DOE/EIS - 0138
Volume III

FINAL
ENVIRONMENTAL IMPACT STATEMENT

SUPERCONDUCTING SUPER COLLIDER

Volume III

December 1988

U.S. Department of Energy

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DEPARTMENT OF ENERGY
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VOLUME III METHODOLOGY FOR SITE SELECTION

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CHAPTER 1 INVITATION FOR SITE PROPOSALS

In February 1987, DOE established an SSC Site Task Force (STF), chaired by Dr. Wilmot N. Hess (Associate Director for High Energy and Nuclear Physics, Office of Energy Research).

The STF consists of DOE key personnel from: Energy Research; General Counsel; Management and Administration; Environment, Safety and Health; and the DOE San Francisco Operations Office. They are:

Wilmot N. Hess, Chairman, SSC Site Task Force, Office of Energy Research

L. Edward Temple, Jr., Executive Director, SSC Site Task Force, Office of Energy Research

Richard H. Nolan*, Deputy Executive Director, SSC Site Task Force, San Francisco Operations Office

Robert L. Forst*, Office of General Counsel

Earle C. Fowler, Office of Energy Research

Daniel R. Lehman, Office of Energy Research

Howard K. Mitchell, Office of Assistant Secretary, Management and Administration

Robert H. Strickler* (replaced by Warren Black in August 1988 who was made a voting member), Office of Assistant Secretary for Environment, Safety, and Health

Donald G. Trost, Office of Assistant Secretary, Management and Administration

Robert A. Zich, Office of Energy Research

The STF was given specific tasks which were:

- o Development of site evaluation criteria and cost considerations for site selection.
- o Preparation of the ISP.
- o Identification of qualified proposals from among those submitted.

*Non-voting member

- o Review and validation of the National Academy of Sciences/ National Academy of Engineering (NAS/NAE) SSC Site Evaluation Committee's report and recommendations of the Best Qualified List (BQL).
- o Implementation of the NEPA process.
- o Development of cost analyses.
- o Confirmation of geotechnical, environmental, and other information provided by BQL proposer organizations.
- o Comprehensive evaluation of BQL proposals.

1.1 SOLICITATION

On April 1, 1987, the DOE issued the solicitation for potential sites for the SSC as DOE/ER-0315, called the Invitation for Site Proposals (ISP). This ISP invited states and other parties to provide land and propose specific sites for the construction and operation of the SSC, the world's largest and most advanced particle accelerator. Proposals were required to be submitted to DOE no later than August 3, 1987. Potential proposers were also requested to provide opportunities for offsetting SSC construction and operation costs to the Federal Government.

Two amendments to the ISP were made by DOE. Amendment 1 (June 24, 1987) made corrections in wording to Sections 2.2.2.1.1 and 3.3.4.1 of the ISP and identified an alternate approach to land acquisition required for the SSC. Amendment 2 (July 14, 1987) made the ISP conform to legislation which had been enacted to prohibit DOE from considering financial or other incentives in the selection of a site for the SSC and delayed the deadline for proposal submittals until September 2, 1987.

Land requirements were identified in the ISP as approximately 16,000 acres to be occupied by the SSC complex. The restrictions cited were:

- o Land offered must be completely within the U.S.
- o Clear title must be provided in a timely manner at no cost to the Federal Government.
- o A real estate acquisition plan must be submitted to DOE.

It was not necessary that land inside the collider ring be owned or even controlled by the Federal Government. General access across the ring would be allowed. In general, it would be possible to continue to use most existing roads, railroads, and utility facilities.

The Government required the unconditional fee simple title to all land on which permanent improvements are planned or anticipated. This included all surface areas (e.g. campus areas, service areas, injector areas, experimental areas) including surface areas that were above tunnels which were less than or equal to 50 ft below ground. To maintain the integrity integrity of a deep tunnel (deeper than 50 ft) in the collider arcs and beam absorbers, a stratified fee estate was sufficient. Enough land to adequately support the SSC in various types of rights-of-way for off-site roads, utilities, and communication lines was also required.

The ISP further defined the SSC as a major Federal action requiring the preparation of an EIS under NEPA.

The ISP stated five qualifications for proposals to be considered. These were (as quoted below):

- "Location entirely in the United States of America.
- Land size and configuration to accommodate the SSC facility as specified in this Invitation, including Figure 1-2 and Table B-1.
- Absence of cost to the Government for land acquisition.
- Capability of providing at least 250 MW of electrical power with at least 500 gpm of industrial water or 200 MW of power with 2,200 gpm of industrial water, or an appropriate interpolated combination.
- Absence of known unacceptable environmental impacts from siting, constructing, operating, and decommissioning the SSC. Reasonable mitigation measures may be taken into consideration."

The ISP also stated that technical evaluation criteria within six major topics and cost considerations would be used for proposal evaluation by the NAS/NAE committee for recommendation of the BQL to DOE and used by DOE to select the most qualified site. In order of importance the criteria were (as quoted below):

- "Geology and Tunneling
  - Suitability of the topography, geology, and associated geohydrology for efficient and timely construction of the proposed SSC underground structures.
  - Stability of the proposed geology against settlement and seismicity and other features that could adversely affect SSC operations.
  - Installation and operational efficiency resulting from minimal depths for the accelerator complex and experimental halls.
  - Risk of encountering major problems during construction.

- o Regional Resources

  - Proximity of communities within commuting distance of the proposed SSC facilities capable of supporting the SSC staff, their families, and visitors. Adequacy of community resources--e.g., housing, medical services, community services, educational and research activities, employment opportunities for family members, recreation and cultural resources--all available on a nondiscriminatory basis.

  - Accessibility to the site, e.g., major airport(s), railroads, and a highway system serving the vicinity and site.

  - Availability of a regional industrial base and skilled labor pool to support construction and operation of the facility.

  - Extent and type of state, regional, and local administrative and institutional support that will be provided, e.g., assistance in obtaining permits and unifying codes and standards.

- o Environment

  - Significance of environmental impacts from siting, constructing, operating, and decommissioning the SSC.

  - Projected ability to comply with all applicable, relevant, and appropriate federal, state, and local environmental/safety requirements within reasonable bounds of time, cost, and litigation risk.

  - Ability of the proposer, the DOE, or both to reasonably mitigate adverse environmental impacts to minimal levels.

- o Setting

  - Ability of the proposer to deliver defendable title, in accordance with the schedule in Section 2.2.2.4, for land and estates in land that will adequately protect the Government's interest and the integrity of the SSC during construction and operation.

  - Flexibility to adjust the position of the SSC in the nearby vicinity of the proposed location.

  - Presence of natural and man-made features of the region that could adversely affect the siting, construction, and operation of the SSC.

- Regional Conditions
  - Presence of man-made disturbances, such as vibration and noise, that could adversely impact the operation SSC.
  - Presence of climatic conditions that could adversely impact construction and operation of the SSC.
- Utilities
  - Reliability and stability of the electric power generating and transmission grid systems. Flexibility for future expansion.
  - Reliability, quality, and quantity of water to meet the needs of the facility.
  - Availability of fuel, waste disposal, and sewage disposal."

The ISP stated cost considerations were important and conjunction with the technical evaluation criteria in selecting the most desirable site. For each proposal meeting the qualification criteria, a life cycle cost (LCC) estimate would be prepared for the construction phase plus a 25-year operating phase. Although cost considerations are significant, primary emphasis would be placed on the results from the evaluation of technical evaluation criteria by the NAS/NAE in the development of their recommendation to DOE. DOE would place similar emphasis in its determination of the preferred site.

1.2 PROPOSALS SUBMITTED AND QUALIFIED

Forty-three proposals for the SSC were received by DOE by September 2, 1987 (see Table 1-1). The initial evaluation consisted of DOE's determination of compliance by the proposals with the qualification criteria. Proposals which met the qualification criteria were sent to the NAS/NAE Committee (see Chapter 2).

Thirty-six proposals were found qualified and forwarded to the NAS/NAE. If a proposal site did not meet the qualification criteria, it was eliminated from further consideration. The proposing organization was informed of the elimination and the criteria not satisfied were enumerated. Those eliminated are also indicated on Table 1-1 in this section.

Table 1-1

PROPOSALS SUBMITTED TO DOE FOR SITING THE SSC

DOE ID.	State - Site	Proposing Organization/ Proposer
1	*Texas - Liberty County	Terrell G. Lara
2	*N/A	Paul Jablonka
3	New Mexico - Estancia Basin	State of New Mexico
4	South Dakota - Northern Great Plains	State of South Dakota
5	*Washington - Mattawa	A-Enterprises
6	Montana	State of Montana
7	Nevada	State of Nevada
8	New Mexico - Dona Ana County	West Texas Council of Govts. & Dona Ana County
9	Wyoming - Cheyenne	State of Wyoming
10	Texas - Far West Texas	West Texas Council of Govts.
11	Utah - Ripple Valley	State of Utah
12	Utah - Cedar Mountains	State of Utah
13	Florida - Jacksonville	State of Florida
14	Kansas - Topeka	State of Kansas
15	Tennessee	State of Tennessee
16	New York - St. Regis Valley	State of New York
17	Louisiana	State of Louisiana
18	Oregon - Columbia River	State of Oregon
19	Arizona - Maricopa	State of Arizona
20	Texas - Amarillo	State of Texas
21	Colorado - Denver	State of Colorado
22	Mississippi	State of Mississippi
23	Illinois - Fermilab	State of Illinois
24	Oklahoma	State of Oklahoma
25	**New York - Wallkill Valley	State of New York
26	Texas - Dallas/Ft. Worth	State of Texas
27	Ohio	State of Ohio
28	Arizona - Sierrita	State of Arizona
29	**New York - Rochester	State of New York
30	Washington - Lincoln County	State of Washington
31	Oregon - University	State of Oregon
32	No. Carolina - Raleigh/Durham	State of No. Carolina
33	Michigan - Stockbridge	State of Michigan
34	Alaska - Denali	State of Alaska
35	Michigan - Dundee	State of Michigan
36	Texas - Garden City	Garden City SSC Commission

*Eliminated as not meeting qualification criteria
**Subsequently withdrawn by the proposing organization

Table 1-1 (Cont)

PROPOSALS SUBMITTED TO DOE FOR SITING THE SSC

DOE ID.	State - Site	Proposing Organization/ Proposer
37	*Utah - Delta Area	Larsen Institute of Technological Evolution
38	Idaho - Idaho National Engineering Lab.	State of Idaho
39	*New York - International	State of New York
40	California - Davis	State of California
41	California - Stockton	State of California
42	*Texas - Devers	O.R. Amy
43	*Texas - Devers	Bill Leatherwood

*Eliminated as not meeting Qualification Criteria
**Subsequently withdrawn by the proposing organization

CHAPTER 2 ESTABLISHMENT OF THE BEST QUALIFIED LIST

2.1 NAS/NAE COMMITTEE EVALUATION PROCEDURES

By prior agreement, the NAS/NAE convened a committee for the independent evaluation of the 36 qualified proposals using the technical evaluation criteria (Section 1.1 above) and cost considerations. The committee was established in June 1987 and developed procedures for review prior to receipt of the proposals. The evaluation of the qualified proposals and the resulting recommendation of the BQL made to DOE is described in Section 2.2; DOE's review and validation of the NAS/NAE report and naming of the BQL are described below.

