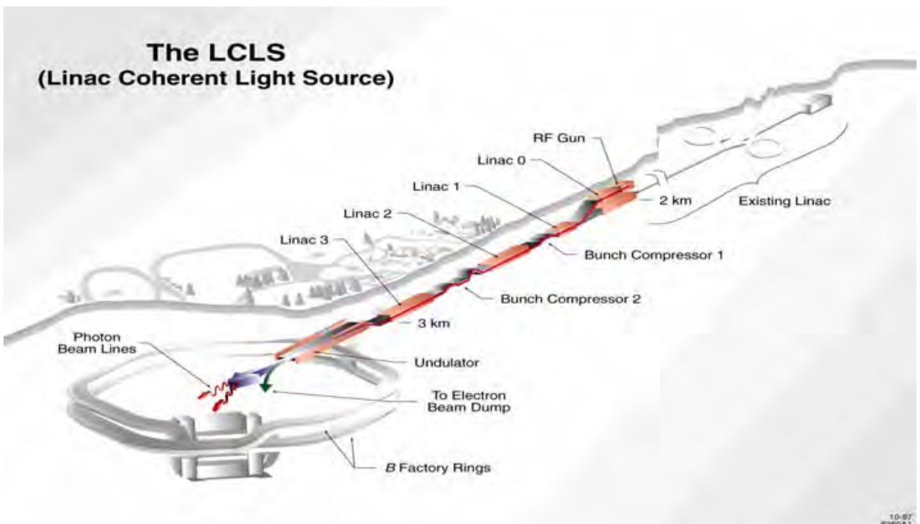
LCLS

DOE/EA-1426

Environmental Assessment for Linac Coherent Light Source Experimental Facility



Stanford Linear Accelerator Center

December 2002

Environmental Assessment for LCLS Experimental Facility

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Preface

This environmental assessment (EA) for the proposed free electron laser experimental facility, known as the Linac Coherent Light Source (LCLS), presents an analysis of potential environmental consequences of the LCLS and compares these consequences to alternatives to the proposed action. This EA will be used to determine whether a 'Finding of No Significant Impact' can be reached or whether an Environmental Impact Statement must be prepared.

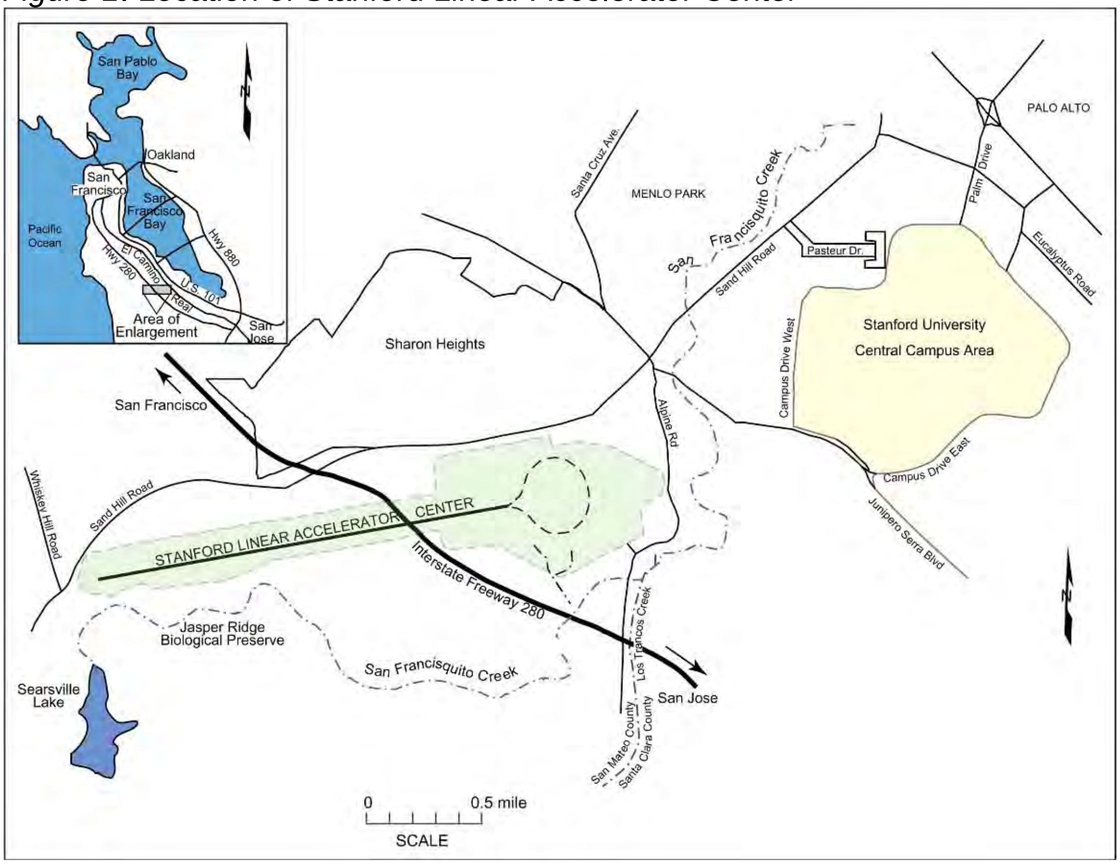
This document complies with the National Environmental Policy Act (NEPA), the Council on Environmental Quality (CEQ) implementing regulations (40 Code of Federal Regulations [CFR] 1500-1508), the Department of Energy's (DOE) National Environmental Policy Act Implementing Procedures (10 CFR 1021), and DOE Order 451.A.

This revised EA contains changes that address public comments generated during the review of the draft EA in October 2002.

1.0 Summary

The Stanford Linear Accelerator Center (SLAC) is a national research facility operated by Stanford University for the U.S. Department of Energy (DOE) in Menlo Park, California (Figure 1). Research at SLAC centers around experimental and theoretical particle physics using accelerated electron beams, and a broad program of atomic and solid state physics, biology and chemistry using synchrotron radiation from accelerated electron beams.

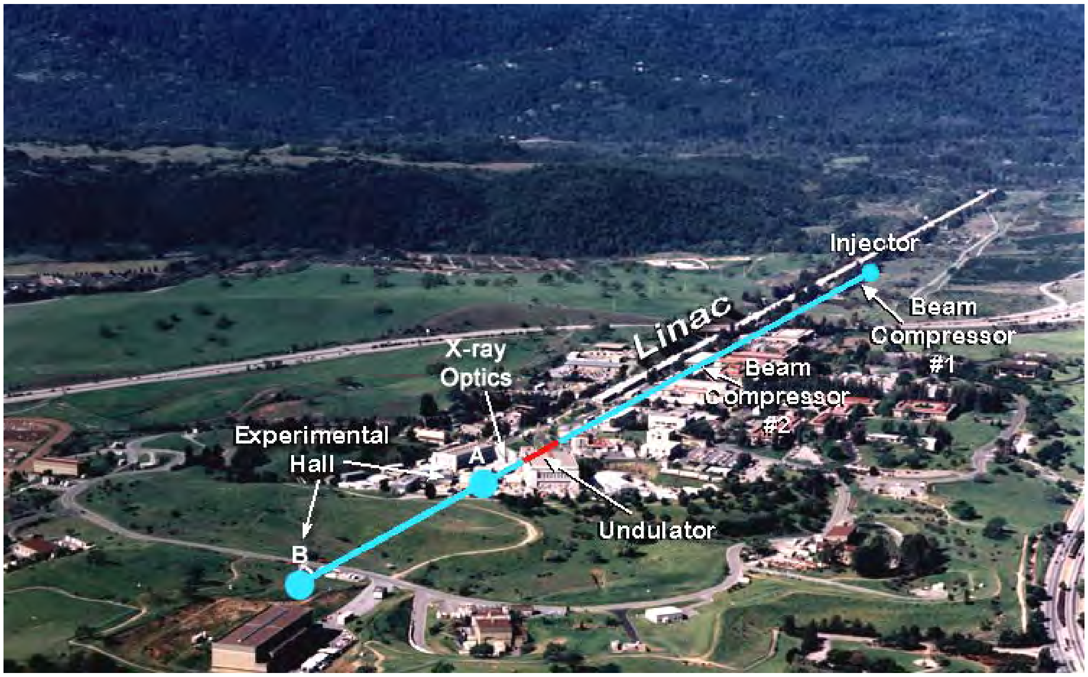
Figure 1. Location of Stanford Linear Accelerator Center



The DOE proposes to construct and operate a new research facility at SLAC, the Linac Coherent Light Source (LCLS), as a collaborative effort with other DOE facilities. The purpose and need for the LCLS is the creation of a new type of x-ray light source from a single pass free electron laser (FEL). The FEL would have a peak brightness 10 orders of magnitude greater and with faster pulses (in the sub-picosecond range), than the most intense synchrotrons currently available. The higher peak brightness would allow examination of much smaller particles, and the faster pulses would allow scientists to evaluate changes within a very short timeframe. As with the first microscope, the ability to explore our world on a finer scale will open up unforeseen frontiers. For example, the synchrotron experiments have revealed the structure of proteins. The FEL would not only reveal structures of the smallest molecules, but would also provide scientists with a tool to evaluate how interactions occur on an atomic level. In a practical sense, the understanding gained may lead to diverse applications ranging from new drugs for combating diseases to understanding how planets form. The LCLS would be the most powerful FEL in the world contemplated at this time.

The LCLS facility would take advantage of the existing infrastructure at SLAC, resulting in significant cost savings. Proposed new construction would consist of two new buildings, called Experimental Halls (A and B), that would be connected by a new tunnel approximately 227 meters (745 feet) in length (Figure 2). The LCLS would use the last third of the three-kilometer (1.8-mile) Linac to accelerate the electrons used in the FEL. In addition, the LCLS would use the existing infrastructure above the Linear Accelerator (Klystron Gallery Building and existing utilities) to house an electron injector, electron beam transport system, and two electron beam pulse compressors for use in the FEL. A new undulator magnet to control electron direction would be housed in an extension of the existing Final Focus Test Beam (FFTB) tunnel. New x-ray optics are planned as part of Hall A.

Figure 2. Aerial View of Proposed LCLS Facilities at SLAC from Northeast



Construction would be accomplished within SLAC's developed areas and within the land leased to SLAC. The current schedule for LCLS calls for a three-year construction schedule, beginning in October 2005.

A preliminary LCLS Hazards Analysis has been prepared to identify and develop mitigating measures for hazards associated with the design, fabrication, installation, and testing phases of the LCLS project. The preliminary Safety Analysis supports the consideration of the LCLS as a low hazard facility in accordance with DOE 5481.1B, Safety and Analysis Review System (SLAC 2002c). The Integrated Safety Management

System (ISMS) has been fully implemented at SLAC, providing a process to systematically integrate safety into work management at all levels so that workers, the public, and the environment are protected during all phases of operations. A summary of potential environmental consequences of the LCLS is presented below in Table 1.

Table 1. Summary of Potential Environmental Effects

Comparison Factors	**No Action: SLAC Current Operations**	**Proposed LCLS Facility**
Building Construction	None in proposed LCLS area.	Negligible. Two new experimental halls, each about 2,000 square meters (about 20,000 square feet) would be constructed in current operational areas.
Tunnel Construction	None.	Negligible. One new tunnel would be built, 227 meters (745 feet) in length. The proposed tunnel would be entirely above the water table. The tunnel area consists of a non-serpentine type of rock that does not contain asbestos fibers. Groundwater and soil in the tunnel area is natural background quality, or below applicable regulatory criteria. SLAC has three large-scale tunnels that total nearly 9 km in length that are both above and below the groundwater table, demonstrating the viability of the proposed new tunnel.
Roads	None.	Negligible. One small road realignment within SLAC.
Parking	New parking is planned.	Negligible.
Traffic	none	Minor. An estimated 4% increase is anticipated once operational.
Utilities (electrical, water supply and sanitary sewer)	Minor increases are projected.	Minor. Minor increases are projected, but are not beyond SLAC's current capacity to provide these resources.
Land Use Conflicts	None.	None.
Air Quality	A facility-wide permit became effective July 2002.	Negligible. Projected emissions from LCLS would be below limits in facility-wide permit during both construction and operations phases.

Comparison Factors	No Action: SLAC Current Operations	Proposed LCLS Facility
Soil Quality	Existing voluntary soil and groundwater investigation and cleanup are ongoing. Extensive sampling of the soil in the area of tunnel and the Far Hall indicates that it has not been affected by past or current operations at SLAC. Detailed assessments of the Research Yard indicate surficial sediment in at or near the Near Hall may contain low levels of PCBs.	Negligible.
Surface Water Quality	Existing site-wide stormwater pollution prevention plan and best management practices are in place.	Negligible. A stormwater management plan will be developed for construction, and the area would be integrated into the site-wide plan, triggering the development of specific best management practices for the operations phase.
Groundwater Quality	Existing voluntary soil and groundwater investigation and cleanup are ongoing. Groundwater beneath the proposed tunnel and both Halls is of natural background quality.	Negligible. Groundwater quality will not be impacted by the construction of the LCLS. The depth to groundwater is 5-10 feet below the construction activities in the Research Yard where the Near Hall and Undulator (including the LCLS Beam Dump device) would be placed. Chemicals resulting from operations are not found in the groundwater in the area of construction.
Sensitive Environments: Wetlands and Designated Critical Habitats	Associated with San Francisquito Creek South of SLAC	Negligible. Construction areas are not near San Francisquito Creek.
Threatened or Endangered Species	Associated with San Francisquito Creek South of SLAC	Negligible. Construction areas are not near San Francisquito Creek.
Cultural Resources	Associated with San Francisquito Creek South of SLAC	Negligible. Construction areas are not near San Francisquito Creek.
Paleontological Resources	Paleoparadoxia replica on display in Visitor's Center was discovered in 1964 in the Research Yard.	Possible during tunnel construction. If bones are encountered during tunnel construction, work would be stopped, and the resource evaluated by Stanford University.
Radiological Aspects	Existing safety program to protect workers and public. No radiation worker injury since SLAC began operations almost 40 years ago. SLAC total dose to maximally exposed individual of public is 5 millirems per year (DOE mandated limit is 100 millirems per year).	Negligible. Worker heath and safety addressed by current program and design features. Additional estimated contribution from LCLS operations to maximally exposed public individual is 0.2 millirems per year, a negligible increase from the current 5 millirems per year, and well below the 100 millirems per year mandated by DOE.

Comparison Factors	No Action: SLAC Current Operations	Proposed LCLS Facility
Environmental Justice	None. The closest minority or low-income area is greater than 4 miles from SLAC. In addition, SLAC does not pose any adverse human health or environmental pollution impacts to the general public or surrounding areas.	None.
Hazardous materials	Chemical usage is subject to review by SLAC Industrial Hygienists to determine minimization, substitution, and site specific usage guidance.	Negligible. Chemical use would be similar to current programs.
Hazardous waste	Existing RCRA Hazardous Waste 90-day generator. Active waste minimization and pollution prevention plans.	Negligible.

Notes: PCB: Polychlorinated Biphenyl

1. TSCA: Toxic Substances Control Act, as amended in 40 CFR Parts 750 and 761 (*Federal Register* June 29, 1998 Volume 63, Number 124, pp35383-35474).

As shown in Table 1, the total cumulative potential environmental consequences during construction and operation of the proposed LCLS Facility would be minor, similar to the No Action Alternative.

2.0 Purpose and Need for LCLS

The purpose and need for the LCLS is to provide upgraded capabilities to study the basic properties of matter. There is a significant need to expand the research opportunities offered by current technology, and the LCLS would have both theoretical and practical importance to a broad range of fields. Major scientific advances are anticipated in physics for fundamental quantum mechanics and molecular and plasma physics, as well as in the fields of chemistry and biology to further the understanding of chemical reactions, and dynamical interactions in biology at the molecular level. This is because the LCLS would not only allow scientists to examine much smaller size samples (i.e. at the atomic level versus an entire protein), but would also allow for the evaluation of minute changes to the sample with time in order to gain understanding of how interactions occur. In a practical sense, unraveling these unknowns may lead to such diverse applications ranging from new drugs to combat disease to understanding how planets are formed.

The LCLS would be a free electron laser (FEL) that would produce x-ray laser pulses that are billions of times more intense than those from existing sources. The FEL, like synchrotron x-ray sources currently in use at SLAC, uses radiation emitted by fast moving electrons as they change direction. A FEL generates tunable, coherent, high power radiation, currently spanning wavelengths from millimeter to visible and potentially ultraviolet to x-ray. It can have the optical properties characteristic of conventional lasers such as high spatial coherence. It differs from conventional lasers because it uses electron beams, instead of bound atomic or molecular states, hence the term ‘free-electron’.

The proposed FEL for the LCLS would be unique in that it would use the existing linear accelerator to increase the speed of bunches of electrons to close to the speed of light. The electron bunches would pass through an undulating magnetic field that forces the electrons to create even smaller and more compressed bunches. The pulse that emerges from the FEL is a series of high intensity bursts from several thousand micro-bunches as they leave the undulator magnetic field. With high energy, peak current, and other design parameters in optimum range, the pulse can be within the Angstrom range (0.0000000001 meter or 3.2×10^{-10} feet).

3.0 Description of Proposed Action and Alternatives

3.1 Proposed Action

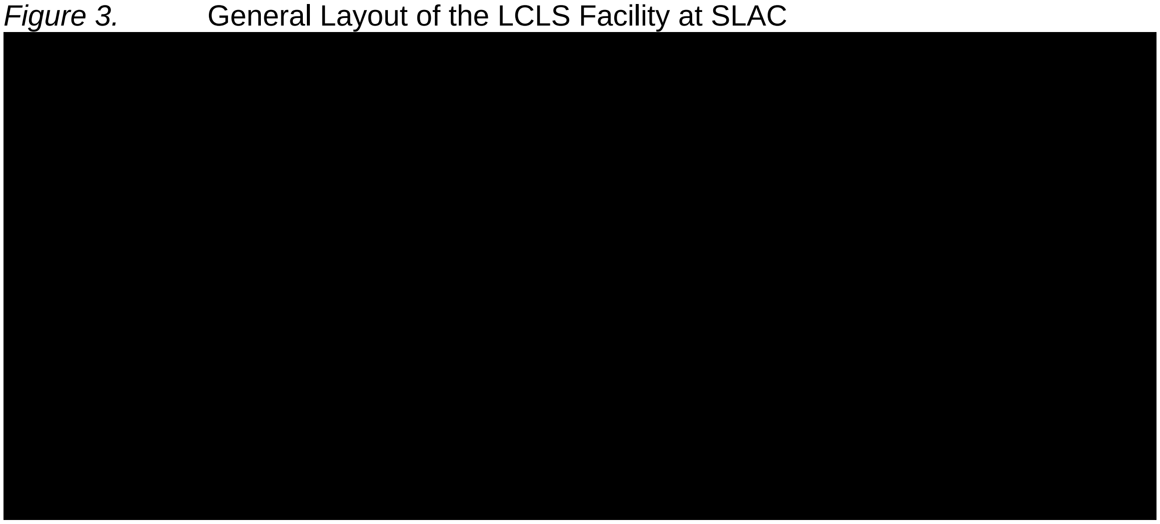
3.1.1 Facility Requirements

Collaborative research over the last four years on key design parameters resulted in a conceptual design for the LCLS. The Design Study Report (SLAC 1998) and the Conceptual Design Report (SLAC 2002a) were used as resources for this environmental assessment (EA).

For facility design, it is estimated that the total number of new SLAC employees as a result of the LCLS would be about 60. The total number of external facility users is not known, but it is predicted that about 40 LCLS users could be onsite in any given day.

