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Proposal to Establish a Site in the San Jacinto Mountains as a National Underground Science Laboratory

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A. Introduction

A dedicated national underground science laboratory (NUSL) is long overdue in the U.S. For the past two decades such facilities have been in operation in Italy, Japan, and Russia, hosting experiments conducting groundbreaking work in physics and astrophysics. Lacking such a facility in the U.S., American scientists have had to work parasitically in existing commercial mines in the U.S. or travel overseas to join foreign collaborations, often spending a large part of their irreplaceable time and hard-won research funds in repeated transit between their home institutions and remote underground laboratories.

Locating a national underground science laboratory in the San Jacinto Mountains of southern California has unique and powerful advantages in terms of both the science possible at such a site as well as the benefits, which would accrue to the U.S. scientific community at large.

The San Jacinto escarpment is one of the steepest and tallest fault bluffs in the United States. This unusual geologic formation allows deep underground access via a modest horizontal bore into the mountain. The maximum available overburden at San Jacinto is over 2,500 meters of hard rock (7000 meters water equivalent). The resulting reduction in penetrating cosmic rays leads to cosmogenic background rates so low that all manner of low-rate, low-background physics experiments (realtime proton-proton and Be-7 solar neutrino measurements, searches for dark matter and neutrinoless double beta decay, etc.) could be performed at this site. Furthermore, as one drills into the mountain, overburdens of all intermediate thicknesses become available for less sensitive, larger-volume projects (nucleon decay searches, long-baseline neutrino oscillation studies, etc.).

In addition to ready access to a range of overburdens, there are numerous reasons why horizontal access is always favored over vertical shaft access for an underground facility: excavation, detector construction, and continuing operations are not tied to nor constrained by a hoist schedule; the size of experimental components are not limited by a critical lift's dimensions or its weight capacity; operating costs are low and are virtually independent of depth; safety is enhanced since emergency egress is not compromised by concurrent power failure.

Located in populous and high-tech southern California, San Jacinto enjoys close proximity to many important assets essential in the creation and ongoing support of a world-class scientific facility. Nowhere else in the world are so many major research and teaching universities, with their supplies of researchers, students, and trained support staff, concentrated so close to a proposed underground laboratory. The city of Palm Springs, a well-known resort destination, is just 20 minutes away from the portal area. Collaborators and equipment can travel to and from the site via several nearby international airports and well-maintained highways, while hotels, apartments, office buildings, construction companies, and other necessary resources are available in abundance in the surrounding vicinity.

Built as a dedicated underground laboratory with an unlimited useful lifetime, it is to be expected that San Jacinto would draw first class experiments to the facility. Reversing the trend of past decades, research money previously spent overseas will be injected into the local economy. In the meantime, a higher fraction of U.S. grant money will go directly towards physics results instead of travel and international transshipment of equipment.

San Jacinto is a unique facility, which could take U.S. science far into the new century. There are many tantalizing new experiments on the near horizon, from mapping out the neutrino mixing parameters to unraveling proton decay, which will be carried out somewhere in the world, deep underground. The time is right for America to establish its own national underground laboratory. San Jacinto is the right place at the right time.

B. Regional Site Description

Palm Springs, California lies on the western edge of the Coachella Valley, within the Colorado Desert. Located approximately 110 miles east of Los Angeles. "Down Valley" to the east, are the smaller cities of Cathedral City, Rancho Mirage, Desert Hot Springs, Thousand Palms, Palm Desert, Indian Wells, La Quinta, Bermuda Dunes and Indio. The permanent year-round Palm Springs population is 45,000, and doubles during the winter season. It is within a few hours drive of five UC campuses with High Energy Physics Programs plus the University of Southern California, the California Institute of Technology, and numerous campuses of the California State University System. Many other private and smaller universities populate the area.

At 487 feet above sea level, Palm Springs is sheltered by the Little San Bernardino Mountains to the north, the Santa Rosa Mountains on the south, and the San Jacinto Mountains to the west with 10,831-foot Mt. San Jacinto, site of the Palm Springs Aerial Tramway. Geography gives Palm Springs its famed warm, dry climate. Known for 354 days of sunshine and less than 5.2 inches of rain, winter temperatures average in the 70s with nights in the mid-40s. The dry desert heat of summer pushes daytime temperatures into the 100s enjoyed by sun lovers.

Palm Springs International Airport, just 3 miles from downtown, handles Alaska Airlines, American Airlines, America West, Continental Airlines, Northwest Airlines and United Airlines with flights throughout the U.S. and Canada. Commuter flights from Los Angeles and Phoenix are frequent. Ontario International Airport is just over an hour northwest. Within approximately a two-hour drive are the Los Angeles International Airport, Orange County-John Wayne Airport and San Diego-Lindberg Field. There is a Greyhound bus terminal in town, and Amtrak provides limited train service and bus connections. There are many rental car agencies, taxis and shuttles within Palm Springs.