2.1.1 Committee Membership

The NAS/NAE Committee was composed of 21 individuals well qualified for the assigned task because of their technical and management expertise and experience. Eight have had extensive experience in managing large scientific enterprises. The membership consisted of:

Edward A. Frieman, Chairman, Scripps Institution of Oceanography and the University of California, San Diego, California

Robert McCormick Adams, Smithsonian Institution, Washington, D.C.

William J. Baumol, Princeton University, New Jersey, and New York University, New York

John E. Cantlon, Michigan State University, East Lansing, Michigan

LLoyd S. Cluff, Pacific Gas and Electric Company, San Francisco, California

Ernest D. Courant, Brookhaven National Laboratory, Upton, New York

Don U. Deere, Consultant, Gainesville, Florida

Thomas E. Everhart, California Institute of Technology, Pasadena, California

Marvin L. Goldberger, Institute for Advanced Study, Princeton, New Jersey

William R. Gould, Southern California Edison Company, Rosemead, California

Lieutenant General Elvin R. Heiberg, III, U.S. Army Corps of Engineers, Washington, D.C.

Edward G. Jefferson, Du Pont Company, Wilmington, Delaware

Herman B. Leonard, John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts

Walter E. Massey, University of Chicago and Argonne National Laboratory, Argonne, Illinois

Paul J. Reardon, Science Applications International Corporation, Princeton, New Jersey

Nicholas P. Samios, Brookhaven National Laboratory, Upton, New York

Roy F. Schwitters, Harvard University, Cambridge, Massachusetts

Charles H. Townes, University of California, Berkeley, California

Victoria J. Tschinkel, Consultant, Tallahassee, Florida

Steven Weinberg, University of Texas, Austin, Texas

Stanley G. Wojcicki, Stanford University, Stanford, California, and the SSC Central Design Group, Berkeley, California

2.1.2 Evaluation Procedures

The Committee formed seven working groups focusing on the six technical evaluation criteria (Section 1.1) and on cost. Each group was composed of committee members having specific expertise in the area of focus of that group. The charter of each working group was to identify strengths and weaknesses of each proposal using a scale of good, satisfactory, and questionable.

The results of these working groups' efforts were used as bases for committee discussions of those sites meriting inclusion in the recommended BQL to be furnished to DOE.

The following conditions should be noted concerning the Committee's work:

- The schedule for evaluation was aggressive and their evaluation was to be based on the information provided in the proposal.
- No explicit weighting or ranking method was implemented due to the complexity of aggregating ratings for all criteria and subcriteria.
- No "appropriate" number of best-qualified sites was previously established.

2.1.3 Discussion of Technical Evaluation Criteria

Favorable site conditions within each of the six technical evaluation criteria and cost considerations were identified by the working groups. Unfavorable site conditions were also identified which were used as comparative among sites. The favorable conditions are illustrative of those identified by the Committee and focus on the characteristics of those sites recommended as the BQL.

These favorable conditions included:

- Geological Basis
  - Groundwater table below tunnel depth
  - Low permeability rock
  - Uniform rock
  - Rock allowing rapid boring or excavation
  - Shallow depths for tunnel
  - Rock having high quality mechanical and chemical characteristics.
- Regional resources
  - Potential for attraction and retention of first-class staff
  - Staff spouse employment opportunities
  - Cultural and recreational opportunities
  - Ease of access to the laboratory
  - Capability of supporting diverse lifestyles
  - Local labor pool
  - Local support of the project.
- Environment
  - Minimal consequences on environmental resources
  - Adequate data for assessment of impacts.
- Other technical criteria
  - Moderate climate
  - Simplicity and timely land acquisition plan
  - Transportation support systems.
- Cost
  - Minimal construction costs
  - Minimal operating costs.

2.2 RECOMMENDED BQL

Table 2-1 summarizes the characteristics the Committee cited in recommending sites as best qualified. The NAS/NAE recommended BQL was:

Arizona/Maricopa
Colorado
Illinois

Table 2-1

NAS/NAE RECOMMENDED BQL AND STATED FAVORABLE CONDITIONS FOR SITING THE SSC

	Cited Favorable Conditions
Arizona	Favorable geology; minimal dewatering or groundwater impacts; requisite regional resources and strong technical labor base at or near the site; minimal environmental degradation; few affected landowners
Colorado	Simple, predictable geology; minimal groundwater impacts; strong regional resources of Denver and Boulder (although somewhat distant); good transportation; minimal environmental degradation; few required relocations
Illinois	Geological formation in which there is extensive tunneling experience; excellent regional resources; extensive transportation system; beneficial infrastructure associated with Fermilab
Michigan	Favorable geology; essential regional resources at or near the site; excellent industrial base; limited environmental degradation
New York/ Rochester*	Favorable predictable geology; requisite regional resources at or near the site; advanced technology industrial base; limited environmental degradation
North Carolina	Favorable geology; strong local attributes, including Research Triangle Park; good regional conditions, including climate
Tennessee	Generally favorable geology; requisite regional resources nearby; minimal environmental degradation; moderate climate; good regional conditions
Texas/Dallas Fort Worth	Excellent geology; regional resources and technological base of major urban center; moderate number of affected landowners; good regional conditions

*Withdrawn by the proposer.

Michigan/Stockbridge
New York/Rochester
North Carolina
Tennessee
Texas/Dallas-Fort Worth

The New York/Rochester site proposal was withdrawn on January 15, 1988, by the proposing organization.

2.3 DOE SELECTION OF BQL

On January 19, 1988, DOE announced the BQL.

DOE received the NAS/NAE report of the evaluation which included an unranked list of its recommended best qualified sites on December 24, 1987. DOE reviewed and validated the NAS/NAE report. Based on a review of the report, discussions with the Academies' Committee and the STF's familiarity with the site proposals, DOE concluded that the Academies followed and fully satisfied the requirements and quidelines outlined in the ISP. (On January 15, the State of New York withdrew its proposal for the Rochester site that had been recommended by the Academies.) On January 19, the Secretary of Energy announced the final BQL to be the same as the seven sites remaining on the Academies' list. The other proposers were provided debriefings by the DOE STF during the following weeks.

CHAPTER 3 IDENTIFICATION OF PREFERRED/FINAL SITE

3.1 REVIEW PROCEDURES

Since January 1988, the STF has been conducting detailed evaluations of the seven remaining BQL sites using the technical criteria and cost considerations contained in the ISP. The STF has gathered additional information concerning all of the technical evaluation and cost considerations. To further verify site proposal information, the STF, during the period April through July 1988, visited each best qualified site to 1) obtain, where necessary, clarification of specific areas of the State's proposal, and 2) tour the site.

Detailed STF analyses and environmental information were presented to the DOE Energy Systems Acquisition Advisory Board (ESAAB) as input into the decision process. After considering the STF and ESAAB findings, the Secretary of Energy designated the preferred site in November 1988.

3.2 PREFERRED SITE

Following announcement of the Best Qualified List (BQL) in January 1988, the Site Task Force began a detailed evaluation of the BQL proposals. The Site Task Force reexamined the proposals, reviewed the supplemental data that had been requested by DOE from the proposers, made site visits, and reviewed data assembled for the Environmental Impact Statement. Within a given technical criterion, each subcriterion was discussed until a consensus was reached on the rating to be given to each proposal on that subcriterion. Similarly, the Site Task Force refined the life-cycle cost estimates for each site using all available data. The Site Task Force neither developed numerical ratings for, nor ranked, the proposals.

The Secretary of Energy, John Harrington, announced his selection of the preferred site, the Texas site, on November 10, 1988, based on the following selection statement. Key input to his deliberations were the SSC Site Evaluation Report (DOE/ER-0392, November 1988), meetings with the proposers, the DEIS, and discussion of summary issues raised by comments which had been received on the DEIS.

The preferred site selection statement and the SSC Site Evaluation Report, which are major references, are reprinted in their entirety at the end of this Chapter 3 for the reader's convenience, but are not a component of the EIS itself.

3.3 FINAL SITE

No sooner than 30 days after the Final EIS is filed with the Environmental Protection Agency, the DOE will publish its Record of Decision in the Federal Register. This will document the site selection decision and the factors considered in the decision. It will also include discussions of alternatives that were considered and mitigation measures selected to avoid or minimize any environmental impacts.

REFERENCES CITED

DOE/ER-0315, "Invitation for Site Proposals for the Superconducting Super Collider (SSC), April 1987," as amended. U.S. DOE/Office of Energy Research/SSC Site Task Force.

DOE/SSC Site Task Force, "Best Qualified Sites for the Superconducting Super Collider," January 1988.

NAS/NAE, Superconducting Super Collider Site Evaluation Committee, "Siting the Superconducting Super Collider," National Academy Press, Washington, D.C., January 1988.

DOE/ER-0392, "SSC Site Evaluations - A Report by the SSC Site Task Force," November 1988.

Selection of the Preferred Site for the Superconducting Super Collider

In early November 1988, the Department's Site Task Force for the Superconducting Super Collider (SSC) completed its report on the evaluation of the seven best qualified site proposals for location of the SSC. The Task Force report has been presented to me and to the Energy System Acquisition Advisory Board, comprised of senior Department officials. In reaching my decision on the preferred site, I have also considered information in the Draft Environmental Impact Statement on the SSC issued in August 1988, and a summary of the comments submitted on the Draft Statement. In addition, certain senior Department officials and I attended a presentation made by representatives of each of the seven states proposing a site which was chosen for the best qualified list. Each state proposer was thus given the opportunity to describe the strengths of its site directly to me.

