory efforts for the Sudbury Neutrino Observatory will soon be realized when data taking begins, and we are entering the

planning phase for a kilometer-cubed-scale neutrino detector that could observe the low fluxes of high-energy neutrinos from very distant and energetic cosmic objects such as active galactic nuclei.

The Laboratory's geoscience capabilities are being deployed to address the national need for a suitable site for the long-term storage of the nation's nuclear waste. For Yucca Mountain, we have prepared a detailed plan focusing on the site's viability and suitability as a repository. Proposed testing and modeling program will demonstrate the viability of the unsaturated zone as an effective barrier, provide understanding of paths in draining infiltration, and confirm unsaturated zone models needed for performance assessment. We are pleased that our geosciences leadership is being utilized by DOE to address this vital national need.

Berkeley Lab has a distinguished record of taking research from the laboratory to products in the marketplace—products that use energy more efficiently or reduce energy-related emissions. Successes include low-emissivity windows, high frequency ballasts for fluorescent lamps, and efficient fixtures for compact fluorescent lamps. We propose to develop a next generation of energy technologies based on research that is still in the laboratory but shows promise of leading to products of greater significance. We propose to explore the use of micro-scale high-intensity lamps to more completely displace incandescents and the use of advance burners to significantly improve combustion efficiency in many applications.

Berkeley Lab has a commitment of excellence, sustained throughout the Laboratory, for the protection of the environment and for safety in day-to-day operations. Berkeley Lab policy—communicated to every employee—is: If work appears unsafe or will create an environmental problem, don't do it. This year we continue to exceed waste minimization goals and to lower emissions levels Labwide. We have proactively engaged our community in establishing a forum for tritium monitoring, for fire service agreements, and for vegetation management. We have established outreach, training, and retention programs to encourage and fully respect diversity and we encourage excellence through the Office of Work Force Diversity.

While we sustain all necessary cost for safe and environmentally excellent operations, we have made significant progress on our management goal to deliver the best research support services at the lowest cost through the reduction of unnecessary administrative costs. These administrative savings have lowered overhead and are also reinvested in necessary maintenance of our research infrastructure. The reinvestments sustain the longevity of DOE's facilities investments and further improve efficiency and effectiveness. Our plan is to work with DOE to ensure that adequate space and investment is provided for the quality and service levels DOE's mission demands.

As the Ernest Orlando Lawrence Berkeley National Laboratory charts its course for the future, we will continue our contribution to the Department of Energy's missions as a vital element of an integrated National Laboratory System. Our goal is to see that our people and our programs continue to serve as valuable resources for the Department of Energy, the nation, and the community at large.

Charles V. Shank
Director

II. THE LABORATORY MISSION

Berkeley Lab is a multiprogram national research facility operated by the University of California for DOE. As an element of DOE's National Laboratory System, its fundamental mission is to provide national scientific leadership and technological innovation to support the DOE's objectives in fundamental science, energy resources, and environmental quality. Berkeley Lab's mission addresses four distinct goals:

- To perform leading multidisciplinary research in the energy sciences, general sciences, and biosciences in a manner that ensures employee and public safety and protection of the environment.
- To develop and operate unique national experimental facilities that are available to qualified investigators: the Advanced Light Source, National Energy Research Scientific Computing Center, Energy Sciences Network (ESnet), National Center for Electron Microscopy, 88-Inch Cyclotron, Biomedical Isotope Facility, and National Tritium Labeling Facility.
- To educate and train future generations of scientists and engineers to promote national science and education goals.
- To transfer knowledge and technological innovations and to foster productive relationships among Berkeley Lab research programs, universities, and industry to promote national economic competitiveness.

The Laboratory mission supports DOE's mission to "provide Americans with a secure and reliable energy system that is environmentally and economically sustainable" and to "ensure that the United States sustains its leadership in science and technology," as enunciated in DOE's Strategic Plan.

CORE COMPETENCIES AND FOUNDATIONS

The ability of the Laboratory to advance its mission depends upon its "core competencies." These are an integration of research disciplines, personnel, skills, technologies, and facilities that produces valuable results for our sponsors and customers. The core competencies can be applied to rapidly changing national needs and new research problems while at the same time undergoing evolution themselves.

Underlying many of our core competencies in specific technical areas are fundamental capabilities, or "foundations." Berkeley Lab has identified eight core competencies and four foundations (detailed below).

Core Competencies

- **Bioscience and Biotechnology:** Structural biology; genome research; bioinstrumentation; molecular cytogenetics; medical imaging; biology of human diseases; biomolecular design; environmental biology.
- **Particle and Photon Beams:** Analysis and design of accelerators; beam dynamics; high-brightness ion, electron, and photon sources; advanced magnet design and R&D; high-frequency rf technology; x-ray optics and lithography; induction linacs and neutral beams for fusion energy.
- **Computational Science and Engineering:** Computational fluid dynamics; applied mathematics; computational chemical sciences; algorithms for scalable systems; discretization algorithms for partial differential equations; distributed memory; visualization techniques.

- **Characterization, Synthesis, and Theory of Materials:** Advanced spectroscopies and microscopies based on photons, electrons, and scanning probes; ceramics; alloys; heterostructures; superconducting, magnetic, and atomically structured materials; bio-organic synthesis.
- **Advanced Technologies for Energy Supply and Energy Efficiency:** Subsurface resources and processes; building technologies; electrochemistry; fossil fuel technologies; energy analysis.
- **Chemical Dynamics, Catalysis, and Surface Science:** Reaction dynamics; photochemistry of molecules and free radicals; surface structures and functions; heterogeneous, homogeneous, and enzymatic catalysis.
- **Advanced Detector Systems:** Major detectors for high-energy physics, nuclear science, and astrophysics; scientific conception and project leadership; advances in particle and photon detection; implementation of new concepts in detector technology.
- **Environmental Assessment and Remediation:** Advanced instrumentation and methods for environmental characterization and monitoring; human health and ecological risk assessment; indoor air quality; subsurface remediation of contaminants; geologic isolation of high-level nuclear waste; actinide chemistry.

Foundations

- **National Research Facilities:** Advanced Light Source; National Energy Research Scientific Computing Center; ESnet; National Center for Electron Microscopy; 88-Inch Cyclotron and Gammasphere; Biomedical Isotope Facility; National Tritium Labeling Facility.
- **Information Management:** High-speed networking and distributed computing, including network congestion studies and remote experiment control; processing and analysis of scientific images; visualization and virtual reality; data-acquisition and analysis systems; mass storage and scientific data management.
- **Engineering Design and Fabrication Technologies:** Custom-integrated circuits; integrated accelerator systems; superconducting magnet assemblies; insertion devices for synchrotron radiation; large-volume semiconductor detector technology; laboratory automation; advanced CAD/CAM facilities for large systems; facilities for materials processing and fabrication.
- **Education of Future Scientists and Engineers:** Undergraduate, graduate, postdoctoral, and faculty involvement in scientific and engineering research through close ties with the University of California system; educational programs for elementary schools, high schools, and colleges.

Strategic Laboratory Missions Plan

These core competencies and foundations position Berkeley Lab's role in the DOE laboratory system. In the *Strategic Laboratory Missions Plan—Phase I* (July 1996, page 22) report, Berkeley Lab is identified as having a principle role in the Fundamental Science Mission, and all eight of its core competencies reflect the specific areas of strength in fulfilling this central DOE mission. Berkeley Lab also has a major contributing role in the Energy Resources Mission, especially through its contributions in the core competencies of particle and photon beams (particularly research in the accelerators for inertial confinement fusion), computational science and engineering, and advanced technologies for energy supply and energy efficiency. Berkeley Lab also has a specialized participating role in the Environmental Quality Mission through its core competencies in advanced technologies for energy supply and energy efficiency and in environmental assessment and remediation (particularly in the area of environmental biotechnology).

DIVISION STRENGTHS

Berkeley Lab benefits from its close working relationship with the University of California at Berkeley, as well as with other universities, laboratories, and industrial institutions. As indicated in the following organization chart (Figure 2.1), the Laboratory is structured to integrate these relationships with its mission in the most effective way possible. The core research strengths of each of the five Berkeley Lab divisions follow.

Computing Sciences

- **Information and Computing Sciences:** Advanced software engineering; information management; network development; scientific imaging and visualization tools; computation tools for the Human Genome Project; biostatistics; distributed control of applications.
- **National Energy Research Scientific Computing (NERSC) Center:** Unsurpassed high-end computing services to the energy research user community; access to six state-of-the-art computers, including the Cray T3E-900, C90 and J90; collaboration and support for external users and computational scientists for modeling, software implementation, and system architecture, as well as science-of-scale projects.

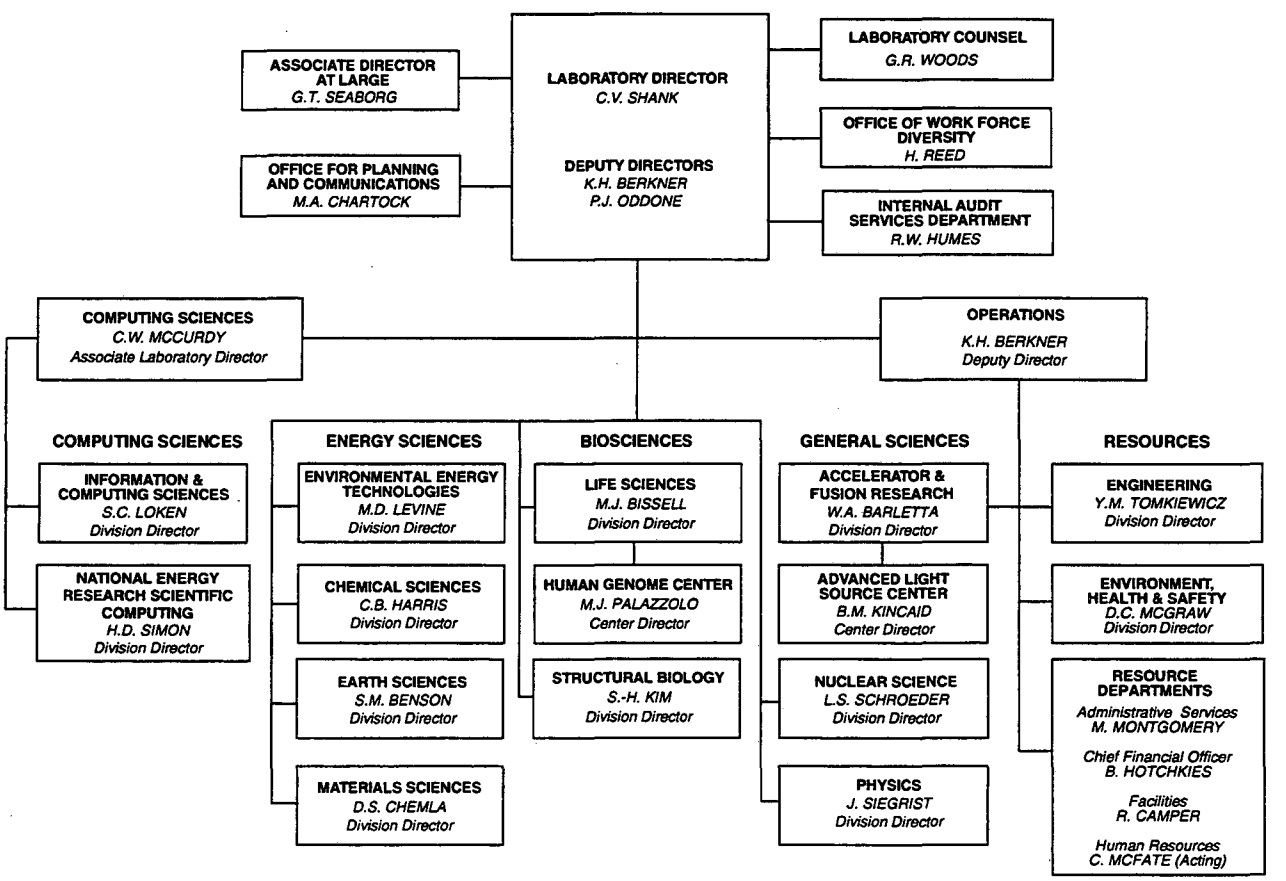

Figure 2.1. Ernest Orlando Lawrence Berkeley National Laboratory organization chart.

- **Energy Sciences Network (ESnet):** Nationwide computer-data-communications network supporting multiple-program, open scientific research. Supports multiple protocols, such as DOD Internet, DECnet Phase IV, Open Systems Interconnection ConnectionLess Network Protocol. Connects more than 30 sites at up to 45 Mbps; DOE contribution to National Research and Education Network (NREN).
- **Center for Computational Science and Engineering (CCSE):** High-resolution numerical methods for partial differential equations; adaptive methodologies; computational fluid dynamics; algorithms for parallel architectures, scientific visualizations.

Energy Sciences

- **Chemical Sciences:** Chemical physics and the dynamics of chemical reactions; structure and reactivity of transient species; electron spectroscopy; surface chemistry and catalysis; electrochemistry; chemistry of the actinide elements and their relationship to environmental issues; atomic physics.
- **Earth Sciences:** Structure, composition, and dynamics of the earth's subsurface; geophysical imaging methods; chemical and physical transport in geologic systems; isotopic geochemistry; physicochemical process investigations.
- **Environmental Energy Technologies:** Energy efficient building technologies; indoor air quality; batteries and fuel cells for electric vehicles; combustion, emissions, and air quality; industrial, transportation, and utility energy use; national and international energy policy studies; aspects of global climate change related to energy.
- **Materials Sciences:** Advanced ceramic, metallic, polymeric, magnetic, biological, and semi- and superconducting materials for catalytic, electronic, optical, magnetic, structural, and specialty applications; exploration of low-dimensional materials; development and use of instrumentation, including spectroscopies, electron microscopy, x-ray optics, nuclear magnetic resonance, and analytical tools for ultrafast processes and surface analysis.

Biosciences

- **Life Sciences:** Gene expression; molecular genetics; genome sequencing studies; cellular differentiation and carcinogenesis; hematopoiesis; macromolecular structure; DNA repair; diagnostic and functional imaging; innovative microscopies; radiation biology; animal models of disease; computational biology; environmental biology.
- **Structural Biology:** Structural and molecular biology of nucleic acids and proteins; genetics and mechanisms of photosynthesis; photochemistry.

General Sciences

- **Accelerator and Fusion Research:** Fundamental accelerator physics research; accelerator design and operation; advanced accelerator technology development for high-energy and nuclear physics; accelerator and beam physics research for heavy-ion fusion; beam and plasma tools for materials sciences and engineering; operation of the Advanced Light Source.
- **Nuclear Science:** Relativistic heavy-ion physics; medium- and low-energy nuclear physics; nuclear structure; nuclear theory; nuclear astrophysics; weak interactions; nuclear chemistry; studies of transuranium elements; nuclear-data evaluation; advanced detector development; operation of the 88-Inch Cyclotron.

- **Physics:** Experimental and theoretical particle physics; advanced detector development; particle database for the high-energy physics community; astrophysics; applied mathematics; innovative educational programs for high schools.

Resources and Operations

- **Engineering:** Engineering design, planning, and concept development; advanced accelerator components; electronic and mechanical instrumentation; scientific applications software development; laboratory automation; fabrication of detectors and experimental systems; shops and technical support for scientific programs and research facilities.
- **Environment, Health and Safety:** Technical support for protecting the safety of Berkeley Lab employees, the public, and the environment; radiation safety associated with accelerator technology, advanced dosimeters, and control of radionuclides; waste management.
- **Resource Departments:** Administrative, financial, human resources, and facilities support for research and Laboratory management.

III. LABORATORY STRATEGIC PLAN

BERKELEY LAB'S VISION AND STRATEGIC OBJECTIVES

Berkeley Lab's Strategic Plan and Vision 2000 support DOE's missions and the Laboratory's national role within the DOE system of laboratories (the most distinguished system of its kind in the world and an essential and major element of the nation's scientific infrastructure). Vision 2000 focuses particularly on our performance as a multiprogram laboratory addressing scientific challenges of national significance:

> ***We will distinguish ourselves as a premier DOE multiprogram national laboratory by performing research of the highest scientific quality. We will build on our educational and technical resources to gain a competitive advantage for addressing problems of national significance and advancing the mission of the DOE.***
>
> ***We will create value for the economy, enhance education, and contribute to the community through partnerships with industry, universities, and other laboratories.***
>
> ***We will make Berkeley Lab the location of choice for facilities and programs. Our operational, administrative, and technical resources will integrate seamlessly with research and engineering programs to make a laboratory that works. All of our activities will be conducted with full regard for the environment, health, and safety.***
>
> ***We are committed to developing our people to their fullest potential. We value and seek diversity in our work force. We will create an environment that respects the individual, encourages leadership, stimulates innovation, fosters integrity, and demands excellence.***

To achieve the Vision 2000 goals effectively and efficiently, Berkeley Lab's research programs are strategically planned and conducted to achieve our national science and technology mission. These efforts are managed as an essential and complementary element to other parts of DOE's laboratory system, as provided in the Strategic National Laboratory Mission Plan.

SITUATION ANALYSIS: KEY CUSTOMERS

As recognized in DOE's Strategic Laboratory Missions Plan, Berkeley Lab has a principal role in fundamental sciences and a major contributing role to the DOE energy resource mission. Its specialized and distinctive capabilities in earth, environmental, and biotechnology sciences provide a valuable resource to DOE's environmental quality mission. This Institutional Plan describes the roles and activities of the Laboratory that advance DOE national missions efficiently and in a manner that incorporates the highest standards for health, safety, and environmental protection. Following is a brief synopsis of the major Laboratory research sponsors—our direct customers, who are at the heart of DOE's missions.

Office of Energy Research

The Office of Energy Research is the Laboratory's primary customer for its fundamental science mission. The Laboratory's research and facilities support in particular the following Office of Energy Research offices: Basic Energy Sciences, Computational and Technology Research, Biological and Environmental Research, Fusion Energy Sciences, and High Energy and Nuclear Physics.

Office of Basic Energy Sciences

Basic Energy Sciences programs in materials sciences will continue to emphasize new and forefront research projects for the synthesis, processing, and characterization of advanced materials. Expanded areas include the design and construction of synchrotron-radiation instrumentation and its application to important programs in materials sciences and advanced materials synthesis and fabrication technologies, especially at the atomic scale. Leading programs continue in x-ray optics, electron microscopy, solid-state physics, surface sciences, catalysis, polymers, biomolecular materials, metallurgy, electrochemical materials, electronic materials (including super- and semiconductors), ceramics, and materials chemistry. The ALS, a third-generation synchrotron-radiation facility, produces the world's brightest beams of ultraviolet and soft-x-ray radiation. The ALS, Center for Advanced Materials (CAM), Center for X-Ray Optics (CXRO), and National Center for Electron Microscopy (NCEM) are organized interdisciplinary research centers that bring DOE resources to bear on scientific challenges of national importance.