Palm Springs is home to some 160 major hotels with 6,500 hotel rooms plus many mid-sized motels, B & Bs, and a variety of large and small resorts. Many condominiums and apartments are available for lease. Known for diversity in dining, the Village of Palm Springs offers hundreds of restaurants with a variety of cuisines and price ranges. There is also ample office and warehouse space available for lease or purchase in and near the city. Land in less developed areas outside the city is available for lease or purchase. Housing, office space and warehousing should thus present no problem either through rental, purchase, or construction. Excellent facilities for all sizes of conferences and workshops are also available. The Palm Springs Convention Center hosts major conventions and consumer shows. It has 66,000 square feet of meeting space, an additional 51,000 feet of contiguous exhibit space and a 400-seat auditorium with full audio-visual support.

The city, accessible in all seasons of the year, is a major tourist destination. A variety of attractions from tennis and golf to hiking and skiing are available.
The cost of living in Palm Springs is indexed at 116.3, based on an American city average of 100. Comparison scores: Sacramento 114; LA/Long Beach 122.0; San Diego 122.8; New York 226.5; Seattle 119.7: Prince William Co. VA 113.3; Rapid City 100.2; Carlsbad 92.8; Minneapolis 99.7. The slightly above averge cost of living is certainly mitigated by the higher standard of living and quality of life, e.g. amenities, culture, schools, etc.

C. Project Description

The San Jacinto NUSL facilities consist of administration, warehouse & assembly buildings located in or near Palm Springs at the base of San Jacinto Mountain, and the underground laboratory located beneath the Mountain. Access to the underground laboratory complex is via a portal near the Valley Station of the Palm Springs Aerial Tramway. One tunnel provides access from the portal to the underground cavern complex. There are several location options for the project buildings: near I-10 & Hwy 111, about 10 minutes from the portal; in Palm Springs, about 10 to 15 minutes from the portal; and near the intersection of Tramway Road and Hwy 111, about 5 minutes from the portal. Many other options are available nearby, and a specific site may be chosen to best meet the needs for the project.
Three buildings are anticipated: a Visitor’s Center & Administration Building of several floors with 30,000 sf gross floor area, a warehouse & assembly building with 18,000 sf gross floor area, and a laboratory building with 12,000 sf gross floor area. No lodging or food services are provided, because these services are readily available in the City of Palm Springs.
The proposed access road and portal are located off the southeast end of a series of four parking lots used for overflow parking by the Tramway. These lots are about 800 meters northwest of Valley Station, and are separated from it by a several hundred meter high ridge. Other portal locations were considered and rejected because of unacceptable impacts on Tramway operations.
The surface infrastructure consists of an access road through the Tramway parking lot, limited exterior parking, electrical service, HVAC & cooling in portal structure, potable water, sewer and communications. Utilities will be located underground to limit the aesthetic impact.
The aesthetic impact of the portal is also minimal. Permanent disturbance is limited to a 35-m long access road from lot to portal and a 5-m long portal structure. After the portal structure, there is a 35-m long cut-and-cover structure that includes an integral compartment above the tunnel to house tunnel ventilation equipment and the cavern cooling plant. The ground surface above the cut-and-cover structure will be disturbed during construction, but will be restored to the original contours and ground cover.
One of the many advantages offered by the San Jacinto site is the range and magnitude of shielding available. Four shielding options are offered, although many intermediate options are possible. Shielding of 5,000 mwe, 6,000 mwe and 6,510 mwe are possible with access tunnels that have a 1 percent up grade from the portal to the cavern complex. Shielding of 7,000 mwe is possible with a down grade tunnel. Tunnel lengths for these shielding options are 4.6 km to 7.6 km.
Fire and life safety, including egress during an emergency, will be a principal concern for building code officials during design of this project. The building code officials having jurisdiction cannot be identified at this time, nor can their response to the fire and life safety issues be determined. Hence, the project proposal contains several alternative and overlapping measures to provide egress requirements. Two means of egress are provided by a single tunnel with a fire-rated separation between the driving lane and the egressway. The underground cavern complex also contains a refuge room.
The tunnel requires a 4.3-meter radius TBM, with a concrete liner where necessary. This configuration provides a 4.8-meter wide by 4.4-meter high driving lane, which easily

accommodates an over-the road truck carrying a standard 20-feet sea container. The tunnel contains a turnout every 500 meters that allows traffic to pass. The egressway is elevated slightly above the driving lane and is protected by a concrete curb. The structural concrete egressway is constructed to provide the necessary 2-hour fire rating and is pressurized by the ventilation system, so that any leaks do not allow smoke to enter. Fire doors to enter the egressway are provided at many locations within the cavern complex and in the tunnel. The tunnel also contains ventilation ducts, utilities and drainage.

The underground cavern complex proposed for the San Jacinto NUSL has been developed to provide fire separations between all occupied areas, two (or more) exits from all occupied areas, exit distances less than 200 feet, and smoke control. All spaces are sprinklered, if water-based sprinkler systems are appropriate. Other fire suppression systems may be more appropriate for specific areas or experiments. In addition, there is a refuge room that provides a safe haven in an emergency.

