5 The Compelling Arguments for Siting DUSEL at Homestake

Many reasons for siting DUSEL at Homestake are presented in great detail throughout this Conceptual Design Report. In this chapter we highlight extraordinary opportunities to positively impact several significant underrepresented communities. This chapter provides an overview and summary of the arguments grouped into the following five categories 1) Physical Characteristics and DUSEL Key Parameters, 2) Local, Statewide and Regional Support, 3) Access to the Underground, 4) Management and Operations, and 5) Forefront Science, Education and Outreach Opportunities.

5.1 Physical Characteristics and DUSEL Key Parameters

Led by Bernard Sadoulet, the S-1 Principal Investigators, having canvassed potential DUSEL users in all disciplines, determined the key parameters, facility requirements and additional advantageous characteristics [51]. The Homestake site characteristics exceed the essential required physical characteristics, including access to depth, available space, support and infrastructure for the research, low radioactivity rock, and a low risk environment, and meets all the additional advantageous parameters.

5.1.1 Depth Requirement

Homestake DUSEL will develop three major *campuses* for stationary experiments at levels 7400, 4850, and 300 feet below ground, corresponding to shielding exceeding, respectively, 7000, 4200, and ~ 150 mwe. At these levels, current planning envisions laboratory footprints of, respectively, 5,000, 11,200, and 900m^2. Homestake DUSEL will also provide access to specialized research environments at levels of 8000, 3900 and 2000 feet below the surface, taking advantage of the long transverse drifts at these levels. A more thorough listing of levels of interest for research in the Homestake facility is presented in Chapter 6, Section 6.5.

5.1.2 Rock Type

Large stable excavated spaces, among them the cavity provided to Ray Davis (dimensions of 20 x 10 x 10 m) exist in Homestake mine at the 4850 Level, 7400 Level (50 x 10 x 3 m), and other levels. Many of these excavations have demonstrated stability for over 40 years. Several geotechnical studies, based on homogeneous rock properties, indicate cavities with 50m spans would be stable at 4850 Level. [40 - 45] The rock in the Yates formation has been documented to contain uranium and thorium concentrations 10 to 20 times lower than in granitic formations. The low radioactivity and the planned provision of radon-reduced air from the surface will provide appropriate environments for many physics experiments requiring radon mitigation.

The Homestake site is located in a geologically interesting and varied environment. The use of the Homestake facility with its existing shafts and drifts will provide a 2700-m *head start* on geomicrobiology studies that will probe the limits, and variety, of life in the underground.

5.1.3 Pristine Regimes

Over 30 km^3 of rock at the Homestake site can be accessed using existing drifts, ramps and shafts. Much of this rock was not the site of mining activities and exists in a nearly pristine state. However, as in nearly all mines, water was pumped from the mining areas. During its 126 years mining gold, the mine was continuously pumped of inflowing water. About two-thirds of this water (documented to be ~ 700 gallons/min) is surface water, while perhaps one third comes from deep sources. Probing underground environments for investigations that are sensitive to dewatering will require drilling out of the impacted zone. The depth will have to be experimentally determined (estimated to be approximately 300 to 500 m). Experiments will require special procedures to ensure the validity of the studies. The vast majority of the Homestake mine's excavations were related to ore extraction and, to a much smaller degree, exploration. There exist large intact blocks in a variety of geological formations that are pristine, impacted neither by excavation nor mining.

5.1.4 Distance from Existing Accelerators

The Homestake site is 1,300 km from Fermilab, 2,500 km from Brookhaven National Lab, 7,400 km from CERN, and 9,000 km from JPARC in Japan. The "Brookhaven – Fermilab Future Long Baseline Study Group" is developing preliminary design features for a very long baseline neutrino experimental program between these sources and Homestake DUSEL [20]. These baselines would cleanly resolve matter effects from CP effects and foster a rich neutrino properties research program, including determining the MNSP matrix elements, especially θ_{13}; determining matter hierarchy; and observing CP violating phase over a large range of variables. The larger detectors required for these measurements, if positioned deep enough, can simultaneously support research in nucleon decay, solar neutrinos, supernovae neutrinos and additional related studies.