Berkeley Lab supports DOE's Chemical Sciences Program in chemical physics, dynamics and mechanisms of chemical reactions and combustion processes, catalysis, electron spectroscopy, atomic physics, photochemistry, theoretical chemistry, chemistry of the actinide elements and their relationship to environmental issues, and electrochemistry on advanced batteries for consumer products and electric vehicle applications.

DOE's Geosciences Program at Berkeley Lab is strengthening its multidisciplinary effort to establish the scientific basis of many energy- and environmental-related technologies, including development of hydrocarbon and strategic-mineral resources, remediation of toxic waste sites, safe disposal of radioactive and toxic chemical wastes, and exploitation of geothermal energy. Earth sciences researchers at Berkeley Lab are among the leading experts in the areas of subsurface imaging of the structure and dynamics of the earth's crust, experimental investigation of the mechanisms by which lithospheric processes influence energy resources, and numerical modeling of geochemical and hydromechanical processes occurring in heterogeneous fractured rock formations.

For Energy Biosciences, Berkeley Lab's program continues to improve understanding of the unique features of photosynthetic organisms for collecting light energy and storing it as chemical energy.

Office of Computational and Technology Research

The Computing Sciences Directorate at Berkeley Lab was formed to pioneer a holistic approach to computational science by bringing together in a single organization:

- The **National Energy Research Scientific Computing (NERSC)** Center: an extremely powerful computing environment incorporating very great computing capability, capacity, and associated storage.
- The **Center for Computational Science and Engineering (CCSE)** and the Berkeley Lab **Mathematics Department**: research groups composed of mathematicians and computational scientists, who are developing the advanced methods, algorithms, and procedures for the solution of very intractable problems in basic science that will make effective use of the NERSC environment.
- The **Energy Sciences Network (ESnet)**: the backbone of DOE's network facilities. ESnet provides access to the NERSC computing environment—and to other research, experimental, and computational facilities—by scientists across the nation and by international collaborators.
- The **Computer Science Research Department**: a computer science research program that concentrates on increasing the effectiveness of the NERSC environment (for example, by resolving network congestion problems, developing protocols that facilitate the remote control of experiments, devising methods to support networked multimedia, and devising new data storage and retrieval strategies to facilitate the use of extremely large datasets).

A major component of Computing Sciences at Berkeley Lab is Large Scale Scientific Computation. This program conducts in-depth studies of discretization techniques and adaptive numerical methods, with particular emphasis on studies in fluid mechanics. These in-depth studies are especially important because fluid dynamics plays a key role in a multitude of scientific and technological areas, including combustion systems, energy-efficient transportation systems, and climatological effects of greenhouse gases. The Large Scale Scientific Computation program focuses particularly on computational fluid and combustion dynamics, supporting the HPCC Grand Challenge Project on Computational Fluid Dynamics and Combustion Dynamics, which is an integrated research effort involving LLNL, LANL, and two university participants (the Courant Institute for the Mathematical Sciences and the University of California at Berkeley).

The Office of Computational and Technology Research also manages the Advanced Energy Projects (AEP) and ER-LTT programs, for whom Berkeley Lab also makes important contributions.

Office of Biological and Environmental Research

Office of Biological and Environmental Research (OBER) related research activities include the following research program areas: gene expression and genome mapping; structural biology; nuclear medicine and functional imaging; carcinogenesis, mutagenesis, and radiation biology; and subsurface science.

Studies on human genome structure and regulation of gene expression are important research growth areas for Berkeley Lab. Research at DOE's Joint Genome Institute and Berkeley Lab's Human Genome Center includes generation of physical and genetic maps, identification and localization of expressed genes on human chromosomes, and development of techniques for efficient sequencing of human DNA and automation of these techniques. Analysis of the biologically relevant signals culled from sequence information is under way. The biological function of the human DNA sequences identified by the Human Genome Center will be determined using genetically engineered mice developed by researchers at Berkeley Lab. Related programs include studies in gene expression within mammary-gland and blood-forming systems, and hematopoietic research.

The thrust of Berkeley Lab's structural biology program is to determine the structure of biologically important molecules and complexes in order to gain insight into their functions. An important new direction is toward x-ray-based research at the ALS, although the program has other facets as well. X-ray crystallography, electron crystallography, and NMR spectroscopy focus on protein and nucleic acid structures. Berkeley Lab has also established a unique center of excellence, the Program for Biomolecular Design, that will bridge the chemical, biological, and computer sciences by combining expertise at Berkeley Lab and UC Berkeley. The aim is to redesign natural biological molecules to create new classes of novel biomolecular structures with applications to major problems in the medical, biological, and environmental sciences relevant to DOE missions.

Research in nuclear medicine includes new studies in molecular biology and continuing studies of improved radiopharmaceuticals and advanced instrumentation for applications to medical science. A systematic search for new, ultrafast, heavy-atom scintillators and the development of solid-state photodetectors for high-resolution, positron-emission tomography have led to new concepts in detection. In parallel with an emerging national trend in molecular nuclear medicine, Berkeley Lab has also initiated studies in four new areas for OBER and NIH: using transgenic animal models to pursue the relationship between genomic variations and the occurrence of atherosclerosis; studying relationships among neuroreceptor concentrations, brain metabolism, mental disorders, and the genome; developing labeled DNA probes (aptamers) for understanding inflammatory diseases, autoimmune conditions, atherosclerosis, and cancer; and monitoring gene therapy.

Berkeley Lab has a number of strong research programs for OBER and NIH in cell, molecular, and radiation biology related to cancer etiology: Control of Growth, Differentiation, and Genomic Stability; Hormones and Extracellular Matrix; Hematopoiesis; Mammary Biology; Oncogenes and Tumor Suppressor Genes; Radiation and Chemical Carcinogenesis; and DNA Repair.

For OBER's Subsurface Science Program, Berkeley Lab research in environmental characterization focuses on the effect of natural subsurface heterogeneity on microbial behavior. The Laboratory is also developing an interdisciplinary program to investigate the processes that lead to changes in the physical and chemical characteristics of the atmosphere and other potential changes in the ecosystem. In addition, the program on radon migration includes unique experimental facilities for studying radon movement in soil and into buildings under controlled conditions. For OBER's Natural and Accelerated Bioremediation Research (NABIR) program, the Lab provides the scientific understanding needed to harness natural processes and develop methods to accelerate these processes for the bioremediation of contaminated soils, sediments, and groundwater at DOE facilities. With Berkeley Lab's Center for Environmental Biotechnology playing a facilitating role, the NABIR program is in the process of identifying the scientific leadership and encouraging the development of interdisciplinary teams for addressing these problems in a creative and effective way.

Office of Fusion Energy Sciences

Fusion energy research at Berkeley Lab focuses on accelerator systems primarily supporting the nation's inertial-confinement energy science programs. The Laboratory's expertise in materials, superconductivity, and computational science are important assets that augment the Laboratory's accelerator research. The Laboratory's heavy-ion fusion accelerator research has focused on the physics of induction acceleration as the means for producing high-current, heavy-ion beams as drivers for inertial-confinement fusion systems. Berkeley Lab's current efforts have resulted in successful completion of the multiple-beam experiment to examine the initial accelerator components for space-charge-dominated beams undergoing current amplification. Specific areas of study will address beam quality (focusability) and cost—two primary accelerator issues to be addressed by the design and construction of a multi-kilojoule accelerator. Such an accelerator will provide the scientific and technical database for building a full-scale fusion driver through conducting a wide range of experiments in beam physics, beam-target interaction physics, and fusion target physics.

Office of High-Energy and Nuclear Physics

In high-energy physics, the Laboratory continues its strong and diverse program of experimental and theoretical research, including the development and operation of innovative detectors and research on advanced accelerator components and concepts. The Laboratory's experimental programs in high-energy physics focus on the properties of quarks and leptons. Efforts to study these particles emphasize the development of sophisticated detectors and their operation at colliding-beam facilities.

The **Collider Detector Facility (CDF)** at Fermilab has been enormously enhanced by the Silicon Vertex Detector, for which Berkeley Lab was the lead institution. This detector has played a crucial role in the CDF discovery of the top quark. Berkeley Lab groups working on this experiment are involved in analysis of B decays, and the measurement of the W mass and top quark masses. The **D-Zero** detector at Fermilab has made important measurements of tri-gauge couplings and analysis of W and Z events. Berkeley Lab is heavily committed to the design and fabrication of the SVX-2 chip for D-Zero being developed jointly with Fermilab. The **B Factory (PEP-II)** at Stanford Linear Accelerator (SLAC). Berkeley Lab is responsible for fabricating the Low-Energy-Ring arc magnets and some of the key "special" magnets in the interaction region, the arc vacuum system, and for a portion of the PEP-II power supplies. Berkeley Lab also has a major part in the B Factory detector, including design and construction of the silicon vertex tracker, the DIRC (Detection of Internally Reflected Cerenkov Light) particle I.D. device, and electronics and computing. The **Large Hadron Collider** at CERN will search for the mechanism of electroweak symmetry breaking and substantially extend the search for new particles beyond those described by the standard model of particle physics. Berkeley Lab is responsible for aspects of the LHC accelerator design and some components, as well as components for ATLAS, one of the two large experiments at the LHC. Berkeley Lab will carry important roles in the silicon tracker and pixel detector arrays and in computing.

Nuclear physics research at Berkeley Lab will continue to focus on the experimental and theoretical investigation of the structure and properties of nuclei, emphasizing studies of nuclei under extreme conditions (temperature, isospin, angular momentum, and energy density). Berkeley Lab research programs are closely coupled with national priorities in nuclear science, as defined in the Nuclear Science Advisory Committee 1996 Long Range Plan for Nuclear Science, and also play an important role in the education and training of young scientists. In addition, ongoing technology development efforts contribute to significant advances in nuclear instrumentation experiments and theory, and in nuclear data evaluation and dissemination.

Relativistic heavy-ion physics carries out experiments at the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory (BNL) and the Super Proton Synchrotron (SPS) at CERN. The main focus of the future high-energy heavy-ion research program at Berkeley Lab is the Relativistic Heavy Ion Collider (RHIC). Berkeley Lab is the lead laboratory for the first approved RHIC experiment, the Solenoidal Tracker at RHIC (STAR) detector, to identify the phase transition between normal nuclear matter and quark matter. The **88-Inch Cyclotron** is equipped with two state-of-the-art electron cyclotron resonance (ECR) ion sources capable of producing high-charge state ions of most elements. Gammasphere has contributed to the discovery of new superdeformed bands and many new physics phenomena, including possible new nuclear symmetries, identical bands in different nuclei, and pairing correlations in superdeformed nuclei. **New low-energy research opportunities** will be opened up by a new high-efficiency mass separator and the 8 π gamma-ray array (on loan from Canada). This combination will enable new research opportunities in nuclear structure and the study of exotic nuclei and transuranic elements at the 88-Inch Cyclotron.

Office of Energy Efficiency and Renewable Energy

The Berkeley Lab program in Energy Efficiency and Renewable Energy comprises a broad set of related activities that provide research support and technology development in the furtherance of national goals to reduce energy demand and cost to consumers, balance environmental concerns with economic development, and enhance energy security. These have been separated into building, utility, industry, and transportation technologies.

Building Technologies at Berkeley Lab will continue activities related to residential and commercial buildings in a program of laboratory and field research, modeling, data analysis, and partnerships with industry to accelerate market impact of our research. This work is a coordinated systems approach to designing building components as well as entire buildings with improved energy efficiency and better conditions for human health, comfort, and productivity.

The work in **Utility Technologies** includes a geothermal energy resources program which consists of delineation and evaluation of geothermal systems, definition of reservoir processes, modeling of reservoir dynamics and exploitation effects, and optimization of field-management practices; reservoir technology work that will lead to more accurate predictions of the responses of a geothermal reservoir to exploitation for optimum management through carefully designed fluid-production and injection operations; and analysis of the energy demand in foreign countries, including China.

Industry Technologies focuses on advanced industrial concepts, including energy-efficient chemical separations and other industrial applications. Work is under way on two projects concerning catalysts for industry: theory-assisted design of metal and zeolite catalysts; and chemistry, immunology, and modeling as tools for the rational design of stable, active enzymes.

In **Transportation Technologies**, Berkeley Lab manages the Exploratory Technology Research Program (ETRP), which is to advance the development of high-performance rechargeable batteries and fuel cells for use in electric vehicles. Performance goals for the ETRP have been established by the U.S. Advanced Battery Consortium. Berkeley Lab is also working in conjunction with the other DOE multiprogram laboratories to assist DOE in its role in the federal/industry Partnership for a New Generation of Vehicles (PNGV) by applying its expertise to combustion and emissions, lightweight materials, and improved manufacturing techniques.

Office of Civilian Radioactive Waste Management

Berkeley Lab continues a strong multidisciplinary program of interrelated geoscience and geological engineering research important to the safe, long-term underground storage of high-level nuclear wastes. This research includes characterization of deep geologic formations, determination of the physical and chemical processes occurring in the repository rocks, analysis of hydrologic and chemical transport mechanisms, and development of predictive techniques for repository performance. Coupled with ongoing basic research, Berkeley Lab is contributing to technology and applied development research at DOE's Yucca Mountain Project as well as to international projects in cooperation with Sweden, Switzerland, Canada, and Japan.

Office of Fossil Energy

Berkeley Lab conducts research for the Office of Fossil Energy that is directed toward making coal more usable, including studies on conversion to gaseous and liquid fuels and reduction of emissions, for example the catalytic conversions of natural gas to higher hydrocarbons; studies in the oil and gas area on characterizing heterogeneous and fractured reservoirs to obtain an improved model of reservoir performance to enhance our ability to manage reservoir production; using the computational capabilities at the national laboratories through the Computational Technologies (CT) program for studies in subsalt imaging, drill-site analysis of rock properties, visualization and virtual reality techniques for the reservoir engineer, control of production-related ground subsidence, and optimization of fluid injection; and understanding selenium's presence in San Francisco Bay and its effects on the Bay's water quality. Studies are also underway on heavy oil tank emissions and on health effects of petroleum products.

Office of Policy, Planning, and Analysis

Berkeley Lab undertakes analysis activities in support of policy issues, including greenhouse gas mitigation strategies in developing countries; characterization of residential energy demand in the U.S.; and market forces in a restructured electric utility sector.

Environmental Management

The Laboratory is implementing site projects for restoration and waste management consistent with DOE's National Environmental Management Program. In collaboration with other labs, Berkeley Lab will help address major technology gaps in environmental restoration. Components are: improved characterization of subsurface environments; development of methods for assured containment and control of contamination; development of advanced remediation technologies; and improved risk assessment and prioritization systems. The methodologies include field testing and tracking contaminant fronts; developing descriptive and predictive mathematical models; characterizing heterogeneous underground systems; designing, demonstrating, and testing containment and cleanup systems at specific contaminant sites; and determining the underlying chemical, biological, and thermodynamic properties involved in mixed contamination.

Office of Environment, Safety, and Health

Berkeley Lab is continuing its strong programs in analytical methods development and statistical studies of environmental and epidemiological factors supported by the Office of Epidemiology and Health Surveillance. The Population at Risk to Environmental Pollution Project focuses on the collection, analysis, and interpretation of data pertaining to relationships between human health and environmental pollution. Computational techniques are developed for the analysis of ecological data, especially small-area geographic data, to investigate alleged departures from expected disease rates, to generate etiologic hypotheses, and to plan clinical trials or cohort studies.

Defense Programs

The Laboratory's unique capabilities in acceleration design and fabrication are being utilized to support the Dual Axis Radiographic Hydrodynamic Test Facility at Los Alamos, and a range of capabilities can assist in nuclear non-profiferation.

Science Education for DOE

The Center for Science and Engineering Education (CSEE) develops and implements programs that utilize Berkeley Lab resources to provide authentic science education opportunities to improve the content of mathematics, science, and technology education in the United States. On an annual basis, CSEE educational activities reach thousands of students and faculty. In addition to DOE, CSEE program customers are the University of California, the National Science Foundation, and the National Institutes of Health. The Laboratory is working to expand Internet-mediated science content to nationwide audiences through the World Wide Web, for example in the support of Hands-On Universe models; and greater outreach to the California student population to ensure a diverse science and engineering workforce for the Department of Energy.

National Institutes of Health

The success of the DOE biosciences and environmental sciences programs at Berkeley Lab has depended not only on DOE support but also on complementary NIH-supported research that is closely coupled to these programs. Several critical technologies—specifically genome sequencing, molecular medicine, biotechnology, and structural biology—build on the unique facilities and expertise available at Berkeley Lab and point toward a growing interaction of DOE- and NIH-funded research in pursuing new goals in biology and medicine. NIH applies Berkeley Lab's unique resources to investigations of the human genome and of carcinogenesis and mutagenesis. The Laboratory is central to the *Drosophila* genome project. Other major focus areas are repair and recombination in yeast and the genetic effect of carcinogens; cell nuclei studied by circular dichroism and related techniques; and culturing human mammary epithelial cells to study breast cancer. NIH also supports programs on radionuclides, NMR, diagnostic image reconstruction, and radio-pharmaceuticals related to advanced instrumentation and disease treatment. Other major NIH-funded programs involve lipoproteins and their relationship to cardiovascular disease; biological structure analysis by electron crystallography to characterize cell-membrane proteins and viruses; the intracellular molecular structure of DNA and sickle hemoglobin; the molecular basis of cell senescence; and initiation of carcinogenesis by chemicals and radiation. Additional studies are funded to investigate how normal growth and cancer cells are controlled by their microenvironments.

Department of Defense

The Center for X-Ray Optics (CXRO) has received funding from ARPA for construction of two beamlines at the Advanced Light Source (one for EUV interferometry and one for EUV metrology), construction of the Nanowriter (an advanced e-beam writer), and supporting research activities. ARPA also funds the MAGIC gigabit testbed—a project to combine high-speed, wide-area-network technology, distributed image-storage systems, and high-speed graphics with aerial and satellite images—to present a user with a virtual reality that corresponds to what he or she would see while traveling through the actual terrain. The Laboratory conducts research on the nanoscale synthesis and characterization of materials at its Institute for Molecular Design. The Laboratory also conducts a program of Bioremediation Education Science and Technology (BEST) for the U.S. Army Corps of Engineers in partnership with Jackson State University and the Ana G. Méndez University System in Puerto Rico.

National Aeronautics and Space Administration

The space radiation environment and what it means to continue human presence in space is one of the most unique of NASA's problems. Berkeley Lab investigators are conducting multidisciplinary research at the molecular, cellular, and tissue levels for understanding the biological impact of solar and galactic cosmic radiation exposure on astronaut health and that of future colonizers. Berkeley Lab leads a partnership with Colorado State University at Fort Collins (CSU) in the NASA-sponsored Specialized Center of Research and Training (NSCORT). The Center provides a wide variety of training options for graduate students and postdoctoral fellows in space radiation biology. The NSCORT grant administered by Berkeley Lab has been renewed for five additional years, through 2002. The Berkeley Lab Astrophysics Group has been instrumental in the development of the Differential Microwave Radiometer installed on the Cosmic Background Explorer (COBE), which has detected anisotropies in the cosmic microwave background. These anisotropies show the primordial seeds of modern structures such as galaxies, clusters of galaxies, and larger-scale patterns.