The construction of the proposed LCLS experimental facilities would make use of key existing structures. The proposal also calls for modifying or removing some existing structures, and constructing two new buildings, called Experimental Halls, and a beam line tunnel between the experimental halls. The current schedule for LCLS calls for a three-year construction schedule, beginning in October 2005. The new facilities will be constructed in two distinct phases each with nine to twelve month duration. It is anticipated that the project will be completed in 2008. The proposed general layout at SLAC is shown in Figure 3.

Figure 3. General Layout of the LCLS Facility at SLAC



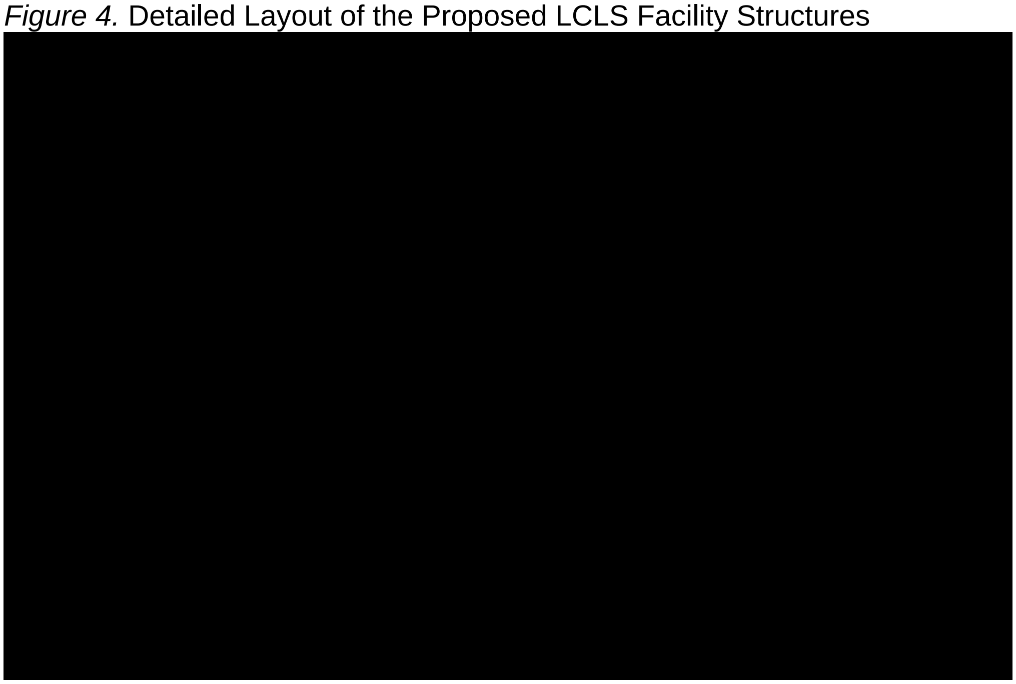
Key existing structures include the use of the last third of Linear Accelerator (Linac) and the Off-Axis Injector Tunnel at Sector 20. Sectors 20 and 25 would be removed and replaced with electron beam or bunch compressors to accelerate electrons beyond the current capacity of the Linac. The FFTB tunnel would be extended to house the LCLS undulator. The undulator is a permanent magnet device that would require modifications to the existing infrastructure, electrical power, and cooling water distribution systems. The LCLS beam dump would also be located in the extended FFTB, adjacent to the proposed Near Hall.

The two new experimental buildings are currently called Hall A (or Near Hall) and Hall B (or Far Hall). Each would be about 2,000 square meters or 20,000 square feet as single story structures. Hall B would be constructed with a second story capable of providing additional office space with more square footage added (not included in size estimate above). A new parking lot would be constructed adjacent to Hall B. Construction of Hall A would require removal of existing Building 111 and surrounding additions, as well as part of Building 102 in the Research Yard. Several smaller modular buildings would also be removed or relocated. The Research Yard is currently used for experiments at SLAC. Hall B would be located on vacant land east of the Research Yard, adjacent to the Stanford Linear Collider Experimental Hall.

Hall A and Hall B would be connected by a new tunnel approximately 227 meters (755 feet) in length and 3 meters (10 feet) in diameter that would provide long beam and short beam experimental capability for LCLS. The beam transport tunnel from the end of the FFTB to Hall A would be lengthened.

The LCLS will have negligible impact on the total flow or quality of stormwater. Rain water will flow from the LCLS site through the existing storm drain system to San Francisquito Creek. The total project would result in about a 2% increase in impermeable surfaces at SLAC with a minor increase in surface run off volume from the new parking lot and Hall B building. The storm drain system has sufficient capacity to handle the minor increase in surface runoff. Given the operations at the LCLS it is not anticipated that there will be any impact on storm

Figure 4. Detailed Layout of the Proposed LCLS Facility Structures



water quality. The small contribution of additional flow will not increase the risk of flooding in San Francisquito Creek. These proposed structures are shown in Figure 4.

3.1.2 Construction

A summary of construction activities is provided for each of the following components of the LCLS:

- Injector
- Linac
- Undulator
- Experimental Halls
- Tunnel

The general location of these components is shown on Figure 3.

Injector

The LCLS would use the existing off-axis tunnel by Linac Sector 20 to house the electron beam injector. The shielding between the off-axis tunnel and the main Linac tunnel would be reconfigured to accommodate the beam pipe, the waveguides, an alignment pipe, and other utilities. In addition, a support building would be modified as a clean room for the laser.

The injector would be powered by the existing klystrons located above the Linac. A klystron is an electron tube about six feet in length that amplifies microwaves by velocity modulation, and is used to power the Linac at regularly spaced intervals called Sectors. There are eight klystrons in a Sector.

The klystron output power would be redirected to the injector tunnel with a new waveguide system. New plumbing and wiring would be provided for magnet power supplies, controls, lasers, vacuum, cooling water, etc. The injector and associated equipment would use power and water lines from the existing Linac.

Linac

The LCLS would use the last third of the Linac, including the existing enclosures and utilities. The Linac consists of the Linear Accelerator itself, which is below ground, and the above ground Klystron Gallery that provides the power to accelerate electrons. The Linac has 30 Sectors total, with a typical Linac Sector having a length of about 469 meters (or 1,537 feet). The sectors are numbered sequentially from Sector 0 (farthest from the Research Yard) through Sector 30 (nearest to the Research Yard), see Figure 3. Electrons are accelerated by the klystrons from where they are injected and reach their peak velocities downstream. The LCLS would inject electrons at Sector 20 in the Off Axis Injector Tunnel and use the existing Linac from Sectors 20 through 30 to accelerate electrons for the FEL.

Two sectors of the Linac (Sector 20 and Sector 25) would be removed and replaced with magnets and vacuum chambers for pulse compressors to accelerate electrons beyond the current capabilities of the Linac in this area. These are known as electron beam or bunch compressors. A new klystron would be required for the new x-band accelerating structure for the electron beam compressors, which would allow the high frequencies that are planned for LCLS experiments. New power and water connections would also be required.

Undulator

The current Final Focus Test Beam (FFTB) structure would be extended to house the LCLS undulator. The FFTB is composed of a tunnel and components. The existing equipment would be removed from the structure, and stored for potential re-use. The Undulator Hall would house the following new LCLS components:

- The electron beam dogleg, which is a designed 'kink' or bend in the electron path used to compress electron bunches.
- The undulator, a permanent magnet device with precise alignment and stability requirements, used to move electrons along specific paths and directions.
- The electron beam dump, where beam energy and radiation are confined within heavy shielding.

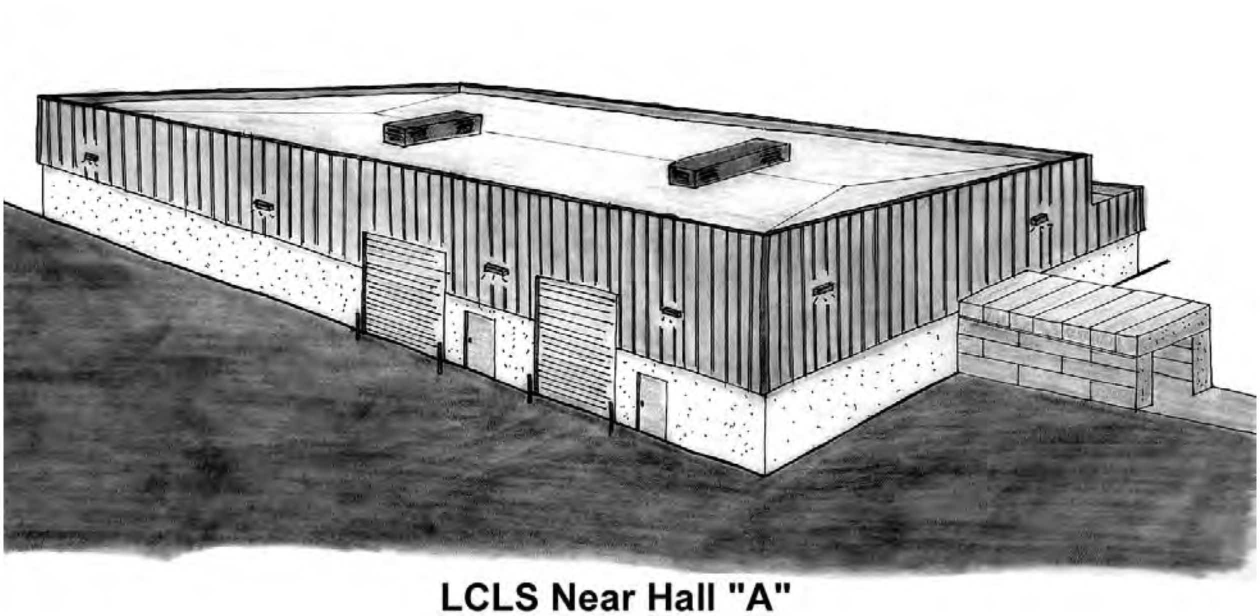
The existing FFTB structure is partially underground to fully above ground as it traverses the Research Yard. Retrofitting would include new stable supports and improved air handling. The proposed LCLS beam dump (a beam dump is an energy absorption device for halting electron particle beams), located upstream of Hall A and would be enclosed in appropriate radiation shielding. No new utility resources are required, but new plumbing, wiring, cable trays, and other appurtenances would be required.

Experimental Halls

The LCLS requires two experimental halls, one immediately after the undulator, and the other 335 meters (or about 1,100 feet) downstream. The two halls would be connected by a beam line enclosure and tunnel.

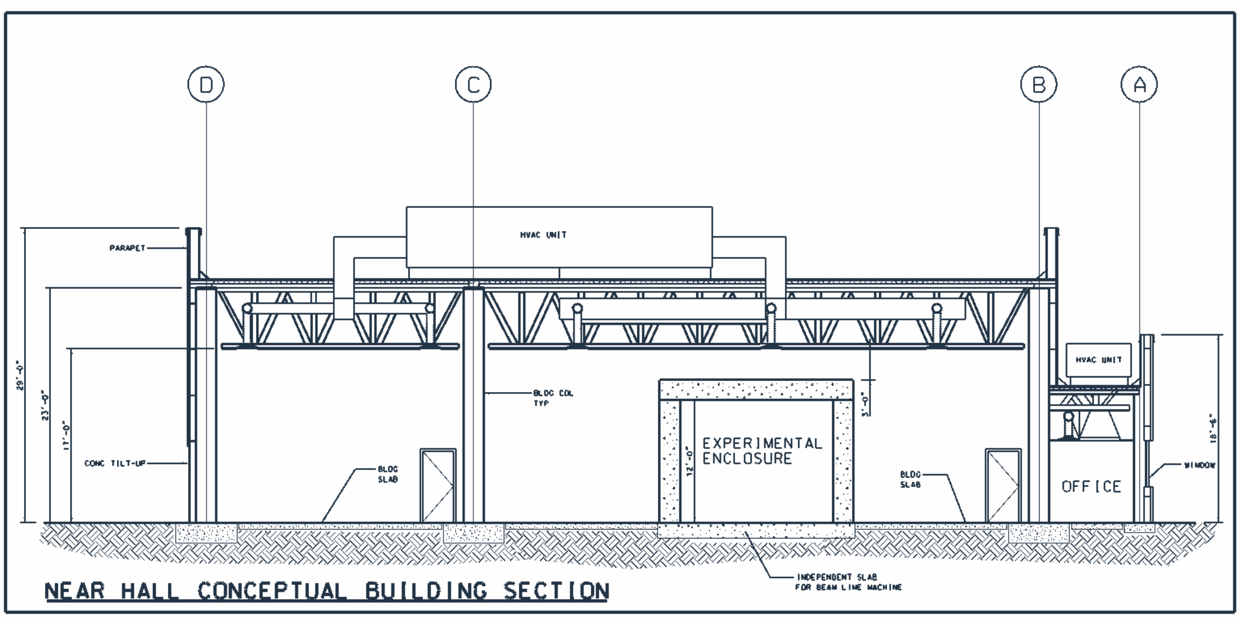
<u>Near Hall:</u> The Near Hall (Hall A) would be constructed in the present SLAC Research Yard. The hall would be approximately 30 meters (about 100 feet) wide at its widest part, by 55 meters (about 180 feet) long in the direction of the electron beam. Cooling water and power would be provided in the building, using existing capacity available from the Research Yard. The Near Hall would house x-ray optics and diagnostic equipment needed for the LCLS. The Near Hall would have 10 offices for LCLS users and on-site operations staff. This hall would include three enclosures for x-ray diagnostic equipment. Figure 5 through 7 present the preliminary design of the Near Hall (Hall A).

Figure 5. Near Hall Architectural Rendering



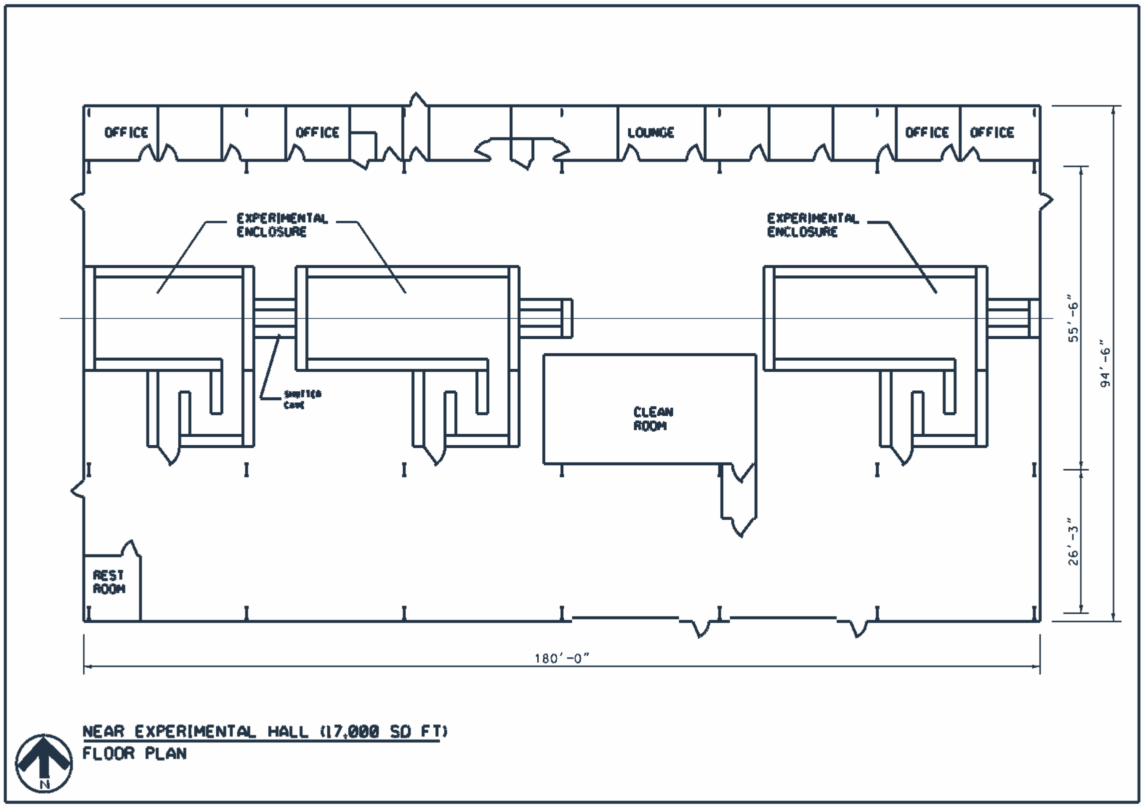
Source: SLAC 2002a

*Figure 6***.** Near Hall Cross Section



Source: SLAC 2002a

Figure 7. Near Hall Floor Plan



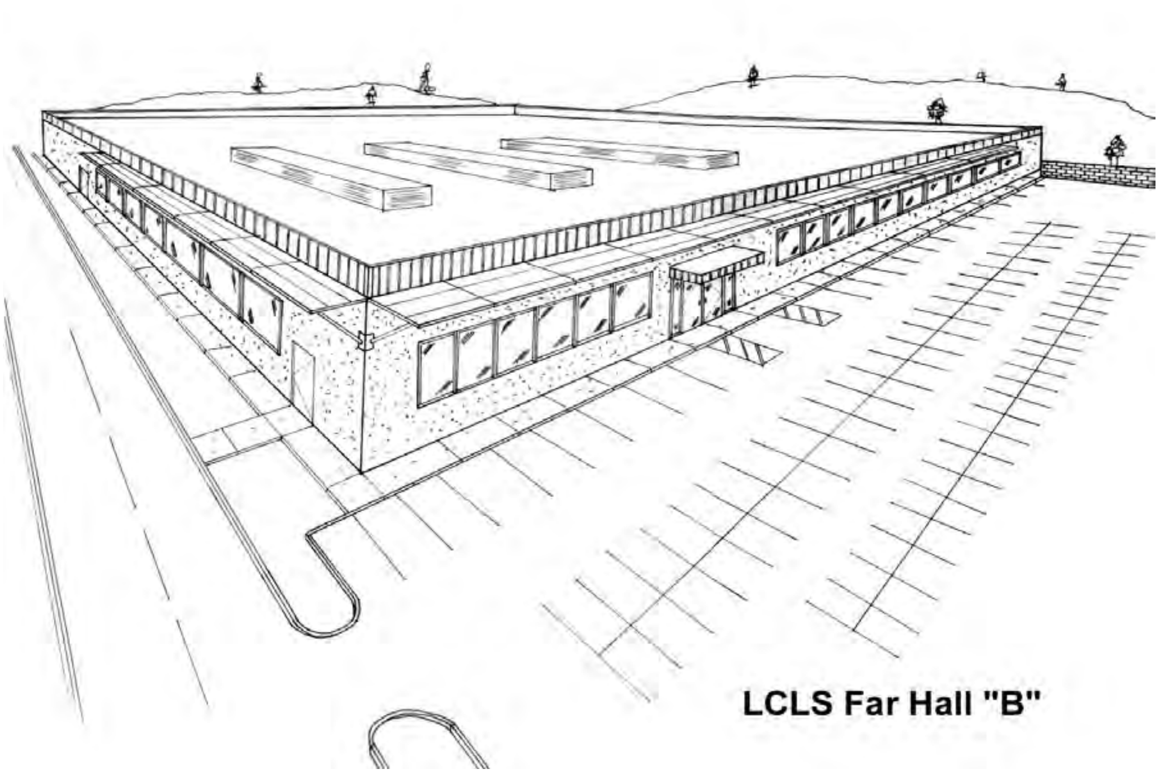
Source: SLAC 2002a

Far Hall: The Far Hall (Hall B) would be located approximately 245 meters (800 feet) past a ridge along the eastern end of the Research Yard. The hall would be approximately 35 meters (about 115 feet) wide, by 55 meters (about 180 feet) long in the beam direction. The beam line is planned to be located 1.25 meters (4 feet) above the floor. The floor would be 6 meters (about 20 feet) below the existing grade, with the ceiling of the first floor at grade level. A second story would consist of offices and laboratory areas. There would be a service ramp for moving equipment, and an adjacent parking area for up to 70 cars.