Other considerations in the layout of the underground cavern complex are ready access from parking, storage and common areas to the experimental caverns, large-scale tunnel access to center of caverns, room for expansion, and the capability to expand by constructing new caverns without significantly impacting ongoing experiments.

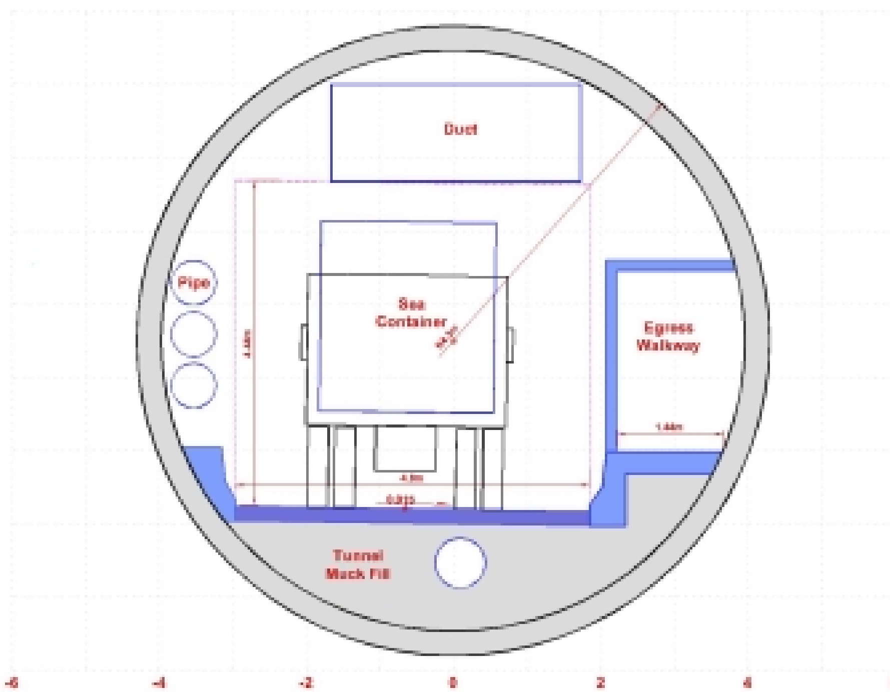
The exact location and orientation of the underground cavern complex is flexible, and will be determined during project design or construction. Changes in orientation of the complex will be accommodated by doglegs in the tunnels.

The TBM tunnels will be driven to the deadends. The floor of the TBM main tunnels adjacent to the caverns will be blasted out flat to provide a flat tunnel bottom. All smaller tunnels will constructed by drill-and-blast methods.

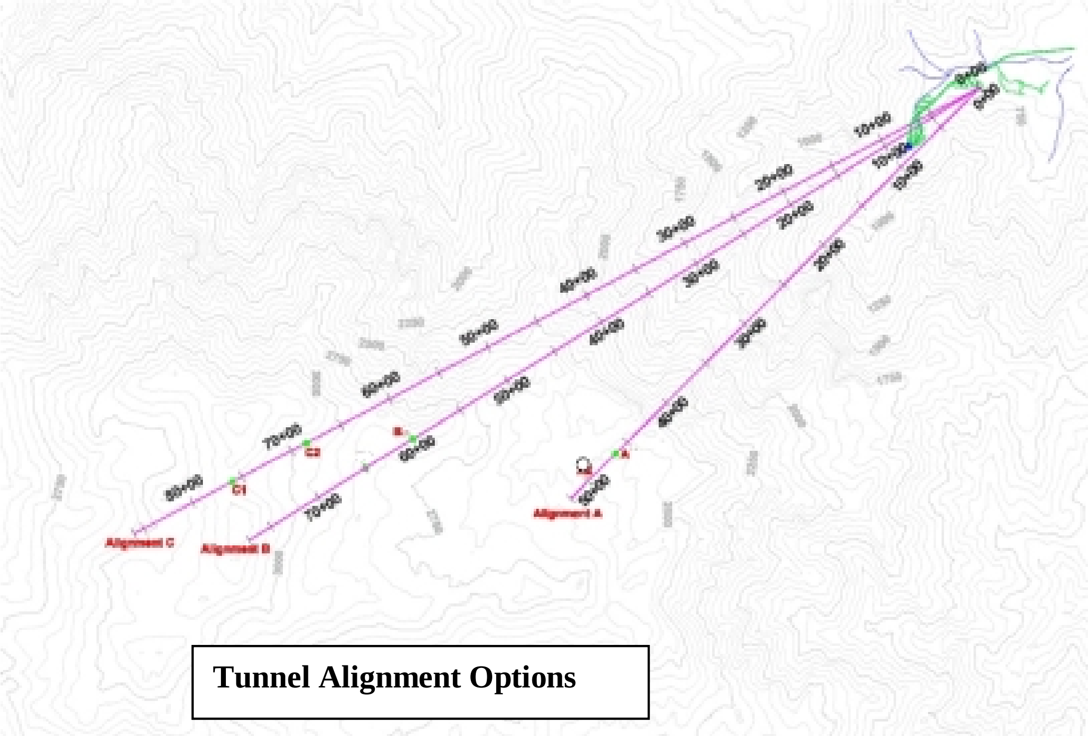
Three experimental caverns, each 20 m by 20 m by 100 m, are provided. In addition, there is a parking and storage cavern located off the main tunnel at the entrance to the complex. A common area cavern provides space for common functions and services, and is high enough for four stories. The refuge cavern and a combination drainage sump & fire reservoir complete the layout of the basic complex. The sump/reservoir is below the grade of the other caverns.