Environmental Protection Agency

Berkeley Lab conducts research on the hydrogeological transport of contaminant plumes from deep underground injection disposal. In the area of global environmental effects, Berkeley Lab is characterizing the emissions of energy technologies, improving global energy projections, fostering international awareness of global trends, and studying effects of tropical deforestation. Berkeley Lab, along with other national laboratories, is also working to develop new ways to advance national environmental goals, including the more efficient use of energy to reduce greenhouse gas emissions.

Department of the Interior

Laboratory scientists are investigating the geochemistry of selenium and other trace elements at Kesterson Reservoir, which has been a terminus of agricultural drainage water in California's San Joaquin Valley. Continuing collaborative investigations are under way to evaluate remediation techniques for the area's soil, with related research at Stillwater Marsh, Nevada.

Agency for International Development

The Agency for International Development is supporting a multiyear effort in which Berkeley Lab will perform research in support of improving the efficiency of energy use in developing countries.

Other Agencies/State and Private

The Laboratory conducts research for the Electric Power Research Institute (EPRI) on chemistry-related research concerning reducing oxidation and scale formation, and on oxygen depletion in compressed-air storage. Another EPRI project is the study of surface modification with metal plasma techniques. The Gas Research Institute supports databases on the influence of clays on seismic-wave attenuation in reservoir rocks. The California Air Resources Board is sponsoring an analysis of polycyclic aromatic hydrocarbons in indoor air. Berkeley Lab's expertise in building technologies is recognized by the California Energy Commission and the energy utilities.

The California Breast Cancer Research Program (BCRP) was established pursuant to passage by the California Legislature of the 1993 Breast Cancer Act. The program is responsible for administering funding for breast cancer research in the State of California. BCRP's goals are based on the intent of the enabling legislation, which is to reduce the human and economic costs of breast cancer in California. The Breast Cancer Act calls for funding innovative and creative breast cancer research that complements—rather than duplicates—research that has been funded by the federal government and other agencies.

STRATEGIES

The Laboratory focuses on providing core competencies that enable DOE's missions—science and technology, energy resources, environmental quality—to succeed through the DOE Laboratory System. As indicated in the Strategic Laboratory Missions Plan, Berkeley Lab plays a principal role in fundamental sciences and a major contributing role in DOE energy resource research, and adds its specialized and distinctive capabilities to DOE's environmental quality mission.

Program Directions

- For **Fusion Energy Sciences**, Berkeley Lab applies its accelerator physics and engineering, and its plasma science capabilities, to address the key questions for Inertial Confinement Fusion. In particular, Berkeley Lab applies its research expertise and experience to assess and develop heavy-ion accelerators or drivers for an inertial confinement energy source. The results of successful single team transport and multiple-beam experiments provide encouragement and justification to conduct larger, more complex experiments.
- **Computational sciences are at the core of our scientific capabilities and impact all programs for the Office of Energy Research.** Advanced computing and networking capabilities are essential for achieving DOE's research and development objectives. Further advances in computing and networking performance are integral to advances in energy-research activities, such as high-energy and nuclear physics, fluid mechanics and combustion sciences, mathematics, engineering, materials, and the life and environmental sciences. In addition, the Energy Sciences Network (ESnet) provides nationwide and international connectivity for the entire DOE community.
- **The Advanced Light Source (ALS) Roadmap provides crucial instrumentation for DOE research programs, giving scientists new probes with unprecedented sensitivity and high resolution.** As a tool for the characterization of advanced materials, development of x-ray lithographic techniques, study of chemical dynamics, and research in structural biology, the ALS has a central role in some of the Laboratory's most important research thrusts, as well as offering significant opportunities for researchers across the country. The Scientific Facilities Initiative provides new levels of service to users, and contributes to achieving ALS Roadmap objectives.
- **In the biosciences, Berkeley Lab is integrating capabilities in genomics, ALS structural biology, and computation with cell and molecular biology.** Prospects include deeper understanding of the origins of diseases and intervention strategies, custom-tailored pharmaceuticals and materials, and microbial engineering to eliminate contaminants from the soil.
- **Berkeley Lab continues to provide leadership in high-energy and nuclear physics and astrophysics for national and international programs.** New Laboratory resources in computation will enable the community of high-energy and nuclear physicists to address the new data and communications requirements for experimental programs at Brookhaven, Fermilab, and SLAC, and at the Large Hadron Collider at CERN.
- **Berkeley Lab is at the forefront of developing energy supply and energy efficient technologies and minimizing the environmental impacts of energy use.** Berkeley Lab continues to play a pioneering role in the development of electromagnetic and seismic methods for imaging subsurface resources, in development of advanced energy efficient building technologies, in studies of indoor air quality, and in research on combustion, emissions, and urban/regional air quality. The Lab also has a leading role in characterizing global energy use and the related greenhouse gas emissions which may lead to global climate change.
- **Berkeley Lab provides leadership in environmental protection and remediation.** Programs include research innovations in chemistry to prevent pollution from industrial products and the manufacturing process; characterization methods; predictive models and risk-assessment methodologies; and environmental biotechnology methods to clean up sites contaminated by toxic

chemical wastes. DOE's new Natural and Accelerated Bioremediation Research Program is strongly supported by the development efforts at Berkeley Lab.

Berkeley Lab is working with the DOE to anticipate needs and develop proposals that address the nation's most pressing scientific, energy, and environmental needs. The Laboratory Directed Research and Development (LDRD) funds are vital for catalyzing and fostering new scientific directions and initiatives. Berkeley Lab is reviewing levels of funding for LDRD and ensuring that the process supports the most promising strategic research directions.

Key Partnerships

- Berkeley Lab is a part of the system of DOE National Laboratories and is applying its capabilities as part of coordinated inter-Laboratory efforts. Key examples are the Joint Genome Institute, the National Spallation Neutron Source, and the Dual Axis Radiographic Hydrodynamic Test Facility.
- **Develop partnerships with other agencies, universities, and industry.** In order to benefit fully from the competencies of the national laboratory system, we must partner with industry, federal and state agencies, and universities to tackle problems of increasing complexity. Partnerships not only among different institutions, but also among different disciplines, will be increasingly productive arrangements with national user facilities such as the ALS and NERSC.
- **Strengthen partnerships with the University of California (UC).** One of the great strengths of the Laboratory is its close relationship with the UC Berkeley campus. Because of the growing importance of interdisciplinary and facility-oriented research (such as computational sciences and the structural biology and genome sequencing projects), partnerships with the campus should be strengthened and broadened to address industrial and national R&D needs.
- The Laboratory is working in partnership with the community to address environmental monitoring of tritium, joint fire service arrangements, and vegetation management for fire prevention and control. The Laboratory seeks mutually supportive relationships with the community based on constructive interactions and trust.

Cost-Effectiveness

- **Cost-Effectiveness.** The Laboratory has established performance improvements in concert with DOE to address streamlined, efficient, and cost-effective management systems. Savings have been accomplished through integration of management, halting peak load staffing, implementing cross-organizational work assignments, and more careful management of employee job performance. From FY 1994 through FY 1996, the research-to-support ratio (FTE-based) has improved from 1.62:1 to 2.36:1.
- **Administrative Services.** A new Administrative Services Department has been established that provides seamless institutional services, cross-functional infrastructure, and feedback on performance. We are promoting a culture in which we measure and analyze performance results and encourage greater communication to assure the development of quality and customer-focused programs. We are working in partnership with DOE and are active in the "Quality Summit" to advance department-wide quality programs and efficiencies.

Empowering Our People

- **Diverse work force.** The Laboratory values diversity in the workplace, and establishes diversity as a permanent part of the Laboratory's institutional culture. We are committed to equal opportunity and affirmative action, and we recognize these policies as the first and most important steps to achieving diversity in our working community.

- **Career growth and training.** More educational opportunities and job-related training—and a wider awareness of these opportunities—are measures for addressing the professional development of Berkeley Lab employees. The new Administrative Services Department enables more consistent skill levels and expectations and provides improve opportunities for staff development, planning, and placement. Our goal is the growth of all Berkeley Lab employees, facilitated by a responsive management.

MANAGEMENT OPPORTUNITIES AND ISSUES

To maintain the Laboratory's scientific leadership and to ensure the full development of its capabilities and resources, Berkeley Lab has identified strategic management issues that it is addressing with DOE through institutional planning and other management forums. These issues, which continue to be developed as an ongoing process within Berkeley Lab's strategic planning activities, can be divided into three main categories: modernizing our research facilities, optimizing performance-based management, and institutionalizing Integrated Safety Management.

Adequate Research Support and Office Facilities

Berkeley Lab will continue to give priority to modernizing and constructing facilities to sustain national programs while also maintaining high standards in the areas of environment, health, and safety. The Laboratory closely coordinates its facilities and institutional planning, safety and health planning, and environmental restoration so that a safe working environment will be provided for implementation of DOE scientific programs. In this manner, information on the program activities for DOE compliance with the National Environmental Policy Act is also fully sustained. Critical elements of Berkeley Lab capital resource and modernization planning are implemented through:

- **Multiprogram Energy Laboratory Facilities Support (MEL-FS).** This program has been vital for infrastructure at Berkeley Lab. A key element for the program will be modernization of support buildings and infrastructure facilities. Recent reversals in the program's funding place the Laboratory infrastructure under severe stress. Old buildings need to be replaced to provide adequate facilities for research infrastructure and support programs.
- **General Plant Projects (GPP).** Small capital projects (up to $2.0 million) supported by GPP are essential for small modifications and additions; for compliance with environmental, health, and safety standards; and for upgrades of obsolete and deteriorated infrastructure such as transformers, switching stations, boilers, chillers, and roofs. At $3.4 million, the current annual budget for GPP projects is inadequate to make substantial progress in meeting identified needs.

Performance-Based Management

Appendix F of the contract between the University of California Regents and the Department of Energy for the operation and management of Berkeley Lab (Contract 98) contains performance measures that are the components of the performance-based management system that the University and DOE utilize for Laboratory oversight and is one mechanism for the implementation of the Government Performance and Levels Act of 1993. The DOE and the University have developed the measures as objective standards against which the University's overall performance under the prime contract is to be assessed.

Science and technology performance assessment guidelines for UC's peer review process are summarized in the document "Laboratory Science and Technology Assessment Process and Criteria." In essence, these guidelines prescribe the use of outside peer review committees, which assess the Laboratory's science and technology programs according to four criteria: quality of science; relevance to national needs and agency missions; performance in the construction and operation of major research

facilities; and programmatic performance and planning. The result of each review is an overall rating of outstanding, excellent, good, marginal, or unsatisfactory.

The long-term goal for Berkeley Lab's performance-based contracting is the integration of the measures, assessments, and reviews for an efficient and productive evaluation of Berkeley Lab's performance. The Laboratory and the University continue to work with DOE to optimize the performance evaluation process, eliminate redundancies, and develop a system that provides positive feedback for improved performance.

ES&H Performance

It is the policy of the Laboratory to integrate its performance in the areas of environment, safety, and health (ES&H) into the planning and implementation of all of its operations to protect the health of employees, the public, and the environment. Laboratory plans integrate ES&H requirements in a prioritized manner to assure that Berkeley Lab can meet DOE's Critical Success Factors for ES&H in the conduct of research. All Conceptual Design Reports and other supporting materials indicate ES&H requirements for program planning.

Among the more significant joint DOE and Berkeley Lab management efforts has been the move from the DOE order system to one of direct application of appropriate legal codes and national standards. Such an approach involves examination of work being conducted, evaluation of the hazards, and implementation of controls tailored to mitigate risks. This approach is now being applied to all Berkeley Lab facilities and activities with the promise that it will enhance hazard communication and consistent understanding of requirements, ensure a disciplined approach to performance-based management, result in a more rational and efficient management of laboratory operations, and increase line management and employee involvement in implementation of the ES&H program.

Effective Relationship with Our Community

The Laboratory seeks constructive relationships with the community and engages in proactive corporate citizenship activities. These activities include mechanisms to incorporate community concerns into decision-making and establishing effective lines of communications and trust. Examples of the Laboratory's current activities include the establishment of a community Tritium Monitoring Task Force, where recommendations will form the cornerstone of additional tritium monitoring beyond the full compliance program currently in place. The Laboratory also worked with the City of Berkeley to address the terms of a first responder fire services agreement, and exhibited leadership on its community-based vegetation management plan. The Laboratory's education and waste management programs also conduct value-added community activities.

The Laboratory has developed a long-range communications plan that includes a proactive approach to communicate with our staff and with all stakeholders and community interests. The Laboratory actively establishes a framework to meet with the community on key issues and fully consider their concerns during the process of decision making.

IV. INITIATIVES

INTRODUCTION

Berkeley Lab's mission to provide national scientific leadership and technological innovation is based on its ability to build and make available its unique resources. These resources allow Berkeley Lab, together with other DOE laboratories, to maintain leadership in basic research, to focus on fundamental and applied research in support of the DOE and other federal and state agencies, and to maintain global technical leadership through science education. Initiatives are provided for consideration by the Department of Energy. Inclusion in this plan does not imply DOE's approval of or intent to implement an initiative.

DOE Integrated National Laboratory System Initiatives

These initiatives are large-scale multi-laboratory efforts that are planned as coordinated efforts among laboratories and reflect the distinctive contributions at Berkeley Lab.

- Heavy-Ion Fusion Science Facility
  (Fusion Energy)
- Computationally Intensive Science at DOE
  (Computational and Technology Research)
- Joint Genome Institute
  (Biological and Environmental Research)
- National Spallation Neutron Source
  (Basic Energy Sciences)
- High-Energy and Nuclear Physics Computing
  (High-Energy and Nuclear Physics)
- Yucca Mountain Percolation Flux
  (Civilian Radioactive Waste Management)
- Energy Technologies
  (Energy Efficiency and Renewables)
- Dual Axis Radiographic Hydrodynamic Test Facility
  (Defense Programs)

DOE Program Initiatives

These initiatives are planned within the larger scientific community and generally reflect Berkeley Lab's specific facilities or competencies.

- Advanced Light Source Roadmap
  (Basic Energy Sciences)
- Molecular Environmental Science
  (Basic Energy Sciences)
- Nanostructured Materials Program
  (Basic Energy Sciences)
- Large-Scale Neutrino Detector
  (High-Energy and Nuclear Physics)

- GRETA (Gamma-Ray Energy Tracking Array)
  (High-Energy and Nuclear Physics)
- Boron-Neutron Capture Therapy
  (Biological and Environmental Research)
- Environmental Management Science Program
  (Environmental Management)

DOE INTEGRATED NATIONAL LABORATORY SYSTEM INITIATIVES

Heavy-Ion Fusion Science Facility

The U.S. Inertial Confinement Energy Program is applying and enhancing its research expertise and experience to assess and develop heavy-ion accelerators as drivers for an inertial fusion energy source for commercial power generation. The results of successful single-beam transport and multiple-beam experiments provide encouragement and justification to conduct larger, more complex experiments. The principal remaining accelerator issues that must be resolved to build a full-scale fusion driver are cost and the preservation of good beam quality under a variety of beam manipulations. These manipulations include acceleration, beam transport, beam bending, beam combining, longitudinal compression, and transverse focusing.

Berkeley Lab had proposed experiments to address nearly all remaining issues, but by late 1995 it became clear that funding was not forthcoming, so we restructured the program. It now has two principal thrusts: (1) accelerator and plasma science and (2) enabling technologies.

Accelerator science itself is largely the science of nonneutral plasmas. This research is synergistic with the new laboratory-wide effort in numerical science inspired by the transfer of NERSC. We plan end-to-end numerical simulations of existing and proposed accelerator systems. But it is still necessary to build a new accelerator for continued progress toward fusion energy.

Our work in accelerator and plasma science and our development of enabling technologies will lead to the construction of a multi-kilojoule accelerator that will not only address the remaining beam-manipulation issues in the same manner as the experiments we proposed earlier, but will also support a wide variety of experiments in beam-target interaction physics, the physics of high-energy density, and fusion target physics.

Together with results from the National Ignition Facility, this "final step" machine will provide *all* the data necessary to determine the feasibility of inertial fusion energy production. We plan to submit a Conceptual Design Report for the new machine in early FY 1999.

Heavy-Ion Fusion Science Facility Resource Requirements ($M)*

Category	Prior Years	1997	1998	1999	2000	2001	2002	Total
Operating	5.0	4.0	7.1	6.6	7.0	5.0	5.0	39.7
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Preliminary estimate of Berkeley Lab Budget Authority (B&RC Code AT) in FY 1995 dollars. Costs include designs and R&D operations, and not include construction R&D.

Computationally Intensive Science at DOE

The level of abstraction accessible to scientists for addressing a scientific problem has often been constrained by software complexities rather than computational capabilities. Powerful computing technology is becoming available more quickly than it is becoming usable. The distance between the formulation of an idea to its realization as a large-scale computer calculation is only slowly being reduced for the scientific world, while the power of the underlying hardware continues to advance along the Moore's law curve, doubling every 18 months. Massively parallel computers provide power hundreds of times greater than the best workstations, but their general application to scientific computing continues to develop only slowly as the software barriers to their use are overcome. What is required is a fundamental change in the interface and software for high-end supercomputing, so that the hardware can achieve its promise as a direct tool for discovery rather than as an adjunct to theory and experiment.

ER Laboratories can take advantage of ER's position of strength in computation to help define and exploit the explosive increase in the utility and efficacy of computationally intensive theory that will accompany the maturing of computational technology over the next 10 years. This new program is intended to be the vehicle by which we realize the vision of a new and expanded role for theory and computation in DOE. It is focused on the creation of centers for computation in critical science areas—where the scientific problems already exist. These centers will be supported by the development of tools from Computer Science, Applied Mathematics, and Computational Science that significantly enhance the ability of scientists to use computers for discovery.

In particular, the new paradigm will be the approach to address critical needs in ER programs for Computation of Scale in areas such as:

- Materials by design
- Computational biology
- Chemical Sciences in environmental problems and combustion
- Climate prediction
- Fusion energy

The initiative, whose design is being first worked out by LBNL and ANL, builds on the NERSC production computing expertise as well as programs in computer science and computational science.

Computationally Intensive Science at DOE Resource Requirements ($M)*

Category	1997	1998	1999	2000	2001	2002	Total
Operating	0.0	0.0	10.0	25.0	50.0	50.0	135.0
Construction	0.0	0.0	0.0	5.0	10.0	10.0	25.0

*Preliminary estimate of total DOE Budget Authority (B&RC code KJ), construction costs are equipment and renovation to be distributed among various laboratories through the Centers for Computation.