Selection and Evaluation Process

Twenty-one months ago, in February 1987, the Department announced the SSC site selection process, which was designed to assure a fair and open competition among states or other proposers which wanted to offer a site for the SSC. This process included the establishment of an SSC Site Task Force of career Department employees reporting to the Director of the Department's Office of Energy Research. Activities of the Task Force included preparing the *Invitation for Site Proposals for the SSC*, and performing a comprehensive evaluation of the best qualified proposals.

On April 1, 1987, the *Invitation for Site Proposals for the SSC* was issued. The *Invitation* included the procedures for selection, qualification criteria, technical evaluation criteria, and cost considerations.

In response to the *Invitation*, the Department received 43 proposals by the deadline date of September 2, 1987. The Task Force reviewed those proposals to determine if they met the qualification criteria. Seven proposals did not meet one or more of those criteria and were disqualified. Thirty-six proposals for sites in 25 states met all the qualification criteria.

On September 17, 1987, the Department forwarded the qualified proposals to the National Academy of Sciences/National Academy of Engineering (NAS/NAE) for their evaluation and recommendations of the best qualified sites. (One proposal, New York, Wallkill Valley, was withdrawn by the proposer in October 1987, leaving 35 sites for further evaluation.) On December 24, 1987, the NAS/NAE submitted their report to the Department which identified eight sites that "merited inclusion" on the best qualified list. (One recommended best qualified list proposal, New York, Rochester, was withdrawn by the proposer on January 15, 1988.)

The Task Force reviewed the report, met with staff of the NAS/NAE and after discussion among Task Force members, unanimously recommended that the Department accept the recommendation of the NAS/NAE that the following proposals be considered the best qualified list of sites. That list was accepted by the Department and was announced on January 19, 1988:

Arizona (Maricopa)
Colorado
Illinois
Michigan (Stockbridge)
North Carolina
Tennessee
Texas (Dallas-Fort Worth)

Following announcement of the best qualified list in January 1988, the Task Force began a detailed evaluation of those proposals. The Task Force re-examined the extensive material submitted as part of each proposal, requested additional information and clarification from proposers, utilized the expertise of other Department employees and contractors where necessary to help evaluate data, conducted personal visits to each site, and met with representatives of the proposers and others as necessary for a thorough understanding of each proposal.

The report by the SSC Site Task Force dated November 1988, is being made available to the public. That report contains a detailed description of the selection procedure, evaluation criteria and cost considerations, background of selection activities, the best qualified sites, and the Task Force's ratings and life-cycle cost evaluation for each site and the supporting rationale. In view of the availability of that report, there is no need to summarize here the material included in the report.

Selection

The evaluation by the Task Force was thorough and was consistent with applicable procedures. The Task Force gave fair and complete consideration to the proposals under the bases for evaluation set forth in the *Invitation*.

After the presentation by the Task Force to me and to the Energy System Acquisition Advisory Board, I solicited the views of the Board and other appropriate senior Department staff. As was stated above, I have also considered the Draft Environmental Impact Statement on the SSC and a summary of the comments on the Draft Statement. Further, I have heard a presentation by representatives of each state proposing a site which was chosen for the best qualified list.

Consistent with the requirements of the National Environmental Policy Act and regulations implementing that Act, my decision at this time is the selection of the preferred site for the SSC. Final site selection will be made after publication of the Final Environmental Impact Statement, which we anticipate will be in early December, and will be incorporated in the Department's Record of Decision, which will be issued no sooner than 30 days after publication of the Final Environmental Impact Statement.

Based on the foregoing, I select, as the preferred site for the location of the SSC, the site proposed by the State of Texas.

I have made this decision for a number of reasons. First, the Texas site is the location that best meets the goal of the SSC site selection process, which is to identify a site that will permit the highest level of research productivity and effectiveness of the SSC at a reasonable cost of construction and operation with minimal impact on the environment. Based on the findings of the Site Task Force and considerations mentioned above, it is clear that, whether considered from an overall perspective or from the perspective of individual site criteria, the Texas site best meets the objectives of the site selection process.

The technical evaluation criteria and cost considerations as described in the *Invitation* form the basis for this conclusion. These criteria include: Geology and Tunneling; Regional Resources; Environment; Setting; Regional Conditions; and Utilities. These are listed in descending order of relative importance. Life-cycle cost estimates prepared for each of the best qualified sites must also be considered in the decision. These cost estimates must be used in conjunction with the technical evaluation criteria in selecting the preferred site, but the primary emphasis must be placed on the results of the technical evaluation criteria.

Under the six technical evaluation criteria taken as a whole, the Texas site is rated the highest overall by the Task Force. The Task Force's ratings and reasoning are persuasive.

In the area of geology and tunneling, several factors were important in the evaluation. These included the geologic suitability of the site, the operational stability and efficiency at the site, and the potential for construction risk. In Texas, the tunnel will be constructed in a uniform, well characterized and understood geologic medium. The characteristics for tunneling are excellent. The chalk and marl in which the tunnel will be constructed are essentially impermeable and no water problems are anticipated. The average tunnel depth of approximately 150 feet is relatively shallow and advantageous from an operational standpoint. There is extensive experience in the area in tunneling this type of material, and the site presents the Department with a minimal construction risk.

The regional resources criterion considers the accessibility and quality of community resources (e.g., housing, employment opportunities for family members etc.), transportation accessibility to the site, the availability of an industrial base to support construction and operation of the SSC, and the extent of the institutional support or opposition present in the area that might affect the Department's ability to construct and operate the SSC. The Texas site presents the Department with a superb array of regional resources to support the SSC. This includes an excellent supply of easily accessible housing at below National average prices, and good employment opportunities for spouses. The site is easily accessible by convenient air and road access and offers an excellent rail network. There is a skilled high-technology and construction labor pool base in the area. There has been exemplary coordination among state and local governmental units as well as the citizenry. A high level of public support exists for the project.

In considering environment, the Department reviewed the SSC's potential environmental impact (with particular emphasis on potential effects on sensitive environments, surface or groundwater resources, and air quality), the ability to meet applicable environmental regulatory requirements, and the potential for minimizing environmental impacts. The technical evaluation rating for environment at the Texas site is outstanding. The natural ecology of the area has already been highly modified through extensive development of the land for pasture and farming. Potential impacts to wetlands and sensitive habitats would be insignificant. The site meets attainment requirements as specified by the National Ambient Air Quality Standards. Finally, the tunnel would be excavated above the groundwater table and the potential for water quality impacts to surface or groundwater is low.

The setting evaluation criterion requires that the Department consider the ability of a proposer to deliver its offer of real estate in a timely manner, the ability to relocate the entire ring or surface facilities at the designated site and the presence of natural and man-made features at the site which might interfere with the construction or operation of the SSC. The Texas site is outstanding in the area of setting. The Department is confident about Texas' ability to deliver its offer of land on schedule. There is a well conceived land acquisition plan and schedule in place. Further, the relocation plan is well prepared and the acquisition team has shown great sensitivity to potentially affected landowners. There is an experienced land acquisition management team in place, and no scheduling problems are anticipated in acquiring the land or in accomplishing the required relocations. Finally, the site allows good flexibility to adjust the final ring location. There are no significant natural or man-made features in the area which would adversely affect construction and operation of the SSC.

With regard to regional conditions, the evaluation is concerned with potential sources of vibration and noise which might affect the operation of the SSC, and with the climatic conditions which could affect construction schedules or operating parameters. Texas is good in this criterion. The vibration levels from roads, railroads, and quarries are generally acceptable and the climate is considered excellent for SSC construction and operational requirements. While there is some concern with vibration from one railroad line at a point over the collider tunnel, increased track maintenance or better cushioning of the railroad bed should minimize this problem to acceptable levels. We believe such measures are relatively easy to accomplish.

In the utilities criterion, the technical evaluation focuses on each proposer's ability to provide reliable and stable electrical power to the SSC, its ability to provide reliable sources of water in sufficient quantity, and ability to provide fuel and handle waste generated by the SSC. The Texas site, as is the case with all the best qualified list of sites, has been rated good in this criterion. This is based on the conclusion that each site can adequately support the SSC's utility needs.

As was stated above, life-cycle cost is also a consideration in selection of a preferred site. The results of the life-cycle cost estimates for each of the best qualified sites yield an average life-cycle cost of $11.0 billion. This estimate covers the construction of the SSC and a projected 25-year operating lifetime for the machine. The range of the estimates is $10.7 to $11.5 billion (excluding any credit to the Illinois proposal for the proposed use of the Tevatron at Fermilab as an injector for the SSC). The total life-cycle cost estimate for Texas is $10.8 billion. This puts Texas among the lowest of the proposals with regard to life-cycle cost. Further, the projected life-cycle cost for the construction of the SSC at the Texas site is consistent with the Department's construction estimate for the SSC as presented to Congress.

Even after considering the possible credit which might be attributed to use of the Tevatron, the cost differences among sites is in a comparatively narrow range. Moreover, there are general inherent uncertainties in predicting costs for the SSC at any site over a 25-year period (possibly 10 percent). Accordingly, even though the Texas life-cycle cost estimate is not the lowest of the best qualified sites, its superior overall technical rating clearly outweighs any cost advantage at any other site.

In summary, the Texas proposal, based on my assessment of the criteria weighed in the objective site selection process, is the superior preferred site. It was rated outstanding on the first four technical evaluation criteria. These are the four most important technical evaluation criteria. No other proposal received outstanding ratings on geology and tunneling, regional resources, environment, and setting. The lowest rating on any technical evaluation criterion for the Texas proposal was good on regional conditions; and good on utilities (for which all sites were rated good).