5.1.5 General Accessibility

Homestake DUSEL will be a dedicated facility, continuously accessible at all times during the year. It will be uncompromised by competing activities such as mining or transportation that impede access in other facilities. Redundant conveyances will ensure safe and continuous access to the underground, even during preventative maintenance and service periods. Current plans include installing a new automated personnel lift providing access from the surface to the 4850 Level and refurbishing the main conveyances in the Ross and Yates shafts to support materiel and equipment transport. We are examining plans to convert the lifts into a "super" lift to provide a substantially larger lifting footprint. Redundant power feeds from the surface will ensure continuous, uncompromised power and communications. Title to the entire 186 acre surface facility and the entire underground site is held by the South Dakota Science and Technology Authority. Ownership of the site by the Authority provides assurance of at least 30 years of access to the site for DUSEL. Access to the underground will not be influenced by future mining activity or changes of ownership. The Homestake site is accessible via the Rapid City airport (which is served by multiple air carriers from Denver, Chicago, Minneapolis and Salt Lake City) and by interstate highways and major rail lines. The site is a ~ 40 mile drive from Rapid City. Within 50 miles of the mine there are three communities, including Lead, providing

all essential services: housing, medical, education, recreation, food, etc. There are collaborating universities in Rapid City and Spearfish.

As the premier underground research facility, access will be assured to all researchers, regardless of nationality, with appropriate training and conformance to facility procedures (such as workers compensation insurance coverage, etc.). Homestake DUSEL will fully conform to NSF policies concerning classified and proprietary research. The vast Homestake site can provide segregated sites and isolated facilities for Homeland Security applications that require isolation without impacting other research efforts.

5.1.6 Safety and Site-specific Requirements

Safety will be a primary focus for the Homestake Interim Lab and DUSEL management. Research in a facility shared with mining operations would have to follow Mine Safety and Health Administration-prescribed safety procedures, which, while instilling a culture of risk awareness, are not always appropriate for science and engineering efforts. Free of this constraint, Homestake DUSEL will develop a customized, state-of-the-art safety program that will embrace many of the essential mining safety components, but will also include the required experimental research safety components. The new Homestake ES&H programs will build on the Homestake mine's century-long safety history and instill a culture of safety at all levels and phases of the scientific programs.

5.1.7 Management

Homestake DUSEL will be a dedicated scientific facility. Indeed, the property donation agreement with Barrick Corp. forbids such uses as extraction of ore or the establishment of solely economic endeavors in the facility.

Management for both the Homestake Interim Facility and DUSEL will assure its users and sponsors that the scientific programs will be directed and managed by scientists and educators. As a dedicated scientific facility, Homestake DUSEL will guarantee unbiased freedom of inquiry to all scientific disciplines, including physics, earth science, geology, engineering and biology.

Education is a principal motivation for the impressive state support for Homestake DUSEL – education and public outreach will be a major focus.

5.1.8 Risk

The Homestake site was operated as a gold mine for over 126 years. The mining, operational, maintenance and geologic records have been transferred to the South Dakota Science and Technology Authority (the Authority). This comprehensive documentation of the physical characteristics and excavation experiences not only serves as a valuable scientific resource, but also gives confidence that Homestake DUSEL can be developed with low risk. The existing and rehabilitated infrastructure will allow a productive science and engineering research program to be established with little delay. The extraordinary support at the state level provides substantial capital to cover startup costs.

5.1.9 Key Parameters

To be responsive to the scientific users in developing the Homestake Interim Laboratory and DUSEL, we will create additional laboratory space as required with a minimal impact on existing research activities.

Before closing the Homestake mine, Barrick Corp authorities established a mine-closure plan that included a full environmental assessment and documentation of conformance to the Environmental Protection Agency's requirements. These documents, which have been included in our Design Reports, are made available to the public by the EPA.

The Authority will obtain all licenses and permits for construction and operation as a part of the rehabilitation for the Interim Facility. Title, insurance and indemnification issues have already been resolved by the Authority.