The complex also contains an UNO-style cavern that is 50-m wide by 50-m high by 200-m long. This cavern is located “across the road” from the other caverns, and is also located below the grade of the main complex. This cavern is accessed during construction by a short tunnel from the main tunnel to the upper level, and by a long, inclined tunnel to the bottom. The inclined tunnel would likely be sealed after experiment construction or allowed to fill during cavern filling. A 20-m by 20-m by 50-m support cavern for the large UNO cavern is also provided.

The anticipated construction sequence of the project is the site work and portal; tunnel excavation & support; simultaneous construction of the second tunnel (if necessary), the connecting tunnels and the experimental caverns, and concluding with outfitting. Prior to construction, the following activities are necessary: a preliminary environmental assessment, simultaneous conceptual design and Phase 1 site investigation, simultaneous design development and Phase 2 site investigation, final development of the environmental mitigation plan and preparation of construction documents. The anticipated duration from project start to beneficial occupancy is five years.

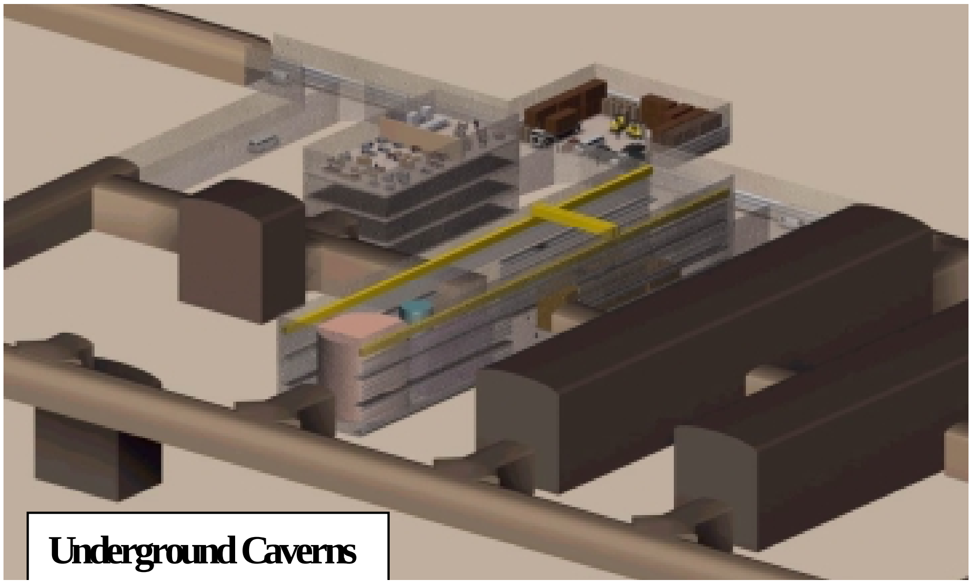


Tunnel Cross Section



Tunnel Alignment Options

Alignment	Tunnel Length (m)	Grade (%)	Ground Elevation at Cavern Complex (m)	Shielding (mwe)
A	4650	1	2543	5000
B	6000	1	2906	6000
C	7600	1	3173	6510
	6850	-5	3010	7000



D. Geology

San Jacinto Mountain is primarily comprised of hard, massive, crystalline igneous rock. The high peaks, San Jacinto and Jean, and the high elevation ridges are all comprised of this granitic-type rock. Lithologically, these rocks can be termed granodiorite, diorite, tonalite, gabbro, and pegmatites, but as a rock mass should provide relatively uniform tunneling and excavation characteristics. Most of the tunnel length and excavated caverns will be in this rock type.

Lesser amounts of metamorphic rock generally occur in the lower elevations and around the mountain flanks. These were initially sedimentary rocks that were metamorphosed into schists, marbles, and gneisses. These rocks display a moderate foliated texture that is oriented northwest with dips ranging from 50 to 80 degrees to the northeast. The igneous rocks that occur in conjunction with metamorphic rocks frequently display foliation. The metamorphics will be encountered in the proximal area of the portal and the first 1,000 meters of the tunnel. While tunnelling conditions could be more diverse than in the igneous rocks, the metamorphic rocks will be relatively softer.