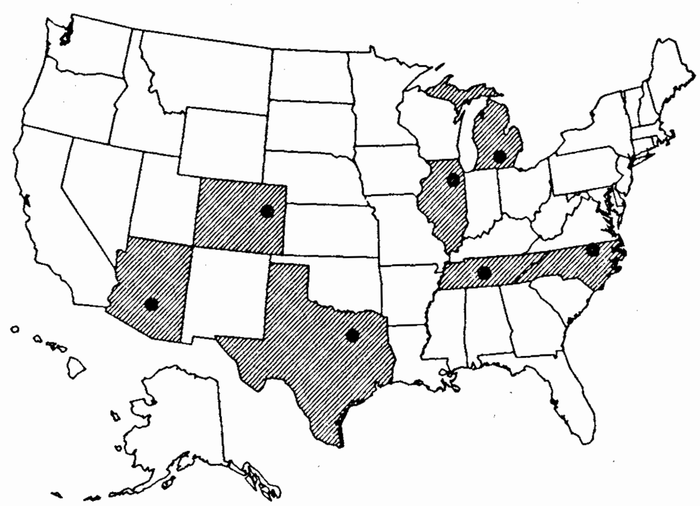
The Texas proposal clearly received the highest overall technical evaluation ratings of any proposal and exhibited no significant overall weaknesses. Thus, I select the Texas site as the preferred site for the SSC.

John S. Herrington
Secretary of Energy

November 10, 1988
Date

DOE/ER-0392

SSC SITE EVALUATIONS



A Report by the SSC Site Task Force

November 1988

DOE F 1325.8
(12-84)

United States Government — Department of Energy

memorandum

DATE: November 7, 1988

REPLY TO ATTN OF: ER-65

SUBJECT: Evaluation of SSC Best Qualified List of Sites

TO: Robert O. Hunter, Jr., Director, Office of Energy Research

In January 1987, President Reagan approved, for submission to Congress, a proposal to construct the world's largest and most advanced particle accelerator – the Superconducting Super Collider (SSC). On February 10, 1987, Secretary of Energy Herrington announced an SSC site selection process to assure a fair and open competition. The Department of Energy (DOE) SSC Site Task Force, which was established later that month, has been a major element in that selection process. The Task Force was responsible for a host of activities, including the following major tasks:

Issuance of the *Invitation for Site Proposals for the Superconducting Super Collider (Invitation)* (DOE/ER-0315) which described the SSC and the resources it requires, solicited proposals of land, gave guidance on proposal preparation, established qualification criteria, and provided the technical evaluation criteria and cost considerations that have been used to evaluate the proposals;

Review and validation of the National Academy of Sciences/National Academy of Engineering Super Collider Site Evaluation Committee (Academies' Committee) report and recommended Best Qualified List (BQL) of site proposals;

Implementation of the National Environmental Policy Act requirements; and

Performance of a comprehensive evaluation of BQL site proposals, including making site visits, conducting cost analyses, and confirming geotechnical and other information provided by BQL site proposers.

This report addresses the last of these major activities and provides to the Director, Office of Energy Research, the Task Force's consensus evaluations regarding the major strengths and weaknesses of the BQL sites when measured against the technical evaluation criteria in the *Invitation*. The report also provides refined life-cycle cost estimates for the construction phase of the SSC plus a 25-year operating phase for each BQL site consistent with the guidance provided in the *Invitation*, as amended, and based on additional site-specific information gathered since the Academies' Committee evaluation.

In reaching a consensus rating for each criterion and subcriterion for the BQL sites, the Task Force did not rank the sites in comparison to one another, nor did it evaluate cost trade-offs (e.g., whether technical strengths for a particular site were sufficient to outweigh higher probable costs or whether lower probable costs were sufficient to outweigh technical weaknesses of a particular site).

It is the judgment of the Task Force that the report represents an accurate assessment of the sites when compared against the technical evaluation criteria and cost considerations defined in the *Invitation* and that it is consistent with the methodology for evaluation approved by the Energy System Acquisition Advisory Board (ESAAB).

Wilmot N. Hess

Wilmot N. Hess
Chairman
SSC Site Task Force

PREFACE

This report concludes a nearly 2-year effort by the Department of Energy's Site Task Force for the Superconducting Super Collider (SSC) to solicit and evaluate sites for SSC construction and operation. The analyses and judgments expressed in the report represent the consensus judgement of the voting members (see Appendix A) following review, analysis, and discussions among all members and advisors. All conclusions have the unanimous approval of the voting members.

To review and evaluate the Best Qualified List (BQL) of sites has been a challenging and difficult task. Any one of these sites would provide a favorable environment in which to construct and operate what will be the world's premier high energy physics laboratory.

To fully and accurately evaluate these sites has required a significant amount of assistance. The seven proposers provided a vast amount of data, and all are to be commended for the diligence and professionalism reflected in their proposals and the presentations that they made to the Task Force during visits to the sites. Without the cooperative assistance of the seven proposal teams, it would have been much more difficult to conduct the in-depth evaluations summarized in this report.

The Task Force also wishes to thank all of the proposers who participated in the site selection process whether or not they were chosen for the BQL. They contributed to the overall success of the site selection process.

The Task Force also acknowledges the many employees and contractors who have provided outstanding professional support (see Appendix B). An enterprise of the scale of the SSC site selection process requires not only the talents of physicists and engineers, it demands the expertise of many who are knowledgeable about real estate acquisition, procurement, construction, environmental protection, law, civil rights, and management. Task Force activities represent a Department-wide effort, with expertise drawn from the DOE Headquarters, the Chicago and San Francisco Operations Offices, and from the national laboratories and other contractors.

In addition, the Task Force is indebted to the many administrative staff and clerical personnel who have provided vital support. The support personnel from Computer Data Systems, Incorporated and Systematic Management Services, Incorporated were critical to completing the Task Force effort. Special acknowledgment is given to the tireless contributions of the many DOE personnel involved, including Mary Confar, Shirley A. Derflinger, Douglas A. Duarte, Joyce T. Esworthy, Robert G. Green, Kathy L. Holmes, Anna E. Lowe, Joan D. Shepley and Judy F. Virts.

Without the dedicated efforts of all of the people involved, the Task Force could not have completed its evaluation.

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EXECUTIVE SUMMARY

With this report, the SSC Site Task Force forwards to the Director, Office of Energy Research, U.S. Department of Energy (DOE), its evaluation of the technical criteria and life-cycle costs for the proposed SSC sites judged to be the best qualified. The criteria against which each site was evaluated are those set forth in the *Invitation for Site Proposals for the Superconducting Super Collider* (DOE/ER-0315) (*Invitation*) which was prepared by the Task Force and issued in April 1987. The methodology followed by the Task Force in this report and in all other phases of the proposal evaluation has been consistent with the SSC site selection process approved by DOE's Energy System Acquisition Advisory Board (ESAAB). The goal of the site selection process is to identify a site that will permit the highest level of research productivity and overall effectiveness of the SSC at a reasonable cost of construction and operation and with minimal impact on the environment.

The Task Force acknowledges that all seven sites are, indeed, highly qualified locations for the construction and operation of the SSC on the basis of technical and cost considerations. In performing its evaluation, which is presented below, the Task Force took an in-depth look at each site on the basis of site visits and extensive technical analyses. A consensus rating for each technical evaluation criterion and subcriterion was developed for each site.

DESCRIPTION OF THE SSC

The SSC will be the world's most powerful particle accelerator. Approximately 10,000 superconducting magnets will focus and guide 2 beams of protons in opposite directions around a racetrack-shaped tunnel approximately 53 miles in circumference and 10 feet in cross-section diameter. The beams will be accelerated to nearly the speed of light and made to collide head-on with an energy of 40 trillion electron volts. The collisions are expected to create new subatomic particles that will be detected and analyzed, thus adding to our understanding of the fundamental nature of matter and energy. Such knowledge will not only answer questions about the physical world that have fascinated mankind since the earliest times, it will benefit society in the areas of technology, education, and industry.

In addition to the extensive tunnel, there will be other important underground facilities, including a series of injector accelerators and, initially, four large interaction halls (and, subsequently, two more halls) in which experiments will be conducted. Numerous support buildings will be located at the surface around the ring, but most of them will be located on the central campus-like setting. The entire SSC complex will occupy approximately 16,000 acres of land as set forth in the *Invitation*. The cost for construction of the SSC is estimated to be $3.2 billion (FY 1988 dollars), and construction could be completed by the fall of 1996.

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THE SITE SELECTION PROCESS

The SSC site selection process, announced by Secretary of Energy John S. Herrington on February 10, 1987, was designed to enable a fair and open competition for states or other proposers wishing to host the SSC. The process called for the establishment of an SSC Site Task Force reporting to the Director of the DOE's Office of Energy Research. The Task Force was formally organized on February 27, 1987, under the chairmanship of Dr. Wilmot N. Hess, Associate Director for the Office of High Energy and Nuclear Physics. Its members include senior personnel from the Office of Energy Research; Office of General Counsel; Assistant Secretary, Management and Administration; Assistant Secretary for Environment, Safety and Health; and the San Francisco Operations Office (see Appendix A). In addition, the DOE's Chicago Operations Office provided substantial technical assistance and administrative support.

The Task Force developed the *Invitation*, which was issued on April 1, 1987, and solicited states and other interested parties to propose a site for construction and operation of the SSC. The *Invitation* described the selection process, the qualification criteria for initial proposal screening, the technical criteria for evaluating proposals in detail, the information required of proposers, and a description of the SSC facility. The *Invitation* was developed with the objective of requesting the minimum amount of information and data necessary to fully evaluate proposed sites against the criteria.

The *Invitation* set forth the qualification criteria, technical evaluation criteria, and cost considerations to be used in the site selection process (see Appendix C). The six technical evaluation criteria were listed in descending order of importance as were the subcriteria within each criterion. Although costs were recognized as significant, primary emphasis overall was to be given to the technical evaluations.

PROPOSALS RECEIVED - ACADEMIES' COMMITTEE REVIEW

In response to the *Invitation*, the DOE received 43 proposals by September 2, 1987, the cutoff date for receipt of proposals. These proposals were reviewed by the Task Force to determine if they met the five qualification criteria set forth in Section 3.2 of the *Invitation*. Seven proposals did not meet the basic qualification criteria and were disqualified. Thirty-six proposals, for sites in 25 states, met all of the DOE's qualification criteria. One proposal, New York, Wallkill Valley, was withdrawn by the proposer in October 1987, leaving 35 sites for evaluation.