Joint Genome Institute

The DOE Joint Genome Institute (JGI) represents a full functional merger of the genome programs of LANL, LBNL, and LLNL. It will pursue a targeted, priority-driven approach in which regions of high biological value and megabase extent (and bounded by publicly-mapped, sequence-based markers) are sequenced first. Also, to improve gene discovery and provide insight into likely function, subsidiary efforts will include obtaining certain types of additional information about the genes in the regions being sequenced. The JGI thus proposes to undertake a coordinated program of high throughput, targeted

genomic sequencing coupled to a suite of inexpensive functional genomic analyses applied to the same genomic domains. To further this overall program, the JGI will operate an approximately 60,000 square foot central facility, the Advanced Sequencing Facility, or ASF. The ASF will be dedicated to the production component of its genomic sequencing efforts, and involve the direct participation of all three national laboratories. Beyond this, the merger of effort embodied in the JGI is reflected in: consolidation and centralization of management functions; unified planning, management and funding based on defined tasks that cut across the participating labs; and strong reliance on outside peer advice and review to guide program planning and funding decisions.

The Berkeley Lab contribution to the JGI is intended to leverage the technology and expertise of its Human Genome Center (HGC) towards megabase sequencing challenges. The HGC is oriented almost exclusively towards developing and implementing directed methodologies for cost-effective and accurate high-throughput human DNA sequencing.

This work has five components: a biology component, an automation group, an informatics group, a production effort, and a biology program.

- The **biology component** of the technology group has developed a directed strategy of DNA sequencing in which high-resolution physical maps are generated so that a small set of standard primer binding sites are positioned every 300 base pairs. This mapped set of templates is then sequenced. Using this strategy, templates can be selected in a minimally redundant fashion, which means that template preparation requirements are reduced tenfold and sequencing reactions can be reduced fivefold.
- The **automation group** develops instrumentation to support the directed sequencing approach. Some of the modules have been completed and are currently in use: an image station that captures and analyzes the mapping information from agarose gels, a colony picker, a robotic library replicator, and a modified Biomek that sets up polymerase chain reaction assays and sequencing reactions.
- The **informatics group** develops software that facilitates the sequencing effort. The developmental effort is aimed at all aspects of the process, beginning with the physical mapping efforts, continuing through the generation of the high-resolution map and template selection, followed by sequencing and assembly of templates, and concluding with the analysis and dissemination of the sequencing information.
- The **production effort** consists of six teams, which can currently generate about 12 MB per year. The goals of the production effort are to maintain the quality of the sequence while lowering the cost per base pair as well as to add additional teams in the next few years and increase the productivity of each team.
- The **biology program** has been reconstituted to be closely integrated with the overall sequencing effort. The biology program will play a role in selecting templates beforehand and then in developing biological programs to interpret the immensity of data in a meaningful way.

Genome Sequencing Resource Requirements ($M)*

Category	1997	1998	1999	2000	2001	2002	Total
Operating							
DOE	40.0	42.5	50.0	50.0	50.0	50.0	282.5
NIH	5.7	6.7	8.0	8.3	8.7	9.0	46.4
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Preliminary estimate of combined LANL, LLNL, and Berkeley Lab Budget Authority from DOE (B&RC Code KP) and NIH.

National Spallation Neutron Source

The Secretary of Energy has identified the National Spallation Neutron Source (NSNS) as the highest priority within the Office of Energy Research for a new construction start. This facility will provide an unprecedented flux of pulsed neutrons for neutron scattering research and is the cornerstone of DOE's strategy to reestablish U.S. preeminence in this field. DOE has designated Oak Ridge National Laboratory as the preferred site for the facility; Oak Ridge has formed a multi-laboratory collaboration to design, build, and commission the facility. Partnering laboratories (LBNL, LANL, BNL, ANL, and ORNL) each have responsibility for different subsystems.

The design parameters of the NSNS have been developed to meet the specific needs of the user community. These requirements have been established through numerous workshops and advisory panels and have been endorsed by BESAC. Specifically, the NSNS is to be designed as a 1-MW facility with sufficient flexibility to be upgraded to significantly higher power. The initial facility configuration will provide a suite of 10 scientific instruments that operate simultaneously using a single neutron source. The neutrons are produced via spallation reactions that result from directing a 1-MW proton beam onto a liquid mercury target with a 60-Hz train of 1-ms-wide pulses. The proton energy of 1 GeV is achieved by an accelerator system consisting of a full energy H^- linac and an accumulator ring. The project is presently on course for a FY 1999 start with completion in FY 2004.

Berkeley Lab has the responsibility of designing and producing the "front end," which includes the H^- ion source, the Low-Energy Beam Transport system, Radio-Frequency Quadrupole accelerator, and the Medium-Energy Beam Transport system. This responsibility builds on the Laboratory's expertise and its successful design and construction of similar systems.

National Spallation Neutron Source Resource Requirements ($M)*

Category	1996	1997	1998	1999	2000	2001	2002	Total
Operating	0.9	1.1	2.5	2.9	2.0	1.5	0.8	11.7
Construction	0.0	0.0	0.0	2.7	4.6	6.2	5.7	19.2

*Preliminary estimate of Berkeley Lab Budget Authority subcontracted through ORNL (B&RC Source KC02). Total amount of funds expected through FY04 is $34M (Operating & Construction).

High-Energy and Nuclear Physics Computing

To address forefront scientific issues, experimental high-energy and nuclear physics on the leading edge calls for complex experiments conducted by very large collaborations to detect and analyze increasingly large numbers of final-state particles and/or events. Experiments at colliders (such as RHIC, LHC, the SLAC B-Factory, and Fermilab) and at fixed-target accelerators produce huge amounts of data that must be cooperatively verified, analyzed, and interpreted by these collaborations. Massive computer simulations are necessary to understand these data and to compare measurements with models and theories. The challenge for the coming years is to provide cost-effective computing capabilities that will allow far-ranging collaborators to have seamless access to data and each other so that work can proceed in a "national collaboratory" mode.

The High-Energy and Nuclear Physics Computing Initiative will provide a National High Energy and Nuclear Physics (HENP) Collaboratory through the advanced computing, simulation, and remote-access capabilities at the National Energy Research Scientific Computing (NERSC) Center at Berkeley Lab. This Collaboratory will be dedicated to developing and applying forefront computing and networking to the kinds of data analysis and simulation requirements that will spring from the next generation of large nuclear and high-energy physics experiments. The HENP Collaboratory will include teraflop-scale processor farms coupled to petabyte-scale robotic data storage with multiuser access to event databases.

The Collaboratory environment will allow remote collaborators to participate in data analysis in a collegial fashion, rather than as isolated groups.

At this time, this HENP Computing Initiative at Berkeley Lab has developed into the following three related projects:

- The **Parallel Distributed Simulation Facility** (PDSF) processor-array pilot project at Berkeley Lab is a demonstration of the collaboration of the NERSC Center, nuclear and high-energy physics researchers, and ICSD. The initial implementation verifies the suitability of the "workstation farm" approach to providing the CPU capability for analysis and simulation of the next generation of large nuclear and high-energy physics experiments. The next step will integrate high-speed networks and robotic storage/retrieval technologies with the arrays of processors to verify this architecture for the massive data access needs of HENP.
- The **HENP Data Access Grand Challenge** is a collaboration of nuclear and high-energy experimental physicists and computer scientists addressing key problems in accessing the huge datasets of large HENP experiments. Berkeley Lab is the leading institution in this collaboration, which includes researchers from Argonne, Brookhaven, Jefferson and Oak Ridge laboratories as well as several universities. The size of the datasets involved (PB-scale) means it is most feasible to keep the entire dataset in a robotic tape storage system with only a small fraction held on a magnetic disk cache.
- The **STAR experiment** at RHIC is seeking to develop a computing facility at NERSC that integrates the technology from both the PDSF and the HENP Grand Challenge. This facility will be developed over four years, beginning in FY 1998, by adding additional processor-array and disk cache capability at NERSC while utilizing the existing networking and robotic storage infrastructure. The facility is both complementary in role and compatible in architecture to the RHIC Computing Facility at BNL, and it serves as a model for other experimental HENP activities at NERSC.

The virtue of utilizing the NERSC Center as a participant in these activities is that it can minimize the costs by incrementally adding hardware and operating personnel to its existing infrastructure while collaborating directly with local scientists. This ensures that NERSC remains closely coupled to the HENP research programs.

High-Energy and Nuclear Physics Computing Resource Requirements ($M)*

Category	1997	1998	1999	2000	2001	2002	Total
Operating	0.0	1.0	2.0	1.3	1.3	1.3	6.9
Construction	0.0	1.2	0.5	1.0	0.9	0.7	4.3

*Preliminary estimate of Berkeley Lab Budget Authority. (B&RC Code KA, KB, and KJ).

Yucca Mountain Percolation Flux

Percolation flux has been identified as one of the most important parameters to quantify for determining the suitability of Yucca Mountain, or any other possible site, for long-term storage of the nation's nuclear waste. In the case of Yucca Mountain, it is particularly important to test the key hypothesis of low seepage into the repository. Preliminary data showing the presence of young water at the repository level accentuate the need to understand the partitioning of flow between slow tuff matrix and fast paths, both in the vicinity of faults and away from mappable features in the potential repository area. Researchers need to know the variation in percolation flux in order to understand the unsaturated zone flow processes and to make more realistic calibrated site-scale and drift-scale models. Performance assessors need quantification of the percolation flux in order to determine the amount and distribution of

water contact in drifts that will impact total system performance. Repository designers also need the information in order to plan the repository layout to avoid potential fast-flow paths and to assure stability of excavation near faults. The overall Yucca Mountain studies are joint programs conducted by a number of DOE Labs, including Sandia, LLNL, LANL, and Berkeley Lab.

Berkeley Lab has prepared a detailed plan focusing on the site's Viability Assessment and Site Suitability determination. The purpose of this proposed testing and modeling program is determination of the percolation flux. The program will demonstrate the viability of the unsaturated zone as an effective barrier, provide understanding of fast paths in draining infiltration, and confirm unsaturated zone site-scale models and drift-scale submodels needed for performance assessment. An extensive set of data will be collected to generate spatial distributions (contour maps) of all parameters relevant to determining percolation flux. The main objectives of the test are to:

- Quantify percolation flux, age of water, and parameter distribution.
- Quantify seepage flux into drifts.
- Determine the impacts of faults on percolation and age distribution.
- Partition the percolation distribution between matrix flow and fast-path flow.
- Calibrate models for site-scale representation of fluxes.
- Confirm conceptual models of the Yucca Mountain system.

This information will be crucial to evaluation of waste isolation capability for the Viability Assessment in 1998, the Site Suitability Decision in 2000, and the License Application in 2002.

Yucca Mountain Percolation Flux Resource Requirements ($M)*

Category	1997	1998	1999	2000	2001	2002	Total
Operating	0.8	2.0	2.0	1.5	1.0	0.5	7.8
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Preliminary estimate of Berkeley Lab Budget Authority (B&RC Code DB).

Energy Technologies

DOE Labs have a distinguished record of taking research from the laboratory to products in the marketplace—products that use energy more efficiently or reduce energy-related emissions. Berkeley Lab successes include low-emissivity windows for residential and commercial buildings and high frequency ballasts for fluorescent lamps. Recent examples include energy efficient fixtures for compact fluorescent lamps and methods to seal leaky heating and cooling ducts in residences. On the horizon are electrochromic coatings that permit the control of the optical properties of windows and a novel natural gas burner suitable for small- to medium-scale boilers that has very low levels of nitrogen oxide emissions.

This initiative focuses on the development of a next generation of energy technologies based on research that is still in the laboratory but shows promise of leading to products of significance on the scale of those listed above. A prime target is the incandescent lamp, which is the least efficient of commonly-used light sources but, for a variety of reasons, has not been displaced by compact fluorescent lamps in most residential applications. The concept is to combine the Laboratory's expertise in light sources with its expertise in semiconductor materials and processes to develop a pinhead-sized, high intensity discharge (HID) lamp. If successfully developed, this lamp could be packaged in an enclosure virtually identical in appearance and function to a regular incandescent lightbulb, but with (depending on the exact technology used) two to four times the efficiency of conversion of electricity to visible light.

A second target is the stationary gas turbines used for generating electricity and, often, for co-generation applications that utilize the waste heat. Such turbines are expected to gain an increasing share of the market for electricity generation and, while generally considered "clean" do have undesirable levels of nitrogen oxide emissions. The concept is to extend the burner technology developed for boilers to the high pressure regime needed for combustion in turbines. Such an extension is non-trivial and will require a dedicated effort, but could have a substantial payoff in reduced levels of urban air pollution.

There are numerous additional opportunities for energy efficiency gains through technology R&D. We intend to focus on opportunities for industry and buildings. As a first step in this effort, we will assess technological opportunities within industry and transportation and will identify the areas and specific R&D endeavors that we can pursue to bring better technologies from the lab to the market.

Energy Technologies Resource Requirements ($M)*

Category	1997	1998	1999	2000	2001	2002	Total
Operating	1.0	2.0	4.0	5.0	6.0	7.0	25.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Preliminary estimate of Berkeley Lab Budget Authority (B&RC Code EE).

Dual Axis Radiographic Hydrodynamic Test Facility

The DARHT (Dual Axis Radiographic Hydro-Test facility) is being constructed at Los Alamos National Laboratory as part of the national-science-based stockpile stewardship program. Its mission is to perform x-ray radiography of dense metal objects in high explosive tests. The principal data product is information on stability of surfaces and interface behavior. Berkeley Lab has been chosen to provide the electron injector and induction linear accelerator for the second of the two axes. The first axis machine is a single-pulse ferrite-core induction linac being constructed by LANL. Simultaneous illumination of the experiment by two pulses incident from perpendicular directions allows the experimenters to create three-dimensional images of the event at one point in time. The second axis accelerator is being designed with the idea of providing four pulses in order to obtain time sequenced images in one direction. The accelerator will be a long-pulse Metglas-core induction linac that is derivative from the work done in the Berkeley Lab Heavy Ion Accelerator Research program. The concept was selected after a seven-month-long Technology Option Study (TOS), which also included a short-pulse ferrite-core design from LANL and an inductive voltage adder diode concept from SNL.

The machine will consist of a 3-MeV diode injector powered by a Marx generator and an 88-cell induction linac. The injector cathode will be a dispenser cathode. The 2-μs, 4-kA electron beam pulse will emerge from the accelerator at 20 MeV. A magnetic chopper will select out four 60-ns pulses, 500 ns apart, to be transported to the target. Further downstream, the beam passes through a chicane to trap target blowoff debris and a final focus/deflector system, which focuses the short pulses on four closely spaced but separate impact locations on a tungsten plate, where the electron energy is converted to x-rays. Berkeley Lab is responsible for everything up to the accelerator exit. LLNL is responsible for everything from that point up to the converter target. Berkeley Lab will provide design assistance to LLNL for the chicane and final transport system.

Dual Axis Radiographic Hydrodynamic Test Facility
Resource Requirements ($M)*

Category	1997	1998	1999	2000	2001	2002	Total
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	18.3	19.7	3.1	0.7	0.0	41.8

*Preliminary estimate of Berkeley Lab Budget Authority (DOD).

DOE PROGRAM INITIATIVES

Advanced Light Source Roadmap

The Advanced Light Source (ALS) produces the world's brightest light in the soft x-ray and vacuum-ultraviolet range of the spectrum. This national user facility is used for basic and industrial research and development across a broad spectrum of the physical, chemical, life, and environmental sciences, as well as in such technological areas as materials analysis, microstructure fabrication, and macromolecular crystallography. To ensure full utilization of this synchrotron-radiation source, the Laboratory has developed a roadmap that will address emerging needs of users from industry, academia, and government laboratories. The ALS Roadmap provides for installation of the full complement of insertion devices (undulators and wigglers) in the ALS storage ring, full instrumentation of the insertion-device beamlines, and a substantial number of front ends for high-performance but cost-effective application-specific bend-magnet beamlines to be developed by the user community. The intent is to arrive at a complete facility that can service a wide community over a broad spectral range and do it in a balanced way.

Elliptically Polarizing Undulator Facility (Beamline 4.0). There is a growing demand for circularly polarized x-rays and for studies of magnetic materials and organometallic molecules. Elliptically polarizing undulators (EPUs) can deliver x-rays of any desired state of helicity. This will complete an EPU project underway with beamlines optimized for microscopy on magnetic materials of interest to the magnetic recording industry and for spectroscopy and circular dichroism studies of the spin states of organometallic molecules of biological importance.

Environmental Science (Beamline 6.0). Devising efficient and cost-effective strategies for environmental remediation depends on knowing the fundamental chemical properties of contaminants and their interactions at the molecular level (molecular environmental science). A new spectromicroscopy beamline will provide spatially resolved chemical-state information about complex specimens comprising many chemical species in the wet and near-natural conditions characteristic of environmental systems in nature.

Nanoparticle Analysis (Beamline 2.0). Outreach efforts in the Bay Area semiconductor industry reveal a strong need for characterization of the chemical properties of the structures in microcircuits at a resolution less than the smallest feature size, as well as the identification of particulate contamination. The advantage of spectromicroscopy is that it provides not merely elemental composition but also the chemical nature of such particles.

Novel Insertion Devices (Beamline 11.0). The spectral range of insertion devices depends on the magnetic field strength and on the period length. A short undulator with a 10-times shorter period than now used would operate with moderate brightness in the multiple-keV photon-energy range beyond that currently accessible with ALS undulators. A wiggler with a few very long periods but a high magnetic field would shift the spectral range to many tens of kiloelectronvolts.

Superbends. The substitution of the central bend magnets in the ALS storage ring with superconducting dipole magnets (superbends) would extend the generation of high-flux, high-brightness x-rays to photon energies of up to at least 30 keV. The added spectral range would enhance the utilization of the ALS by broadening the range of users.

Bend-Magnet Front Ends. Bend-magnet beamlines at the ALS combine high performance with low cost, making them attractive for development of beamlines dedicated to long-term research programs (application-specific beamlines) by the user community.

In addition to insertion devices and beamlines to carry the light from the insertion devices and bend magnets to experimental stations, full exploitation of the state-of-the-art capabilities of the ALS requires accelerator upgrades, which include modernizing the control system to maintain reliability and installation of a third-harmonic cavity to improve beam lifetime under the highest brightness conditions. The Roadmap also provides for completion of the unfinished second floor of the ALS building to provide office, light laboratory, and support space for users, a new office building to provide permanent office and laboratory space for ALS staff, and other infrastructure improvements, including additional power and cooling-water capacity.

Advanced Light Source Roadmap Resource Requirements ($M)*

Category	1998	1999	2000	2001	2002	2003	2004	2005	Total
Beamline 4.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
Beamline 6.0	1.5	2.4	0.0	0.0	0.0	0.0	0.0	0.0	3.9
Beamline 2.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0	4.0
Beamline 11.0	0.0	0.0	0.0	0.0	2.0	2.0	0.0	0.0	4.0
Superbends	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	4.0
Bend-Magnet Front Ends	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	4.0
Instrumentation	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.5	20.0
Accelerator Upgrades	0.5	2.3	4.9	3.0	1.5	1.5	4.0	4.0	21.7
Operations Increment	0.0	1.0	0.4	0.4	0.5	0.5	0.5	0.5	3.8
Infrastructure	1.5	2.5	5.0	20.5	10.5	6.0	10.0	4.0	60.0

*The table shows resources required to implement the entire Roadmap. ARIM and capital equipment are used to fund some accelerator and beamline projects, as reflected in the staggered funding profile. Specific funding sources for other projects are not yet identified. Funding for facility operations is not included.