Based on review of historical aerial photographs, the existing surface material is fill that was moved during construction of the adjacent Stanford Linear Collider (SLC) Experimental Hall.

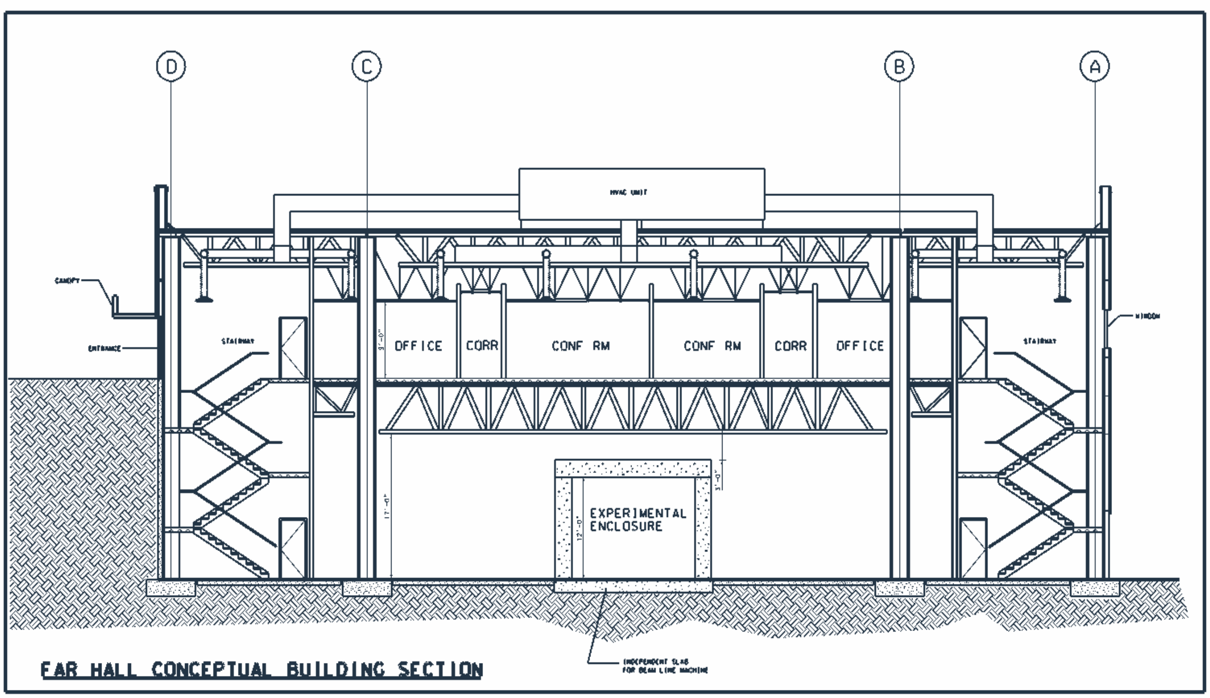
Figures 8 through 10 present the preliminary design of the Far Hall (Hall B).

Figure 8. Far Hall Architectural Rendering



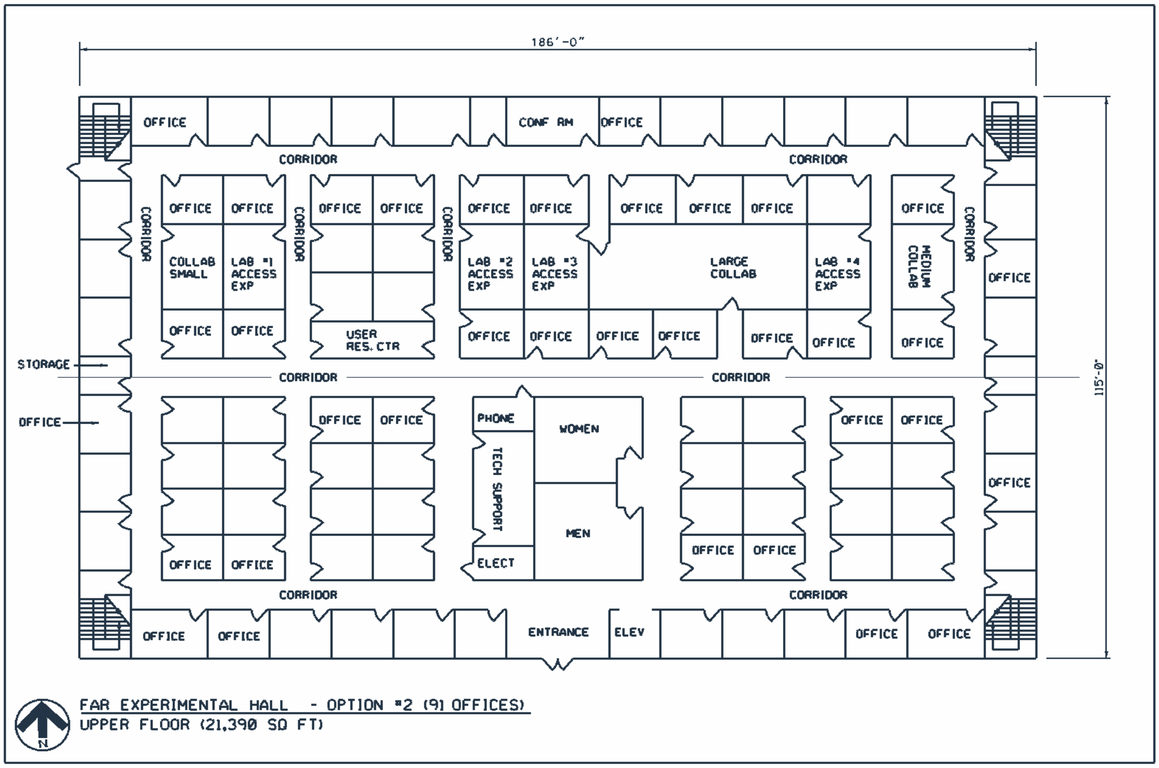
Source: SLAC 2002a

Figure 9. Far Hall Cross Section



Source: SLAC 2002a

Figure 10. Far Hall Floor Plan (Second Floor)



Source: SLAC 2002a

Tunnel

A new tunnel, extending from the Near Hall (Hall A) to the Far Hall (Hall B) for a distance of 227 meters (745 feet), would be constructed. It is planned to be 3 meters (10 feet) in diameter, and would house the accelerated electron beam line to be used in the FEL. There would also be space for utilities and maintenance access. It would be at a stable elevation, preliminarily planned to be at 245 feet above sea level. Groundwater elevation at the proposed LCLS Tunnel is between 230 and 240 feet in this area, based on the past 35 years of groundwater monitoring data. Therefore, the LCLS tunnel is expected to be constructed entirely above the water table.

The geology in the tunnel area from the ground surface downward, consists of fill, unconsolidated sediments of the Santa Clara Formation (sands, gravels, silts and clay), and the Ladera Sandstone (silty sandstone to siltstone that is weakly to moderately well consolidated). The LCLS tunnel would be constructed below the fill and the Santa Clara Formation, and is estimated to be located primarily within the Ladera Sandstone, based on lithologic information from nearby wells and exposures of the Ladera Formation in the Research Yard. None of the geologic materials at SLAC contain serpentine or any other mineral that contains asbestos. The geology of the areas is presented in Section 4.4.

SLAC has several tunnels with a total length of about 9-km (more than 5 miles). These underground structures include the Linear Accelerator (constructed by cut and fill), the Positron Electron Project (PEP) and PEP II Tunnel (constructed by both boring and cut and fill), and the Stanford Linear Collider (SLC) Tunnel (constructed primarily by boring). The geologic materials that the existing tunnels have been constructed into are the same type of materials at the proposed LCLS Tunnel.

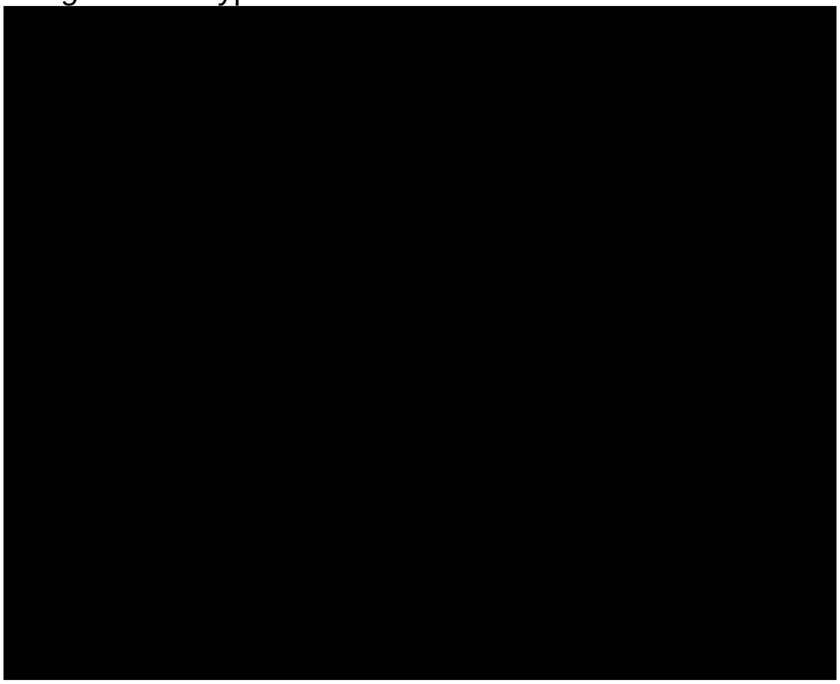
SLAC's tunnels are variously located above the water table, below the water table and at the water table. All of the tunnels are constructed with an underdrain system to prevent groundwater from infiltrating the tunnel. Where the tunnels are located entirely below the water table, groundwater infiltration is also diverted by as series of PVC pipes.

Groundwater infiltration through the pipes is small, due to the low hydraulic conductivity of the Ladera Sandstone bedrock. For example, the total quantity of groundwater infiltration into the PEP Tunnel (where submerged in groundwater) is less than 2 gallons per minute (gpm). Groundwater entering the underdrain system below the Linac and the PEP Tunnel is collected and sent to the stormwater system. Groundwater that infiltrates into the PEP Tunnel through 'weep holes' and direct infiltration is collected and sent to the sanitary sewer as a permitted discharge. All groundwater from the SLC Tunnel is discharged to the sanitary sewer as a permitted discharge.

The LCLS Tunnel is expected to be constructed by both cut and fill and boring methods. In addition to geotechnical borings that will be performed to support the LCLS Tunnel design, environmental samples will be collected to characterize the area and determine appropriate disposal for excavated materials. Much of the excavated material will be re-used onsite if the characterization data meet re-use criteria for unrestricted land use. It is anticipated that there will be 56,200 cubic yards (cy) excavated for this project with almost 94% (52,700 cy) re-used on site as clean fill. Alternately, it is expected some excavated materials may be disposed of offsite at a Class II Landfill. Estimates range between 3,000 and 4,000 cy or 6% of the excavated material will be disposed of in this manner. Soil data collected near the proposed LCLS are described in detail in Section 4.7.

Typical PEP and SLC tunnel construction is shown in Figure 11.

Figure 11. Typical SLAC Tunnel Cross Section



3.1.3 Operation

Operations at the LCLS would be focused on conducting experiments for SLAC research and to accommodate users of the FEL. The experiments generally would consist of exposing samples such as proteins or crystals to the free electron laser, and analyzing the resultant data. The Near Hall (Hall A) would be mainly used for conducting experiments. The Far Hall (Hall B) would also have experimental spaces, but would provide most of the offices and laboratory support areas.

Operations schedules are not known, but are assumed to be similar to SSRL operations, which remain open 24 hours a day, seven days a week. The LCLS can only service a single experiment at a given time, and each experiment is expected to require less than five people. Given a potential for multiple experiments in a day, setup, and closure of other experiments, a total of 60 new SLAC employees and 40 LCLS users on any given day were used for parking and office purposes.

The experiments would use a variety of materials, from crystals to biomolecules, depending on the type of experiment. Initial types of LCLS experiments are planned in the following areas:

- Structural studies on single particles and biomolecules – considered by many to be a very promising and practical growth area because evaluations today are limited by the low intensity and long pulse length of current radiation sources.
- Femtosecond Chemistry – determining molecular structure changes as a result of chemical reactions.

- Nanoscale dynamics in condensed matter – space-time correlation of material changes down to picoseconds,
- Atomic physics – evaluating electron cloud distortion in fields exceeding atomic orbit.
- Plasma and warm dense matter – this matter is found inside large planets. The LCLS can create warm dense matter using metal targets and probe the character of this matter by observing the way it scatters light.
- X-ray laser physics – research to further the advance and use of FELs and improve on design capabilities.

Ancillary and support operations would include a clean room, a vacuum shop, and a machine shop. The clean room would house laser systems. Vacuum assembly of beam line components and experimental components would also require a clean room area. The machine shop would be used for cutting, grinding and polishing experimental components. The major chemical usage at the LCLS would be within the ancillary and support operations. Based on the clean room and machine shop at SSRL with comparable operations to the LCLS, chemicals that may be used include those listed in Table 2.

Table 2. Anticipated Types of Chemicals at LCLS Clean Room and Machine Shop

Chemical Category	Example	Maximum Container Size	Typical Storage Requirements	Est. Annual Use- Routine Operations
Lubricants And oils	WD-40, Machine Oil #2	5 gallons	outside or indoor chemical storage cabinet, some may require storage as a flammable depending on flash point	25 gallons
Solvents	Ethanol, acetone	20 gallons	flammables cabinet	70 gallons
Gases	Helium, nitrogen	600 cubic feet	indoor or outdoor gas cylinder storage	5000 cubic feet
Cutting Fluids	Aluminum cutting fluid	less than one gallon	weld area chemical storage cabinet, may require flammable storage depending on cutting fluid type	5 Gallons
Paints	Primer, machine paint	one gallon	flammable or nonflammable storage, depending on paint type	10 gallons
Welding Flux	Scotch Weld	5 pounds	weld area chemical storage cabinet, may require flammable storage depending on weld type	10 pounds
Adhesives, glues	Loctite, carpenters glue	0.9 gallon	Chemical storage cabinet	1 gallon
Silica gels	Abrasive Bead Blaster	2 pounds	miscellaneous chemical storage cabinet	5 pounds

Source: Compiled from 2001 chemical inventory for SSRL machine shop and clean room vacuum assembly.

Based on the 2001 chemical inventory for the SSRL machine shop and vacuum assembly clean room, small amounts of many other chemicals could be used at the planned clean room and machine shop at the LCLS. The largest volume in this miscellaneous category is household-type cleaners. In addition to chemicals that may be used in the clean room and machine shop, lead for shielding purposes would be used. Lead storage, handling, and purchase are centralized through the use of a lead coordinator (SLAC 2000c). Beryllium would also be used in beam line components. Beryllium is often used in beam line components. SLAC has monitored airborne beryllium at machining operations since the 1970s, and no current machining operations at SLAC produce detectable levels of toxic beryllium dust (SLAC 2000d). Only the less toxic beryllium copper alloys are machined or manufactured onsite in very small amounts (usually once every 6 months). Pure beryllium components have not been machined at SLAC, and this would continue to be the case for the LCLS.

Wastes generated as a result of LCLS ancillary and support operations would be similar to wastes generated in the machine shop and vacuum room at current synchrotron experimental facilities. Based on the 2001 waste inventory for the Machine Shop at SSRL, about 200 kilograms of wastes were disposed of, including oil-filled equipment, solvent debris, oily solids, aerosol cans, and batteries. All hazardous waste would be collected for appropriate disposal within 90 days. SLAC currently uses a 15 gallon or 45 day pickup schedule for potentially hazardous waste.

Some experiments would generate small amounts of waste (for example, the metal targets in the warm dense matter experiments are less than one cubic millimeter of sample). The volume of waste generated from experiments would typically be on the order of milligrams (less than an ounce). For research that may involve potential biohazards, approval must be received by Stanford University's Administrative Panel on Biosafety. Researchers must be appropriately trained, comply with all policies and procedures specified in the ES&H Manual, complete and sign a biohazards handling agreement, and have a written response plan in the event of potential accidents (SLAC 2002). No radioactive wastes would be produced by the LCLS experiments. SLAC waste management procedures would be in effect for experimental wastes.

3.1.4 Waste Minimization and Pollution Prevention

The inherent design of the LCLS (that is, the use of several existing facilities such as the Linac and FFTB, and associated infrastructure to the extent possible) is consistent with DOE's policy on Waste Minimization and Pollution Prevention (DOE 1992a). By reusing components, LCLS would avoid and reduce the generation of hazardous substances and wastes. It is anticipated that a large percentage of the project's facility needs will be met with existing infrastructure. Beam line components not destined for reuse in LCLS would be evaluated for their salvage potential. The magnets, beam positron monitoring devices, beam containment systems, and machine protection systems (ionization chambers, monitors, temperature detectors, and microswitches) can all be re-used, and are in good working condition.

SLAC has a comprehensive site-wide Storm Water Pollution Prevention Plan (SWPPP). Pollution prevention would begin before construction, with the development of a stormwater pollution prevention plan for use during construction activities. After the LCLS project is operational, the site-wide SWPPP would be in effect, triggering the development of site-specific best management practices (BMPs). The BMPs for the LCLS would be focused on minimizing pollution in surface run-off to the storm drains.

In addition, SLAC has a comprehensive Waste Minimization / Pollution Prevention Program Plan. Chemical use and disposal would be evaluated for potential reductions in chemical type and amount, as well as specific better management practices. The Waste Minimization / Pollution Prevention Program Plan has resulted in the reduction or elimination of many targeted chemicals. SLAC was selected to receive a “2000 Environmental Quality Award” by the City of Menlo Park as the result of the elimination of a specific volatile organic solvent that was used in the Plating Shop.

3.1.5 Decommissioning

The decommissioning of the LCLS facility and equipment is not anticipated to be performed for decades in the future. Once the decision to decommission LCLS is made, a plan will be written ensuring the best available technology is used and that all closure activities are in accordance with applicable laws and regulations, as reflected in established SLAC and DOE policies and procedures. In general, the major facilities at SLAC (Linac, SPEAR, and PEP) have remained in use once constructed, and decommissioning activities are performed mainly on individual components. This pattern of continued use may apply to the LCLS as well.

For a project of this type, a comprehensive radiological survey would be performed, and if any components or materials were determined to have residual radioactivity, they would be placed in secure areas pending future reuse or ultimate disposal. Controls promoting safe storage of radioactive materials at SLAC are well developed and implemented, and are approved by DOE as being effective for protecting the environment and the public. Any radioactive materials from the decommissioning of LCLS would be stored onsite within Radiologically Controlled Areas (RCAs). RCAs are regularly monitored and managed by radiation safety professionals to ensure public safety.

Decommissioning would be expected to consist of the following two general stages: assessing the current conditions, and determining appropriate decommissioning procedures. Components would be placed into a state of protective custody, and could include the following operations: initial decontamination, disconnection of some or all operating systems, drainage of liquid-filled systems, physical and administrative controls to limit access, characterization surveys, and surveillance and maintenance, as necessary. Appropriate decommissioning procedures would be developed, and could include removal and dismantling, cleaning of equipment, materials, and buildings, as appropriate. Items could be stored for future use, or packaged according to DOT specifications, and shipped to an appropriate disposal site. The NEPA process would be used as appropriate, to assist decision-making during the decommissioning process.

3.2 Alternatives to the Proposed Action

3.2.1 No Action

Under this alternative, the LCLS program would not occur, and existing facilities at SLAC would continue to operate under current management practices. In the event that LCLS would not be built, research in the proposed areas would be stalled by current technology limitations. There is no other Linac or synchrotron in the world capable of producing a 14 GeV electron beam with properties suitable for the LCLS.