The DOE asked the National Academy of Sciences and the National Academy of Engineering to assist in the SSC site evaluation process by providing an independent evaluation of the qualified site proposals against the set of requirements in the *Invitation* and to recommend an unranked Best Qualified List (BQL) of sites. The Academies' assistance was sought in the interest of enlisting an independent evaluation that would further the goal of a credible and objective site selection process. On September 17, 1987, the DOE forwarded the qualified proposals to the Academies' Super Collider Site Evaluation Committee (Academies' Committee), which was composed of 21 members chosen on the basis of technical, professional, and managerial experience. The Task Force also supplied life-cycle cost estimates. The Academies' Committee formed seven working groups (one for each technical evaluation criterion and one for the life-cycle cost). Each technical evaluation criterion working group was charged with providing an initial evaluation of each subcriterion within that working group's area of responsibility as a basis for presentation to and discussion by the full Committee. The Academies' Committee discussed the working group evaluations of the 35 proposals during its final meeting. The Chairman asked the full Committee to discuss each site until a consensus was reached that it should or should not be placed on the BQL. The recommended BQL is unranked; at no point did the Committee consider what would be an appropriate number of BQL sites. Geographic distribution was not a factor in the Committee's decision, nor did the Committee limit BQL sites to one per state.

The Committee's report *Siting the Superconducting Super Collider*, which was forwarded to the DOE on December 24, 1987, identified eight sites that "merited inclusion" on the BQL:

Arizona (Maricopa)
Colorado
Illinois
Michigan (Stockbridge)
New York (Rochester)
North Carolina
Tennessee
Texas (Dallas-Fort Worth).

The New York proposal was withdrawn by the proposer on January 15, 1988.

DETERMINATION OF BQL

The Task Force reviewed the Academies' Committee report for conformance with the technical evaluation criteria, subcriteria, and cost considerations in the *Invitation*, including their relative importance, to ensure that the evaluation and supporting material were sufficient and appropriate to 1) permit the DOE to accept the BQL and 2) provide for debriefing proposers not included on the BQL. After review of the report, meetings with the Academies' staff, and meetings among Task Force members, the Task Force unanimously agreed that the BQL be accepted without modification. The BQL was announced by the Secretary of Energy on January 19, 1988, and consisted of the seven remaining sites on the Academies' recommended list.

EVALUATION OF BQL SITE PROPOSALS

The Task Force assessment of proposals began with the review to determine qualified proposals in September 1987. Following this review, and while the Academies' Committee was conducting its review, the Task Force was familiarizing itself with the 35 qualified proposals. To accomplish this, the Task Force assigned lead responsibility for each technical evaluation criterion and the life-cycle cost to an individual Task Force member. In consultation with other Task Force members and advisors, each lead member assessed each proposal in his respective area of responsibility and reported his observations to the entire Task Force.

Following announcement of the BQL in January 1988, the Task Force began a detailed evaluation of the BQL proposals. Utilizing the same committee structure that had been used for the proposal familiarization, the Task Force re-examined the proposals and the supplemental data that had been requested. From these reviews, areas requiring clarification or additional data were identified and questions were submitted to the proposers.

Staff from a DOE contractor, RTK, accompanied by a DOE representative, conducted 1-week visits to each site (concentrating on environmental and geological issues) and provided summary reports to the Task Force. The Task Force subsequently visited each BQL site between April and July. These Task Force visits permitted in-depth familiarization with the site and its vicinity and allowed members to meet with representatives of the proposer to clarify questions and outstanding issues. At the end of each visit, questions were left with the proposer for response within 4 weeks, and the Task Force documented its findings.

Following all site visits, the Task Force committees reviewed all supplemental data, including that assembled for the preparation of the Environmental Impact Statement. They then prepared reports in their technical areas and made presentations to the full Task Force. Following committee presentations, intensive discussions were held by the Task Force as a whole to review committee findings. Within a given technical criterion, such as geology and tunneling, each subcriterion was discussed until a consensus was reached on the rating to be given to each proposal on that subcriterion. Potential ratings were "outstanding," "good," "satisfactory," "poor," or "unsatisfactory." Once consensus was reached on the ratings for all subcriteria within a criterion, the Task Force discussed what the overall rating should be for each proposal on that criterion. When consensus was reached on the overall criterion rating for each proposal, the Task Force proceeded to the next criterion. At the final session, all ratings were revisited. No ratings were changed during that final session. The Task Force neither developed numerical ratings nor ranked the proposals.

The Task Force also discussed the life-cycle cost analyses, including the appropriate credit to be given to the Illinois site for the presence of Fermilab. These analyses build upon the work done for the SSC *Conceptual Design Report (CDR),* SSC-SR-2020, in 1986 and, more specifically, upon the analyses prepared for all qualified sites which were reviewed by the Academies' Committee. Those life-cycle cost estimates were refined for this report utilizing the supplemental data submitted by the proposers, the site visits, and more detailed geotechnical investigation. This allowed more precise estimates in many areas, including tunneling (better definition of rock types) and utilities (better rate and load information). The Task Force reached consensus on the cost estimates for each site and on the range of credits that should be used for the Illinois proposal. The Task Force methodology is discussed more fully in Chapter 4.

EVALUATION SUMMARIES

The results of the Task Force evaluations of technical criteria and cost considerations are summarized below by state. Additional technical details are provided in Chapter 3, "Site Descriptions," Chapter 5, "Technical Evaluations," and Chapter 6, "Life-Cycle Cost."

ARIZONA

The Maricopa site is located in a desert region approximately 35 miles southwest of Phoenix. The collider ring encircles the Southern Maricopa Mountains and passes through portions of the Northern Maricopa Mountains.

The site geology is satisfactory overall for SSC construction using a combination of cut-and-cover and tunnel boring methods. Several distinct rock types will be encountered, including fanglomerate (a weakly cemented sedimentary rock), granitic rocks, and a complex, layered sequence of volcanic and sedimentary rocks. Most of the tunnel (68 percent) will pass through fanglomerate, with up to 18 percent shallow enough to be completed by cut-and-cover techniques. A structural lining will be required for the fanglomerate portion of the tunnel and locally through zones of fracturing in the granites. All underground portions of the facility will lie above the regional water table; hence, water problems are unlikely.

Although the geology is favorable in many ways, there are geologic weaknesses, most notably: the need for multiple tunneling techniques required for the three major rock types; concern over the likely mixed-face tunneling in the volcanics and at the granite-fanglomerate contacts; the interception of possible faults and shear zones in the granitic segments of the mountainous areas; and the need for some deep shafts in the approximately 11 miles of the ring that would pass under mountainous terrain. The geologic complexity of the Maricopa site and the limited extent of geologic studies in the area (initiated largely for this project) create the potential for major unforeseen problems to arise during construction.

The various regional resources needed to support the construction and operation of the SSC are satisfactory. There are essentially no existing housing supplies or other community resources within a projected 45-minute commute from this site. However, the ample and expanding supplies of housing and other community resources of the rapidly growing Phoenix metropolitan area would be available beyond a 50-minute drive once site access roads and other upgrades are constructed. Public school systems and job opportunities for family members are excellent in the Phoenix area. Air accessibility is good. The industrial and construction base resources needed to build and operate the SSC are satisfactory, but distant. There is very limited individual opposition. The institutional program is weak and the involvement of state and local agencies has been minimal.

The site provides a good environment for the SSC. There are no wetlands, farmland, or developed mineral resources, and, because the water table is so deep, there is little potential for water contamination. Careful construction practices will be required to minimize disruption of the sensitive desert ecosystem. The SSC might impact cultural resources (such as historic trails), scenic views, and air quality.

The site provides a good setting for the SSC. A majority of the land required for the site is Federal land under the administration of the Bureau of Land Management of the Department of the Interior. Only six relocations would be required by the land acquisition plan, which would use a private contractor managed by the Arizona Department of Transportation. Uncertainty over the potential designation of a portion of the site as a Wilderness Area limits the site somewhat in terms of flexibility to adjust the ring position during final design, and the limitation on operation and construction such designation could cause.

The regional conditions for the site are satisfactory overall. A mainline railroad crosses the site near two interaction regions. Calculations and field measurements indicate that vibrations caused by passing trains will not exceed the SSC tolerances, but only by a narrow margin. The climate should not affect SSC construction or operations, although the potential for flash flooding will have to be considered.

Power, water, and waste disposal facilities for the site are good overall.

The life-cycle cost for constructing the SSC at the Maricopa Site and operating it for 25 years is estimated to be $11.5 billion, in 1988 dollars.

COLORADO

The Colorado site is located near Fort Morgan in a rural area approximately 65 miles east-northeast of the Denver metropolitan area.

The uniform, predictable nature of the geology at the site presents good conditions for tunneling. The region is relatively flat and is underlaid by the Pierre Shale, a homogeneous, low-strength, and easily tunneled sequence of claystone. The tunnel will be entirely within the claystone at a depth ranging from 70 to 200 feet and averaging 125 feet. Although groundwater problems are minimal in this impermeable shale, the entire tunnel will have to be lined immediately to prevent slaking (drying out and crumbling of the claystone upon exposure to air). The elastic nature of the claystone may require additional supports, such as drilled piles or spread footings, beneath experimental hall foundations to prevent settlement and rebound as heavy detectors are moved about.

The regional resources of the area are considered satisfactory for the needs of the SSC. Although Fort Morgan and Brush are nearby, it will take a 75-minute or longer commute to reach an ample supply of community resources to support the site, even after construction of new two-lane access roads and other needed improvements. The distant Denver metropolitan area has good public school systems and employment opportunities for family members, excellent recreational and cultural opportunities, and good access to other research institutions. Air accessibility is good. The Denver area's industrial and construction base is excellent. There is very limited individual opposition. State and local institutional planning and coordination activities have been exemplary.

The site is considered outstanding from an environmental standpoint. Impacts on water quality, air quality, and scenic and cultural resources are estimated to be low, and only moderate impacts are anticipated to floodplains, wetlands, sensitive habitats, and farmlands.

The site setting is generally good in that there are only 157 parcels and 67 ownerships, and there would be only 23 relocations required. Although the State proposes to acquire approximately 52,520 acres of land in fee simple, only the land and estates required in the *Invitation* will be transferred to DOE, and the remainder will be held by the State to protect the facility and to provide for potential shifting during final design. Combined with the relatively flat, rural nature of the site, this provides great flexibility for final ring positioning. This intrinsically attractive situation is moderated somewhat by the lack of thoroughly developed land acquisition and relocation plans.