Sediments occur at the mouth of Chino Canyon in the form of an alluvial fan. This wedge of sand and gravel extends horizontally for about 8,300 meters from Valley Station to the flat desert floor. The steep surface, with a grade of 5%, has many historic distributary channels, but most flows are contained in a linear drainage channel that was excavated many years ago. The portal and tunnel will be in rock and not pass through any alluvium.

While the mountain is bounded on the west by the active San Jacinto fault system and on the north and east by the active San Andreas fault system, this structural block has a low level of seismic activity. There are no mapped or documented faults along the tunnel alignment or cavern areas. Any possible encountered faults would most likely be minor individual shears that would have a minor effect on tunnel properties or groundwater.

Samples of rocks, which are representative of the type to be found in the laboratory caverns, were collected and counted by gamma spectrometry. The Uranium and Thorium content was about 2 ppm.

E. Environmental issues

Environmental issues can be divided into three main concerns of potential effect on the biology, potential effect on the groundwater, and the visual impact in Chino Canyon.

The habitat of the bighorn sheep is of great concern to environmental groups, regulatory agencies, and to the general public. Many areas of San Jacinto Mountain, including areas of Chino Canyon, fall into the critical habitat of the sheep. Chino Canyon is also an area that has been disturbed for over 60 years since the construction of Tramway Road, the tramway, and its associated terminals. A proposed major golf course and residential housing development are in the late stages of project approval. We sincerely believe that construction and operation of the tunnel and laboratory complex will have no impact on the bighorn sheep.

Boring a tunnel 20 miles away from a famous tunnel case history that involved groundwater resources has raised concerns. However, there are night and day differences between this site and the site for the 1935 water tunnel. The 1935 tunnel: was located in intensely sheared metamorphic rock; crossed a major active fault zone; had fault-controlled groundwater inflows; used drill and blast tunnel methods; was constructed with a single liner, and had a relatively low amount of overburden. The proposed NUSL project: will be located in the core of the crystalline batholith; does not cross known faults (in an area that has been studied by numerous geologic researchers); will use a tunnel boring machine; will reduce any encountered groundwater inflows with appropriate methods; and have greater overburden (hence better rock) in the core of the mountain. Therefore, based on the anticipated conditions, we believe any water inflow that does occur can be mitigated. More importantly, this project is commited to the lowest possible impact to the groundwater resource.

During operation this project will have a minimal visual impact on views within Chino Canyon. The most impact will occur during construction, a estimated 3 and 1/2 year period, during which material excavated from the tunnel will be hauled from the canyon, construction workers will access the site, and an existing parking lot will be used as a lay down area for the contractor. After construction, the laboratory traffic will be minimal and an area of approximately 1 acre will be needed outside the portal area.

This project should not have an effect on the bighorn sheep. Its effect on the groundwater will be minimal and we are committed to mitigating any impact that may occur. Finally, project operation will not have a visual impact on the canyon and the impact during the construction period will be temporary. We feel this project is environmentally responsible and will not have a cumulative or long term negative impact on the environment of Chino Canyon and San Jacinto Mountain.

In order to more firmly establish whether any of the effects mentioned above might preclude locating the NUSL in the vicinity of the Tramway, we engaged a law firm in Palm Springs whose practice is limited to environmental law. In their opinion, based upon the history of development in Chino Canyon, the limited effect the NUSL would likely have on habitat in the area, federal and state law, and legal actions which have involved other proposed developments in Chino Canyon, they are of the opinion that the NUSL will not have a significant impact on any species, and further, that the development of the NUSL and its effects would be well within the parameters required by both state or federal law.

F. Laboratory Management Plan

The University of California, Office of the President has committed to participate in the management of the proposed Underground Laboratory at San Jacinto. UC has broad experience in managing projects on this scale. These include the Keck Telescope, Lick Telescopes at Mt. Hamilton, and White Mountain Research Station. Within UC's management of the three DOE Labs (LLNL, LANL and LBNL), perhaps the most relevant example is the management of the ALS users' facility at LBNL. If the San Jacinto site is ultimately chosen, one or more of these facilities might provide a good model under which UC could participate. We mention below four examples of UC management of large research facilities. We describe the Keck model in some detail, since it appears closest to what is being proposed for the Underground Laboratory.

White Mountain Research Station (WMRS) is a UC Multicampus Research Unit with administrative headquarters at UCSD. Field and laboratory-based research is conducted at its facilities by faculty from all UC campuses. WMRS has agreements with the Forest Service, Bureau of Land Management and other entities to enable research on public lands.

Lick Observatory at Mount Hamilton is managed by UC Observatories, a Multicampus Research Unit headquartered at UC Santa Cruz.

The Advanced Light Source (ALS) is managed by UC as part of its contract to manage LBNL. The facility is owned by DOE, and serves as a users' facility for the entire condensed matter and biological community. Institutions outside of LBNL are able to construct their own beamlines, but must make a fraction of the beam time on their line available to the entire community.