3.2.2 Siting LCLS at an Alternative SLAC Location

Under this alternative, the LCLS would be sited at another location at SLAC, still using the existing Linac. This alternative is not viable because the LCLS layout must be aligned with the axis of the Linac. It is not possible to bend the Linac beam very much without destroying its unique properties (very short bunch length, very high peak current). The proposed layout of the LCLS x-ray beam and the buildings that would house x-ray experiments must be aligned with the axis of the Linac and can not be sited elsewhere on the SLAC site. Therefore this alternative is not viable.

Another alternative would be to build the entire LCLS Facility at SLAC, including the construction of a new Linac at SLAC. The current Linac location was selected based on geotechnical and hydrologic investigations conducted prior to the construction of the existing Linac. This alternative would require substantial additional investigations, and potential environmental effects would be greater because of the additional construction of a new 1-km linac, and other key existing structures that are present at SLAC. The size of the project facility alone would be increased by a factor of ten. In addition, costs would be prohibitively high because key existing structures at SLAC would need to be duplicated.

These two alternatives were not considered reasonable, and therefore dismissed from further analysis.

3.2.3 Siting LCLS at another DOE Site

Under this alternative, the LCLS project would be built at a collaborator lab and not at SLAC. Potential sites, based on collaborator laboratories, could be Argonne National Laboratory, Lawrence Livermore National Laboratory, or Brookhaven

National Laboratory. However, none of these facilities has a 1-km linear accelerator available to accelerate electrons for the FEL.

The SLAC site is the best choice among alternative sites for the LCLS because it makes use of a portion of the two-mile Linac as the source of a high quality electron beam for the LCLS free-electron laser. There is no other Linac or synchrotron in the world capable of producing a 14 GeV electron beam with properties suitable for the LCLS.

The cost to duplicate the LCLS Linac elsewhere would more than double the proposed LCLS budget. Substantial savings would be achieved by using existing facilities at SLAC, and component re-use provides environmental advantages.

Potential environmental effects would be expected to be higher than the proposed action because a new 1-km Linac and other key existing structures would need to be built. In addition, costs would be prohibitively high because key existing structures at SLAC would not be used. This alternative is not considered to be reasonable, and is therefore dismissed from further analysis.

In summary, this report evaluates the environmental consequences of the LCLS against the No Action Alternative since no other alternatives are viable to be brought forward for analysis.

4.0 Description of Existing Environmental Conditions

4.1 Location

SLAC is located in San Mateo County, California, on 426 acres of low, rolling foothills between the alluvial plain to the east and the Santa Cruz Mountains to the west, on the San Francisco Peninsula, about halfway between the cities of San Francisco and San Jose. (See Figure 1 on page 1.)

4.2 Climate and Topography

Climate: The climate in the SLAC area is Mediterranean. The characteristic feature of this climate is dry summers. The location near the Pacific Ocean also has a moderating influence on local temperatures, causing winters to be warmer, and summers cooler, with little variation in the annual temperatures. The annual range of temperatures based on monthly averages, is 8.6 to 19.1 degrees Celsius, or 47.5 to 66.4 degrees Fahrenheit. The lowest temperatures are in January, with highest temperatures in July and August (National Climate Data Center, 2002).

Almost all precipitation occurs as rain, and the distribution of precipitation is highly seasonal. About 70% of precipitation occurs during the four-month period of December through March (National Climate Data Center, 2002). The average annual rainfall varies from just under 20 inches per year on the eastern end of SLAC to slightly over 25 inches on the western end of SLAC, based on information compiled in 1962 (Sokol 1962).

Topography

SLAC is located in the foothills of the Santa Cruz Mountains, above the alluvial plain that borders the western margin of the San Francisco Bay. The foothills of the Santa Cruz Mountains are a series of oak and grass covered rolling hills that attain a maximum elevation of about 115 meters (375 feet) above mean sea level at SLAC.

Construction of SLAC and the I-280 highway has altered local topography, although the regional topographic aspect and drainage directions have not been changed. In particular, land at the present day Research Yard at SLAC was excavated to a maximum of about 25 meters (75 feet) to maintain a constant elevation of the Linac and to provide natural shielding.

4.3 Land Use and Population

Land Use

The area occupied by SLAC is developed for research use. The land for the LCLS has been developed, and currently contains offices and laboratories used for high-energy physics experiments. Areas adjacent to buildings are generally used for parking, and are covered with asphalt/concrete pavement. Undeveloped land and landscaping are adjacent to research areas.

Land adjacent to SLAC includes intermixed residential, commercial, agricultural, and undeveloped areas. SLAC is bordered by Sand Hill Road to the north, with the commercial/residential development of Sharon Heights across the street. Neighboring areas to SLAC also include residential (Stanford Hills), commercial (Portola Valley Training Center), agricultural (Webb Ranch and Portola Valley Training Center), and undeveloped areas, in particular the Jasper Ridge Biological Preserve to the south, which is operated by Stanford University.

Population

SLAC is established as a DOE National User Facility. Many researchers come to SLAC for short periods to participate in scientific or experimental programs at SLAC. The User Lodging Facility is planned to be completed in 2003 to provide affordable and convenient short-term accommodations for researchers. The planned facility would be a three-story structure with about 100 rooms.

The populated area around SLAC is a mix of condominiums, apartments and single-family housing. SLAC is surrounded by 6 communities: Atherton, West Menlo Park, Woodside, Portola Valley, Stanford, and Palo Alto. Population data from U.S. Bureau of Census 2000 results are presented for the surrounding communities in Table 3. In addition, approximately 1,700 workers are on the SLAC premises on an average weekday.

Table 3. Demographic Data for the Area Surrounding SLAC

Geographic Area	Population (persons)	Population Density (per square mile)	Housing (units)	Land Area (square miles)
Atherton	7,194	1,470	5,505	4.90
W. Menlo Park	3,629	6,492	1,451	0.56
Portola Valley	4,462	648	1,772	9.16
Palo Alto	58,598	2,255	26,048	25.99
Woodside	5,352	456	2,030	11.74
Stanford	13,315	4,833	3,315	2.76
Total	92,550	not applicable	37,091	55.09

Source: 2000 U.S. Bureau of Census Population Data

4.4 Geology, Soils, and Seismic Conditions

This section describes the geology at SLAC, from oldest to youngest rocks. The soil is then described, followed by a summary of seismic conditions in the area.

Geology

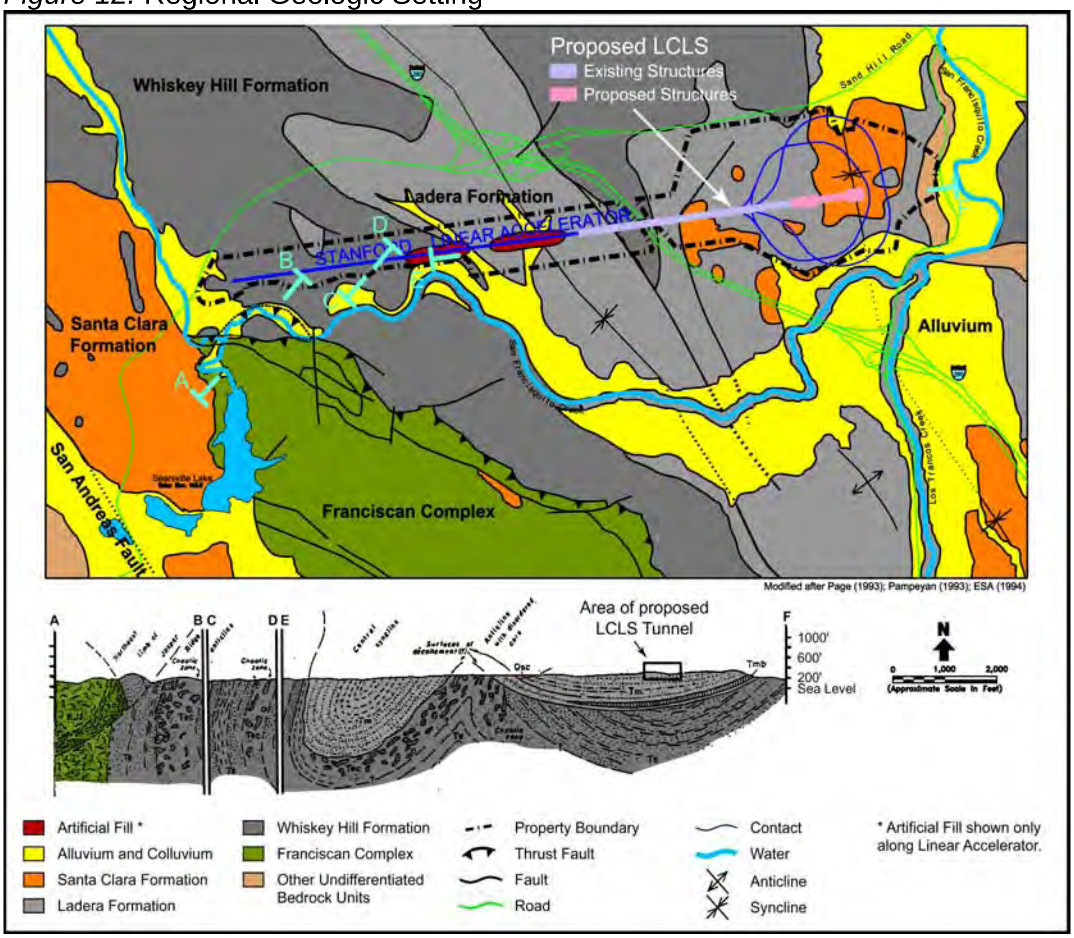
SLAC is located on bedrock uplands east of the Santa Cruz Mountains and west of San Francisco Bay. The basement rocks (oldest rocks) in the entire area are the Franciscan Complex, an assemblage of greywacke, greenstone, chert, and serpentine that are at least 138 million years old. Due to complex folding and faulting, these basement rocks crop out in Jasper Ridge Biological Preserve south of SLAC.

The predominant geologic formations at SLAC are two bedrock marine sedimentary units, the Eocene Whiskey Hill Formation (55 to 38 million years old) and the Miocene Ladera Sandstone (24 to 5 million years old) (Page and Tabor 1967, Pampeyan 1993, and Page 1993). Based on regional information, these rocks are estimated to be in excess of 2000 feet thick at SLAC. These units are folded sandstones, siltstones and some claystones, weakly to moderately well cemented, that formed in a shallow water marine environment. Small fractures are common that may be filled with gypsum. The older Whiskey Hill Formation crops out in the western part of SLAC. The younger Ladera Sandstone crops out predominantly in the eastern part of SLAC.

The Whiskey Hill Formation and Ladera Sandstone are overlain locally by thin and isolated remnants of the Santa Clara Formation, a terrestrial sedimentary unit composed of unconsolidated sands, silts and gravel deposits, and by recent alluvium associated with San Francisquito Creek.

The LCLS Tunnel is expected to be constructed primarily in the Ladera Sandstone beneath the surficial deposits of the Santa Clara Formation. A geologic map of SLAC is shown in Figure 12.

Figure 12. Regional Geologic Setting



Soils

Soils at SLAC are based on a US Department of Agriculture mapping in 1991 (USDA 1991). Designated soil groups at SLAC are defined by the USDA as:

- *Accelerator-Fagan Association and Accelerator-Fagan Urban Complex:* These are the main soils at SLAC, and consist of clay-loam soils. They formed in material weathered from softer sandstone and siltstone at SLAC. Permeability is moderately low to low, with available water capacity being moderately high to high.
- *Botella Loam and Botella-Urban Land Complex*: These are thicker and better drained soils that formed from unconsolidated sediments, such as alluvial materials that are locally found at SLAC.
- *Urban Land Association*: These are areas where no soil exists or where more than 85 percent of the surface is covered by asphalt, concrete, or buildings.

Seismic Conditions

The area is part of an active tectonic area, with the San Andreas Fault located about a mile west of SLAC. The United States Geological Survey (USGS) estimates that there is a 21 percent chance that there would be one or more earthquakes of magnitude 6.7 or greater along the San Andreas Fault in the next thirty years. If the probability for an earthquake greater than 6.7 magnitude for major faults in the San Francisco Bay area is added together, there is a 70 percent chance that one or more earthquakes of this magnitude would occur in the 30 year time period. These probabilities are estimates based on past earthquakes frequency determined from rock core samples, and may vary by ten percent (USGS 2002).

4.5 Air Quality

This section describes SLAC's non-radiological air program. Air monitoring for radiological parameters is presented in Section 4.8.2.

SLAC is subject to air quality regulatory programs administered by the Bay Area Air Quality Management District (BAAQMD) for permitted and exempt sources, USEPA Region 9 for solvent cleaning, ozone depletion requirements, community 'Right-to-Know' requirements, and San Mateo County for accidental releases. SLAC has a total of 38 current sources listed in its BAAQMD facility-wide permit, including 31 permitted and 7 exempt sources. The San Francisco Bay Area was designated as a non- attainment area for ozone in 1998.

On October 20, 1999, BAAQMD adopted revisions to regulations that made SLAC subject to BAAQMD Title V permitting program. Pursuant to these regulations, SLAC applied for a Synthetic Minor Operating Permit (SMOP) on June 1, 2000. SLAC's SMOP application was approved by the BAAQMD July 2002, and became effective as of that date.

The SMOP imposes new facility-wide emissions limitations for such chemicals as VOCs, hazardous air pollutants (HAPs), paints and coatings, and epoxies and adhesives. The SMOP emissions limitations are above SLAC's actual baseline emissions as determined by an air emissions inventory performed during 1999 and 2000. The incremental increase in air emissions associated with the LCLS project, when combined with the existing baseline emissions, is not anticipated to cause SLAC to exceed or even approach the SMOP emission permit limitations.

4.6 Hydrology

4.6.1 Surface Water

SLAC is located within the San Francisquito Creek Watershed, which encompasses an area of approximately 40 square miles and extends from the Santa Cruz Mountains to the San Francisco Bay. Creeks that are part of the watershed include Bear Creek, Martin Creek, Corte Madera Creek and Los Trancos Creek. The watershed traverses five municipalities (Palo Alto, East Palo Alto, Menlo Park, Portola Valley, and Woodside), and portions of both Santa Clara and San Mateo counties (CRMP 2002).

San Francisquito Creek flows easterly near the southern border of SLAC, and joins with Los Trancos Creek before turning northeast and eventually discharging into San Francisco Bay. The headwaters for San Francisquito Creek are found along the foothills of the Santa Cruz Mountains where several streams coalesce. The ultimate source of streamflow is runoff from precipitation in the Santa Cruz Mountains, a portion of which is captured in Searsville Lake.

Searsville Lake is located about 1,500 feet south of SLAC's western boundary in Jasper Ridge Biological Preserve (previously shown on Figure 1). This lake was created as a result of Searsville Dam, which was built in 1892 for flood control and was used in the past as irrigation supply. Searsville Lake is upstream of SLAC.

4.6.2 Groundwater

The LCLS is not expected to impact current groundwater conditions during or after its construction. Groundwater at SLAC is bedrock groundwater from the thick sequence of marine sandstones that dominate SLAC's geology. This groundwater has naturally high total dissolved solids, sulfate and chloride levels that make it unsuitable for drinking. In addition, the bedrock has low hydraulic conductivity, and well yields are too small (less than 60 gallons per day) to provide a single private well with adequate supply (SLAC 2001b). Aquifers downgradient of SLAC are from the unconsolidated sediments of the Santa Clara Formation, and recent alluvium that do not occur in sufficient saturated thickness at SLAC to form an aquifer. Groundwater is not used as a water supply source at SLAC. The closest downgradient well to SLAC is located about 500 feet south of SLAC, along the stream margin of San Francisquito Creek, across the creek from SLAC. The well is used for agricultural purposes.

The general regional pattern for groundwater flow for the entire SLAC site is easterly toward San Francisquito Creek, which occurs both south and east of SLAC. Groundwater gradients and elevations at SLAC have been modified locally by earthwork associated with the grading and construction of the SLAC facility. In addition, local gradients and groundwater elevations have been altered to varying degrees by the presence of three major underground structures at SLAC:

- Linac (Linear Accelerator)
- Positron Electron Project (PEP) Tunnel
- Stanford Linear Collider (SLC) Tunnel

The Linac, PEP Tunnel, and SLC Tunnel are large-scale underground structures constructed in the Whiskey Hill Formation and the Ladera Sandstone. The Linac extends approximately 12 meters (about 35 feet) below ground surface. A drainage system was constructed below the Linac to control groundwater infiltration. This system collects about 3 gallons per minute of groundwater from Sectors 20 to 30 (Figure 13) that is discharged to the storm drain system

The SLC and PEP Tunnels also have drainage systems constructed beneath the tunnels to limit groundwater influx into the tunnels. The PEP tunnel was constructed by both boring and excavation and excavation methods. The SLC tunnel was primarily by boring into the bedrock, and was only excavated at specific areas.

Groundwater elevation data are limited in the area of the PEP and SLC Tunnels; thus the effects of these structures on local groundwater flow patterns are not defined.

Fractures and Local Groundwater Flow

Fractures occur in outcrop and in core samples within the bedrock Ladera Sandstone and Whiskey Hill Formation at SLAC. However, fractures do not appear to be a significant preferential flow pathway at the SLAC site based the small size of observed fractures and that are generally disconnected (SLAC 2001b).

4.6.3 Floodplains and Wetlands

Examination of the most recent Federal Emergency Management Agency (FEMA) floodplain maps for the area indicates that no area of SLAC is located within the 100-year floodplain (FEMA 2002). As shown in Figure 14, the 100-year flood would be confined to the current channel of San Francisquito Creek that is located south of SLAC.