5.2 Local, Statewide and Regional Support, including Available Funding and Property Agreement

The State of South Dakota has been an exceptionally strong and steadfast supporter of DUSEL for the past six years. The State has worked actively with the scientific advocates for Homestake DUSEL to obtain the transfer of the property from the Homestake Mining Company, its former owner, and then from Barrick Corp. following its merger with the Homestake Mining Company. In January 2004, the two parties signed an Agreement in Principle to transfer title of the facility to a South Dakota public entity. In February 2004, the South Dakota legislature created the South Dakota Science and Technology Authority, endowed it with bonding authority, enacted the required state indemnity and immunity statutes, and funded it with $14.3M to be added to an existing $10M Department of Housing and Urban Development grant.

The State contracted with Dynatec Mining Ltd. to establish the preliminary engineering plan for the reentry and rehabilitation of the facility and to provide a realistic cost and schedule estimate for DUSEL. A summary of the Dynatec Plan [47] is provided in Appendix A10. A major focus of this plan deals with the Homestake mine's accumulated water.

The current governor of South Dakota, Michael Rounds, has made Homestake DUSEL a cornerstone of his administration's goals of promoting research, education and economic diversification in South Dakota. In October 2005, the State legislature approved (with a remarkable 96 to 4 favorable vote) an additional $19.9M for the Authority to fully fund the Homestake site rehabilitation, to provide funds for indemnification and an adequate contingency for initial basic operations of the underground laboratory, and to provide initial insurance. A summary of the state legislation is provided in Appendix A6. The State funding represents a commitment of ~$50 for every person in South Dakota to support the Homestake Interim Laboratory and DUSEL. In April 2006 the property donation was completed; title was transferred in May 2006 [see Appendix A6]. The Authority moved to the Homestake site and has added staff to maintain the facility and prepare for its reentry and rehabilitation. The Authority continues to discuss rock disposal and shared water treatment facilities with Barrick. The "open cut" at the Homestake site could provide a nearly limitless rock-disposal site adjacent to the Homestake site. The Authority continues to pursue these synergistic, shared activities that can yield tremendous advantages to DUSEL in the longer term.

Locally there exists effectively unanimous support for Homestake DUSEL. The educational and outreach potential for underrepresented minorities, in particular Native Americans, have united the local, state and regional support for DUSEL at Homestake. At DUSEL workshops we have had good representation by the Oglala Lakota College and the Sinte Gleska University. A good example of this support was at the recent Program Advisory Committee meeting and Letter of Interest Workshop in February 2006, all the meals for the ~120 participants were provided by the Lead, Deadwood, Rapid City, and Spearfish local governments and community booster groups.

In South Dakota a single Board of Regents that governs six universities has been, and continues to be, a strong DUSEL supporter. Working with the University of California, the Board is developing plans to advance physics education in the state, leading ultimately to establishment of a doctoratoral program in physics. Following the recent call for DUSEL-related R&D proposals by the NSF and DOE, UC Berkeley partnered with three South Dakota campuses to propose the development of a low background counting facility. An established education and outreach program in the region, the *Center for the Advancement of Math and Science Education* (CAMSE) [53], funded by a NSF grant, will relocate approximately half of its existing program to the Homestake site from Black Hills State University. The Homestake Scientific Collaboration and the Authority are hosting regional workshops to engage the South Dakota and nearby regional academic institutions in the Homestake DUSEL scientific and education programs. Included are institutions in Wyoming, Montana, Nebraska and North Dakota.

We are working with the State to provide advanced Internet connectivity to Homestake DUSEL as well as to the research universities in South Dakota (South Dakota School of Mines and Technology, University of South Dakota, and South Dakota State University). Phase 1 of this state program would connect Homestake DUSEL, Earth Resources and Observation Center (EROS) [52] and the research universities to the national grid through the major hub at Kansas City and provide ~10 GB/s connectivity. New fiber would be installed from the surface to the research levels in the facility to ensure seamless connectivity from the experiment to the surface facilities and hence to the external research participants.

The regional support for Homestake DUSEL was dramatically reinforced in June 2006 with the dramatic announcement by T. Denny Sanford of a $70M donation to establish an interim facility, including a science education facility, and to assist in the creation of a deep laboratory at the Homestake site. Combining the State's contribution of $46M with the Sanford Gift of $70M provides Homestake DUSEL with approximately half the estimated capital required to establish DUSEL and begin research early.