In the Keck model, CalTech owns the facilities and the instrumentation is owned by CARA, a non-profit organization with equal representation from CalTech and UC. The site and its operations are managed by CARA, which also has a scientific advisory board. CARA operates the telescopes for the benefit of the entire scientific community, with a fraction of the observing time dedicated to UC faculty.

There are two distinct tasks involved in running a facility such as Keck. The first part has to do with the maintenance and operation of the facilities and the instrumentation. The second task is that of assigning priority to research time on the facility. In the case of the Underground Laboratory, we would anticipate that an organizational structure similar to Keck would be appropriate. In particular, there would be a Board of Directors, which controls the facility, and a Technical Advisory Board, which oversees the selection of projects, which will receive time at the facility.

In terms of overseeing the construction of the Underground Laboratory, we point out that UC has vast experience in this area. In particular, the construction of entire campuses, as well as their continued expansion, provides ample instances to show UC's expertise in this area. The construction planned at the San Jacinto site is of a standard variety, and the challenges lie in good management practices, rather than achieving any technical innovations. Under these circumstances, UC can be expected to do extremely well in estimating and bringing in the construction on time and on budget.

If a national deep underground laboratory site is chosen to be developed at San Jacinto, it is still possible that some experimenters will require the low excavation costs or the naturally low radioactivity background available at the WIPP site. Since the UC manages Los Alamos for the DoE and since Los Alamos would be an integral part of the scientific management of the WIPP facility, it might be desirable to set up a common management structure. To this end, we have had discussions with the UC and the proponents of the WIPP facility regarding a joint management for both sites.

G. Education and Outreach

A National Underground Science Laboratory sited in Palm Springs would create significant opportunities for public exposure and education. Currently, 375,000 tourists a year visit the Palm Springs Tramway and management expects that number to increase to as many as half a million/year. Less than 15 minutes off Interstate10, a NUSL in the Coachella Valley would offer unprecedented public access to and appreciation of a national investment in physics research and education. As environmental mitigation for recent expansion, the Tramway has plans in place to install a Visitor's Interpretive Center (VIC) on the biology of San Jacinto Mountain. Pending site selection, management has expressed an interest in adding physical sciences display materials to the VIC, possibly in Valley Station or near Highway 111.

The NUSL design incorporates accommodation for visitor tours into the tunnels and laboratory caverns. Non-polluting vehicles, operated by trained guides, would transport visitors, teachers and student groups to special observation areas. Photographs and videos would offer views of inaccessible areas.

An Underground Observatory Museum, featuring hands-on, Exploratorium-style displays and interactive computer screens, would offer a memorable experience of the role of science in revealing the wonder and mystery of the physical universe, including stars, atoms, supernovae, and our own Sun. For example, a cosmic ray counter near the entrance, compared to one inside the mountain, would offer a tangible demonstration of the NUSL's impressive shielding power.

The demographics of the Coachella Valley and surrounding region offers a diverse ethnic and socioeconomic mix that includes students that may not have considered majoring or pursuing careers in science. The sheer scale of this national facility would leave a deep and long-lasting impression, and has the real potential to spark excitement and awe in young people.

The proximity of Southern California institutions of higher education puts opportunities for graduate and undergraduate training within driving distance. Economies of scale, for example the University of California's robust network of programs for minority outreach and education, would amplify the educational impact of a NUSL based here.

H. Schedule and Cost

Project Schedule

The project schedule logically breaks down into three parts:

1. environmental assessments, site investigation and project design
2. heavy civil construction, and
3. outfitting

Part 1 is a staged sequence of increasingly more detailed studies that will be finished in about 16 months from project start. Each of the subparts (environmental assessments, site investigation and project design) will be conducted in each phase. The standard design phases are conceptual design, design development and construction documents. Also included are preliminary environmental assessments early in the 16-month period, and development of an environmental mitigation plan. The 16-month time period also includes bidding and contractor selection.

Part 2, heavy civil construction includes mobilization and site work, TBM procurement, tunnel construction, construction of the connecting tunnels in the cavern complex, and construction of the experimental and support caverns. This phase is anticipated to take 36 months.

Finally, Part 3 is preparation of the finished underground excavations for occupancy. This outfitting includes HVAC, ventilation, lights, floors, fire alarm, fire suppression, fire separations and miscellaneous items. This phase is anticipated to take 8 months.
Beneficial occupancy is anticipated to occur 5 years after project start.

Estimated Capital Costs

Capital costs are provided in seven WBS categories. The following three categories have zero capital cost: WBS 1-Land & Easements, WBS 6-Cost of Money and WBS 7-Quality of Life. The other four categories contain all capital costs for San Jacinto: WBS 2-Surface, WBS 3-UG Access, WBS 4-UG Caverns, and WBS 5-Permits & Fees. An across-the-board 25 percent contingency is applied to all four categories.