Molecular Environmental Science

A new interdisciplinary field, molecular environmental science (MES), has emerged in the last few years in response to the need for basic research to underpin long-term solutions to environmental problems. The objectives of MES research are to provide information on the chemical and physical forms (speciation), spatial distribution, and reactivity of contaminants in natural materials and man-made waste forms, and to develop a fundamental understanding of the molecular-scale environmental processes, both chemical and biological, that affect the stability, transformations, mobility, and toxicity of contaminant species.

Important applications of vacuum ultraviolet (VUV)/soft x-ray spectroscopy and microscopy to molecular environmental science have been made over the past five years at several synchrotron light sources, including SSRL, NSLS, and most recently at the ALS. Based on the successes of these efforts and the unique information on environmental processes provided by VUV/soft x-ray synchrotron techniques, the MES community has identified the need for new synchrotron facilities with unique capabilities in the

VUV/soft x-ray regions at the ALS. In addition to the scientific opportunities provided by these proposed facilities, there is also a pressing need to accommodate many new synchrotron users in the MES area who have saturated existing facilities. For example, MES research in the VUV/soft x-ray region has approximately doubled within the last two years at SSRL and NSLS, and it has tripled at the ALS.

In March 1997, a national workshop on molecular environmental science in the soft x-ray region was convened at the Berkeley Lab to critically examine specific issues with respect to the scientific case, capabilities, opportunities, needs, and future prospects for MES-SR research in this spectral regime. The workshop identified several areas of particular need for MES research that could be addressed by VUV/soft x-ray techniques. Specifically, because chemical reactions at the surface of natural solids play dominant roles in many environmental processes, molecular-level studies of contaminant reactions at interfaces (solid-liquid, solid-gas, liquid-gas) are an important focus of MES research. The VUV/soft x-ray SR region has traditionally been one of the domains of surface science research. However, experimental MES studies in this spectral region are complicated by the need for in-situ studies with aqueous solutions, spatial and spectral resolution, and the ability to characterize the speciation of contaminants at very low concentrations. Together, these requirements comprise the "Three S's" of MES experimental research. The combination of new technologies provided by third-generation, high brightness SR sources, improved vacuum techniques, and improved detectors provides the opportunity for new applications of traditional VUV/soft x-ray surface science methods to MES issues. This proposal is to establish MES beamlines at the ALS to provide powerful tools for this study of molecular processes occurring at environmental interfaces, to translate this fundamental information into useful models, and to correlate these models with studies on natural samples.

Molecular Environmental Science Resource Requirements ($M)*

Category	1997	1998	1999	2000	2001	2002	Total
Operating	0.0	3.5	3.5	3.5	2.6	2.6	15.7
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Preliminary estimate of Berkeley Lab Budget Authority (B&RC Code KC03).

Nanostructured Materials Program

The Nanostructured Materials Program, in the Materials Sciences Division, is a new Center for Advanced Materials program dedicated to the development and application of novel approaches for designing materials and devices. Its premise is that the two existing paradigms for materials production—chemical synthesis and lithographic patterning of complex, interconnected structures—are converging towards similar nanometer-length scales. The focus of the program is on linking these paradigms and coordinating the efforts of chemists and biochemists, who are building and studying increasingly large and complex architectures at the molecular level, with those of physicists, who are building and studying progressively smaller structures using, for example, lithographic patterning. By integrating these sciences, new materials and technologies could be developed that would have a critical impact in the energy area and on the nation as a whole, with applications in sensors, energy storage, electronics, photonics, structural materials, and coatings.

Three major research areas are being addressed through this interdisciplinary effort:

1. Development of nanometer-scale building blocks for constructing new materials.
2. Connectivity and integration of these building blocks to form complex structures and devices.
3. Combinatorial synthesis of novel materials.

The first two areas will focus on developing tools that will allow the fabrication and study of structures and devices in a largely unexplored size realm, i.e., 2 to 100 nm. Manipulation of structures on

the nanometer level by physicists and chemists has revealed a remarkable size-dependence of their properties. Consequently, the properties of these nanostructures, and devices incorporating them, open a new realm of materials research. The third area will extend the recently developed combinatorial methods of synthesis/analysis that are already having a huge impact in biomedical research, to the discovery of new solid-state materials. This requires applying the lithographic and analytical methods developed for physics to the synthetic methods of chemistry. This technology could lead to the discovery of a range of materials with greatly improved properties for use in devices and complex structures.

The foundation of Berkeley Lab's expertise in these areas lies in long term fundamental materials science research supported over the past decade by OER's Office of Basic Energy Sciences, Division of Materials Sciences. Establishing this effort as a Center for Advanced Materials program recognizes the interdisciplinary nature of the new thrust, and its direct impact on DOE Technology offices and U.S. industrial needs. The Institute brings together scientists from academia, government, and industrial laboratories. Initially, this new program includes participants from Berkeley Lab, the University of California campuses at Berkeley and Los Angeles, and Rice University, with industrial scientists from a number of major U.S. companies.

Nanostructured Materials Program Resource Requirements ($M)*

Category	1997	1998	1999	2000	2001	2002	Total
Operating	0.0	1.5	1.5	1.6	1.6	1.6	7.8
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Preliminary estimate of Berkeley Lab Budget Authority from DOD and DOE.

Large-Scale Neutrino Observatory

Detection of high-energy neutrinos offers unique opportunities for high-energy physics and for astrophysical investigations. There are mechanisms in the cosmos that are able to accelerate charged particles to energies many orders of magnitude beyond what will ever be attainable with earth-based accelerators. Because neutrinos are not deflected by magnetic fields and interact only weakly with matter, they can be used to find and study these sources of acceleration beyond our galaxy, and other objects for which all other types of radiation would be absorbed by the intervening matter encountered over cosmic distances. The detectors currently being planned, built, or deployed (AMANDA, Antarctic ice; BAIKAL, deep fresh water; and NESTOR/ANTARES, deep ocean water) point the way toward a very large detector system—on the scale of a square or cubic kilometer—necessary to observe the low fluxes of high-energy neutrinos from very distant and energetic cosmic objects such as active galactic nuclei. Other scientific goals will be making sensitive searches for WIMPS (Weakly Interacting Massive Particles—a possible form of dark matter), understanding neutrino oscillations (by observations of tau neutrinos), and detecting, if possible, supernovae and currently unexplained phenomena such as gamma-ray bursters, which may be accompanied by a detectable neutrino signal.

The main challenge for neutrino astronomy is to detect and reconstruct rare events while rejecting the relatively copious cosmic-ray muon background. This requires data of the highest quality and maximum information content. In addition, certain technical and logistical challenges are connected with scaling up the number of detector elements in a cost-effective manner. A powerful new technical concept developed at Berkeley Lab centers around a combination of analog and digital signal processing that begins in the optical modules located at depth (in either the ocean or polar ice). Digital data from each optical module will be transmitted through a single electrical cable to a local substring module, multiplexed with data from other modules, and thence sent over large distances to a base station. Berkeley Lab has been doing leading-edge development work on full-custom integrated circuits for recording the full signal waveform, and has developed a system concept applicable to the kilometer scale. These circuits have been tested

recently at a depth of over a kilometer in South Polar ice and have revealed never-before-measured complex waveforms. Berkeley Lab is also involved in developing simulation codes leading to understanding the detector system geometry, triggering modes, data acquisition, fault analysis, and physics performance. The next stage is for a broader approach to the development of the microcircuit technology and larger-scale simulations of the detector performance.

Deployment of detector elements in deep ocean also requires development. It will be necessary to work with the oceanographic and maritime communities and apply their expertise to solving this particular problem, and Brookhaven National Lab is participating in this area. The individual technologies for deployment exist—it is a matter of engineering a solution for low cost, high reliability, scalability, and ease of maintenance. At the end of the design phase, a plan for a fully engineered design and scientifically optimized km-scale detector for high-energy neutrino astrophysics will be in hand. Such an array, located deep on the ocean, will also be of interest to earth scientists and oceanographers. Deployment of full-function prototypes could begin in 2000.

Large-Scale Neutrino Observatory Resource Requirements ($M)*

Category	1998	1999	2000	2001	2002	Total
Operating	0.0	1.5	1.5	1.5	1.0	5.5
Construction	0.0	0.0	0.0	0.0	4.5	4.5

*Preliminary estimate of Berkeley Lab Budget Authority (B&RC Code KA).

GRETA (Gamma-Ray Energy Tracking Array)

For many years Berkeley Lab has been one of the leaders in the development of gamma-ray detector arrays with high-energy resolution, high efficiency, and good peak-to-background ratios. This type of array is an important tool for the study of nuclear properties. Researchers at Berkeley Lab have conceived the idea and carried out the construction of Gammasphere, which is currently the most powerful array of its type in the world. Since April 1993, this national facility has been in use at the 88-Inch Cyclotron, and over 140 experiments have been carried out with about 200 participating users. It is expected that detector arrays will continue to improve, and many new areas of physics will become accessible with more powerful gamma-ray detector arrays. Both U.S. and European communities are working on the next generation of detector array.

A new concept for a gamma-ray array is being developed by a Berkeley Lab group. It is a shell consisting of closely packed, highly segmented Ge detectors, and it could reach a total efficiency of ~60%, which will give a resolving power 1000 times higher than that of current arrays. In such an array, each gamma ray interacts several times with the Ge detector. Therefore, with events of high gamma-ray multiplicity, it is important to identify the interactions belonging to a particular gamma ray. The high granularity of the segmented Ge detector enables us to resolve each of the scattering interactions and determine its position and energy. A tracking algorithm, using the position and energy information, will then identify the interactions belonging to a particular gamma ray. The gamma-ray energy is obtained by summing only these interactions.

To realize such a detector array, R&D efforts are being pursued in three areas:

1. Manufacture of segmented detectors that can give high-energy resolution and three-dimensional position information;
2. Improvement of electronics based on pulse-shape digitization and digital processing of signals to give the energy and coordinates of the interaction points.
3. Development of an algorithm to identify interaction points belonging to a particular gamma ray.

A 12-segment prototype detector has been purchased and is currently being tested, together with the electronics, data processing method, and tracking algorithm. The immediate goal for the next year or so is to establish the feasibility of such a detector. In 1999 we plan to have a 36-segment prototype along with the new electronics required. By 2000 we should be ready to order a "cluster" of seven such segmented detectors which can be used both to do more realistic tests and to perform experiments. Full operation, with multiple clusters, could be achieved by 2004. A preliminary estimate of the schedule and budget is as follows.

GRETA Resource Requirements ($M)*

Category	1998	1999	2000	2001	2002	Total
Operating	0.2	0.3	0.4	0.5	0.6	2.0
Construction	0.0	0.3	1.5	4.0	10.0	15.8

*Preliminary estimate of Berkeley Lab Budget Authority (FY 1996 dollars), including equipment (B&RC Code KB).

Boron-Neutron Capture Therapy

A brain cancer called glioblastoma multiformae (glioma) afflicts some 12,500 people a year in the U.S. alone and is almost impossible to treat by currently available means. One highly promising treatment approach is Boron-Neutron Capture Therapy (BNCT), in which the patient is given a medicine that contains boron. The boron-containing compound selectively accumulates in the malignant cells. The cancerous area is then exposed to a focused beam of neutrons. After capturing neutrons, the boron nuclei break apart, emitting very short-range radiation that destroys the cancer cells. Although glioma is the top-priority target, because its location and complicated geometry make it so resistant to complete removal through surgery, other cancers might also prove treatable with BNCT if suitable boron compounds can be developed.

Now is the right time to re-examine BNCT in a tightly focused program of applied research and development that culminates in clinical trials. Two key advances have made it attractive: new, more-effective ^{10}B-enriched tumor-seeking compounds are available, and improved neutron sources can be made using accelerator technology rather than nuclear reactors. Berkeley Lab is in a unique position to host the development of this "next-generation" BNCT because it has accelerator expertise, surplus equipment from the decommissioned Bevalac accelerator, and a long tradition of collaboration with medical centers having world-class cancer research programs, such as UCSF.

To take advantage of these strengths, Berkeley Lab has formed a clinical working group, the West Coast Neutron Capture Therapy Association, that brings together personnel in all the relevant specialties from national laboratories and major university medical centers. We are seeking DOE support of a multifaceted BNCT program, encompassing technology development, basic science, clinical trials, and technology transfer. The goal is an aggressive, parallel-track R&D program that will build a Berkeley Lab treatment facility, develop ^{10}B-enriched compounds and supporting clinical techniques such as dosimetry and delivery verification, and conduct clinical trials on human patients by 1999.

Boron-Neutron Capture Therapy Resource Requirements ($M)*

Category	1997	1998	1999	2000	2001	2002	Total
Operating	0.0	0.0	1.0	1.0	1.0	1.0	4.0
Construction	0.3	2.4	1.8	0.0	0.0	0.0	4.5

*Preliminary estimate of Berkeley Lab Budget Authority (B&RC Code KP). Funding to be determined is also anticipated starting in FY 1998 from NIH/NCI.

Environmental Management Science Program

The United States involvement in nuclear weapons development for the last 50 years has resulted in the development of a vast research, production, and testing network known as the nuclear weapons complex. The Department has begun the environmental remediation of the complex encompassing radiological and nonradiological hazards, vast volumes of contaminated water and soil, and over 7,000 contaminated structures. The Department must characterize, treat, and dispose of hazardous and radioactive wastes that have been accumulating for more than 50 years at 120 sites in 36 states and territories. The Office of Environmental Management (EM) is responsible for waste management and cleanup of DOE sites, and for conducting the program for waste minimization and pollution prevention for the Department.

The variety and volume of the Department's current activities make this effort a challenge. In some cases, fundamental science questions will have to be addressed before a technology or process can be engineered. There is a need to involve more basic science researchers in the challenges of the Department's remediation effort. The Office of Energy Research (ER) addresses fundamental, frequently long-term, research issues related to the many missions of the Department. The Environmental Management Science Program will use ER's experience in managing fundamental research to address the needs of technology breakthroughs in EM's programs.

In the first round of proposals submitted for FY96 funding, Berkeley Lab had eight proposals selected. These proposals represent the foundation for future contributions in groundwater and soil remediation. Key areas of Berkeley Lab studies include waste characterization, remediation technology, fractures in the subsurface, geophysics, and characterization and remediation strategies. The total budget for these eight proposals is $6.9M over three years. Additional proposals in FY97 are under consideration.

Environmental Management Science Program Resource Requirements ($M)*

Category	1997	1998	1999	2000	2001	2002	Total
Operating	2.3	3.5	5.0	5.0	5.0	5.0	25.8
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Preliminary estimate of total DOE Budget Authority (B&RC code EM).

V. OPERATIONS AND INFRASTRUCTURE STRATEGIC PLAN

Berkeley Lab's strategic planning focuses on aligning the Laboratory's management and operational systems to support DOE national research programs and achieve Vision 2000 (see Vision, Section III). A number of organizational systems have been identified as critical factors for measuring the Laboratory's performance. These systems directly support DOE's Strategic Plans, including core values and corporate management goals. The material in this section describes the quality management and operational systems plans that support Berkeley Lab's programs and are key to successful infrastructure management and institutional planning. Berkeley Lab operational and strategic plans are coordinated through a Comprehensive Planning Calendar.

ENVIRONMENT, SAFETY, AND HEALTH

Berkeley Lab's environment, safety, and health (ES&H) programs, which are integral to program performance, fully support DOE's strategies for ensuring the safety and health of workers and the protection and restoration of the environment. Excellence and timely implementation of environmental, safety, and health activities are critical to the success of each of Berkeley Lab's—and DOE's—core business areas. Berkeley Lab strongly endorses DOE's vision that the highest priority of all our activities is daily excellence in the protection of the worker, the public, and the environment. Berkeley Lab's ES&H programs correspond to and cooperate with the DOE goals in support of this vision. ES&H priorities are set and followed in accordance with DOE's ES&H Management Plan. The programs described below are fundamental to the attainment of this vision and represent the performance commitment of Berkeley Lab employees to trust, communications, and continuous improvement in all Berkeley Lab activities. The Strategic Planning for Environment, Safety and Health is defined in the documents noted below, and a summary is given here.

It is the policy of Lawrence Berkeley National Laboratory to integrate environment, safety, and health performance into all of its operations to ensure employee and public safety and the protection of the environment. The Laboratory has developed the following institutional ES&H goals to guide its integrated ES&H program:

- Provide employees with a safe workplace.
- Design and operate facilities and research activities to minimize adverse impact on public health and the environment.
- Produce and use only materials that can be disposed of safely and will minimize waste.
- Promptly communicate the known hazards of our activities and the related methods necessary for safety and health protection.
- Use available technology, engineered safeguards, and responsible science to mitigate all significant risks arising from its research and related activities.

The objectives of ES&H in the conducting of research activities are to ensure the integrity of human health and safety and the environment in which we operate, to manage resources with a value-added perspective, to maintain a capability that is not currently supported by other Laboratory programs, to provide opportunities for staff development, to build new competencies that could prove useful to future Laboratory and DOE ES&H programs, and to support the Laboratory's technology transfer mission.

The Laboratory's ES&H Performance Measures are utilized to improve performance and institute a more quantitative framework for Berkeley Lab's ES&H trends and activities. For employee health and

safety, representative measures include those that document occupational radiation doses and accidental frequency and severity rates (expressed as cases or days lost per 200,000 hours worked). Environmental Performance Measures include measuring and controlling public radiation doses from Berkeley Lab operations, continuing waste minimization activities, and reducing environmental releases. One goal is to manage waste disposal more effectively and efficiently, including significantly reducing the total amount of hazardous wastes generated when compared to prior years. Waste minimization indicators include the percent of Laboratory office waste recycled, and the total number of waste streams recycled. In addition, the Laboratory has established procedures to assure that there will be no discharge of materials into the sewer system above established standards.

HUMAN RESOURCES

Effective Human Resources activities are critical to the success of Berkeley Laboratory programmatic initiatives. The HR Department works to align itself with the needs of its internal customers in furtherance of these initiatives. In addition, the Department works cooperatively with DOE and the University of California to ensure that human resource activities at the Laboratory are fully responsive to their current and future needs.

Human resources activities at Berkeley Laboratory are guided by five overarching performance objectives, developed jointly by the Laboratory, DOE, and the University. Our sister laboratories, Lawrence Livermore National Laboratory and Los Alamos National Laboratory, have also been involved in the development of these performance objectives. The objectives are:

1. **Cost Effectiveness.** The Laboratory strives to have cost-effective HR practices.
2. **Work Force Excellence.** The Laboratory develops and motivates its work force to excel in meeting its programmatic needs as well as those of its customers.
3. **Equal Opportunity.** The Laboratory works to strengthen its commitment to and accountability for equal opportunity, affirmative action, and work force diversity.
4. **Customer Needs.** Human Resources has a system for identifying and evaluating customer needs and for building and maintaining positive customer relationships.
5. **HR Leadership in Deploying Mission/Business Strategy.** The Laboratory aligns its HR plan with its strategic or institutional plan and supports the principle of the DOE Contractor HR Strategic Plan.