In all, Homestake DUSEL has received unequaled support at all levels – local, state and regional—making it the premier site for DUSEL.

5.3 Access to the Underground Facilities

The depths available at the Homestake site are appropriate for the world-class research program envisioned by the US and international users of DUSEL. To establish and support this research program, both space underground and convenient access to that space must be provided by the host facility. Homestake's Interim Laboratory staff will complete most of the prerequisite steps needed to establish access to DUSEL.

The Homestake Interim Laboratory plans provide for reentry to the facility and the rehabilitation of the Yates and Ross lifts. A variety of improvements to underground access will be completed,

including a high-speed, automated personnel lift, dedicated to the 4850 Level, that will give superior access compared to multi-mode or shared-access lifts. In our current schedule the 4850 Level laboratory could be prepared for beneficial occupancy as early as 2008. This early availability will substantially alleviate the underground space shortage documented in the S-1 Report "Deep Science"[5] and Appendix A4. This access to underground research space at the Homestake site will significantly stimulate the US research and development program for many of the essential research fields highlighted in the S-1 report. An active research and development program, coupled to early scientific results obtained from the Homestake Interim Laboratory, will significantly enhance the potency of the arguments for DUSEL.

Homestake's Early Implementation Program substantially reduces the risks inherent in creating a deep facility over other proposed sites. It provides accelerated access for key scientific programs and allows a smooth transition to the full DUSEL program. See chapter 4 for discussion of the transition from the Homestake Interim Laboratory into DUSEL.

Homestake DUSEL will be dedicated to scientific purposes; it will not be compromised or fettered by competing mining or economic interests. This will permit excavation underground to proceed according to scientific priorities rather than those imposed by a host mining entity. The dewatering program will similarly be established without competition from other interests. Access to the existing space will be guaranteed for at least 30 years, and additional regions of the facility will be made available as research programs require additional space.

5.4 Management and Operations

Management and operation of the Homestake Interim Laboratory will begin as a authority-run laboratory. The Authority has title to the facility, has started to refurbish the surface buildings, is adding staff to maintain the property and to prepare for rehabilitation, and has dealt with the legal, indemnification, immunity, and insurance issues for the site. The Authority will be the facility management entity for the Homestake Interim Laboratory.

The management plans include a strong partnership with the scientific collaboration and the creation of several critical scientific management positions. Independent expert oversight and review committees will be established.

The initial tasks for the Homestake Management team will be 1) the reentry and rehabilitation; 2) establishment of the 4850 laboratory; 3) establishment of the science education center, and 4) preparation for DUSEL.

The management team for DUSEL will evolve out of the structures established for the interim laboratory. This approach has many advantages for DUSEL. Many of the key safety and operations management positions will have been staffed, with key personnel trained and functioning in their roles. The process of establishing the scientific program is in place and is operating. The initial Letters of Interest have been solicited and, with the Program Advisory Committee's advice, the initial scientific program is being developed from these responses. The engineering and safety reviews are being established, as are operational procedures and rules of conduct. This presents the NSF with a functioning laboratory to be expanded and adapted into a full-fledged DUSEL. The framework for the Interim Laboratory management and operation has been designed to permit this smooth transition into DUSEL.

The scientific collaboration working with the Authority has vast experience with underground experiments and underground research laboratories. Its members bring direct international experimental experiences from Sudbury, Gran Sasso, Kamioka, Strippa, Oroville, Soudan, WIPP, Yucca Mountain, and other national and international underground research laboratories. There is a strong national laboratory participation in the Homestake DUSEL proposal, making resources and expertise at the Lawrence Berkeley, Brookhaven, Fermi, Oak Ridge, and Los Alamos National Laboratories available to assist with the planning of the facility. This national laboratory experience incorporates planning for large-scale experiments and also establishing and operating user facilities, including establishing management and safety procedures.