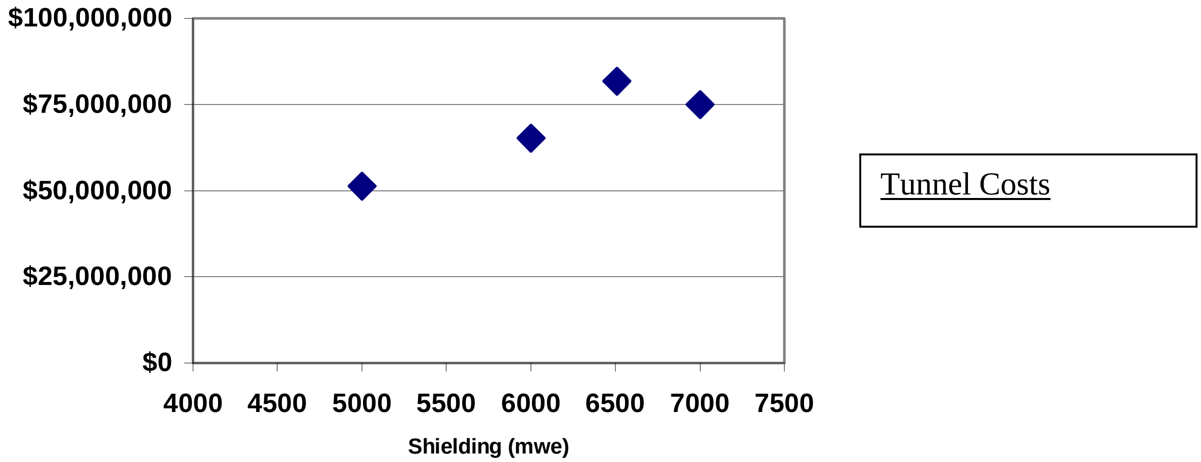
Tunnel costs, WBS 4, are estimated to range from $51,300,000 to $81,800,000. The cheapest option is for 5000 mwe and the most expensive is for 6510 mwe. Nearly $7,000,000 may be saved, and an additional 500 mwe is achieved by selecting to construct a shorter downgrade tunnel.

Total costs are estimated to range from $133,500,000 to $178,125,000. These costs include surface buildings, portal, tunnel, the cavern complex, excluding Cavern D, and outfitting (HVAC, cooling, lights, floors, fire alarms, fire suppression, fire separations, etc.)
The least expensive option breaks down as follows:

Surface	$6,600,000
UG Access	$51,300,000
UG Caverns	$33,200,000
Permits & Fees	$15,700,000
Contingency	$26,700,000

Estimated Operating Costs

The WBS operating cost categories are: fees, utility costs, maintenance, equipment & transportation, staff, outside costs & subcontracts. The San Jacinto project will have no fees; utility costs from electrical power, water, sewer, communications, waste haulage; maintenance costs for the portal, tunnels, UG space, and systems; equipment and transportation costs for forklifts and shuttles; six permanent staff; and outside costs and subcontracts for services like janitors, plumbers, etc. The estimated costs are $1,667,000 annually.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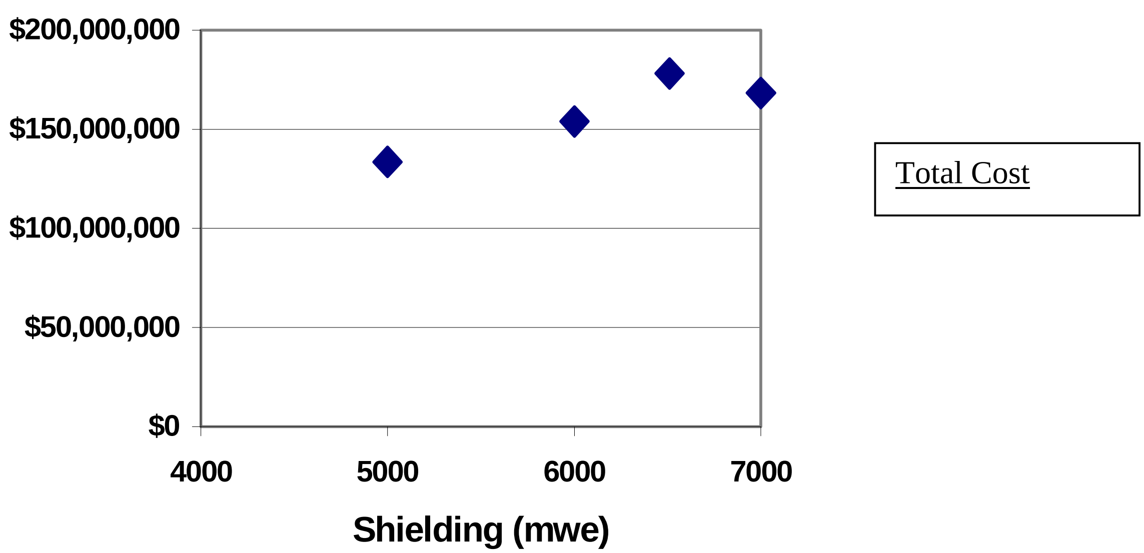
Shielding (mwe)
Tunnel Costs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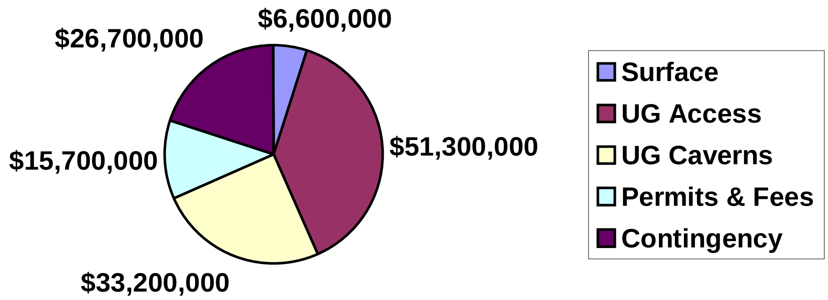