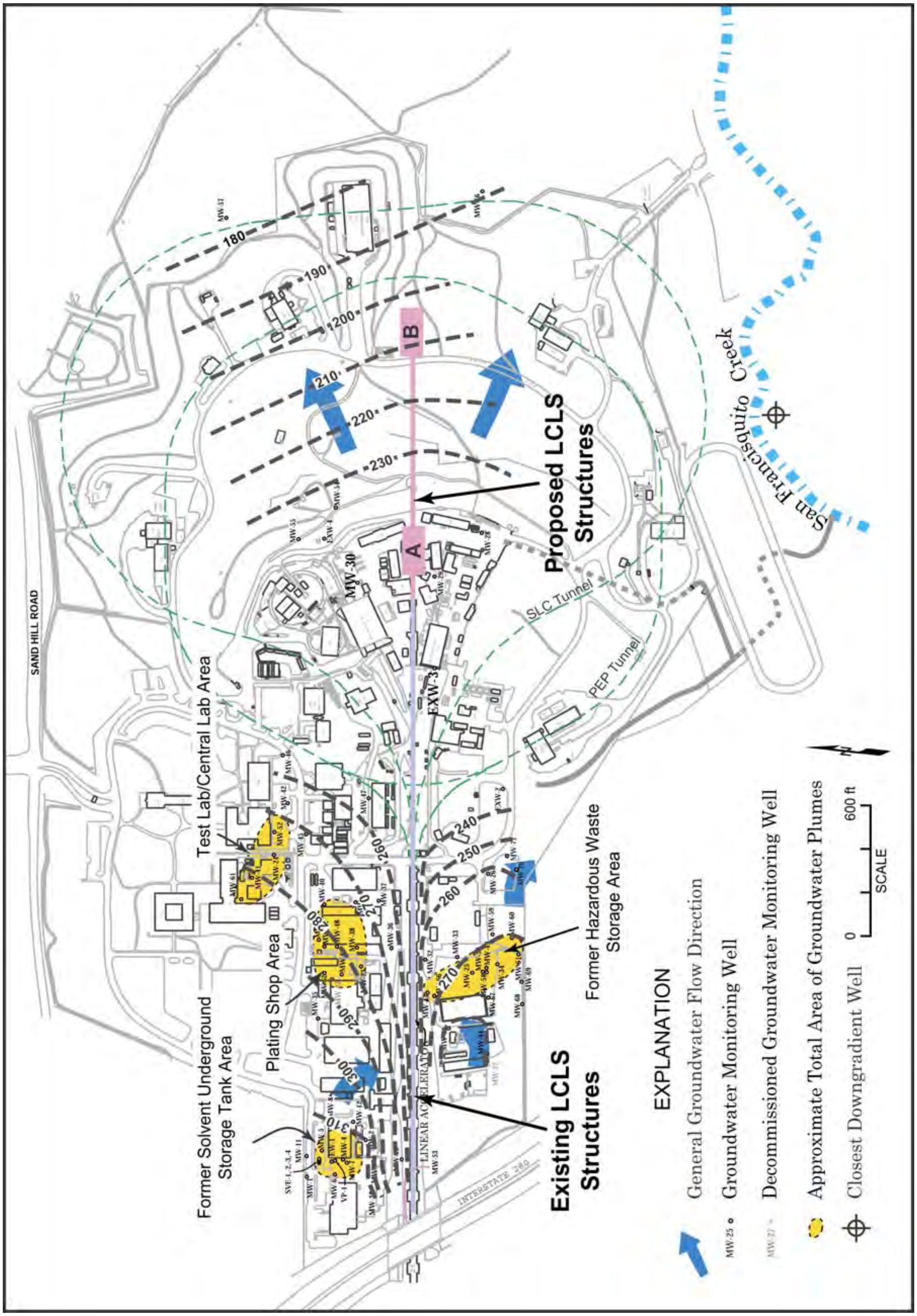


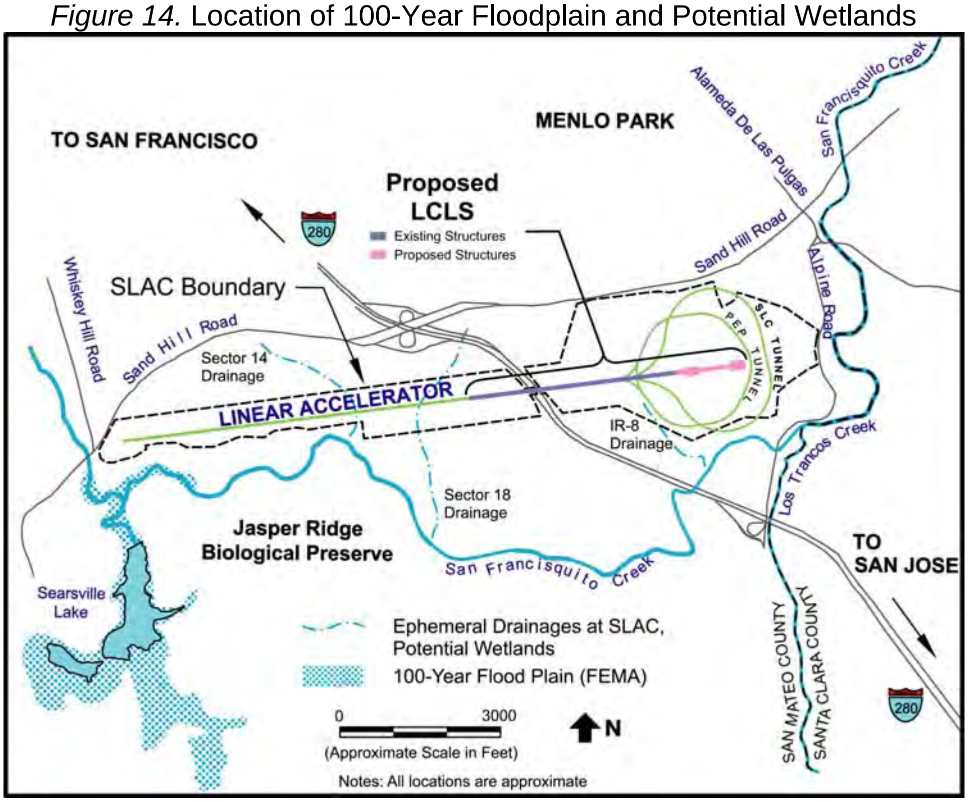
Figure 13. Groundwater Flow and Groundwater Investigation Areas

In addition, a study conducted in 1974 estimated the flood plain that would result from maximum catastrophic failure of Searsville Dam upstream of SLAC (Delta Consulting Engineers 1974). This floodplain would represent about six times the 500-year peak flow for both San Francisquito Creek and Los Trancos Creeks (which is completely downstream of SLAC), based on data collected by Santa Clara Valley Water District (Santa Clara Valley Water District 1987). Even the maximum catastrophic release of water from failure of the dam would not encroach on the SLAC Facility, except for one ephemeral drainage area by SLAC's Linac Sector 18.

There are several natural ephemeral drainages that drain to San Francisquito Creek at SLAC that are possible wetlands. Four drainages traverse the Linac, and were modified during construction of the Linear Accelerator to flow underneath the Linear Accelerator. Representatives from the Army Corps of Engineers and Department of Fish and Game stated during an onsite visit in 1998 that the drainage near Sector 18 of the Linac appears to be a wetland (SLAC 2001a).

SLAC is currently operating under the assumption that wetlands may exist within and adjacent to San Francisquito Creek drainages (SLAC 2001a).

Figure 14. Location of 100-Year Floodplain and Potential Wetlands



The Army Corps of Engineers generally considers significant wetlands as being greater than 10 acres. By comparison, the total potential wetland acreage from all ephemeral drainage areas is less than one acre of SLAC's 426-acre lease holding.

4.7 Soil and Groundwater Quality at SLAC

This section summarizes soil and groundwater conditions at SLAC for non-radiological chemicals. Radiological parameters are discussed in Section 4.8.

SLAC is not on the National Priority ('Superfund') List. Evaluation by the United States Environmental Protection Agency, Region 9 (USEPA), in 1987 and 1992 determined that SLAC was in the category of 'No Further Response Action Planned' (USEPA 2001).

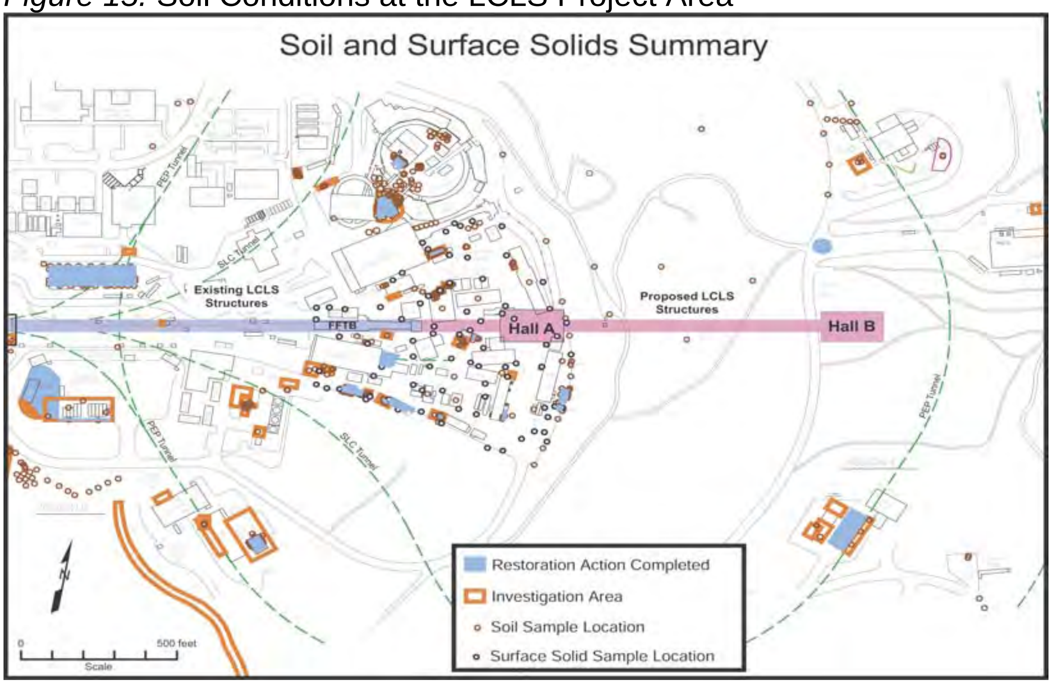
SLAC is following a site-wide process developed in 1992 for the identification of areas requiring restoration (ESA 1993 and SLAC 1993). These areas are generally divided into 'soil-only sites' that primarily contain low levels of polychlorinated biphenyls (PCBs), and 'groundwater sites' with primarily volatile organic compounds (VOCs). The PCBs are present as a result of their past use in electrical equipment, and the VOCs are associated with past chemical use in the support function of fabrication activities (i.e. plating shop).

The San Mateo County Department of Environmental Health Services Division provides oversight of sites where only soils are concerned. The Regional Water Quality Control Board (Regional Board) provides oversight of groundwater.

Subsurface Material

SLAC sampled soil and bedrock near the LCLS project area as part of site characterization activities (Figure 15). Subsurface materials in the area of the tunnel and the Far Hall (Hall B) are expected to represent natural background conditions because no site activities have occurred in this area (Converse 1995).

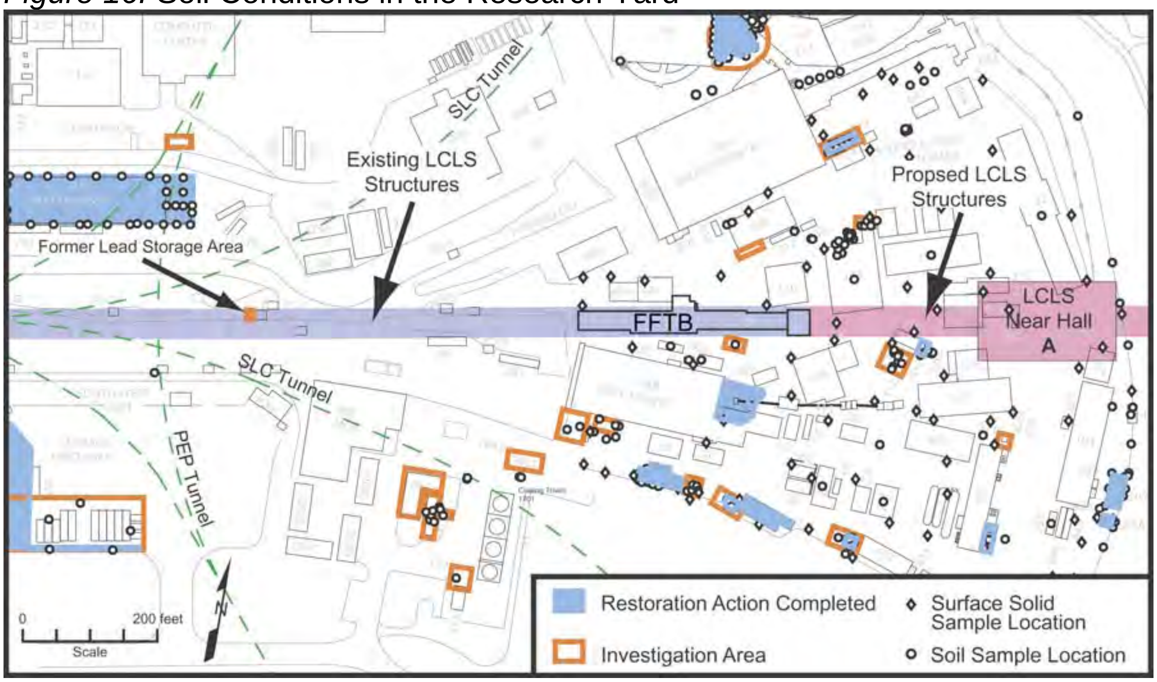
Figure 15. Soil Conditions at the LCLS Project Area



In the Research Yard, subsurface materials have been affected by the presence of low levels of PCBs, petroleum hydrocarbons, lead and volatile organic chemicals. The most prevalent chemical is PCB. Several restoration activities have been completed in the research yard.

Figure 16 presents a close up view of soil and sediment data in the Research Yard. There is a lead storage area within the proposed LCLS, as shown by the small orange box along the proposed LCLS alignment. Based on other lead storage area investigations, there may be small quantities of lead present in the surface soil within the immediate vicinity. The closest potential source area of PCBs to the LCLS was removed in Fall 2001. No point sources for PCBs have been identified in the LCLS Area based on review of historical operations and random sediment sampling. Based on sediment data collected within the Research Yard at SLAC, low levels of PCBs are likely to be found in the area of the LCLS Near Hall (Hall A). . Soil with detectable PCBs requires disposal at a Class II Landfill.

Figure 16. Soil Conditions in the Research Yard



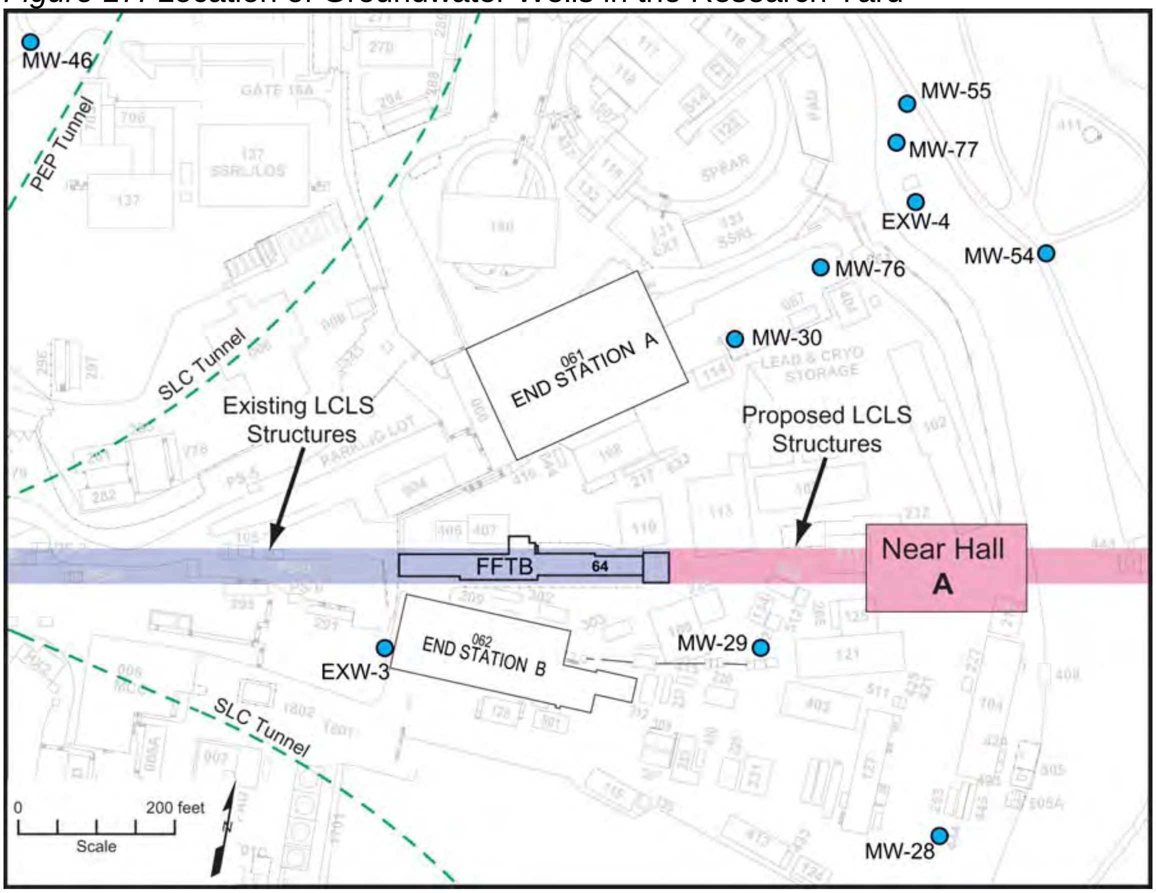
Groundwater

Four groundwater sites (previously shown in Figure 13) have been identified based on the site-wide characterization data and priority ranking process described in Section 2.7. These areas are:

- Former Solvent Underground Storage Tank (FSUST) Area
- Former Hazardous Waste Storage Area (FHWSA)
- Plating Shop Area
- Test Laboratory and Central Laboratory (TL/CL) Area

These sites are in an investigation and/or restoration process. In addition to the groundwater sites, SLAC has a site-wide monitoring program for groundwater. The construction and operation of the LCLS is not expected to affect groundwater. Groundwater beneath the proposed LCLS tunnel and halls are expected to represent background conditions. Groundwater in some areas of the Research Yard contains detectable levels of freons and tritium that are below the drinking water standard. Tritium in groundwater is discussed in Section 4.8.2, *Contributions to Background Radiation Levels from SLAC Operations*. Groundwater wells in the vicinity of the LCLS in the Research Yard are shown on Figure 17.

Figure 17. Location of Groundwater Wells in the Research Yard



4.8 Radiological Aspects

This section describes basic radiological information for the SLAC facility. A brief description of natural background is presented to compare the background level to data from SLAC's radiation monitoring program. Worker health and safety is a primary objective at SLAC. In addition, environmental monitoring is performed for air, solids, and groundwater.

4.8.1 Natural Sources of Radiation and Background

Radiation from natural sources permeates the universe and is an inherent aspect of life on earth. All living things are continuously exposed to this natural radiation, both externally from cosmic radiation and natural radioactive material in the earth, and internally from natural radioactive materials taken into the body via air, water, and food. The public also receives, and generally accepts the risks associated with, radiation exposure from medical x-rays, nuclear medicine procedures, and some consumer products (for example, tobacco, building materials, and some water supplies).

The standard unit in the United States for expressing the amount of radiation received or absorbed is the millirem (mrem). As shown in Table 4, an average member of the public in the United States receives 300 millirem per year (mrem/year) from natural sources of radiation and 60 mrem/year from human-made sources (NCRP 1987a, NCRP 1987b), for a total of approximately 360 mrem/year, or 1 mrem/day.

The data presented in Table 4 are approximations and are subject to some variation. For example, the radiation dose from cosmic radiation at sea level in the United States averages 32 mrem/year with a range of 25 to 50 mrem/year, depending on geographic location. By comparison, the radiation dose from cosmic radiation at an altitude of approximately one mile, such as on the Colorado Plateau, averages 63 mrem/year, with a range of 50 to 100 mrem/year, dependent on altitude (NCRP 1987a, NCRP 1987b).

Table 4. Natural and Human-Made Sources of Radiation Exposure to the Public

Source of Radiation	Annual Average Dose (mrem/yr)	Type of Radiation Source
Natural	60	Cosmic, Primordial and Cosmogenic
Natural	40	Internally-deposited (not including radon or radon daughters
Natural	200	Internally deposited radon and radon daughters
Medical Procedures	50	Human-Made
Consumer Products	10	Human-Made

Source: NCRP 1987a and NCRP 1987b

Exposure to some types of radiation, both human-made and natural, is voluntary or can be controlled. Average dose equivalents to individual members of the public from medical x-ray examinations can range from one mrem for an extremity examination to over 400 mrem for a barium enema (NCRP 1987a). A 5-hour jet flight across the US can result in a dose equivalent of 3.5 mrem, due primarily to cosmic radiation (NCRP 1995).

4.8.2 Contributions to Background Radiation Levels from SLAC Operations

High-energy particles are absorbed by design at nine locations at SLAC: the Beam Switch Yard (BSY), the Positron Source (PS), the Final Focus Test Beam (FFTB) dump, the damping rings (DR), the Next Linear Collider Test Accelerator (NLCTA), the Positron-Electron Project II (PEP-II) facility, the Linac, the SSRL facility, and Beam Dump East, which is associated with End Station A. A Beam Dump device consists of a thick barrier designed to absorb the remaining energy of a particle beam after the beam is no longer usable for research, in a manner protective to people and the environment. All of the areas listed above are areas of deliberate and controlled beam loss. “Beam loss” is an expression indicating the controlled transfer of energy from a beam for research usage at a experiment station and/or removal of energy from no-longer usable particle beams to help promote radiation safety. These areas are also potential sources of residual radiation and detectable radioactive gas emissions.