The fulfillment of these objectives is approached in consultative partnership with our stakeholders and customers. An example of this has been the establishment of weekly meetings with a key stakeholder/DOE-OAK Human Resources staff. These meetings allow the stakeholder and HR staff to provide each other with current information and to work on joint solutions to problems.

In addition, as a result of joint planning meetings with key programmatic customers, HR has assigned a Staffing Specialist to Computing Sciences and one to the Human Genome Center to support their special needs. Plans are in place to institute quarterly meetings with the Directorate and key programmatic customers (Computing, Energy, Life, and General Sciences) to determine how HR can best support the customers' staffing, training and other HR-related needs in the short and long term.

During the past fiscal year, the Human Resources Department has undergone radical restructuring and continues a critical revaluation of its systems, procedures, and practices in order to increase efficiency and cost effectiveness. The Payroll unit was transferred from the Finance organization to join Compensation and Benefits, thereby reducing handoffs and eliminating redundant work. Conference Coordination and Employee Buying Service activities were moved from HR to Finance, freeing HR to focus on core HR functions. Administrative policy activities were moved from the Operations Directorate Office to HR to strengthen existing policy functions. In addition, a project manager was assigned to assist with the coordinated development of the HRIS and FMS infrastructure computer systems.

An intense, well-structured effort has been launched in connection with the implementation of HRIS. This effort involves multiple task groups (all customer-based) under the direction of the HRIS/FMS Project Manager. These groups are critically reviewing all HR transaction processes and procedures with an eye to re-engineering them as much as possible before they become part of the HRIS.

The Human Resources Department has also pursued its objectives of work force excellence and cost effectiveness in the Compensation arena. The primary effort has been to replace generic families, such as Administrative Services (nonexempt) and Administrator or Administrative Specialist (exempt), with new job families that better describe the work being performed and, by doing so, align Laboratory pay practices with current market practices. New job families for nonexempt administrative personnel were implemented at the beginning of the 1997 fiscal year. The five classifications of Administrative Services were redefined to include job families with two or three levels (e.g., Payroll Assistant, Human Resources Assistant, and Purchasing Assistant).

A particularly innovative initiative launched by HR this year has been its partnership with the Administrative Services Department and the Site Access Office to develop seamless service for new employees and guests. This has involved joint planning meetings that focus on streamlining processes and re-engineering as necessary. The three groups have also partnered to co-locate their physical space to best serve the Laboratory community.

WORK FORCE DIVERSITY

As we move into the next century, one of the more dramatic changes affecting employers is the increasing diversity of both the State of California and the nation at large. The challenge for Berkeley Lab will be to continue to expand our efforts to create a climate in which diversity in the work force is valued. This means actively seeking such diversity and fully supporting the contributions and changes that it brings about. By recognizing, creating, and celebrating a diverse culture, the Berkeley Lab will provide an environment that is accessible, equitable, and hospitable to all its employees and guests. Creating a workplace where diversity can thrive will also enable us to attract the qualified staff that we need to continue to conduct world-class science. In more recent years, the term "work force diversity" has been recognized at the Laboratory to mean that there is a broader set of issues than the traditional focus on affirmative action compliance. In effect, there is a new emphasis on harnessing diversity to the cause of scientific excellence. The term is essentially used to describe a new workplace culture in which a fundamental set of guiding principles and values form the community context in which diversity is practiced. Five key principles form the basis of the Laboratory's definition of diversity.

1. Differences in ethnicity, culture, gender, age, and lifestyle are valued for the variety of perspectives they bring to the workplace. New perspectives and old perspectives are equally important.
2. Differences are not only welcomed but actively sought.
3. Management takes these differences into account in setting policies, motivating people, and giving rewards.
4. The sense of being valued motivates all employees to put forth their best efforts and therefore leads to higher productivity.
5. The spirit of mutual regard and cooperation leads to synergism—the state in which working together yields results greater than the sum of individual efforts.

In addition to these key principles, the Laboratory's Work Force Diversity Office, in partnership with senior management, will undertake the following specific programmatic initiatives, as well as a wide range of programs that will enhance our ability to attract and retain qualified individuals:

- Aggressively seek women, people of color, and individuals from other protected classes who have the potential to achieve excellence at Berkeley Lab. Initiate new recruitment methods that identify potential candidates early in their educational careers.
- Mentor employees so that they can achieve excellence.
- Ensure a working atmosphere that is supportive and gives a sense of belonging to employees from all cultures.
- Provide resources to help managers and supervisors implement the Laboratory's affirmative action program.
- Develop new capabilities for the Laboratory and each division to review its performance with regard to affirmative action issues.

In particular, the Laboratory's Affirmative Action Program plan outlines activities—such as special recruitment, training, and employee development programs—aimed at improving access to the workplace for people in underrepresented groups. It also serves as a working document that describes current policies, practices, and results in the area of affirmative action. It represents the Laboratory's framework for an affirmative approach that will increase the representation of people of color and women in segments of our work force where they have been underrepresented. The program also is a vehicle for increasing the employment of persons with disabilities and special disabled and Vietnam-era veterans. The program describes the hierarchy of responsibility for Laboratory affirmative action; the mechanisms that exist for full Laboratory participation in the Affirmative Action Program; the policies and procedures governing recruitment at all levels; the Laboratory's plan for monitoring, reporting, and evaluating affirmative action progress; and the special affirmative action programs and plans the Laboratory has used and will continue to use in its efforts to increase the representation and retention of groups historically underrepresented in our work force.

The Laboratory will direct proactive efforts toward reduction and/or elimination of underutilization in job groups and/or classifications through the use of training programs and employment pools, and by targeting of management-level positions. In this way, the Laboratory will attain all of its work force statistical goals.

While the Laboratory is strongly committed to recruit women and people of color into its work force, equally important is to retain its employees. In positioning the Laboratory to compete effectively in the marketplace to recruit promising scientists to the Laboratory, HR has restructured its scientist and engineer classification and pay program. This new structure, along with the recent establishment of scientist and engineer leadership positions, provides more clearly defined career paths in the areas of both scientific accomplishment and scientific management, formalizes accountabilities, and improves succession-planning capabilities. Berkeley Lab has taken the following specific steps to achieve its goals:

- Strengthened the Laboratory's competitiveness in the recruitment marketplace, including an active advertising campaign, strong representation at job fairs, and training programs.
- Created outreach recruitment programs, including a widely distributed job listing, professional seminars, and search committees, with extensive participation of managers and supervisors.
- Created special employment and internship programs, including summer student and youth employment programs, as well as education programs for members of groups historically underrepresented in the science and engineering fields.

Additionally, since its beginning the Laboratory has had a strong commitment to train the next generation of scientists and engineers. The education programs of the Center for Science and Engineering Education are instrumental in encouraging young people, especially women and people of color, to enter careers in science and engineering, better positioning them to attain their career goals. Berkeley Lab is now exploring ways to maintain contact with these students after they have completed a Laboratory program and as they progress through the educational system. In this way, the Laboratory can continue to encourage and assist them in achieving their goals and address its own future human resource needs.

FACILITIES PLANNING

Site and Facilities Context

The Laboratory's 82-hectare (200-acre) site is immediately adjacent to an internationally recognized research university, the University of California, Berkeley (UCB). Laboratory research benefits particularly from the easy access afforded by a five-minute shuttle bus ride between the Berkeley Lab and UCB. Interactions with faculty, creation of joint appointments in service of the national priorities of the Lab, notable ease in hosting national and international guests and lecturers, and cooperative sharing of research libraries are hallmarks of this unique multiprogram national laboratory site.

As the Laboratory is actively committed to supporting researchers and is continually vigilant about creating conditions that protect the Berkeley Lab staff, the public, and the environment, it has prioritized buildings and spaces for modernization, adaptive reuse, and replacement.

Berkeley Lab has one of the highest space utilization rates of all multiprogram Laboratories. Indeed, the Laboratory has resorted to subdivision of spaces in order to accommodate research requirements. The Laboratory's research activities occupy virtually all available usable space. While the majority (92%) of main site laboratory and support spaces are functional and space in these buildings is actively sought by researchers, some 77% of the Laboratory space requires rehabilitation. Some buildings still in use were constructed as early as 1940 (see Figures 5.1 and 5.2).

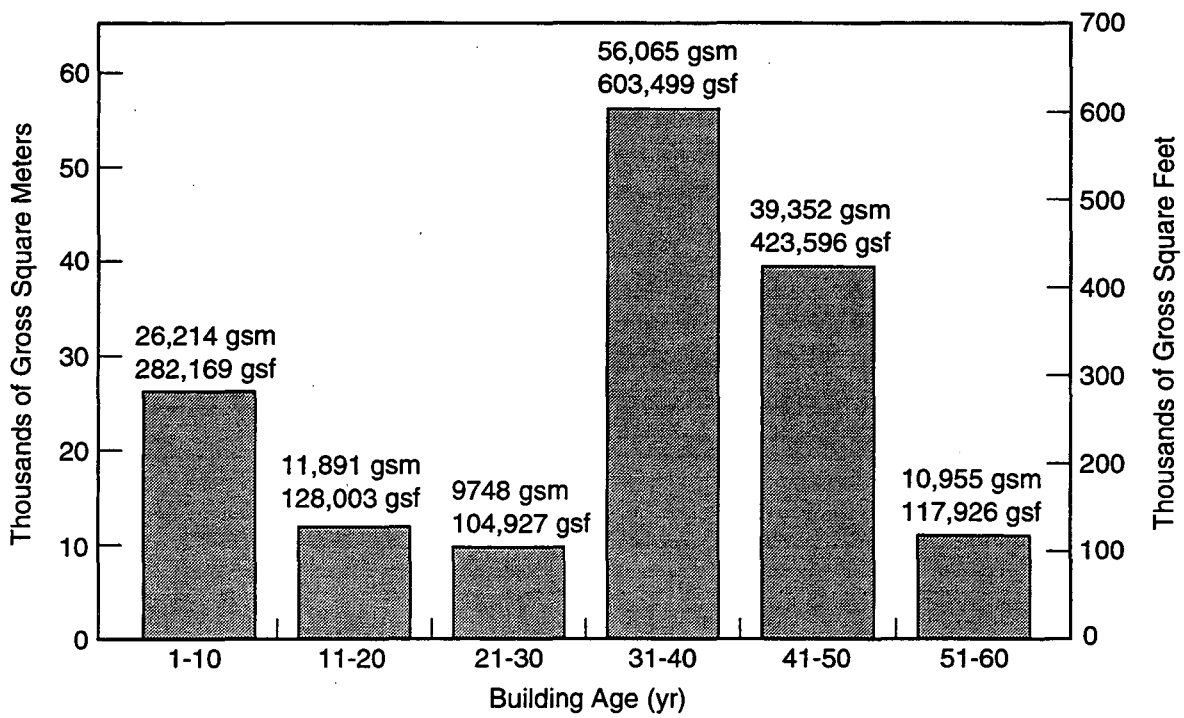

Figure 5.1. Age of Laboratory buildings.

Eighty-four percent of Berkeley Lab's buildings and space are located at the Berkeley Hill site (see Table 5.1 below). In 1997, there were 76 buildings of conventional construction and 113 trailers and temporary structures at the main site. Approximately 6% of the Laboratory's space is located on the UCB campus as provided under the UC-DOE Contract. In addition, some administrative support and laboratory research space is leased in commercial buildings located in the adjacent communities

(approximately 10% of the Laboratory's space). This conventional lease space is used to meet program needs which can not otherwise be accommodated on the main site.

Table 5.1. FY 1997 Berkeley Lab Space Distribution.

Location	Area (Ksm)	Area (Mgsf)	% of Total
Main site	157	1.69	84
UC Berkeley campus	11	0.11	6
Local off-site leased	18	0.19	10
Total	186	1.99	100

The 1997 replacement plant value (RPV) of Berkeley Lab facilities is estimated to be 844 million dollars (see Table 5.2 below). This includes all on- and off-site buildings occupied by Berkeley Lab. The RPV of the Berkeley Hill site infrastructure includes all site improvements, utilities, communication systems and accelerators.

Table 5.2. FY 1997 Facilities Replacement Plant Value.

Type	Value ($M)	% of Total
Buildings*	844	77
Utilities†	259	23
Total	1103	100

Includes all facilities, all sites
*Baseline FY 97
†Baseline FY 95

Approximately 123,000 square feet of the Laboratory's space (at the main site) is substandard and in need of replacement (see Figures 5.2 and 5.3 below). This space is needed by existing research missions and much of it remains in use pending replacement. The vast majority, some 77%, of the Laboratory's main site space serves the research mission quite well. For example, 96% of computer spaces, 98% of Wet Lab space, and 86% of Dry Lab space are rated as adequate or functional in 1997. The Laboratory must continue to upgrade facilities which are rated as "functional" rather than "adequate" to ensure that they continue to meet researcher necessities and continue to meet all applicable and new health, safety, environmental and performance standards. Evaluation of building condition and usability is based on categories utilized in the former Strategic Facilities Initiative (SFI) that have been modified for present use. These categories are:

- **Status 1—Adequate.** Structure, systems, and components are adequate for current use. Building structure, safety, and utilities are adequate in capacities, technological quality, and reliability to support functions required by occupants and processes.
- **Status 2—Functional, Can Be Economically Upgraded.** Structure, systems, and components are functional for current use but are approaching technological obsolescence. Can be economically upgraded.
- **Status 3—Substandard, Cannot Be Economically Upgraded.** Structure, systems, and components have been used beyond their normal life span, and cannot be economically upgraded.

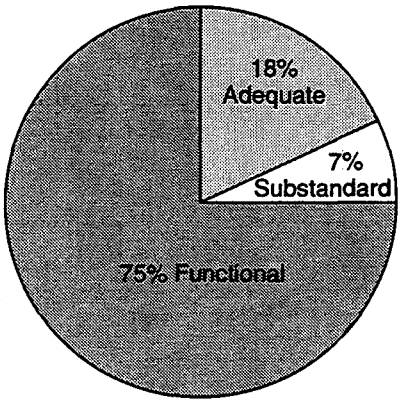

Figure 5.2. Condition of Laboratory space.

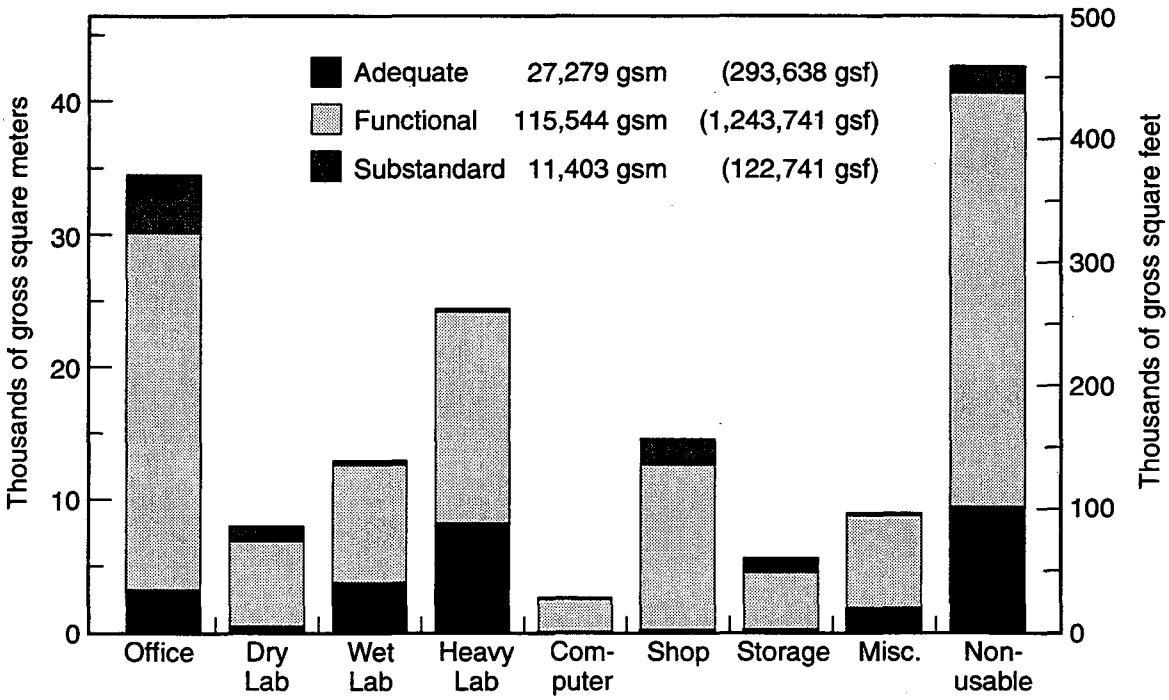

Figure 5.3. Use and condition of Laboratory space.

Facilities Plans and Options

The Laboratory's Long Range Planning provides for anticipated national needs in energy technology and supporting research. The sites and buildings available can accommodate a net increase of 37,000 gsm (0.4 Mgsf) to the existing main site for a total of approximately 186,000 gsm (2.0 Mgsf). However, the two most pressing needs in a cost-effective management approach are to:

- Ensure that the existing laboratory assets continue to be used to the maximum extent possible and continue to operate in a safe and productive manner.
- Ensure that inadequate buildings are replaced so that the Laboratory's ES&H and operational performance standards can continue to be met.

Berkeley Lab has an integrated approach to facilities planning, which is closely coupled to Institutional and Program Plans.

Candidate facilities projects are reviewed by a multi-Divisional Project Coordination Committee (PCC). Review by this committee ensures that all infrastructure-related units are informed of upcoming projects and needs so that coordinated planning can occur. All project candidates, including non-capital alterations, are ranked using three rating systems:

1. Each item is ranked by the submitting organization.
2. Each item is scored using DOE's Risk-Based Prioritization Method (RPM).
3. Each item is scored using DOE's Capital Asset Management Process (CAMP).

The PCC's recommendations (and all other candidates) are reviewed by management within the Operations Division and submitted to the Director's Action Committee for final review for inclusion in plans and for advancement to DOE's Site Office Manager and DOE Program Manager.

The Laboratory has a maintenance plan designed to extent the useful life of all facilities to the maximum extent practical. Buildings that are in need of upgrade to ensure that they can continue to meet ES&H and performance standards have been identified and projects to upgrade these facilities have been developed and prioritized. However, General Plant Projects (GPP) and Line Item Projects (LIP) funding limitations restrict implementation of these plans. In addition, those buildings that cannot be economically upgraded and are therefore candidates for demolition and replacement have also been identified and projects identified to replace this space have been developed. However, pressing needs for space during the interim will require that all spaces continue to be utilized prior to demolition and replacement. (See the Facilities Resources Requirements discussion, below.)