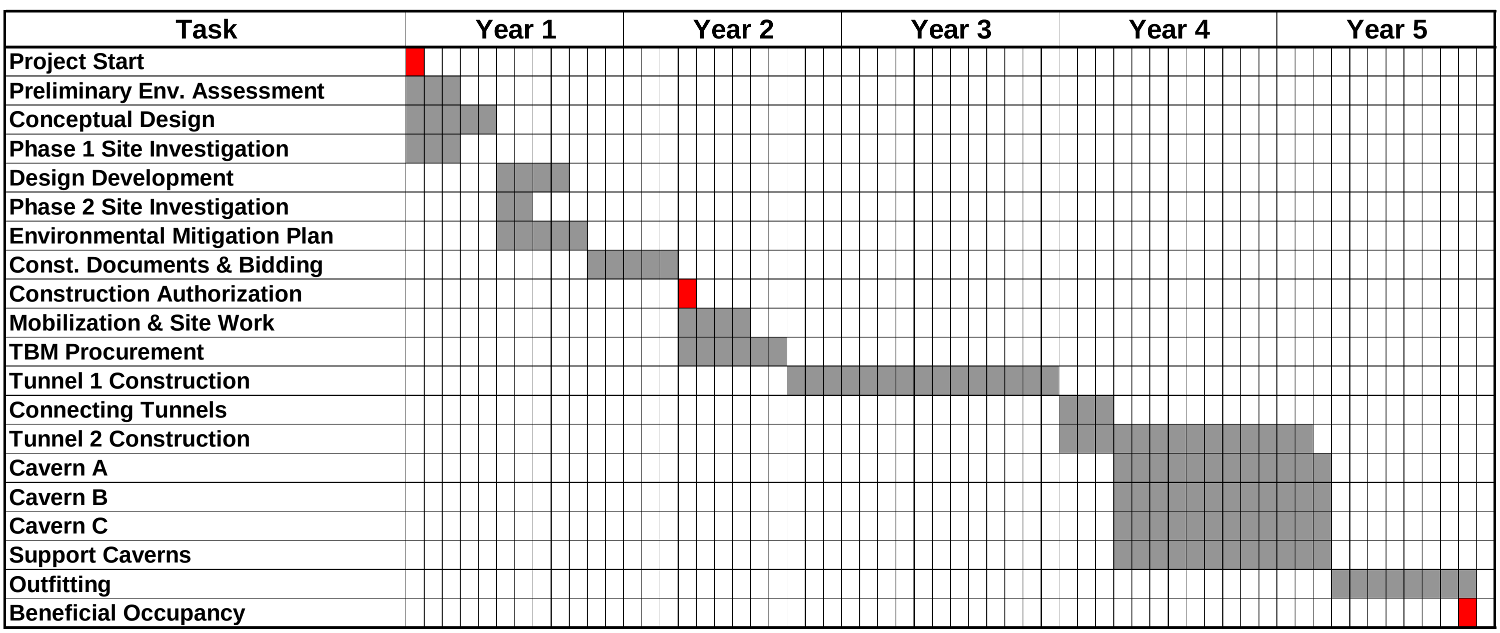

Project Schedule

I. Conclusion

This proposal illustrates that the San Jacinto NUSL site has no show-stoppers, and many significant benefits. Potential show-stoppers that have been eliminated by the information described above are:

- Biologic, aesthetic and groundwater environmental issues
- Clarification of jurisdictional and regulatory requirements
- Geologic and tunneling conditions
- Site ownership

Potential benefits are:

- Outstanding quality of life in the Palm Springs area
- Numerous outreach opportunities
- Enthusiastic support for the project by Palm Springs Aerial Tramway
- Easy access for 6-meter sea containers (also 12-meter)
- 24/7 access for personnel with no increases in operating cost
- Savings in many aspects of the underground operation. Substantial savings, due to drive in access, for an UNO cavern (Cavern D, including the support cavern, and access tunnels). The estimated cost for a dry, stable cavern & floor slab is about $70,000,000.