These potential sources of radiation are discussed in terms of their potential environmental effects in the following areas:

- External radiation exposures at the SLAC boundary
- Radioactive air emissions (gases)
- Surface water runoff and groundwater
- Soil

External Radiation
Seven real-time electronic monitoring stations measure and record doses from x-rays and neutrons at or near the SLAC site boundary. Signals from these monitoring stations are fed into a central control station. The monitors measure both background radiation from natural sources and any faint environmental radiation associated with SLAC operations. In addition, SLAC has a site boundary environmental monitoring program that uses solid state dosimeters to integrate measurements of x-ray and neutron radiation doses. The radiation dose above background was 5.3 mrem in 2001 to a hypothetical maximally exposed member of the general public at the boundary monitoring stations, assuming residency for 24 hours per day, 365 days per year. The five-year average dose to the maximally exposed individual is 4.8 mrem per year (R. Sit, personal communication, March 2002).

Radioactive Gases
In compliance with the National Emissions Standards for Hazardous Air Pollutants (NESHAPs), a report prepared by SLAC calculated the maximum release levels of airborne radionuclides from the nine areas discussed above, using the USEPA-approved software code CAP88-PC, Version 2.0, 2001. These calculations yielded a theoretical dose of 0.032 mrem/year, to a maximally exposed individual, which represents less than one percent of the NESHAPs standard of 10 mrem/year, as discussed in the SLAC Annual Site Environmental Report (SLAC 2001a).

As described above, the total naturally occurring dose to the public from background sources is about 300 mrems per year, and SLAC's total contribution of 5.3 mrems to a hypothetical maximally exposed individual represents less than 2 percent of the background levels.

Surface Runoff and Groundwater
The possibility of radioactivity in surface water runoff and groundwater, along with potential activation in soils and sediments, has been addressed at SLAC. Tritium is the primary radionuclide of interest in water, while gamma-emitting species are the potential concern in soil. Surface water and groundwater are routinely monitored, and the data indicate that there have been no offsite releases of radioactive substances.

Groundwater sampling for tritium was initiated in 1967 in well EXW-4 (formerly Well-24). The data since January 1992 show levels of tritium decreasing from 16,700 picocuries per liter (pCi/L) to 7,350 pCi/L through November 2001. By comparison, the Environmental Protection Agency's safe drinking-water standard for tritium is 20,000 pCi/l. EXW-4 is next to a high-power device that absorbs the last of the unused energy of the beam from the nearby End Station A. Additional groundwater monitoring wells have been installed around EXW-4, and near other electron beam termination facilities. Tritium above the detection limit (300 pCi/L) has only been detected in groundwater at one other well (MW-30), which is located east of End Station A.

Soil
Excavation areas are routinely assessed and analyzed for radionuclides. Characterization samples of surface soils and gamma spectral analyses done to date have not indicated any onsite or offsite radioactivity associated with SLAC accelerator operations. Only naturally occurring radionuclides have been detected in soil and sediment environmental samples taken around the SLAC site.

4.9 Vegetation and Wildlife

The undeveloped portions of SLAC have vegetation that is characteristic of both grasslands (perennial and annual) and oak woodland plant communities. Annual grasses in these areas include bromegrass (*Bromus spp.)*, wild oats (*Avena spp.)*, fescues (*Festucca spp)*, bentgrass *(Agrostideae spp.)*, and foxtail (*Agrostis spp.*). Occasional oak trees and groves of oak and hemlock occur on the north slopes and in tributary drainages. Common plants in this upland habitat type include valley live oak (*Quercus lobata*), coast live oak (*Quercus agrifolia*), purple needle grass (*Stipa pulchra*), mustard (*Brassica campestris*), and bull thistle (*Cirsium vulgare*).

The adjacent San Francisquito Creek and other perennial drainages support a thick growth of willow, hemlock, oak, and considerable brush, primarily coyote brush (*Baccharis*). Jasper Ridge, located outside of SLAC's southwestern boundary, is thickly wooded on the north side with madrone, fir, and some redwood, as well as oak, hemlock, and willow. Jasper Ridge would not be affected by LCLS.

Fauna associated with the undeveloped portions of SLAC include small rodents, numerous passerine birds, and mourning doves. Mule deer are the largest herbivorous browsing mammal observed in the area. The Western Meadowlark, California Quail, and common shrews are representative of small omnivores expected to occur at SLAC. Skunks, raccoons, bats, barn swallows, garter snakes, rattlesnakes, and arboreal salamanders are representative of first level carnivores that could occur at the site. The American kestrel and red-tailed hawk are also expected to occur at SLAC (SAIC 1991). Other large predators that may be found at SLAC include red and grey foxes. SLAC personnel have also reported seeing bobcats, coyotes, and mountain lions. Feral cats are present at SLAC and represent an additional predator.

Special status plant species are generally associated with specific rock and soil types (e.g. serpentine) and these rock and soils are not present within the SLAC leaseholding.

Threatened and Endangered (Sensitive) Species
Stanford University's Center for Conservation Biology performed a series of surveys in 1997, 1998, and 1999 to assess the condition and distribution of key biotic resources within the San Francisquito Creek watershed, including several transects at SLAC. The survey area included Searsville Lake, San Francisquito Creek, and several other creeks in the San Francisquito Creek watershed upstream and downs stream of SLAC. The surveys included the use of GPS/GIS, night surveys for amphibians, electrofishing, trapping, and netting. Genetic samples of steelhead trout were also taken for analysis in 1998. These creek surveys also generated location-specific data used to create distribution maps and gain baseline information (Launer and Holtgrieve 2000 and Westphal, Seymour, and Launer 1998).

The results of this work suggest that three special-status species may occur on or immediately adjacent to SLAC: the California red-legged frog (*Rana aurora, subspecies draytonii*), the San Francisco garter snake (*Thamnophis sirtalis tetrataenia*), and the steelhead trout (*Oncorhynchus mykiss*). All three of these identified species are aquatic or semi-aquatic species associated with San Francisquito Creek and ephemeral drainages that are not located near the LCLS Experimental Halls or Tunnel.

In addition to the evaluation of the San Francisquito Creek area, Stanford University Natural Resource Inventory (SUNRI) maintains a detailed inventory of special-status species that have been observed on Stanford University property (SUNRI 2000). A list of all special-status species that are expected to occur on Stanford University property is presented in Table 5.

Table 5. List of Special-status Species Expected to Occur on Stanford University Lands

Species	Common Name	Current Status: Federal (F) or State (S) Listing	Habitats	Location and relation to SLAC
Thamnophis sirtalis tetrataenia	San Francisco Garter Snake	endangered (F); endangered (S)	Terrestrial and Aquatic – Freshwater	Northeastern edge of species distribution. Stanford Campus specimens may be genetic intergrades with common garter snake. Possible at SLAC, but never sighted.
Clemmys marmorata	Western Pond Turtle	denied protection (F); special concern (S)	Aquatic - Freshwater	San Francisquito drainage from Searsville Dam to Stanford Golf Course and shopping center Possible in SLAC's ephemeral drainages, but never sighted.
Amblystoma tigrinum californiense	California Tiger Salamander	candidate (F); special concern (S)	Aquatic - Freshwater	Lake Lagunita to Stanford Campus Possible in SLAC's ephemeral drainages, but never sighted.
Rana aurora draytonii	California Red-Legged Frog	threatened (F) special concern (S)	Terrestrial and Aquatic - Freshwater	San Francisquito Drainage Possible in SLAC's ephemeral drainages, but never sighted.
Rana boylii	Foothill Yellow-Legged Frog	may be subject to emergency listing (F); special concern (S)	Terrestrial and Aquatic – Freshwater	Formerly in upper San Francisquito Drainage and at Stanford Foothills Possible in SLAC's ephemeral drainages, but never sighted.
Ischnura gemina	San Francisco Forktail Damselfly	Denied protection (F); status unclear (S)	Terrestrial	Distribution is poorly known Unknown at SLAC.
Oncorhynchus mykiss	Steelhead Trout	threatened (F)	Aquatic - Freshwater	San Francisquito Creek Watershed Trout not likely in SLAC's ephemeral drainages.

Species	Common Name	Current Status: Federal (F) or State (S) Listing	Habitats	Location and relation to SLAC
Accipiter striatus	Sharp-Shinned Hawk	special concern (S)	Terrestrial	Breeds on Stanford Campus two miles from SLAC Not sighted at SLAC
Athene cunicularia	Burrowing owl	may be subject to emergency listing (F); special concern (S)	Terrestrial	Occasional record from Stanford two miles from SLAC Not sighted at SLAC.
Eremophila alpestris actia	California Horned Lark	former candidate (F) status unclear (S)	Terrestrial	May breed adjacent to Stanford Campus Not sighted at SLAC.
Tadaria brasiliensis	Mexican Free-Tailed Bat	special concern (S)	Terrestrial	Many buildings on Stanford campus (common in area; highly colonial) Not in developed portions of SLAC.
Plecotus townsendi	Townsend's Big-Eared Bat	status unclear (F) special concern (S)	Terrestrial	Stanford Campus (one record); sensitive to human intrusion; inhabits old building and caves Not in developed portions of SLAC
Antrozous pallidus	Pallid Bat	special concern (S)	Terrestrial	Old records on Stanford Campus; arid areas Not in developed portions of SLAC
Myotis lucifugus	Little Brown Bat	special concern (S)	Terrestrial	Possible in Green Library Roof; inhabits caves or large trees with cavities Not in developed portions of SLAC

Source: Stanford Natural Resources Inventory 2000, and SLAC 2000a

`http://ccb.stanford.edu/sunri/frontpage1.html`

Evaluation of potential bats at SLAC was a study initiated by Stanford's Center for Conservation Biology in the summer of 2000. Results are not yet available; however, no bats have been observed in the Research Yard Buildings. Animals observed living in the Research Yard include swallows nesting on the eaves of end stations (returning each year around April), ravens, and pigeons. Raccoons, opossum, snakes, and skunks pass through, but do not reside in the Research Yard (Sandy Pierson, personal communication, 2002).

Habitats

U.S. Fish & Wildlife Service designated over four million acres of California, including San Francisquito Creek, as critical habitat for the California red-legged frog on March 6, 2001. In addition, the National Marine Fisheries Service officially designated critical habitat for steelhead trout, including San Francisquito Creek and its tributaries downstream of Searsville Lake effective March 17, 2000.

Critical habitat does not occur at SLAC. Critical habitats are defined as those areas possessing the physical or biological features essential to the conservation of a particular species that requires special management considerations or protection. Critical habitats may include adjacent riparian areas that provide the following functions: shade, sediment transport, nutrient or chemical regulation, stream bank stability, and input of large woody debris or organic matter. The Research Yard, LCLS Tunnel area and Far Hall are located on developed land that is disturbed, or topographically and spatially distinct from San Francisquito Creek, and therefore are not critical habitat.

4.10 Cultural and Paleontological Resources

The Stanford University Staff Archaeologist compiles and maintains maps and detailed descriptions of all archaeological sites known on Stanford property, many of which lie along San Francisquito Creek. The Staff Archaeologist was consulted regarding the potential for cultural resources for the proposed LCLS project. Although there are several prehistoric lithic archaeological sites at SLAC, none are in the LCLS project location (Dr. Laura Jones, personal communication, 2002).

There are no designated historic register landmarks at SLAC. The LCLS project would be accomplished within the existing SLAC boundary; therefore, no state or federal historic properties would be affected by activities at SLAC, and no further DOE action is required to comply with Section 106 of the National Historic Preservation Act.

Potential paleontological resources exist near the LCLS. In October 1964, during the excavation for the linear accelerator beam switchyard in SLAC’s Research Yard, the fossil skeleton of an ancient sea mammal was unearthed at SLAC. The mammal, Paleoparadoxia, is a member of an extinct family of large herbivorous marine mammals that inhabited the northern Pacific coastal region during the Miocene epoch (20 to 10 million years ago). This specimen was excavated, and a replica is on display at the SLAC Visitor Center, with the original donated to the Museum of Paleontology at University of California-Berkeley (SLAC 1998b). This specimen is the only complete post-cranial skeleton of Paleoparadoxia discovered in North America. The Miocene sedimentary rocks that are present in this area contain abundant shell fragments and occasional shark teeth, as well as other fossils.

4.11 Utilities (water supply, sewer, and electricity)

The LCLS would result in a slight increase in water, sewer, and energy use at SLAC, but these increases are within SLAC's current capacity to provide these resources.

The City of Menlo Park Municipal Water Department furnishes the water supply at SLAC. The ultimate source of this water is from the City of San Francisco-operated Hetch-Hetchy aqueduct system from reservoirs in the Sierra Nevada.

Use of water at SLAC averages about two-thirds for cooling equipment (such as the Linac) and one-third for domestic water uses (such as irrigation and drinking water) Water consumption for SLAC in 2001 was about 101 million gallons. The LCLS is anticipated to increase water use by 5% over the current average use.

SLAC's wastewater is discharged to the sanitary sewer under three separate discharge permits (Permit Numbers WB970401-F, WB970401-P, and WB970401-HX) issued jointly by the South Bayside System Authority and West Bay Sanitary District. SLAC has a permitted discharge capacity of 64,000 gpd as an annual average. The current actual discharge averages around 45,000 gpd. This will increase slightly with the operation of the LCLS.

SLAC's electric power is purchased through a consortium of three Bay Area DOE labs: Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory, and SLAC. This consortium is centrally managed by the DOE Oakland Operations Office. Currently, the power is purchased from two electric power companies, the Western Area Power Administration (WAPA) and Pacificorp (Portland), and transmitted to SLAC via the Pacific Gas and Electric distribution system. SLAC's power originating from WAPA is "curtailable" by contract, which reduces its cost, but can subject the lab to brownouts at times of high summer consumption in the State. SLAC's peak power demand varies between 50 and 70 MW, depending on the experiments that are being run at the lab at any given time. The PEP rings currently consume about 20 MW, a level that would increase somewhat in the next few years as more radio frequency stations are added to the facility to improve its performance. SSRL and the SLAC campus use about 4 MW each. Total annual energy consumption is close to 400 GWH.

Electrical consumption at SLAC is not projected to increase significantly beyond current baseline projections as a result of the proposed action, since the LCLS would be using the capacity formerly used by other Linac experiments.

About 85% of the power consumed for experimental operations is dissipated into the various cooling systems as heat. Five cooling towers, with a total cooling capacity of about 80 megawatts, circulate water through heat exchangers, and by evaporation, dissipate this heat energy. A small proportion (approximately 5%) of water circulating through the cooling towers is discharged to the sanitary sewer to control the build up of solids in the water and prevent plugging of the heat exchangers.

Discharge is automatically controlled to keep the amount of solids at an acceptable level.

4.12 Traffic and Parking

Access to SLAC is provided at two locations. The main access is located on Sand Hill Road, opposite Saga Way, which is a signalized intersection. A secondary access to SLAC is provided for SLAC employees through a shared driveway (Ansel Way) off Alpine Road. The Alpine Road access has no traffic signal. Both locations have a manned security gate. The Sand Hill gate is manned 24 hours per day, 7 days per week. The Alpine gate is open Monday through Friday (excluding holidays) from 6 a.m. to 9 a.m., and 2:45 p.m. to 6:00 p.m. Within SLAC, there are public-accessible areas, and the Accelerator Area. The Accelerator Area is accessed through two security gates, one of which is manned 24 hours a day, 7 days per week.

Methods of commuting to SLAC include private vehicles, shuttle bus, and bicycle. Caltrain is a primary commute method when combined with shuttle services. Stanford's free Marguerite shuttle service operates the SLAC shuttle Monday through Friday year round, connecting SLAC to Stanford Campus destinations. The shuttle runs every 30 minutes from 7:30 to 5:50 p.m. There is also a dedicated Marguerite that runs from Caltrain/Palo Alto Station and Valley Transit Authority bus hub to SLAC twice each morning to coincide with the northbound and southbound Caltrain schedules, and vice versa in the afternoon. The City of Menlo Park also operates a free shuttle between the Menlo Park Samtrans/Caltrain station and SLAC along the Sand Hill corridor.

SLAC has approximately 1900 employees, users and graduate students with additional traffic due to visitors and vendor deliveries. Assuming each person leaves or enters the site three times per day, since many people bring lunch or use the SLAC cafeteria, 5,700 vehicle trips enter or exit SLAC on a daily basis. Approximately 90% use the main entrance on Sand Hill, and about 10% use the Alpine Road access point. Security guards posted at both gates report that there are minimal delays at the Sand Hill entrance with approach lane occasionally being fully used. Insignificant delay was observed at the Alpine entrance but with some difficulty for those turning left across oncoming traffic during the afternoon commute.

The LCLS is expected to add approximately 60 new employees and less than 40 users per day when operational.

Parking

SLAC has adequate acreage for new parking facilities; however, parking adjacent to developed areas is a priority. Additional parking has been added to the SLAC visitor lot off Sand Hill Road, and other parking areas might be added based on need.

The LCLS would not increase the need for parking outside the Accelerator Area. The LCLS has incorporated a new parking area adjacent to the Far Hall (Hall B) that would provide parking spaces for additional 70 cars. The LCLS would also try to create an additional 20 traffic spaces within the Research Yard adjacent to the planned Experimental Hall. Parking within the Research Yard is generally considered to be close to capacity.

5.0 Potential Environmental Effects of the Proposed Action and Alternatives

5.1 Proposed Action

5.1.1 Effects from Construction

Currently the LCLS calls for a three-year construction schedule, beginning in October 2005. Potential short-term environmental impacts during this time are described in this section, and include the following:

- Worker health and safety considerations
- Increased traffic
- Disassembly of existing buildings and FFTB components and associated scrap materials
- Potential paleontological resources
- Increased fugitive dust emissions and noise
- Groundwater and surface water protection considerations
- Increased hazardous materials and production of hazardous waste if LCLS components are fabricated onsite

Other than traffic, most of the potential impacts due to construction are limited to within site boundaries. In addition, potential water considerations such as erosion or increased sediment loading in surface water runoff would be addressed and mitigated in accordance with a project specific stormwater pollution prevention plan.

The LCLS Preliminary Hazards analysis describes potential hazards associated with the LCLS during design, fabrication, installation and testing phases of the project with mitigating controls for each identified hazard (SLAC 2002c). Workers may encounter hazards associated with construction activities including excavation, heavy equipment, high voltage, traffic, dust, fumes, and noise. These are addressed through engineering and/or administrative controls, and personal protection equipment. A soil management plan would be developed based on site-specific data, so worker exposure and soil disposal methods would be known. Re-use and disposal of excavated material would be based on the results of the site specific characterization data. There would be no potential radiological effects during construction.

The project will consist of two distinct phases each with 9 to 12 month durations. It is anticipated that the Near Hall (Hall A) and the tunnel extension will be constructed in 2006. The Far Hall (Hall B) and parking lot will be constructed during 2007. This will decrease traffic that results from the project by spreading it out over time. It is anticipated that there will be 2 to 3 additional trucks entering and leaving the site per day during the construction phases. In addition, there will be approximately 30 additional contractor vehicles during this time. Off-site disposal of soil will take place within one four-week period. It is expected that 9 to

12 trucks per day will be transporting soil for off-site disposal during this short period. The trucks would be leaving the site at either the Alpine or Sand Hill gates heading towards Interstate 280. The major construction traffic would be an onsite issue. Traffic at SLAC may require re-routing or temporary road closure.

Disassembly of existing buildings and FFTB components and associated scrap materials will follow procedures described in Section 3.15 Decommissioning.