The regional conditions are outstanding in that no major highways or railroads cross the ring, vibrations from other sources are at least ten times lower than SSC tolerances, and the moderate winter weather will affect SSC construction and operations only minimally.

Power, water, and waste disposal facilities for the site are good overall.

The life-cycle cost estimate for constructing and operating the SSC at the Colorado site is $11.2 billion in 1988 dollars.

ILLINOIS

The Illinois site is located 40 miles west of downtown Chicago near the city of Batavia in a region of flat to rolling terrain. Glacial sediments form a thick mantle over a bedrock sequence of limestone, shale, and dolomite. This simple, well-understood, bedrock geology is outstanding for tunneling. The collider tunnel will be constructed entirely within a deep uniform sequence of high-strength, essentially impermeable dolomite; hence, most of the tunnel can be left unlined. There are no major faults at the site, and joints in the rock are widely spaced.

The Tevatron at Fermilab is proposed for use as the injector complex, and long tunnels connecting this surface facility to the deep collider tunnel will have to be constructed. Shafts will range in depth from 330 to 610 feet, averaging 435 feet. Because the overlying glacial sediments and weathered bedrock carry large amounts of water, all shafts will penetrate some thickness of saturated rock and will require ground support and water control prior to excavation. Experimental halls will be excavated as large underground caverns in the dolomite.

The Chicago metropolitan area is the Nation's third largest, and it provides outstanding regional resources. The SSC campus area would incorporate the Fermilab site and is located in a heavily populated suburban area. The excellent public school systems, family employment opportunities, cultural and recreational opportunities, and access to major research institutions are somewhat offset by a high cost of living. The site is served by an extensive network of highways and public transportation. Air accessibility is excellent. The area has one of the largest industrial and construction bases in the Nation. Although State and local governments have been supportive of the project, a strong and vigorous organized opposition has developed.

From an environmental standpoint the site is good. Relatively few acres of prime farmland would be impacted, and there would be minimal impacts on mineral resources, wetlands, and air quality. An existing regional groundwater overdraft condition would be aggravated, and increased noise levels may annoy residents living near the service areas.

Strong opposition by many landowners, the relatively large number of ownerships (approximately 3,000), and the limited flexibility to adjust the ring position during final design provide a poor setting for the SSC. Moreover, the complicated and demanding land acquisition will be overseen by a state agency that has essentially no experience in this area.

The site's regional conditions are generally good. Criss-crossed by highways and railroads and with nearby quarries, the site has many sources of vibration, although it is well within vibration tolerances according to mathematical calculations. Winter weather is of concern, but no significant downtime is anticipated.

Power, water, and waste disposal facilities for the site are good overall.

The life-cycle cost for constructing the SSC at the Illinois site and operating it for 25 years is estimated to range between $10.4 billion and $10.9 billion, in 1988 dollars. The Illinois site benefits from use of the existing Tevatron as the injector. The range reflects uncertainty in projecting the lifetime for a productive Tevatron high energy physics program beyond the SSC start-up and in projecting the cost to upgrade the 150-GeV main ring. The $10.9 billion figure assumes a 5-year operating life beyond SSC start-up, the $10.4 billion figure, a 15-year operating period.

MICHIGAN

The Michigan site is located approximately 60 miles west of metropolitan Detroit in a triangle bounded by the three metropolitan areas of Ann Arbor, Lansing-East Lansing, and Jackson. This rural region is characterized by glacial lowlands with low hills, lakes, and numerous ponds and swamps.

The site bedrock lies beneath a mantle of glacial sediments and is composed of an interlayered sequence of low-strength sandstone, limestone, and shale, which is satisfactory for SSC construction. The moderately permeable sandstones are a major source of groundwater for the region; hence, a continuous waterproof liner will be needed for both structural support and water control in the collider tunnel. The collider tunnel will be located at an average depth of 140 feet. Shaft depths range from 75 to 185 feet. All shafts will require significant water control measures prior to excavation, and a cast-in-place liner will be installed from surface to tunnel depth. Significant water-control measures will also be required for the experimental halls, whether they are built as very large cut-and-cover excavations or as underground caverns in the sandstone.

The Michigan site is outstanding in terms of regional resources. The three small metropolitan areas that fall within a 45-minute commute offer an ample supply of housing, excellent public school systems, and good job opportunities for family members. There are two major research universities nearby and a mature industrial and construction base in the Detroit metropolitan area. Air accessibility is good. The site is served by a good network of roads and highways. An excellent institutional outreach program has consolidated support for the project, and there is very limited individual opposition.

The site is considered good from the standpoint of environmental impacts. There would be little impact visually, and air quality, community resources and cultural resources would be minimally affected. Groundwater is already overdrafted locally, and the tunnel would pass through a major aquifer. Dewatering of excavations during construction may locally affect water supplies. Wetlands and water quality impacts are of some concern.

The Michigan site includes 801 parcels and 221 relocations and is satisfactory in terms of setting. A relatively inexperienced private contractor will acquire the land. The rural site provides flexibility for adjusting the final ring position, but this is compromised somewhat by the extensive wetlands and nearby community and recreational centers.

The site was judged outstanding in terms of regional conditions because of the near absence of vibration and noise concerns. Winter weather is of concern, but no significant down time is anticipated.

Power, water, and waste disposal facilities for the site are good overall.

The life-cycle cost for constructing the SSC at the Michigan site and operating it for 25 years is estimated to be $11.5 billion in 1988 dollars.

NORTH CAROLINA

The North Carolina site is located in a sparsely populated rural area approximately 15 miles north of downtown Durham. The geological setting of the site is considered good for SSC construction. Slightly rolling woodlands of the Piedmont Province are rooted in thick, compacted residual soil that grades downward into weathered bedrock and eventually to unweathered rock. Located at an average depth of 170 feet, the collider tunnel will pass through a structurally complex series of metamorphosed volcanic and sedimentary rocks that have been intruded by granitic rocks. Although seven different rock types will be encountered, they are similar enough in terms of their engineering properties to be considered a single unit for the purpose of tunneling. Faults and fractures occur near the contacts between the granitic and other rocks, and internally within the granites. Much of the collider tunnel can be left unlined in the high-strength granitic and volcanic rocks; however, structural support and water control may be required in these fracture zones. The shafts, which range in depth from 70 to 275 feet, will need to be lined and structurally supported in the soil and weathered bedrock sections. The state proposes that all experimental halls be constructed as underground caverns; however, there may be insufficient thickness of unweathered bedrock to support the roofs of two halls, and cut-and-cover excavations may have to be considered.

The area has good regional resources. The campus will be within a 45-minute commute of most of the Raleigh-Durham metropolitan area, its principal employment centers, three major research universities, and the Research Triangle Park. Public school systems are satisfactory. The site is served by numerous highways, but good immediate access to the campus area will be limited for several years pending road improvements. Air accessibility is good. The industrial and construction base is good overall, but limited in several areas. There is significant organized opposition and tenuous institutional support at the local level.

The site is good from an environmental impact perspective. Air quality standards have been met in the area, scenic impacts will be low, and there are no mineral resource impacts. However, some valuable wetlands would be affected, and the fractured bedrock poses the potential for groundwater contamination.

The site is comprised of more than 800 parcels and almost as many ownerships. Based on the site visit, the Task Force estimates a total of approximately 180 relocations (the proposal estimated 111). The setting is considered satisfactory in that flexibility for final ring location is offset by an inadequate number of staff for land acquisition as well as by organized landowner opposition.

The site's regional conditions are generally good. Highways and railroads at the site are at greater distances from the interaction points than required. There is uncertainty about the vibrational levels from an existing rock quarry relatively near the site and another under construction. There are no adverse climate conditions in the region.

Power, water, and waste disposal facilities for the site are good overall.

The life-cycle cost for constructing the SSC at the North Carolina site and operating it for 25 years is estimated to be $10.7 billion in 1988 dollars.

TENNESSEE

The Tennessee site is located approximately 30 miles southeast of Nashville on a mature plain whose geology is outstanding for SSC construction. The rock beneath the site is a thick, uniform sequence of high-strength limestone that comprises a single, homogeneous construction unit. No major faults disrupt the rock sequence. Karst features (solution-widened joints, caves, and sinkholes) are present near the surface but should not be encountered during tunneling. The tunnel will be constructed at an average depth of 405 feet (shafts range in depth from 285 to 670 feet). The strength of the rock together with its low water permeability will allow the tunnel and most shafts to be left unlined, with only occasional rock bolts needed for support. The limestone also provides excellent foundation conditions for the experimental halls, which will be excavated as deep underground caverns at an average depth of 385 feet.

The regional resources of the area are satisfactory for the SSC. The campus is near the city of Murfreesboro. The suburbs of Nashville and several sizable towns lie within an approximate 45-minute commute. Overall, the public school systems tend to be average or below average.

Family employment opportunities are good, but cultural amenities and access to research institutions are somewhat limited. Otherwise very favorable cost-of-living indices are moderated by housing costs at or above national averages. The metropolitan area and the site vicinity, in particular, are served by an extensive network of highways. Air accessibility is good. Many new firms have recently been attracted to the region, but the industrial and construction base (with the exception of the emerging automobile industry) is limited. There is some individual opposition, and organized opposition may be developing. Institutional programs and outreach activities are limited.

The site is considered good from an environmental impact standpoint. There would be minimal impacts on land resources and only moderate impacts on surface waters and wetlands. Sensitive habitats such as cedar glades are of possible concern as is the fact that the region is not in compliance with existing ozone standards.

An experienced land acquisition team, a good acquisition plan, and outstanding flexibility for final ring location combine to make the site outstanding in terms of setting despite the large number of ownerships involved (approximately 800). There are 128 relocations, and this should pose no problem.

Vibrations resulting from nearby roads, railroads, and quarries would be ten times below SSC tolerances. This, combined with a good climate, make for an outstanding site in terms of regional conditions.

Power, water, and waste disposal facilities for the site are good overall.

The life-cycle cost for constructing the SSC at the Tennessee site and operating it for 25 years is estimated to be $10.7 billion in 1988 dollars.

TEXAS

The site is located in Ellis County, approximately 25 miles south of Dallas and 35 miles southeast of Fort Worth, in a semi-rural setting of flat to rolling prairies.