5.5 World-class Science, Education and Outreach Opportunities

The breadth of Homestake DUSEL's scientific programs and the time scale for establishing them contribute to the compelling arguments for siting DUSEL at Homestake. Homestake is a massive site, capable of supporting and fostering essentially all of the disciplines and experiments presented in the many national and international studies of DUSEL science. In the long term these efforts will strengthen DUSEL by increasing the users of the facility and stimulating a larger user pool. These research efforts would continue to operate as DUSEL is constructed.

The experiments in Homestake's Early Implementation Program address some of the most important and exciting programs facing physicists, biologists and earth scientists today. Homestake management is working actively with dark matter collaborations, nuclear-astrophysics accelerator groups, and several collaborations pursuing neutrinoless double beta decay experiments. As research and development phases for these experiments mature, we anticipate that several of these initial efforts will advance to be included in the Initial Suite of Experiments. We note in passing that the 300 Level space has attracted more attention from several fields, including physics experiments that require modest shielding for R&D efforts and education and outreach endeavors than has been previously discussed at S-1 meetings.

The Program Advisory Committee report highlighted the importance of developing shared infrastructure facilities and establishing the site baseline characteristics before rehabilitation commences. An experienced group of underground physicists has joined South Dakota university faculty in proposing a state-of-the-art low background counting facility. Efforts that have been initiated include water sampling, establishing a seismic array, and developing a database of geological, hydrological, and geochemical site features.

By providing this early access to underground facilities, we are assisting in creating a more advanced and technologically sound suite of experiments to be considered for DUSEL. Homestake DUSEL is preparing to host a larger suite of experiments and enabling more research opportunities for DUSEL by substantially expanding the time window for these experiments and by having already prepared much of the necessary suite of support services and facilities. Homestake management is establishing the world's first deep multidisciplinary facility for science, one that will advance several fields that are in dire need of underground facilities now.

Education and public outreach have been made a major focus of the Homestake DUSEL proposal, responding to the regional needs. The state has pledged substantial capital and personnel to the creation of a state-of-the-art science and education center. Coupling new initiatives to the existing South Dakota *Center for the Advancement of Math and Science*

Education program will enable a similarly accelerated start for the education and outreach efforts at Homestake DUSEL.

5.6 Summary

The Homestake site offers the lowest risk site for DUSEL. It offers the best "time to science" and also to education, public outreach, and collateral gains for the region. The proximity to several underrepresented communities will enable Homestake DUSEL to have significant impact. Education and public outreach will be an integral part of our efforts from the start. Homestake DUSEL enjoys outstanding local, statewide, and regional support, unlikely to be equaled by other proposed DUSEL sites; it is without vocal or public opposition.

Research of the highest importance for our physics, earth science, and engineering communities will be addressed in the near future. The efforts will be completely science and education driven, with no conflict with, or disturbance from, mining, transportation, or other priorities.

Homestake's site characteristics will foster the full spectrum of research promoted by the S-1 report and other national and international studies. Its plans for making underground space available at deep, intermediate, and shallow sites will accommodate a broad spectrum of experiments envisioned by the S-1 study. This spectrum will expand as the programs mature. Several Homestake formations are low in intrinsic radioactivity, a factor of 10 to 20 lower than typical granitic formations. Homestake DUSEL will provide clean rooms, new laboratory space with radon-reduced air and the ability to host the most sensitive experiments, helping make it the premier underground research laboratory in the world.

Homestake DUSEL is easily expandable in all dimensions – additional underground laboratories will be developed in a phased approach over the coming decades to accommodate our continually evolving research efforts. The rock at Homestake is known to be capable of hosting large stable excavations for decades.

Homestake DUSEL has an experienced and capable management team in place to establish the Interim Laboratory, to plan for and to provide a smooth transition to DUSEL. The scientific collaboration has vast experience in all the disciplines proposed for DUSEL, as well as experience in establishing and operating user facilities.

We propose a phased plan for creating DUSEL. The first steps, managed and operated by the Authority, will establish much of the essential infrastructure and initiate scientific and engineering investigations. This interim facility will significantly alleviate the world-wide shortage of underground laboratory space. Homestake DUSEL will then evolve to provide the space and infrastructure required for an ambitious Initial Suite of Experiments and subsequent expansions as required by the science.