One or more paleontological resources may be encountered during the boring activities for the tunnel and grading activities for either of the experimental halls. If bones or large-scale fossils are encountered, work would be stopped, and the resource evaluated by Stanford University. In the past, graduate students have been available during construction to evaluate potential resources, and this method would be pursued again for the LCLS.

Potential construction-related impacts associated with the proposed action would also include increased fugitive dust, noise from general construction activities, temporary onsite traffic disruption near the project area, and disposal of waste and debris. Emissions from excavation of soil for the experimental halls are anticipated to be below the permitting thresholds contained in Bay Area Air Quality Management District (BAAQMD) Regulation 8, Rule 40 and the toxic air contaminant risk screening trigger levels contained in BAAQMD Regulation 2, Rule 1, Table 2-1-316. Fugitive dust emissions would be mitigated by water spraying of excavations and roads.

Construction-related noise impacts would be limited to the immediate construction area. Both the Near and Far Hall will be built in areas of lower elevation where sound is buffered by the surrounding topography. In addition, there are available SLAC program that measure noise at the construction site and at the SLAC site boundary that ensure noise levels are kept within regulated limits. Any noise resulting from construction related traffic will be limited in scope and duration and will be mitigated if found to create a nuisance.

Groundwater quality will not be impacted by the construction of the LCLS. The depth to groundwater is 5-10 feet below the construction activities in the Research Yard where the Near Hall and Undulator (including the LCLS Beam Dump device) would be placed. Chemicals resulting from operations are not found in the groundwater in the area of construction. Shielding will be designed and engineered to prevent any interactions between the facility and groundwater.

Construction work for the LCLS will take place at least 1500 feet from the San Francisquito Creek. SLAC anticipates no impact from construction activities on San Francisquito Creek. Federal regulations allow authorized states to issue general permits to regulate industrial storm water or non-point source discharges. California is an authorized state and, in 1991, the State Water Resources Control Board adopted the Industrial Activities Stormwater General Permit (General Permit). SLAC filed a Notice of Intent to comply with the General Permit. The goal of the General Permit is to reduce pollution in the waters of the state by regulating storm water discharges associated with industrial activities.

The General Permit was re-issued in 1997 and SLAC follows the Storm Water Pollution Prevention Plan (SWPPP). The SWPPP includes the Storm Water Management Program (SWMP) and both generic and specific Best Management Practices (BMPs). The SWMP presents the rationale for sampling, lists the sampling locations, and specifies the analyses to be performed. A Stormwater Pollution Prevention Plan for Construction will be written for this project and will guide construction activities. This plan will primarily focus on preventing additional sediment reaching San Francisquito Creek and proper management of heavy equipment and materials storage. Once the facility is built it will be managed under the requirements of the site-wide SWPPP.

In addition, if parts for the LCLS are machined onsite, then increased activity in machine shops and the Plating Shop would increase overall chemical usage and waste. As described in Section 3.1.3, lead and beryllium components would not be machined or fabricated onsite. SLAC has an air permit with the BAAQMD for Title V Synthetic Minor Operating Permit (SMOP). This permit, which was approved by the BAAQMD July 2002, requires the reporting of emissions during construction, and then, on an annual or semiannual basis, emissions reporting due to regular operations. The incremental increase in air emissions associated with the LCLS project is not anticipated to cause SLAC to exceed or even approach the SMOP emission permit limitations.

No cultural or historical resources have been identified at the LCLS area. Wetlands, critical habitat, and threatened or endangered species are not expected to occur at the Near Hall or Far Hall construction areas due to the distance from San Francisquito Creek. The retrofitting for the injector tunnel at Linac Sector 20 and the installation of undulator magnets occur entirely within existing facilities therefore poses no additional impact.

5.1.2 Effects from Routine Operations

This section describes potential environmental effects from routine operations at the LCLS. Potential environmental hazards associated with routine operations include:

- Potential increases in air emissions
- Potential increases in traffic
- Potential increases in utilities (water, sewer, and electrical)
- Potential impact to stormwater and groundwater quality
- Potential hazardous chemicals
- Radiological aspects

Air emissions from the LCLS are projected to be below SLAC's proposed sitewide limits. There are no additional permitted sources associated with the LCLS operation at this time.

Based on a conservative estimate of 1900 employees and users with additional traffic due to visitors and vendors, about 5,700 vehicle trips enter or exit SLAC on a daily basis. Approximately 90% use the main entrance on Sand Hill Road. The LCLS is expected to add approximately 60 new employees and less than 40 users per day when operational. This increase is approximately the same as the flux in the number of SLAC employees over a year, 60 to 100 people, due to shutdowns, construction activities, temporary labor etc. Thus SLAC can readily manage the slight increase in traffic from the LCLS.

The LCLS would result in a slight increase in water, sewer, and energy use at SLAC, but these increases are within SLAC's current capacity to provide these resources.

Operations at the LCLS will not significantly impact stormwater quality. Additional vehicles may contribute increases in oil and fuel as is the case in any parking lot or roadway; however, all parking areas at SLAC are managed through Best Management Practices under the sitewide Storm Water Pollution Prevention Plan (SWPPP) to minimize potential impacts. The stormwater leaving the SLAC site is and will continue to be sampled and analyzed for potential pollutants under the SWPPP. The temperature of water leaving SLAC has been measured at various places and at different times of the year. It is always within normal range (from 15.9 to 17.6 degrees centigrade) and always colder at the site boundary than that found in San Francisquito Creek taken at the same time period. Water from the LCLS operations is limited to roof and parking lot run-off and is not expected to impact the temperature of stormwater leaving the SLAC site.

Groundwater quality will not be impacted by operations of the LCLS. The depth to groundwater is 5 to 10 feet below the Near Hall and Undulator (including the LCLS Beam Dump Device) in the Research Yard, and at least 25 feet below the base of the Far Hall. Use of chemicals in the operations of the LCLS will be in small quantities and indoors and thus unlikely to impact soil or groundwater. The closest groundwater supply well is at least 1500 feet away from the LCLS site and on the other side of San Francisquito Creek. Operations at the LCLS are very unlikely to impact this water supply well.

Potential environmental effects are described below for hazardous chemicals and radiation.

Hazardous Chemicals

Safety measures to address and assess chemical safety are based on Material Safety Data Sheets (MSDS), using a guideline of one-tenth of one percent of a toxic chemical being present in the MSDS to initiate a safety assessment. SLAC Industrial Hygienists evaluate chemical type, recommend less toxic substitutes where possible, and evaluate site specific worker exposures. Surveys are performed and medical surveillance is provided to assess long term exposures for employees who routinely work with chemicals. Fume hoods are provided where necessary, as are eyewash stations and showers. SLAC has implemented additional safety measures that include installation of nonporous workstation surfaces, elimination of eating or drinking in chemical areas, proper use of personnel protective equipment, specific chemical handling procedures for use, storage and transport of chemicals, and proper hygiene.

Any worker who may come into contact with chemicals has specific training for hazardous materials handling and disposal. In addition, SLAC provides stormwater awareness training to appropriate personnel.
Wastes expected to be generated as a result of LCLS operations would be similar to wastes generated at current experimental facilities. For example, waste management at the SSRL clean room and machine shop are on a 15-gallon/45-day pickup schedule, whichever occurs first.

There may be minor increases in air emissions from LCLS operations from small-scale solvent and facility maintenance emissions, increased fuel combustion due to space heating needs, increased refrigerant emission due to space cooling needs, and possible cryogenic and/or process gas emissions. Note, however, that these increases may not be in criteria pollutants or air toxics as defined under federal and state law, and therefore would not require emissions offsets. Metal cutting and grinding operations are classified as exempt sources for air emissions.

Radiation
Potential radiation effects from the LCLS operations are discussed below for human and environmental effects. Potential human effects are discussed separately for workers and the surrounding residential population.

The SLAC Radiation Safety Program is designed to ensure that radiation doses above background received by workers and the public shall be as low as reasonably achievable (ALARA), as well as to prevent any person from receiving more radiation exposure than is permitted under federal government regulations (DOE 1994). The main provisions of the ALARA program ensure that:

- Access to high radiation areas is controlled.
- The accelerator facilities and the associated detectors are provided with adequately shielded enclosures.
- Designs for new facilities and significant modifications incorporate dose reduction, material control, and waste minimization features in the earliest planning stages.

Several technical, operations, and administrative systems exist to implement the program, as described in the SLAC Radiological Control Manual (SLAC 1992a) and the SLAC Guidelines for Operations (SLAC 1992b).

Ionizing radiation would be generated during LCLS operations when the electrons radiate energy or interact with materials such as the beam pipe (vacuum chamber) or other components. The vacuum chamber and the concrete housing walls are designed to absorb nearly all of this radiation. Induced radioactivity in materials may persist after the beam is turned off. The level of this induced radioactivity is very low. Slightly higher levels of induced radioactivity could develop in collimators, stoppers, and other devices specifically designed to intercept and absorb rather than transmit, part or most of the electron beam. Personnel transporting such activated components from LCLS operations would be expected to receive radiation doses well below 100 mrem/year (natural sources alone contribute 300 mrem/year), and most probably non-measurable due to the low level of induced activity expected from LCLS operations.

<u>Occupational Radiation Exposure</u>: Activities that could expose workers to radiation would include the same processes that produce potential exposure to the public. The DOE in Title 10 CFR Part 835 (DOE 1997) specifies an annual total radiation dose limit to radiation workers from both internal and external radiation sources of 5 rem (5,000 mrem). In addition, SLAC maintains an administrative control level of 1.5 rem (1,500 mrem). During operation of LCLS, access control systems (for example, the Personnel Protection System and the beam line Hutch Protection System) and administrative search procedures ensure that no personnel remain inside the shielded enclosures or accelerator housing during operation. Occupational exposure of personnel is most likely to occur in the vicinity of experimental hutches. Shielding of these areas is designed so as to minimize occupational exposure and keep it below administrative limits. Local shielding and appropriate beam containment would be used as necessary (SLAC 1998a).

The radionuclides that would be produced (15O, 13N, 11C, and 41Ar) are all short-lived, with half-lives less than two hours. Releases under normal operations could occur only after the beam is shut down and personnel access entries are opened. Gaining access to the LCLS and tunnel housing would be delayed 30 minutes following shutdown to limit these exposures. After that delay time, because of the decay of the radionuclides produced in air, no measurable radioactive gases could diffuse out of the housing into occupied areas.

Occasionally, when a conscious and intentional decision is made to access the LCLS beam enclosure less than 30 minutes after beam shutdown, radioactive gases in the air could result in a slight increase in radiation exposure. However, worker exposure, as a result of early entry, would produce a radiation dose of much less than 100 mrem or less than one third of the dose received from natural sources. Immediately after shutdown, the dose rate from rapidly decaying radioactive gases would, at most, be 0.63 mrem/h (Fasso 1997a).

Activation of beam line components and support structures would be confined to the LCLS housing, and no release of activated material would occur from these areas. Occupied areas would be routinely monitored to ensure that the dose equivalent to persons working near LCLS would be maintained as low as reasonably achievable (ALARA), in accordance with established SLAC policy.

All areas accessible to workers would be routinely monitored and appropriate signs posted.

The average measured dose equivalent to radiation workers at SLAC in the period 1997 through 2001 was 88 mrem, and the average maximum dose equivalent was 480 mrem. The average dose equivalent to general employees for the same period was 43 mrem. The average dose equivalent for all exposed workers was 59 mrem. For comparison, the DOE specifies an annual total radiation dose limit to radiation workers from both internal and external radiation sources of 5,000 mrem. Based on that experience, it is expected that individual doses from the proposed LCLS project would be maintained well below 100 mrem/year for non-radiation workers and be less than 500 mrem to the maximally exposed radiation worker. There would be no more than 50 workers that would be exposed to any radiation from LCLS in the course of normal operations. Based on a lifetime (age 20 – 64 y) risk of 3.69 x 10^{-4} fatal cancers per rem for adult workers (NCRP 1997), the maximally exposed worker would have an annual probability of fatal cancer induced by radiation of approximately 4 x 10^{-6}. The average exposed worker would have an estimated annual risk of approximately 5 x 10^{-7}.

Potential Public Exposure from Radiation and Airborne Radionuclides: Radiation exposure to the public from DOE facilities is controlled and minimized in accordance with DOE Order 5400.5 (DOE 1990). The DOE stipulates a 100 mrem/year dose limit to a member of the public from all routine DOE activities, including a maximum of 10 mrem/year for airborne emissions of radioactive materials. The latter limit is also specified by USEPA regulations in Title 40 Code of Federal Regulations (USEPA 1996).

Potential radiation sources associated with normal operations at the LCLS project are very small. Calculations for total potential radiation exposures to the closest hypothetical maximally exposed resident off the SLAC site, 487 meters (1640 feet) from the LCLS, show that the contribution from LCLS would be less than or equal to 0.2 mrem in a year (Mao 2002b) as compared to the DOE dose limit of 100 mrem/year. The User Lodge would provide only temporary accommodations for members of the public (not SLAC users). Exposure to a resident at the User Lodge, assuming a residency of 60 days per year, would be a maximum dose equivalent of 0.06 mrem per year. This calculated exposure from radioactive gases and external radiation would be less than one percent (1 %) of the total background radiation received from natural sources.

The expected dose equivalent at the closest portion of SLAC site boundary (0.3 km or 985 feet) would not exceed 1 mrem per year. All forms of radiation would be monitored and corrective actions (for example, rescheduling of beam operations, installation of additional shielding) would be taken as necessary to maintain the dose equivalent at the SLAC boundary below 10 mrem in any given year (Mao 2002).

Based on the saturation activity in the various enclosed spaces of LCLS, the maximum quantities of radionuclides that could be released (Fasso 1997b) and the resultant maximum potential radiation dose to the public were calculated using the USEPA-approved software code CAP88-PC, Version 2.0. The potential dose associated with airborne radioactive emissions from LCLS operations to the public based on a hypothetical maximally exposed individual was calculated to be no greater than 7.5×10^{-6} mrem in one year (Sit 2002) or less than 10 millionths of a percent of the allowable DOE dose protecting the public.

Potential Environmental Radiological Effects: Groundwater is not expected to be affected by LCLS operations because the facility will be 5 to 25 feet above the groundwater table. The only potential long-lived radioactivity that could be produced in water would be tritium. Groundwater near the proposed beam dump device is about 5 to 10 feet below ground surface. This device would have adequate shielding so that there are no expectations of any significant tritium production from LCLS (Sit 2002). The proposed location of the LCLS beam dump device is near the current FFTB structure within the Research Yard, about 5,000 feet (about 1500 meters) from the eastern site boundary. Groundwater flow is very slow (approximately 3 feet per year) in the Research Yard, and is generally towards the east.

Water in a closed-loop cooling system used to cool beam-line components can be exposed to radiation that has the potential to produce some activation in the water. Samples from a similar facility (SPEAR) showed no detectable tritium (using assays with a 500 pCi/l detection limit), and therefore detectable quantities of tritium are not likely to be produced in the closed-loop cooling system used at the LCLS. It is possible that repair of cooling-system equipment could involve the draining of cooling water from all, or part, of the system. There are procedures in place requiring analysis of cooling water for radioactivity (including tritium) before it is removed from the system. These procedures also include environmentally-protective methods of handling any cooling water that does contain detectable radioactivity. Soil is not expected to be affected by LCLS operations because of shielding and short life of most radionuclides that could be present in soil (Sit 2002a). The radionuclides of interest and their respective half-lives are provided below:

- Oxygen-15, with a half life of two minutes,
- Nitrogen-13, with a half life of 10 minutes,
- Carbon-11, with a half-life of 20 minutes and
- Argon-41, with a half-life of less than 2 hours

No radioactive waste is expected to be routinely generated by the operation of LCLS. Over the course of its service life, however, low concentrations of radioactivity may be induced in some LCLS components. For a project of this type, a comprehensive radiological survey would be performed, and if any components or materials were determined to have residual radioactivity, they would be placed in secure areas pending future reuse or ultimate disposal.

5.1.3 Potential Accidents and Emergencies

Potential accidents, and emergency situations that have the potential to occur during operations at LCLS are:

- Normal industrial hazards
- Mechanical system failure
- Chemical spills
- Fire
- Earthquake
- High voltage
- Radiation Exposure

Each potential scenario is described below, along with SLAC's safeguards that are in place to minimize damage from these potential situations.

Normal industrial hazards would include the most frequent accident scenarios, such as falling or back injuries from improper lifting. In addition, potential mechanical system failure could occur. These are hazards that SLAC's Integrated Safety Management System (ISMS) address, implementing safety awareness and preventive measures into work management at all levels so that workers, the public, and the environment are protected. Environmental hazards from potential chemical spills are expected to be minor based on maximum chemical container size, projected chemical usage being inside a building, and the safeguards and best management practices (BMPs) that SLAC has implemented to avoid potential drips or spills.

The potential for accidents and anticipated response for emergencies at SLAC is addressed and minimized by the SLAC ES&H Program as documented in the SLAC Environment, Safety, and Health Manual (SLAC 2002b). SLAC's total reportable accident, injury and illness record is illustrated in Figure 18. The current

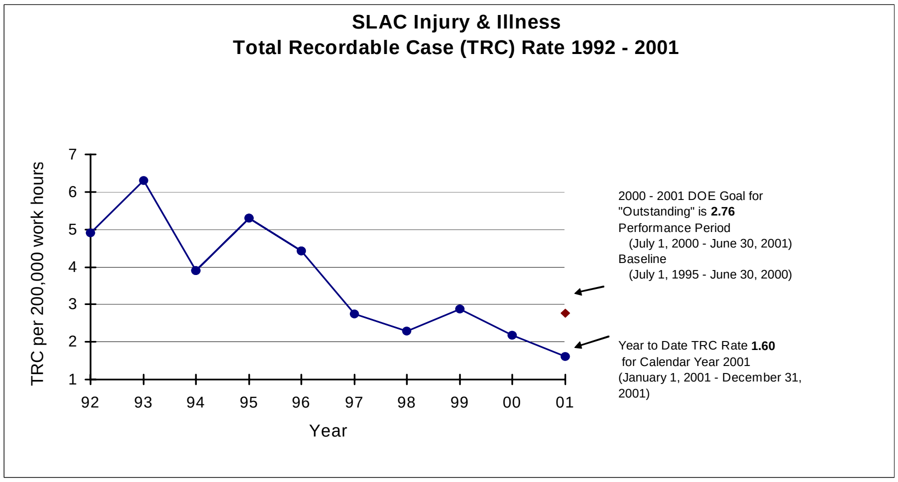


Figure 18. SLAC Injury and Illnesses, Total Reportable Cases

Total Reportable Cases (TRC) rate is 1.4, for the first three quarters of 2001. The DOE average TRC rate is 2.4 during the same time period (DOE 2002).

Fire

The most reasonably foreseeable major incident would be a cable fire caused by an electrical overload condition. Fire safety is addressed by the SLAC ES&H Program (SLAC 2002b). The Palo Alto Fire Department (PAFD) operates an onsite fire station (Station 7) to provide immediate fire-fighting and emergency response support to SLAC. PAFD personnel conduct fire safety inspections and citation programs and provide training in the use of fire extinguishers to SLAC personnel.

The probability of fire at LCLS would be expected to be similar to that for other research areas at SLAC. The LCLS experimental facilities and research halls would be fabricated of essentially nonflammable components, and no large quantities of flammable materials would be used during operations.

The most reasonably foreseeable incident with any substantial consequence would be electrical cable insulating material catching on fire, initiated by an overload condition. Cable plant design for the proposed LCLS would be rated low-smoke, non-halogen whenever possible, and isolating fire breaks would be installed in the cable runs to prevent fire propagation.

A cable fire would be expected to develop slowly, providing sufficient time for egress by employees. Smoke detectors would enunciate at the onsite fire station, the SLAC Main Control Center, the LCLS Control Room, and the City of Palo Alto dispatch center, providing early warning of a developing fire and initiating the onsite response. Typical response time is three minutes and the response would consist of the onsite engine, an additional engine offsite, and one paramedic unit.