The chalk and marl underlying the site form a sequence of uniform, well-characterized, and structurally competent rock that is outstanding for tunneling. Although the marl (25 percent of the ring) will require a lining for structural support and to prevent slaking (breaking up upon exposure to air), both the chalk and marl are impermeable; hence, water control during construction and operation will not be a problem. Several faults cross the ring, but they are inactive, and the site lies in an area of very low earthquake potential. The state proposes that all experimental halls be constructed by deep (190 to 265 feet) open-pit excavations. Three halls may rest on more elastic shale and marl, and may require additional support to assure stability under detector loads. The low-strength chalk, however, should provide acceptable, stable foundation conditions.

Regional resources for the site are outstanding. The city of Waxahachie is located inside the ring, and the campus is within an easy commute of other attractive residential areas and employment centers of the Dallas-Fort Worth metropolitan area. Housing prices and the cost of living are very attractive. Public school systems are satisfactory. Air accessibility is excellent. The metropolitan area and the site vicinity in particular is served by an excellent network of roads. The industrial and construction base is outstanding. Exemplary coordination of all appropriate local and state governmental units was effectively implemented. There is a high level of public support with very limited individual opposition.

The area is viewed as outstanding from the environmental perspective in that the extensively developed pasture and farmland have already been highly modified, and the SSC would have a minimal impact on surface water, groundwater, wetlands, and ecological resources.

A well-conceived land acquisition plan and schedule, a strong management team, and good flexibility in adjusting the final ring location make for an outstanding setting. The 614 parcels and 175 relocations should present no scheduling problem.

A favorable climate and generally acceptable vibration levels from the roads, railroads, and quarries provide good regional conditions. Increased track maintenance may be needed for one railroad line that passes only 25 feet above the collider tunnel.

Power, water, and waste disposal facilities for the site are good overall.

The life-cycle cost for constructing the SSC at the Texas site and operating it for 25 years is estimated to be $10.8 billion in 1988 dollars.

EQUAL OPPORTUNITY

The *Invitation* requirement that all community resources be available on a nondiscriminatory basis was viewed by the Task Force as a critical element of the selection process. To assure that the education, employment, and housing resources were available on a nondiscriminatory basis, an on-site civil rights assessment of each BQL site was conducted by a representative of DOE's Office of Equal Opportunity. Some states had visible and effective mechanisms in place. In several states the educational resources were subject to active court orders or decrees. While the need for such a legal remedy indicates a weakness, its presence was viewed positively because it establishes a viable mechanism to help ensure compliance.

Although concerns still exist in the various states, there are continuing efforts to improve the mechanisms to resolve them. Accordingly, the Task Force concluded, based upon the available information, that (a) each state met the minimum requirements of the *Invitation*; (b) the community resources are available on a nondiscriminatory basis; and (c) mechanisms are in place to provide due process should a problem arise.

2

INTRODUCTION

The ultimate secrets of matter and energy are to be found in the world of fundamental particles. These particles compose all matter, and the laws they obey apparently apply at any time and place in the universe. The goal of high energy physics is to map out this world and to discover the rules that govern its behavior.

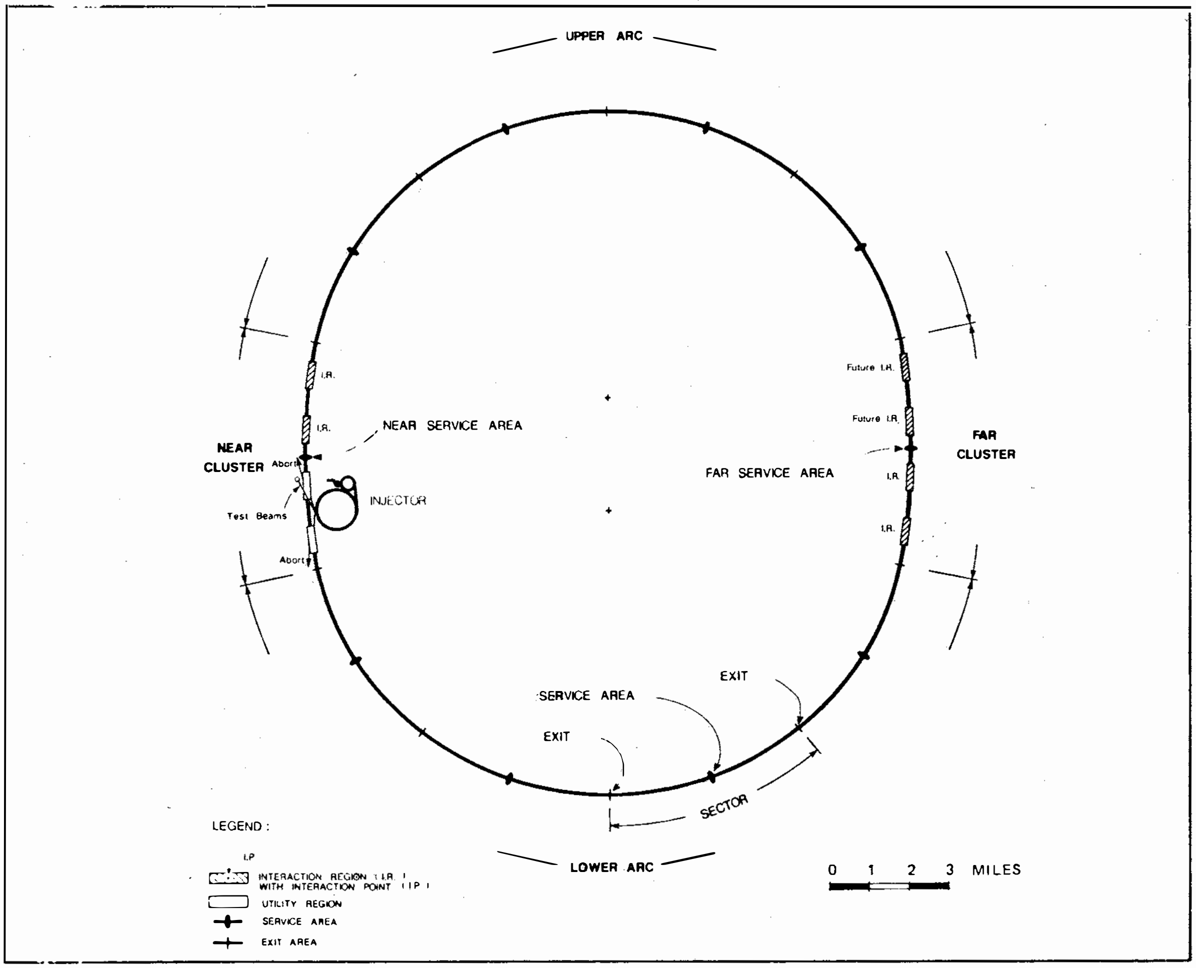
The SSC will be the most powerful scientific instrument ever made to probe the world of elementary particles. Its major feature is a racetrack-shaped tunnel, approximately 53 miles in circumference, in which the basic constituents of matter will be created and studied at an energy of 40 trillion electron volts, 20 times greater than at any existing facility. Particle physicists in the United States and abroad agree that the construction of the SSC will give scientists access to an instrument unrivaled in the world for making frontier discoveries well into the next century.

The racetrack-shaped tunnel has an approximate 10-foot inside diameter and will be located with the centerline at least 35 feet underground. Inside the tunnel, two rings of superconducting magnets will steer two beams of protons in opposite directions and bring the beams into head-on collisions inside particle detectors located at the interaction points shown in Figure 1. Service areas are located approximately every 5 miles and consist of a cluster of surface buildings containing cryogenic refrigerators, helium compressors, power supplies, support facilities, and points of access. Midway between two service areas is a small building enclosing an access shaft to the collider tunnel.

SSC TECHNICAL DESCRIPTION

The SSC consists of five basic components: (1) an injector complex of four cascaded accelerators in which protons will be accelerated from rest to about 1 TeV; (2) the collider ring, wherein dual beams of protons will be accelerated to 20 TeV and then stored; (3) the experimental areas containing the particle detectors; (4) the campus area; and (5) the site infrastructure consisting of roads and utilities. Each is described in greater detail below.

Figure 1. Typical layout of the SSC.