There are no Inactive Surplus facilities at Berkeley Lab. No Inactive Surplus facilities are anticipated. The pressing need for space at Berkeley lab necessitates adaptive re-use or re-utilization of any space that is not fully utilized for an on-going research mission. Structural rehabilitation and the identification of resources to complete timely re-use alterations are priorities at this site.

Facilities Resource Requirements

Berkeley Lab has intensive use of its facilities, so that space is at a premium. All space is used, and when space becomes available it is reoccupied or adaptively reused for new purposes. The Laboratory now ranks among the top federal facilities in space utilization. Although the buildings have been maintained and continue to be used, some older buildings do not meet modern performance standards. Use of these spaces is inefficient, costly, and requires reliance on administrative controls to ensure that modern operational safety requirements continue to be attained.

The GPP backlog is growing each year. Facilities plans recognize this situation and the Laboratory's inability to meet the pressing (highly rated using DOE's CAMP and RPM ranking systems) needs with a $3.5M GPP budget. There is a pressing need to increase the GPP allocation to $7M. Such a need has been recognized by many DOE landlord offices.

Berkeley Lab has received funds for only a single Multiprogram Energy Laboratory Facilities Support (MEL-FS) Line Item Project in the past four years. This situation has challenged the Laboratory to operate in a manner that continues to maintain the performance standards of DOE, our employees, and the community. A few buildings require upgrades in excess of $2.0M and therefore require Line Item funding under DOE rules. These projects are identified in the Five-Year Construction Plan. In addition, a number of Laboratory buildings, particularly some of those constructed during the materials shortages of World War II (including converted barracks), are inadequate and their deficiencies cannot be economically corrected. Replacement of these buildings will eliminate the operational problems associated with their continued use. The Five-Year Construction Plan (Table 5.3) identifies the priority replacement buildings. DOE's support for the Five-Year Plan as presented in this report is necessary to ensure the continued cost-effective operation of the Laboratory.

Table 5.3. Major Construction Projects, Berkeley Lab , FY 1997 – FY 2003.

Plan for programmatic and general purpose facilities, including funded, budgeted, and proposed construction (FY BA, $M)

Project	TEC	Prior†	1997	1998	1999	2000	2001	2002	2003
FUNDED PROGRAM-RELATED PROJECTS:									
Human Genome Laboratory (KP) 3,809 gsm (41,000 gsf)	24.7	23.6	1.1						
ALS Structural Biology Support Facilities 1,031 gsm (11,100 gsf)	7.9	7.9							
Hazardous Waste Handling Facility (EM)	13.1	13.1							
SUBTOTAL - FUNDED PROGRAM RELATED	**45.7**	**44.6**	**1.1**						
FUNDED MEL-FS PROJECTS (KG):									
Fire & Safety Systems Upgrade Proj., Ph I	4.6	4.6							
Hazardous Materials Safeguards, Ph. I	4.7	4.7							
Sanitary Sewer Restoration, Phase 1 1,036 m (3,400 ft)	2.4	2.4							
SUBTOTAL - FUNDED MEL-FS PROJECTS	**11.7**	**11.7**							
TOTAL FUNDED	**57.4**	**56.3**	**1.1**						

Project	TEC	1997	1998	1999	2000	2001	2002	2003
PROPOSED PROGRAM-RELATED PROJECTS:								
ALS Roadmap (KC) 1,877 gsm (20,200 gsf)	39.5			9.2	16.5	9.2	4.6	
TOTAL - PROPOSED PROGRAM RELATED	**39.5**			**9.2**	**16.5**	**9.2**	**4.6**	
PROPOSED MEL-FS PROJECTS:								
Elect. System Rehab, Ph. IV	6.5		2.4	4.1				
Mechanical Systems Upgrade	4.7		2.5	2.2				
Rehab Building Operating Systems - B 74	7.5			1.0	6.3	0.2		
Rehab Struct. Support and Operating Sys. - B 77	8.0			1.0	6.3	0.7		
Rehab Building Operating Systems - B 62	4.6				0.6	1.8	2.2	
Water Utility Upgrade	4.1				0.7	2.5	0.9	
Rehab Building Operating Sys. - B 70 Complex	4.6*					0.9	1.9	1.8
Replace B 29	12.4*					0.9	2.0	9.5
Rehab Building Operating Sys - B 50 Complex	3.2*						1.2	2.0
Operations Building Replacement	2.7*						0.7	2.0
Rehab Building Operating Systems - B 83	0.9*							0.9
Upgrade Low Conductivity Water System	0.8*							0.8
SUBTOTAL - PROPOSED MEL-FS PROJECTS	**60.1**	**0.0**	**4.9**	**8.3**	**13.9**	**7.0**	**8.9**	**17.0**
TOTAL PROPOSED	**120.8**	**0.0**	**4.9**	**18.5**	**38.9**	**23.2**	**14.5**	**16.9**
TOTAL FUND, BUDGET & PROP MEL-FS PROJECTS (Excludes Program and Hazardous Waste Handling Facility Related Projects)	**194.4**	**1.1**	**4.9**	**18.5**	**38.9**	**23.2**	**14.5**	**16.9**

*TEC to 2003 only; additional outyear funding projected.
†Prior costs for previous years.

Berkeley Lab has operated with the same GPE funding level for many years. The purchasing value of these dollars has declined and the Laboratory has not been able to replace equipment with identified safety and operational problems at this funding level. Funding at $3.0M will allow for a reduction in the GPE backlog and the timely replacement of equipment that does not meet safety and operational standards.

INFORMATION MANAGEMENT

The major goal of Berkeley Lab's efforts in Information Management is to provide cost-effective, technologically appropriate support for the programmatic mission and administrative functioning of the Laboratory. To achieve this goal, the following objectives have been developed:

- For corporate data: To implement a data-warehouse-based environment where data are entered only once, and then made conveniently available to all authorized users; to reduce the Laboratory's dependence upon paper reports to a minimum; and to provide appropriate protection for and disposition of all data and records.
- For the dissemination of scientific and technical information: To increase the use of generally accessible electronic media such as the World Wide Web, and to encourage the development of a paperless exchange of scientific and technical results, reports, and journal articles.
- For telecommunications: To provide reliable full connectivity and ample bandwidth to every staff member. (Note: The interpretation of what constitutes "ample" bandwidth is changing rapidly. Our current standard is megabits-to-the-desktop, but increasing use of desktop video, remote control of experiments, and other elements of the collaborative-laboratory concept, is rapidly rendering this insufficient.)
- For the staff: To provide state-of-the-art and transparent computing and communications resources for DOE programs and services to every scientific, engineering, and administrative employee. These services include advanced network communications technology that keeps pace with demand, workstation support services and technical support for telecommuting and telework, transparent access to computing resources, upgraded central computing and mass storage facilities, and proper control of access to sensitive files.

These goals underpin Berkeley Lab's mission for research and development, design and operation of user facilities, education and training, and technology transfer. Together with the human and facilities resources of the Laboratory, the information resources provide a flexible and responsive operating environment for the implementation of DOE programs. Effective information management is vital to the success of this mission, and will require the allocation of adequate DOE resources for effective implementation.

COMMUNICATIONS AND INVOLVEMENT

Strengthening communications and involvement at all levels, internal and external, to build trust with the public and Berkeley Lab employees is a key element of the Berkeley Lab Strategic Plan. This emphasis parallels the Department of Energy's goal to change its culture to one of openness, communication, and trust. A Laboratory-wide Communications Plan was issued in 1995 and has been instituted. The Laboratory has taken many steps, including establishing a community-based Tritium Monitoring Task Force, discussion that lead to a fire services agreement, and a community-developed vegetation management plan.

Communications and interactions with local government, agencies, citizens' groups, schools, the news media, and other stakeholders requires regular interactions between Lab and community members. The purpose of these is to respond to the information requirements of specific groups, including elected

officials, city staff, site neighbors, and employees. Activities have included briefings for elected officials, attending local community meetings, and hosting or sponsoring meetings with the public. Berkeley Lab values its relations with local communities and is committed to an expanding outreach effort.

Berkeley Lab will also continue to enhance two-way interactions between management and the work force through training programs for Laboratory leadership, increased opportunities for employee development and feedback, and improved communication mechanisms and programs. Integration of electronic communications systems and networks, essential for effective linkage of Berkeley Lab personnel and programs, and development of World Wide Web-based technologies to share information are being implemented.

VI. RESOURCE PROJECTIONS AND TABLES

Resource projections for the Institutional Plan provide a description of the budget authority (BA) to implement the research programs. The resource tables also indicate actual FY 1996 BA and FY 1997 projected BA for comparison. These tables include:

- Resources by Major Program:

  Resource Summaries (Tables 6.1(a) and (b))
  Secretarial Level Resources (Tables 6.2(a) and (b))
  Program Office Resources (Tables 6.3(a), (b), and (c))
  Work for Others Resources (Table 6.4)

- Subcontracting and Procurement:

  Subcontracting and Procurement (Table 6.5(a))
  Small and Disadvantaged Business Procurement (Table 6.5(b))

- Laboratory Staff Composition (Table 6.6).
- Experimenters at Designated User Facilities—1996 (Table 6.7).

The FY 1998 estimate is based on FY 1998 DOE budget guidance, the President's Request, and assessments by Berkeley Lab Divisions. For Fiscal Years 1999 and beyond, operating cost projections are in FY 1998 dollars and construction costs are in actual-year dollars (as indicated in the DOE guidance). For FY 1999 to FY 2002, the growth assumptions in program areas as tabulated range from 0% to 1.5% per year. These growth assumptions are based on the general direction indicated by DOE program personnel. Specific trend levels have been established within each program activity.

The resource projections that follow include all funded and budgeted construction projects, the projected MEL-FS program, and the approved Environmental Restoration and Waste Management program funding. The new initiatives' resource projections are indicated in Section IV, and are not included in this section unless incorporated in budget submissions. Construction project cost details are provided in Section V.

Table 6.1(a). Funding Summary (Fiscal Year Budget Authority $M).

Category	1996	1997	1998	1999	2000	2001	2002
DOE Operating	197.1	228.9	279.0	299.9	310.3	311.1	311.8
WFO Operating	51.7	52.7	59.3	61.4	63.6	65.5	67.5
Total Operating	**248.8**	**281.6**	**338.3**	**361.3**	**373.9**	**376.6**	**379.4**
Capital Equipment	40.6	25.1	24.6	32.5	36.3	41.2	41.1
Program Construction	21.6	13.5	15.2	26.1	43.4	51.1	32.5
MEL/FS—Revitalization	4.7	0.0	4.9	9.8	12.3	7.8	8.9
Environ Restoration	1.5	0.0	0.9	0.5	0.5	0.6	0.6
General Plant Projects	3.4	3.5	3.5	3.5	3.5	3.5	3.5
General Purpose Eqpmnt.	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Total Lab Funding	**322.5**	**325.7**	**389.3**	**435.6**	**472.0**	**482.7**	**467.9**

Table 6.1(b). Personnel Summary (Fiscal Year FTE).

Category	1996	1997	1998	1999	2000	2001	2002
DOE Effort	1,298	1,352	1,622	1,839	2,009	2,053	1,971
Work for Others	384	404	462	476	490	502	516
Total Direct	**1,682**	**1,756**	**2,084**	**2,315**	**2,499**	**2,556**	**2,486**
Total Indirect	**808**	**810**	**813**	**815**	**818**	**818**	**818**
Total Lab Personnel	**2,490**	**2,566**	**2,897**	**3,130**	**3,317**	**3,374**	**3,304**

Table 6.2(a). Secretarial Office Funding Summary
(Fiscal Year Budget Authority, $M).

Office/Program	1996	1997	1998	1999	2000	2001	2002
Office of Energy Research (ER)							
Operating	158.8	186.8	226.7	245.7	255.2	255.9	259.6
Capital Equipment	33.8	21.5	21.6	29.4	33.2	38.0	37.9
Construction	29.0	16.7	23.6	39.4	59.2	62.4	44.9
Total	**221.7**	**225.0**	**271.9**	**314.5**	**347.7**	**356.4**	**342.4**
Assistant Secretary for Energy Efficiency and Renewable Energy (EE)							
Operating	19.0	16.0	16.3	15.9	16.1	16.6	16.8
Capital Equipment	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.7	0.3	0.0	0.0	0.0	0.0	0.0
Total	**20.4**	**16.2**	**16.3**	**15.9**	**16.1**	**16.6**	**16.8**
Assistant Secretary for Fossil Energy (FE)							
Operating	2.2	2.5	2.4	2.3	2.5	2.6	2.7
Total	**2.2**	**2.5**	**2.4**	**2.3**	**2.5**	**2.6**	**2.7**
Assistant Secretary for Environmental Restoration and Waste Management (EM)							
Operating	11.1	13.1	15.8	17.1	17.1	17.3	15.1
Capital Equipment	(0.2)	0.5	0.6	0.6	0.6	0.6	0.6
Construction	1.5	0.0	0.9	0.5	0.5	0.6	0.6
Total	**12.4**	**13.6**	**17.3**	**18.2**	**18.2**	**18.4**	**16.3**
Assistant Secretary for Defense Programs (DP)							
Operating	0.0	1.0	4.9	5.9	6.3	5.5	4.0
Total	**0.0**	**1.0**	**4.9**	**5.9**	**6.3**	**5.5**	**4.0**
Office of Nonproliferation and National Security (NN)							
Operating	0.0	0.7	0.8	0.8	0.8	0.8	0.8
Total	**0.0**	**0.7**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**
Assistant Secretary for Policy, Planning, and Program Evaluation (PO)							
Operating	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Assistant Secretary for Environment, Safety and Health (EH)							
Operating	0.6	0.5	0.5	0.5	0.5	0.5	0.6
Total	**0.6**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.6**
Work for Other DOE Contractors							
Operating	5.3	8.3	11.5	11.7	11.8	11.9	12.0
Capital Equipment	5.3	2.3	1.6	1.6	1.7	1.7	1.8
Total	**10.6**	**10.6**	**13.1**	**13.3**	**13.4**	**13.6**	**13.8**
Total DOE							
Operating	197.1	228.9	279.0	299.9	310.3	311.1	311.8
Capital Equipment	39.7	24.3	23.7	31.6	35.5	40.3	40.2
Construction	31.2	17.1	24.5	39.9	59.8	63.0	45.5
Total	**268.0**	**270.2**	**327.2**	**371.5**	**405.6**	**414.4**	**397.5**

Table 6.2(b). Personnel by Assistant Secretary Level Office (Fiscal Year FTE).

Office/Program	1996	1997	1998	1999	2000	2001	2002
Office of Energy Research (ER)							
Direct FTE	1,045	1,116	1,349	1,560	1,724	1,767	1,698
Assistant Secretary for Energy Efficiency and Renewable Energy (EE)							
Direct FTE	163	141	142	139	140	144	147
Assistant Secretary for Fossil Energy (FE)							
Direct FTE	21	20	19	18	20	20	22
Assistant Secretary for Environmental Restoration and Waste Management (EM)							
Direct FTE	66	62	79	83	83	84	74
Assistant Secretary for Defense Programs (DP)							
Direct FTE	0	5	27	32	34	30	22
Office of Nonproliferation and National Security (NN)							
Direct FTE	–	3	4	4	4	4	4
Assistant Secretary for Environment, Safety & Health (EH)							
Direct FTE	3	3	3	3	3	3	4
Total DOE							
Direct FTE	**1,298**	**1,352**	**1,622**	**1,839**	**2,009**	**2,053**	**1,971**
Work for Other DOE Contractors							
Direct FTE	62	82	101	103	104	105	107
Work for Others—Non-DOE							
Direct FTE	322	322	361	373	386	397	409
Work for Others—Total	384	404	462	476	490	502	516
Total Lab Direct	**1,682**	**1,756**	**2,084**	**2,315**	**2,499**	**2,556**	**2,486**
Total Lab Indirect	**808**	**810**	**813**	**815**	**818**	**818**	**818**
Total Lab Personnel	**2,490**	**2,566**	**2,897**	**3,130**	**3,317**	**3,374**	**3,304**

Table 6.3(a). Office of Energy Research Funding and Personnel
(Fiscal Year Budget Authority, $M).

Office/Program	1996	1997	1998	1999	2000	2001	2002
AT Magnetic Fusion							
Operating	4.9	11.6	4.2	7.2	8.2	9.2	9.2
Capital Equipment	0.3	0.1	0.1	0.1	0.1	0.1	0.1
Total	5.2	11.7	**4.3**	**7.3**	**8.3**	**9.3**	**9.3**
KA High Energy Physics							
Operating	20.8	21.5	26.3	30.7	30.7	31.2	31.8
Capital Equipment	4.7	4.8	4.8	6.5	5.5	5.2	6.9
Construction	8.0	9.0	9.0	9.0	9.0	9.0	9.0
Total	**33.5**	**35.3**	**40.1**	**46.2**	**45.2**	**45.4**	**47.7**
KB Nuclear Physics							
Operating	17.9	17.6	18.0	18.3	19.9	20.6	21.6
Capital Equipment	3.3	3.4	3.6	4.5	9.3	14.2	17.2
Construction	3.4	3.8	4.3	4.0	4.0	4.0	4.0
Total	**24.6**	**24.8**	**25.9**	**26.9**	**33.2**	**38.8**	**42.9**
KC02 Materials Sciences							
Operating	43.9	42.2	46.7	47.4	49.6	50.2	48.7
Capital Equipment	5.2	4.4	4.4	4.4	4.4	4.4	4.4
Construction	3.2	2.5	4.0	15.2	32.5	40.2	21.6
Total	**52.2**	**49.2**	**55.2**	**67.1**	**86.6**	**94.9**	**74.8**
KC03 Chemical Sciences							
Operating	8.0	8.2	8.5	9.0	9.3	9.6	9.9
Capital Equipment	1.0	1.1	1.1	6.1	6.1	6.1	1.1
Construction	1.4	0.0	0.0	0.0	0.0	0.0	0.0
Total	**10.4**	**9.3**	**9.6**	**15.1**	**15.4**	**15.7**	**11.0**
KC04 Engineering and Geosciences							
Operating	2.2	2.3	2.7	2.7	2.9	3.0	3.0
Capital Equipment	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Total	**2.4**	**2.4**	**2.8**	**2.8**	**3.0**	**3.1**	**3.1**
KC06 Energy Biosciences							
Operating	1.0	1.0	1.3	1.4	1.5	1.5	1.6
Capital Equipment	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	**1.1**	**1.1**	**1.3**	**1.5**	**1.5**	**1.6**	**1.7**
KG Multiprogram Energy Laboratories—Facilities Support							
Operating	1.2	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Construction	4.7	0.0	4.9	9.8	12.3	7.8	8.9
Total	**6.0**	**0.0**	**4.9**	**9.8**	**12.3**	**7.8**	**8.9**
KJ Computational and Technology Research							
Operating	34.4	43.4	67.0	70.0	72.4	68.2	69.6
Capital Equipment	13.7	4.0	3.9	4.1	4.2	4.3	4.4
Total	**48.1**	**47.4**	**70.9**	**74.1**	**76.6**	**72.5**	**74.0**

Table 6.3(a). Office of Energy Research Funding and Personnel
(Fiscal Year Budget Authority, $M) (continued).