Should a fire occur in any part of the LCLS complex, it is expected that there would be no personnel injuries and minimal property damage. No impacts to the public or environment, beyond those resulting from any other structure fire, are expected. The research program would likely be impacted due to the necessary facility repair.

Earthquake

SLAC is located in a tectonically active area; therefore SLAC has a detailed earthquake Emergency Preparedness Plan (SLAC 2000a), which outlines the procedures to be followed in the event of an earthquake severe enough to cause possible structural damage or personal injury. As described in Section 4.4, *'Seismic Conditions,'* there is a 21 percent chance that there would be one or more earthquakes of magnitude 6.7 or greater along the San Andreas Fault one mile west of SLAC in the next 30 years (USGS 2002).

Facilities constructed on the SLAC site employ design and construction techniques so that seismic risks are reduced to acceptable levels. These are detailed in the ES&H document *Specification for Seismic Design of Buildings, Structures, Equipment, and Systems at the Stanford Linear Accelerator Center* (SLAC 2000b). These design criteria apply to both new and existing LCLS facilities, and require attainment of specific seismic performance levels for each type of building, structure, equipment or system. SLAC Earthquake Safety committee review is required for the LCLS design.

The LCLS project would incorporate proven safety design features to ensure that in the event of an earthquake, the electron beam would be terminated and the radiation levels at the site boundary would be negligible. In addition, all mechanical components of the LCLS would be secured to protect persons working in the area. Damage resulting from an earthquake would not release any radionuclides, and the production of penetrating radiation would cease instantly with the loss of the electron beam. Returning the accelerator to operation following an automatic shutdown, which would occur in the event of an earthquake, would not expose the public or the work force to any significant additional radiation other than the minute quantities expected from normal operations.

The 1989 Loma Prieta earthquake resulted in very little functional damage to SLAC. The low damage is a result of design features of the Linac, which is held up by a series of adjustable jack-like mechanisms. This flexible design allowed for site-specific adjustments and re-calibration after the earthquake.

High Voltage

Potential hazards associated with high-voltage lines and equipment exist throughout SLAC, but established policies and procedures, together with an excellent safety record, show that these hazards can be effectively managed.

The LCLS accelerator housings and associated electrical components are potential sources of electrical hazards, as are the other accelerator areas at SLAC. Electrical safety at SLAC is addressed by the SLAC ES&H Program (SLAC 2002b) and the Guidelines for Operations (SLAC 1992b). These include a Lock and Tag Program for Control of Hazardous Energy (SLAC 1992c). Some energy sources in the LCLS facility would be deactivated when the Personal Protection System (PPS) is in the ‘access allowed’ mode (that is, permitted access or restricted access).

The probability of a high-voltage accident at LCLS would be the same relative to other experimental facilities at SLAC. No offsite effects on the public or the environment would be possible from such events, except for potential temporary power losses (brownouts or blackouts) stemming from the incident.

Radiation Exposure

Possible accidents involving radiation at LCLS include beam-loss events and release of induced radioactivity into the air from normally sealed spaces. The most serious radiation accident that could occur during LCLS operations would be the total loss of the injector beam at the maximum possible current and energy. Based on maximum credible beam power for the LCLS of 150 kilowatts and beam loss at a point where the shielding is least extensive, the calculated dose equivalent rate to the nearest member of the general public (a distance of 487 meters or 1640 feet) would be about 0.56 mrem/hour (Mao 2002b) as compared to the DOE dose limit of 100 mrem/year. This rate would last for only a fraction of a second, thereby producing a negligible radiation dose. Assuming such an event occurs once in a year, the resultant maximum potential dose equivalent at the site boundary would still be completely negligible, with no adverse effect on the population.

Should such a serious accident occur, the maximum potential dose outside the shielding would be 20 rem/hr, therefore not exceeding the maximum permitted dose rate during an accident, 25 rem/hour (SLAC 2002b). The corresponding maximum integrated dose equivalent outside the shielded areas would not exceed 0.55 mrem (0.00055 rem), assuming the Beam Shut-Off Ion Chamber (BSOIC) System would turn off the beam within 0.1 seconds. If the BSOIC shutoff does not occur, the maximum permitted dose of 3 rem (SLAC 2002b) would be delivered in 9 minutes. An operator would know that there was a beam loss because there would be a vacuum loss, and operations would cease to function. By comparison, the DOE (DOE 1997) specifies an annual effective dose equivalent limit for workers from both internal and external radiation sources of 5 rem.

The SLAC Radiation Safety Program and the various Radiation Safety Systems minimize the potential for accidents involving worker and public exposure to radiation. Shielding exists between beam-housing areas and areas that are occupied during operation, in order to maintain radiation exposures as low as reasonably achievable (ALARA). The PPS controls entry into and exit from accelerator housing areas and the Hutch Protection System (HPS) controls entry into and exit from beam line experiment areas called hutches; doors to these areas are interlocked to prevent access whenever the potential exists for radiation generation. A Beam Containment System (BCS) prevents the accelerated beam from diverging from the desired channel or producing excessive radiation in occupied areas. Finally, the BSOIC System utilizes radiation monitors outside the shielding barriers to verify that external radiation levels do not exceed design levels (SLAC 1999). In addition, these monitors shut off the beam if radiation levels exceed either 10 or 100 mrem/h outside the shielded areas, depending on the occupancy factors.

In almost 40 years of cumulative accelerator and collider operations at the various SLAC facilities (SPEAR, PEP, and SLC), it is noteworthy that no radiation injury has ever occurred. Exhaustive precautions have been developed and implemented to minimize the probability of such an event, beginning with a thorough search of the entire area prior to operation to assure that there is no person left in the housing either by accident or design. A search team member physically investigates every possible area large enough for a human being while maintaining a line-of-sight with other team members. After the search, but before the accelerator is turned on, the housing is locked, the lights in the housing are automatically flashed on and off for two minutes and then dimmed, and a recorded message is played stating that the beam is coming on, serving as both visual and audible warnings. There are also emergency shut off buttons or cables within the housing areas, which can be activated to stop the start-up process. When the accelerator is on, each of the enclosures within the shielding barriers becomes a Very High Radiation Area, as defined in the DOE occupational radiation protection regulations (DOE 1997).

5.1.4 Cumulative Effects

Potential cumulative effects are evaluated for the 15 year anticipated time frame by consideration of the potential environmental effects during construction, routine operations, and potential accidents. Cumulative effects include human health and environmental media.

Hazardous Chemicals
During construction, emissions from excavation of soil for the experimental halls are anticipated to be below the permitting thresholds contained in Bay Area Air Quality Management District (BAAQMD) Regulation 8, Rule 40 and the toxic air contaminant risk screening trigger levels contained in BAAQMD Regulation 2, Rule 1, Table 2-1-316. Also, emissions from the use of architectural coatings and adhesives during construction of the new experimental halls are not anticipated to cause SLAC to exceed or even approach its SMOP emission limits. Chemical usage may increase during LCLS construction if fabrication occurs in onsite shops. Potential exposures during routine operations at the clean room and machine shop are predicted to be minor based on site specific evaluation of chemical type and quantities from comparable at SSRL clean room and machine shop. Potential chemical accidents are not expected to have adverse environmental effects, based on predicted amounts of chemical use, the location of use inside a building, as well as safeguards that are in place to minimize potential spills. Therefore, potential cumulative effects are not expected to be of concern for human health or the environment, and should be comparable to SLAC's existing operations for the same time period.

Radiation:
No radioactivity is expected during the three-year construction phase. SLAC is providing radiation risk calculations for LCLS operations even though low dose radiation risk estimates are not well defined. The uncertainties in risk estimates result in a 90 percent confidence interval for the lifetime risk for fatal cancer from 1.20×10^{-4} rem^{-1} to 8.84×10^{-4} rem^{-1}, with an average risk for the U. S. population of 3.99×10^{-4} rem^{-1} (NCRP 1997). SLAC has assumed that a maximally exposed individual for any single year would also be exposed at the maximum rate for the entire 15 years of operation, which would be very unlikely. For the population risk

estimate, the calculations are made assuming that each individual in the estimated population of 1200 people within 0.5 km (1,640 feet) of the SLAC boundary are exposed to 0.1 times the maximum annual dose equivalent each year of operation for the 15-year period. This is based on an analysis of the dose as a function of distance from the LCLS (Mao 2002b).

The estimated maximum annual dose equivalent from the LCLS operation to an individual located at the site boundary, about 0.5 km (1,640 feet) from LCLS, is 0.2 mrem (Mao 2002). Based on a lifetime (0 – 90 y) risk of 3.99×10^{-4} cancer fatalities per rem for the general population (NCRP 1997) the maximally exposed member of the general public (0.0002 rem/year) would have an estimated annual probability of fatal cancer induced by LCLS-produced radiation of 9.0×10^{-10}. The lifetime risk of fatal cancer to an individual who is maximally exposed each year over the projected exposure period of 15 years is approximately 1.2×10^{-6}, with a 90 percent confidence interval ranging from 0.4×10^{-6} to 2.6×10^{-6}. The natural lifetime risk of fatal cancer in the U. S. population is about 0.2. The added risk to the maximally exposed individual from all SLAC operations, assuming an annual dose equivalent of about 5 mrem for 70 years is about 1.4×10^{-4}. LCLS would add far less (less than one percent) to the existing risk from SLAC to this individual.

The population residing within 0.5 km of the SLAC boundary (within 1 km of the LCLS) is about 1,200 people. The average annual dose equivalent to this population from LCLS operation is estimated at 0.02 mrem (Mao 2002b). If the entire population of 1200 people received this dose equivalent each year for the 15 years of operation, the potential cumulative radiation-induced fatal cancers in this population would be about 1.4×10^{-4}. As a comparison, the cumulative number of naturally occurring cancer deaths expected in this population would be about 240.

Workers engaged in this proposed project would not be expected to incur any harmful health effects from the radiation exposures that they would receive during normal operations. The maximum exposure to a radiation worker from the LCLS operations is not likely to exceed 0.5 rem in one year, and the average annual dose equivalent to an individual worker would not exceed 0.1 rem, as compared to the DOE dose limit of 100 mrem/year. The number of radiation-induced fatal cancers in the potentially exposed population of 50 individuals over the operating period of 15 years is less than 0.03, with a 90 percent confidence interval ranging from 0.009 to 0.07. The cumulative number of naturally occurring cancer deaths expected in this population would be about 10. Additional risks to workers under potential accident scenarios are not anticipated to occur because of SLAC worker health and safety precautions, and medical monitoring to evaluate dosage.

5.1.5 Conformity with State Implementation Plans

Federal clean air laws require areas with unhealthy levels of ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, and inhalable particulate matter to develop plans, known as State Implementation Plans (SIPs), describing how they would attain national ambient air quality standards (NAAQS). The San Francisco

Bay Area was designated as a non-attainment area for ozone in 1998. On November 1, 2001, the California Air Resources Board approved the San Francisco Bay Area 2001 Ozone Attainment Plan for the 1-Hour National Ozone Standard as a revision to the SIP. The 2001 Plan contains a control strategy with seven new stationary source measures, five new transportation control measures, and eleven further-study measures.

The USEPA rejected the California Ozone Attainment Plan in January 2002, and a revised plan must be submitted. In general, the USEPA has established criteria and procedures for demonstrating conformance with a SIP. The BAAQMD has a no net increase policy that requires emissions from new permitted sources to be offset by emissions reductions at other sources within the district.

There may be minor increases in air emissions as a result of the LCLS, as a result of small-scale solvent and facility maintenance emissions, increased fuel combustion due to space heating needs, increased refrigerant emissions due to space cooling needs, and possible cryogenic and/or process gas emissions. Note, however, that these increases may not be in criteria pollutants or air toxics as defined under federal and state law, and therefore would not require emissions offsets.

The LCLS project would conform to the BAAQMD rules and regulations, which in turn conform to the SIP. Conformance with the November 2001 ozone attainment measures, when revised, would be accomplished on a SLAC-wide basis, and is not linked to the LCLS.

5.1.6 Environmental Justice

In accordance with Executive Order 12898, dated February 1994, DOE has proposed to establish procedures for identifying and addressing disproportionate adverse human health and environmental effects of their programs, policies, and activities on minority populations, low-income populations, American Indian tribes, and populations of non-English speaking residents. The closest low-income area to the LCLS is East Palo Alto, greater than 4 miles from SLAC.

The proposed LCLS does not pose any adverse environmental pollution or impacts to the general public or surrounding areas; therefore, none of the groups that are subject to Executive Order 12898 would be affected by the proposed action.

5.2 No Action

Under the No-Action alternative, DOE would not construct the proposed LCLS facilities. The short-term construction impacts would not occur. In addition, increases in site wide consumption of utilities and increased water discharges to the sanitary sewer related to LCLS construction and operations would not occur. Chemical usage and radiation effects from the LCLS would not occur. Potential increases in air emissions beyond SLAC's existing baseline emissions as a result of the LCLS would not occur.

6.0 Persons and Agencies Contacted

Bay Area Air Quality Management District (web site)

Lawrence Byers, SLAC Non-Radiological Air Quality

Rick K.Challman, SLAC Long Range Development Committee

Federal Emergency Management Agency (web site)

Jack Hahn, SLAC Environmental Safety and Health Division

Dr. Laura Jones, Stanford University Research Archaeologist

Dr. Kenneth Kase, SLAC Radiation Physicist

Dr. Alan Launer, Stanford University Research Biologist, Center for Conservation Biology

Sandy Pierson, SLAC Manager, Research Yard

Kirk Stoddard, SLAC Environmental Protection Group

U.S. Census Bureau (web site)

Bradley P. Youngman, Chair, SLAC Earthquake Safety Committee

7.0 Glossary and Acronyms

Accelerator - a device which raises the energy of elementary particles to high energies to allow the exploration of the structure of matter at extremely small distances. There are two main types of accelerators, those, which use protons, such as the Tevatron at the Fermi National Accelerator Laboratory (FNAL), and those that use electrons, such as the Linear Accelerator at SLAC. Unlike reactors, accelerators consume energy rather than produce energy.

ALARA - as low as reasonably achievable, radiation safety program to ensure that radiation doses above background received by workers and the public shall be as low as reasonably achievable

BAAQMD - Bay Area Air Quality Management District.

Background Radiation - All sources of radiation at a given point other than the source in question. Radiation received either naturally from the earth or cosmic rays from outer space, or received artificially as a result of weapons testing. This term also includes radiation from medical x-rays.

Beam or Bunch Compressors: Proposed method of accelerating electrons for the LCLS beyond the current capability of the Linac using a new X-band accelerating structure

Beam Dump - An energy-absorption device for halting a particle beam.

Blowdown - Discharge of mineral-laden cooling-tower water to reduce the concentration of total dissolved solids (TDS) in the cooling system. Cooling towers remove heat by evaporation, which increases the mineral content of the water remaining in the system. Removal of a portion of this water helps maintain system efficiency and reduce maintenance. Blowdown from SLAC's cooling tower system empties into the sanitary sewer.

BSOIC - Beam Shut-off Ion Chamber.

BSY - Beam Switchyard

CRMP - Coordinated Resources Management Process; for San Francisquito Creek

DOE - United States Department of Energy

DR - Damping Rings

Electron - A subatomic particle with a non-zero rest mass occurring in nature. It has a negative electrical charge of one unit. More technically, the electron is a fermion which undergoes only weak, electromagnetic, and gravitational interactions.

EA - Environmental Assessment

ES&H - Environment, Safety, and Health Division

FEL - free electron laser

FEMA - Federal Emergency Management Agency

FFTB - Final Focus Test Beam

FHWSA - Former Hazardous Waste Storage Area

FSUST - Former Solvent Underground Storage Tank

GeV - Giga-electron-volt; represents one billion electron volts

gpd - gallons per day

HAP- Hazardous Air Pollutant

HPS - Hutch Protection System

ISMS- Integrated Safety Management System

LCW - Low-Conductivity Water, which is used for cooling accelerator and experimental apparatus. LCW is domestic water that has been distilled to remove or reduce its mineral content in order to increase the water's resistance to the flow of electricity.

LCLS - Linac Coherent Light Source

Linac - the Linear Accelerator at SLAC

LOS - Level of Service (for traffic flow)

mrem - millirem; equal to one-thousandth of a rem (0.001 rem, or 10^{-3} rem). See rem.

MW - megawatt

NAAQS - National Ambient Air Quality Standards

NCRP - National Council on Radiation Protection and Measurements

NEPA - The National Environmental Policy Act, which requires that all environmental impacts and alternatives to a proposed action are considered before resources are committed for that action and before decisions are made.

NESHAPs - National Emissions Standards for Hazardous Air Pollutants

Neutron - An electrically neutral particle with a mass equal to 1,838 electron masses. Neutrons are stable when bound in nuclei, but a free neutron decays into a proton, an electron, and a neutrino having a half-life of twelve minutes.

NLCTA - Next Linear Collider Test Accelerator

OSHA - Occupational Safety and Health Administration.

PAFD - Palo Alto Fire Department

PCB - polychlorinated biphenyl

PEP - Positron Electron Project

Positron - The positively charged antiparticle of an electron. Electron-positron pairs may be produced from gamma rays, and may subsequently combine to produce gamma rays by annihilation.

PPS - Personal Protection System

PS - Positron Source

Radioactive - Giving off radiant energy in the form of particles or rays produced by the disintegration of atomic nuclei. Radioactivity can be produced spontaneously in fissionable materials, or it can be induced in material that is not inherently radioactive, creating activation products. In sufficient doses, this radiant energy can be harmful to plant and animal life.

Radionuclide - A radioactive isotope of a particular element. For a given element, two or more nuclides that have the same number of protons but different numbers of neutrons in their nuclei are called isotopes. Radioactive isotopes are now called radionuclides.

rem - a special unit used for expressing an ionizing radiation dose that incorporates both physical and biological factors. This unit allows the direct comparison of biological dose from all forms of ionizing radiation such as x-rays, gamma rays, beta particles, protons, and neutrons. The natural background dose of ionizing radiation for an individual in the mid-Peninsula region is approximately one hundred millirem (100 mrem), or one-tenth of a rem (0.1 rem).

RWQCB - Regional Water Quality Control Board.

SLAC - Stanford Linear Accelerator Center. The center is dedicated to research in high-energy physics and in those fields that make use of its synchrotron radiation facilities.

Stanford University operates it as a national facility for DOE. Primary facilities onsite include the two-mile linear accelerator, the SPEAR and PEP storage rings, and the Stanford Linear Collider. SLAC is located approximately one mile west of the Stanford University campus in the foothills on the San Francisco Peninsula in California.

SIP - State Implementation Plan

SLC - Stanford Linear Collider

SMOP - Synthetic Minor Operating Permit

SPEAR - Stanford Positron-Electron Asymmetric Ring, originally a small colliding-beam-storage-ring facility, and now a dedicated synchrotron radiation facility at SLAC; SPEAR3 is a 1998 upgrade to the facilities.

Synchrotron Radiation - Radiation produced in accelerators when the path of a charged, relativistic particle is changed, usually in a magnetic field produced by a bending magnet. The spectrum of radiation is continuous from the low, visible region of light up to into the tens of kilovolts range of energy.

SSRL - Stanford Synchrotron Radiation Laboratory

SUNRI - Stanford University Natural Resource Inventory

TL/CL - Test Laboratory and Central Laboratory Area

TRC - Total Reportable Cases

USDA - United States Department of Agriculture

USEPA - United States Environmental Protection Agency

USGS - United States Geological Survey

Vacuum Chamber - An airtight metal vessel designed to maintain a vacuum from 10^{-6} to 10^{-10} Torr.

VOCs - Volatile Organic Chemicals

WAPA- Western Area Power Administration

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