Office/Program	1996	1997	1998	1999	2000	2001	2002
KP Biological and Environmental Research							
Operating	23.5	38.9	50.1	56.9	58.6	60.4	62.2
Capital Equipment	5.2	3.5	3.5	3.5	3.5	3.5	3.5
Construction	8.3	1.4	1.4	1.4	1.4	1.4	1.4
Total	**37.0**	**43.8**	**55.0**	**61.8**	**63.5**	**65.3**	**67.1**
KT University and Science Education							
Operating	1.1	0.0	2.0	2.0	2.0	2.0	2.0
Total	**1.1**	**0.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**
Total, Office of Energy Research							
Operating	158.8	186.8	226.7	245.7	255.2	255.9	259.6
Capital Equipment	33.8	21.5	21.6	29.4	33.2	38.0	37.9
Construction	29.0	16.7	23.6	39.4	59.2	62.4	44.9
Total	**221.7**	**225.0**	**271.9**	**314.5**	**347.7**	**356.4**	**342.4**

Table 6.3(b). Energy Efficiency and Renewable Energy Funding and Personnel
(Fiscal Year Budget Authority, $M)

Office/Program	1996	1997	1998	1999	2000	2001	2002
EB Solar and Renewable Resource Technologies							
Operating	2.0	1.4	1.4	0.8	0.5	0.5	0.5
Total	**2.0**	**1.4**	**1.4**	**0.8**	**0.5**	**0.5**	**0.5**
EC Building Technology, State and Community Sector							
Operating	11.8	8.7	9.0	9.4	9.7	10.0	10.0
Capital Equipment	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Total	**12.4**	**8.7**	**9.0**	**9.4**	**9.7**	**10.0**	**10.0**
ED Industrial Sector							
Operating	0.7	0.9	0.9	0.9	0.9	0.9	0.9
Total	**0.7**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**
EE Transportation Sector							
Operating	2.6	3.1	3.2	3.3	3.5	3.6	3.8
Total	**2.6**	**3.1**	**3.2**	**3.3**	**3.5**	**3.6**	**3.8**
EL Federal Energy Management Program							
Operating	1.9	1.8	1.8	1.6	1.6	1.6	1.7
Total	**1.9**	**1.8**	**1.8**	**1.6**	**1.6**	**1.6**	**1.7**
WB In-House Energy Management							
Construction	0.7	0.3	0.0	0.0	0.0	0.0	0.0
Total	**0.7**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Total, Assistant Secretary for Energy Efficiency and Renewable Energy							
Operating	19.0	16.0	16.3	15.9	16.1	16.6	16.8
Capital Equipment	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.7	0.3	0.0	0.0	0.0	0.0	0.0
Total	**20.4**	**16.2**	**16.3**	**15.9**	**16.1**	**16.6**	**16.8**

Table 6.3(c). Fossil Fuel and Other DOE Program Funding and Personnel (Fiscal Year Budget Authority, $M).

Office/Program	1996	1997	1998	1999	2000	2001	2002
AA Coal							
Operating	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Total	0.5	0.4	0.4	0.4	**0.4**	**0.4**	**0.4**
AB Gas							
Operating	0.3	0.5	0.5	0.4	0.6	0.6	0.6
Total	**0.3**	**0.5**	**0.5**	**0.4**	**0.6**	**0.6**	**0.6**
AC Petroleum							
Operating	1.5	1.7	1.6	1.6	1.6	1.7	1.8
Total	**1.5**	**1.7**	**1.6**	**1.6**	**1.6**	**1.7**	**1.8**
Total, Assistant Secretary for Fossil Energy							
Operating	2.2	2.5	2.4	2.3	2.5	2.6	2.7
Total	**2.2**	**2.5**	**2.4**	**2.3**	**2.5**	**2.6**	**2.7**
EW Environmental Restoration and Waste Management—Defense							
Operating	2.6	4.7	4.7	4.8	4.9	5.1	5.1
Capital Equipment	0.0	0.3	0.3	0.3	0.3	0.3	0.3
Total	**2.6**	**5.0**	**5.1**	**5.1**	**5.2**	**5.4**	**5.4**
EX Environmental Restoration and Waste Management—Non0.0Defense							
Operating	8.5	8.4	11.1	12.3	12.2	12.3	10.1
Capital Equipment	(0.2)	0.2	0.3	0.3	0.3	0.3	0.3
Construction	1.5	0.0	0.9	0.5	0.5	0.6	0.6
Total	**9.8**	**8.6**	**12.2**	**13.0**	**13.0**	**13.1**	**10.9**
Total, Assistant Secretary for Environmental Restoration and Waste Management							
Operating	11.1	13.1	15.8	17.1	17.1	17.3	15.1
Capital Equipment	(0.2)	0.5	0.6	0.6	0.6	0.6	0.6
Construction	1.5	0.0	0.9	0.5	0.5	0.6	0.6
Total	**12.4**	**13.6**	**17.3**	**18.2**	**18.2**	**18.4**	**16.3**
DP Defense Program Activities							
Operating	0.0	1.0	4.5	5.5	5.9	5.5	4.0
Total	**0.0**	**1.0**	**4.5**	**5.5**	**5.9**	**5.5**	**4.0**
GB Other Defense Program Activities							
Operating	0.0	0.0	0.4	0.4	0.4	0.0	0.0
Total	**0.0**	**0.0**	**0.4**	**0.4**	**0.4**	**0.0**	**0.0**
Total, Assistant Secretary for Defense Programs							
Operating	0.0	1.0	4.9	5.9	6.3	5.5	4.0
Total	**0.0**	**1.0**	**4.9**	**5.9**	**6.3**	**5.5**	**4.0**
GC Nonproliferation and National Security							
Operating	0.0	0.6	0.8	0.8	0.8	0.8	0.8
Total	**0.0**	**0.6**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**

Table 6.3(c). Fossil Fuel and Other DOE Program Funding and Personnel (Fiscal Year Budget Authority, $M) (continued).

Office/Program	1996	1997	1998	1999	2000	2001	2002
Total, Office of Nonproliferation and National Security							
Operating	0.0	0.7	0.8	0.8	0.8	0.8	0.8
Total	**0.0**	**0.7**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**
PE Policy Analysis and Systems Studies							
Operating	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Total, Assistant Secretary for Policy, Planning, and Program Evaluation							
Operating	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
HC Environment, Safety and Health—Non0.0Defense							
Operating	0.6	0.5	0.5	0.5	0.5	0.5	0.6
Total	**0.6**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.6**
Total, Assistant Secretary for Environment, Safety and Health							
Operating	0.6	0.5	0.5	0.5	0.5	0.5	0.6
Total	**0.6**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.6**

Table 6.4 Work for Others Funding and Personnel
(Fiscal Year Budget Authority, $M).

Office/Program	1996	1997	1998	1999	2000	2001	2002
Work for Other DOE Contractors							
Operating	5.3	8.3	11.5	11.7	11.8	11.9	12.0
Capital Equipment	5.3	2.3	1.6	1.6	1.7	1.7	1.8
Total	**10.6**	**10.6**	**13.1**	**13.3**	**13.4**	**13.6**	**13.8**
Work for Others—Federal Agencies							
Department of Defense	9.5	7.0	7.7	7.9	8.2	8.4	8.7
EPA	4.7	4.0	2.7	2.7	2.7	2.7	2.7
HHS/National Institute of Health	12.8	12.2	13.9	14.2	14.6	15.0	15.5
Department of Interior	0.7	0.3	0.2	0.2	0.2	0.2	0.2
NASA	4.8	4.7	5.5	5.5	5.6	5.7	5.8
National Science Foundation	1.1	0.6	0.1	0.1	0.1	0.1	0.1
Nuclear Regulatory Commission	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Federal	7.5	7.2	10.2	11.4	12.3	13.0	13.7
Total Federal Operating	41.0	35.9	40.2	41.9	43.6	45.0	46.6
Total	**41.0**	**35.9**	**40.2**	**41.9**	**43.6**	**45.0**	**46.6**
Other State/Private		7.8	10.2	10.5	11.0	11.5	12.0
Universities	4.9	4.8	4.8	4.8	4.8	4.8	4.8
State/Local Gov't/Non-Profit	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Domestic	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Other State/Private	1.7	7.8	10.2	10.5	11.0	11.5	12.0
Total Other State/Private Operating	10.7	16.8	19.1	19.4	20.0	20.4	21.0
Capital Equipment	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Total	**13.4**	**19.6**	**21.9**	**22.2**	**22.8**	**23.2**	**23.8**
Work for Others—Non-DOE							
Operating	51.7	52.7	59.3	61.4	63.6	65.5	67.5
Capital Equipment	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Total	**54.5**	**55.5**	**62.1**	**64.2**	**66.4**	**68.3**	**70.3**

Table 6.5(a). Subcontracting and Procurement (Obligated, $M).

		Projected		
	FY 1996	FY 1997	FY 1998	FY 1999
Subcontracting and Procurement from:				
Universities	11.8	11.2	11.2	11.2
All Others	125.6	126.2	126.2	126.2
Transfers to Other DOE Facilities	2.4	2.8	2.8	2.8
Total External Subcontracts and Procurement	139.9	140.2	140.2	140.2

Table 6.5(b). Small and Disadvantaged Business Procurement (Fiscal Year Budget Authority, $M).

	FY 1996	FY 1997 Projected
Procurement from S&DB	55.5	59.0
Percent of Annual Procurement	55.8	56
	99.5*	106*

*Available subcontracting dollars.

Table 6.6. Laboratory Staff Composition (FY 1996).

Full & part time employees	Total	PhD	MS/MA	BS/BA	Other
Professional Staff					
Scientists	998 (28.1%)	797 (22.5%)	92 (2.6%)	83 (2.3%)	26 (0.7%)
Engineers	305 (8.6%)	47 (1.3%)	83 (2.3%)	120 (3.4%)	55 (1.6%)
Management & Administration	519 (14.6%)	22 (0.6%)	76 (2.1%)	179 (5.0%)	242 (6.8%)
Support Staff					
Techs	1008 (28.4%)	13 (0.4%)	107 (3.0%)	241 (6.8%)	647 (18.2%)
All Other	718 (20.2%)	187 (5.3%)	45 (1.3%)	238 (6.7%)	248 (7.0%)
	3548 (100%)	1066 (30.1%)	806 (22.7%)	861 (24.2%)	1218 (34.3%)

Table 6.7. Experimenters at Designated User Facilities—1996.

	Number of Experimenters	Number of Organizations
ALS		
Laboratory	109	4
Other Federal Laboratories	15	5
University	93	20
Industry	8	3
International	68	21
Total	**293**	**53**
NERSC*		
Laboratory	35	1
Other Federal Laboratories	210	19
University	249	81
Industry	41	18
International	3	1
Total	**538**	**120**
88-Inch Cyclotron		
Laboratory	77	1
Other Federal Laboratories	41	6
University	72	24
Industry	56	14
International	64	24
Total	**310**	**69**
NCEM		
Laboratory	77	3
Other Federal Laboratories	2	2
University	61	17
Industry	12	11
International	26	15
Total	**178**	**48**
Grand Total		
Laboratory	**298**	**9**
Other Federal Laboratories	**268**	**32**
University	**475**	**142**
Industry	**117**	**46**
International	**161**	**61**
Total	**1319**	**290**

***NERSC moved from LLNL to LBNL during 1996. Data is combined for FY96. Also, for NERSC, data is available for Number of Projects (approxomately the number of Principal Investigators). There are about nine times as many individual users as number of projects.**

VII. ACRONYMS AND ABBREVIATIONS

AA	Affirmative Action
AAP	Affirmative Action Plan
ACTI	Advanced Computational Technology Initiative
ACTS	Advanced Computational Testing and Simulation
AECR	Advanced Electron Cyclotron Resonance
AEM	Analytical Electron Microscope
AGS	Alternating Gradient Synchrotron
ALS	Advanced Light Source
ARIM	Accelerator and Reactor Improvements and Modifications
ARM	atomic resolution microscope
ARPA	Advanced Research Projects Agency
ATLAS	A Toroidal LHC Apparatus
B&R	budget and reporting code
BA	Budget Authority
BES	Basic Energy Sciences (Office)
BEST	Bioremediation, Education, Science, and Technology (Program)
BGS	Berkeley Gas-Filled Separator
BNCT	Boron-Neutron Capture Therapy
BNL	Brookhaven National Laboratory
CAD/CAM	computer-aided design/computer-aided manufacture
CAM	Center for Advanced Materials
CAMP	Capital Asset Management Plan
CCSE	Center for Computational Science and Engineering
CDF	Collider Detector Facility (at Fermilab)
CDR	conceptual design report
CEB	Center for Environmental Biotechnology
CEDR	Comprehensive Epidemiologic Data Resource
CEQA	California Environmental Quality Act
CERN	European Organization for Nuclear Research
CFC	chlorofluorocarbon
CFO	Chief Financial Officer
CFP	Comprehensive Facilities Plan
CIEE	California Institute for Energy Efficiency
COBE	Cosmic Background Explorer
CP	charge conjugation parity
CRADAs	Cooperative Research and Development Agreements
CSEE	Center for Science and Engineering Education
CT	Computational Technologies (Program)
CXRO	Center for X-Ray Optics
DARHT	Dual Axis Radiographic Hydro-Test (Facility)
DECnet	a properietary network protocol from Digital Corporation
DIRC	Detection of Internally Reflected Cerenkov Light
DNA	deoxyribonucleic acid
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/EM	U.S. Department of Energy, Office of Environmental Research
DOE/ER	U.S. Department of Energy, Office of Energy Research
DOE/OAK	DOE Operations Office, Oakland
DOI	U.S. Department of Interior
DP	Office of Defense Programs

DTL	
EBMF	Electron Beam Microcharacterization Facility
ECM	extracellular matrix
ECR	electron cyclotron resonance
EDT	Employee Development and Training (Unit)
EEO	equal employment opportunity
EH&S	Environment, Health and Safety Division (LBNL)
EM	Environmental Management
EOS	Equation-of-State
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPRI	Electric Power Research Institute
EPU	elliptically polarizing undulator
ER	Office of Energy Research (see also OER)
ER-LTR	Energy Research–Laboratory Technology Research
ERWM	Environmental Restoration and Waste Management
ES&H	environment, safety, and health
ESnet	Energy Sciences Network
EUV	extreme ultraviolet
FE	Office of Fossil Energy
FEMP	Federal Energy Management Program
FNAL	Fermilab National Accelerator Laboratory
FTE	full-time equivalent
FWP	Field Work Proposal
FY	fiscal year
Ge	Germanium
GFS	gas-filled separator
GPE	General Purpose Equipment
GPP	General Plant Projects
GRETA	Gamma-Ray Energy Tracking Array
gsf	gross square feet
gsm	gross square meters
HENP	High Energy and Nuclear Physics (Collaboratory)
HEPA	high-efficiency particulate air
HGC	Human Genome Center
HPCC	high-performance computing and communications
HR	Human Resources (Department)
HREM	high-resolution electron microscope
HRIS	Human Resources Information System
HVAC	heating, ventilating, and air-conditioning
HVEM	high-voltage electron microscope
I&SFP	Inactive and Surplus Facilities Program
ICSD	Information and Computing Sciences Division
I.D.	identification
IM	Information Management
INPA	Institute for Nuclear and Particle Astrophysics
IR	interaction region
IRM	information resources management
ISM	*in-situ* microscope
JAERI	Japan Atomic Energy Research Institute
JPL	Jet Propulsion Laboratory
Ksm	thousand square meters
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory

LDRD	Laboratory Directed Research and Development Program
LEBT	low eneregy beam transport (system)
LETS	Laboratory Employee Time System
LHC	Large Hadron Collider
LIGA	Lithographie Galvanoformung, Abformung
LIP	Line Item Projects
LLNL	Lawrence Livermore National Laboratory
M&O	maintenance and operations
MBone	Multicast Backbone
Mbits	megabits
MEBT	medium energy beam transport (system)
MEL-FS	Multiprogram Energy Laboratory Facilities Support
MEMS	microelectromechanical systems
MEP	Master Emergency Plan
Mgsf	million gross square feet
MSAP	Management Skills Assessment Program
NABIR	Natural and Accelerated Biomediation Research
NAREEP	Native American Renewable Energy Education Program
NASA	National Aeronautics and Space Administration
NCEM	National Center for Electron Microscopy
NCI	National Cancer Institute
NEPA	National Environmental Policy Act
NERSC	National Energy Research Scientific Computing
NIH	National Institutes of Health
NMR	nuclear magnetic resonance
NOW	Network of Workstations
NSF	National Science Foundation
NSNS	National Spallation Neutron Source
OÅM	one-Ångstrom microscope
OBER	Office of Biological and Environmental Research
OBES	Office of Basic Energy Sciences
OER	Office of Energy Research (see also ER)
OPA	Outstanding Performance Award
ORNL	Oak Ridge National Laboratory
ORTP	Oil Recovery Technology Program
OSHA	Occupational Safety and Health Administration
PC	personal computer
PDSF	Parallel Distributed Simulation Facility
PEP	Positron–Electron Project
PET	positron emission tomography
PNGV	Partnership for a New Generation of Vehicles
PNNL	Pacific Northwest National Laboratory
QCD	Quantum Chromodynamics
RADAR	Radiation Protection Data Base Management
R&D	research and development
RDAC	Research and Development Associated with Construction
RFQ	radio-frequency quadrupole
RHIC	Relativistic Heavy-Ion Collider
rms	root-mean square
RNA	ribonucleic acid
ROI	Return on Investment
RPM	Risk Prioritization Matrix
RPV	replacement plant value
SDC	Solenoidal Detector Collaboration

SDP	Site Development Plan
SEMPA	Scanning Electron Microscope with Polarized Analysis
SFIA	Surplus Facilities Inventory and Assessment
SIA	Semiconductor Industry Association
SLAC	Stanford Linear Accelerator Center
SLC	Stanford Linear Collider
SMOKE	Surface Magneto-Optic Kerr Effect
SNL	Sandia National Laboratories
SNO	Sudbury Neutrino Observatory
SPLEEN	Spin Polarized Low-Energy Electron Microscope
SPS	Super Proton Synchrotron
SQUID	superconducting quantum interference device
SSRL	Stanford Synchrotron Radiation Laboratory
STAR	Solenoidal Tracker at RHIC
STI	scientific and technical information
SVX	silicon vertex
SXR	soft x-ray
TEC	total estimated cost
TOF	Time-of-Flight
TOS	Technology Option Study
TPC	Time Projection Chamber
TTD	Technology Transfer Department
UC	University of California
UCOP	University of California, Office of the President
UCSF	University of California, San Francisco
VOC	volatile organic compound
VUV	vacuum ultraviolet
WFO	work for others
YAC	yeast artificial chromosome
XANES	x-ray absorption near-edge structure spectroscopy

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