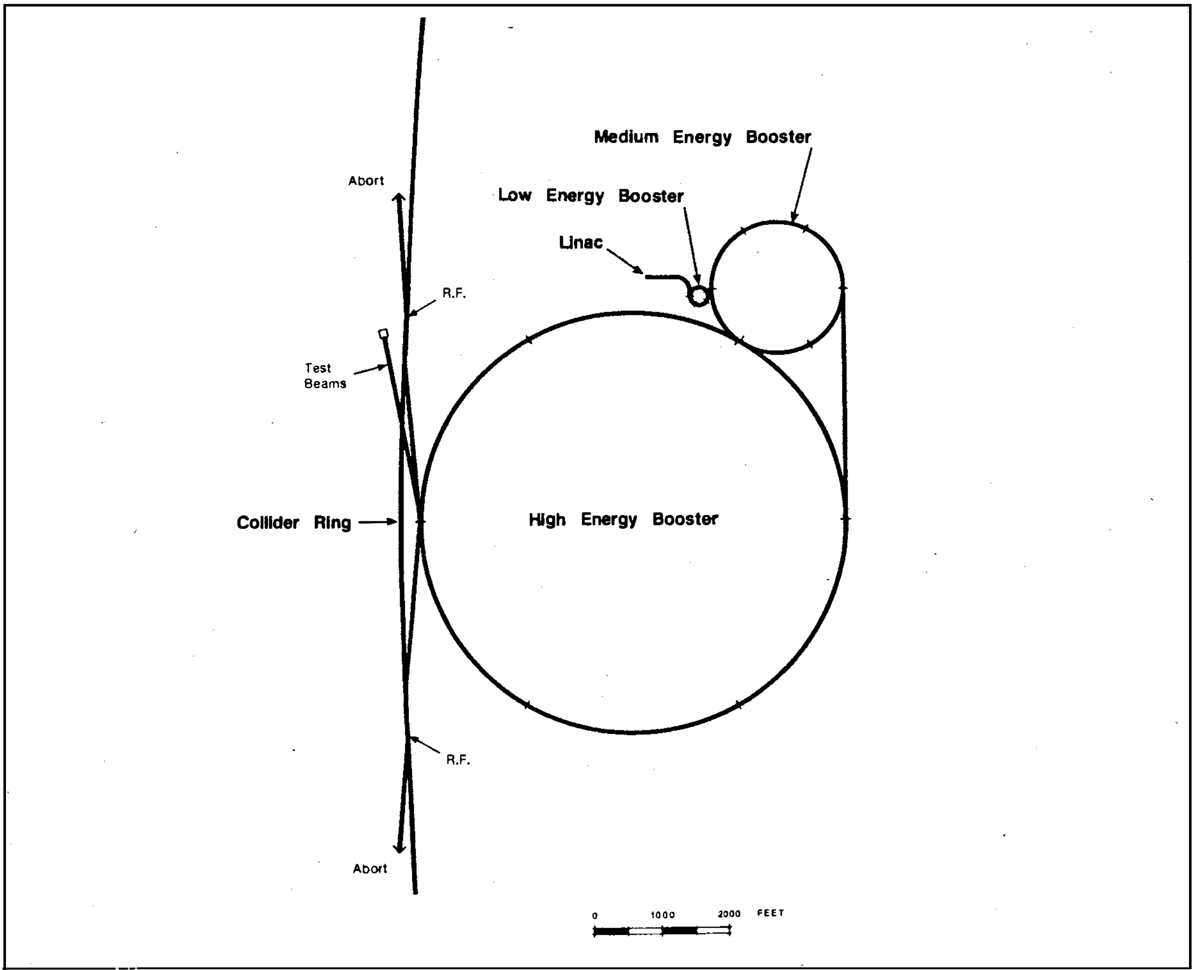


THE INJECTOR COMPLEX

The SSC injector consists primarily of a series of four separate accelerators, a linear accelerator (linac), a low energy booster (LEB), a medium energy booster (MEB), and a high energy booster (HEB), each accelerating the protons to higher energies while maintaining their bunched beam structure (Figure 2). Two prime performance objectives apply to the SSC injector: (1) its final energy must match the lowest energy permitted by the magnetic field of the collider ring, and (2) its beam must have a concentrated high flux of protons to achieve the specified interaction rates in the collider ring.

The first step of the injection system is a linac in which the protons generated in an ion source are accelerated from rest to an energy of 0.6 GeV. The linac is approximately 500 feet long and consists of many radio-frequency (rf) cavities in line. From such a linac, the protons are transported through a beam pipe into an LEB. The LEB is designed to raise their energy to

Figure 2. Typical arrangement of the injector complex.



7 GeV. This accelerator is about 820 feet in circumference and uses conventional magnets. From the 7-GeV LEB accelerator, the next step of the injection process is an MEB in a ring of approximately 1.2 miles in circumference, where the protons have their energy raised to approximately 100 GeV using conventional magnets.

The HEB is the last step in which the energy achieved is 1,000 GeV or 1 TeV, the minimum energy necessary for injection into the collider ring. The HEB is, itself, an accelerator of impressive proportions, approximately 4 miles in circumference. It uses superconducting magnets cooled by liquid helium in a system similar to that employed in the collider.

The conventional facilities of the injector complex include buildings and enclosures for the linac, the LEB, and the MEB. In addition to the tunnel for the HEB, there are six power-supply buildings, one building for the refrigeration system, two injection areas, one rf area, and two extraction/abort areas.

THE COLLIDER RING

The most important construction feature of the SSC is the 53-mile collider ring and tunnel whose internal diameter is 10 feet. In the most convenient accelerator designs the collider ring lies in a horizontal plane. In the *CDR* the collider tunnel was allowed to vary from the horizontal plane (not more than one half degree) to accommodate a possible slope on hypothetical sites.

Inside the tunnel are two rings of superconducting magnets, each consisting of bending (dipole) and focusing (quadrupole) magnets, which steer and confine two beams along approximately oval orbits. The bunches of 1-TeV protons received from the high energy booster are apportioned between the two collider rings and accelerated in opposite directions. For most of the circumference, the two beams travel in separate, parallel vacuum chambers, one above the other. At the interaction points, the counter-rotating beams, having been focused to less than one thousandth of an inch in transverse dimensions, can be brought into collision. The two beams are directed to collide head-on in the heart of the particle detectors, which surround the beams at the interaction points. The interaction points at which the beams intersect are grouped in two zones called "clusters." In the present design, two special utility regions for beam injection, extraction, and abort and for the rf acceleration systems are included in one of the clusters.

The collider ring will contain a number of support structures and facilities that involve conventional design and construction techniques. In the *CDR*, 10 sets of buildings, nearly uniformly spaced around the collider ring, would house the services needed for the refrigerators, compressors, and power supplies. Additional structures at 10 locations would be provided for intermediate accesses.

THE EXPERIMENTAL AREAS

The experimental areas containing the particle detectors will surround the interaction points and will be located in two regions clustered diametrically opposite each other on the collider ring circumference. Each developed experimental area will have surface structures and underground enclosures. At the beam level are the collision hall and the access hall enclosures. A typical collision hall will have a height of 60 feet with a central gallery approximately 75 feet by 70 feet, and a 40 feet by 40 feet gallery at each end along the beam direction. The symmetrical design of the detector requires that the beams enter the halls about halfway up the walls. Each hall may have a unique design in order to adapt it to local site conditions and to its intended use. Recent considerations indicate that one of the halls may be as large as 160 feet long by 120 feet wide (single span) and 130 feet high. A tunnel bypassing each experimental area makes it possible to detour equipment and tunnel services around the collision hall.

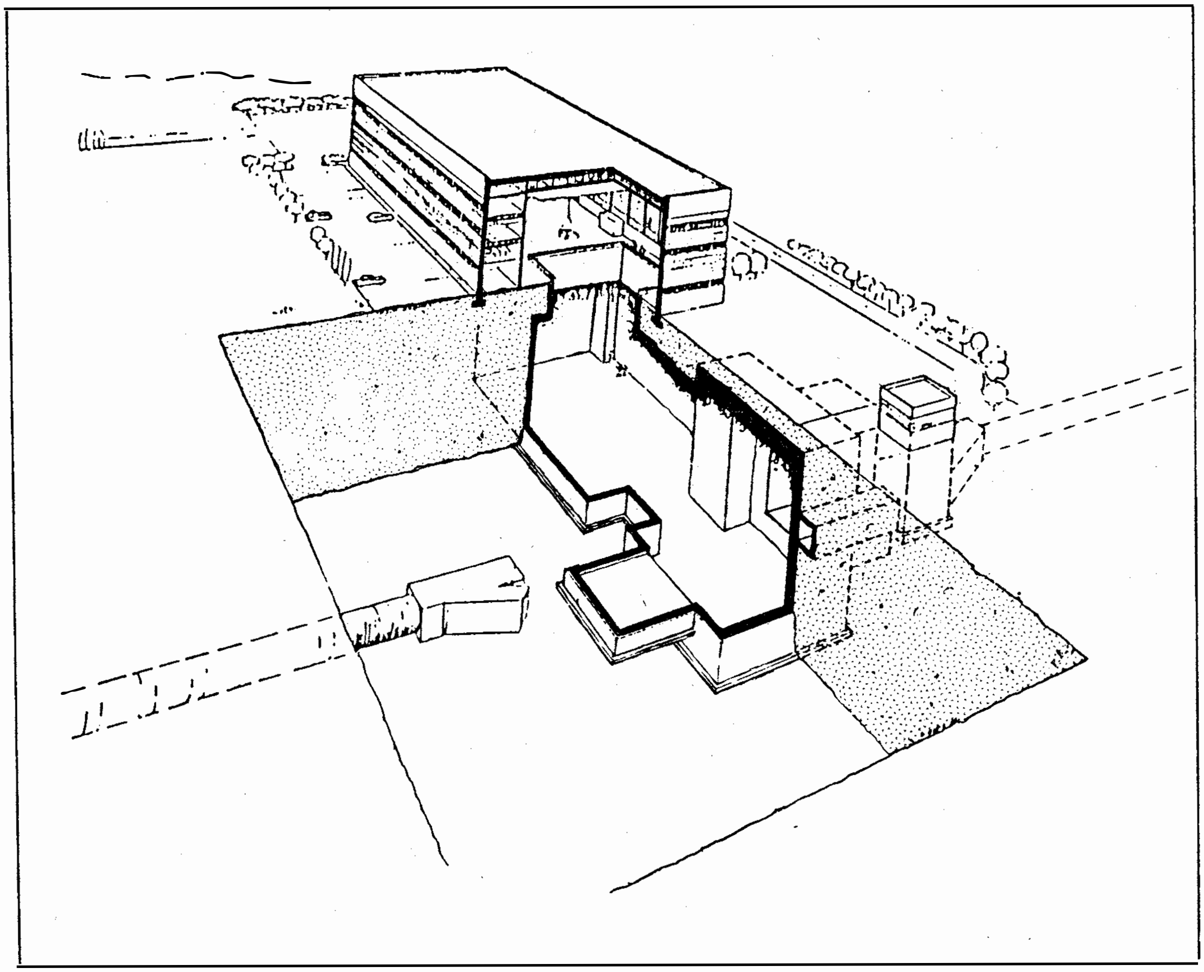
A subterranean access hall at each experimental area will provide assembly areas. Because of the enormous weight of individual detector components and their number, a thick concrete floor with steel plate will be used in both the collision and access halls to support loads up to 9 tons per square foot.

In a typical arrangement, a staging building at ground level above the access hall will provide space for the experimental teams to make subassemblies of their experimental apparatus and to maintain and operate their equipment. The building will contain workshops, offices, a light-duty laboratory, and rooms for electronics and computers. An overhead crane in the staging hall will permit work at either the staging level or the access hall below. Figure 3 is a cutaway illustration of such an experimental facility. The details of the configuration will depend on the local conditions and the depth of the collider tunnel.

THE CAMPUS AREA

The campus complex may consist of 15 or more buildings clustered in 4 major groups – central laboratory building and auditorium, industrial buildings, warehouses, and auxiliary support buildings.

Figure 3. Cutaway illustration of an experimental facility.



A central laboratory building provides office and laboratory space for administrative and technical personnel. One building might contain all of the major offices of the facility and light laboratories for the development and testing of electronic components. It could also include accelerator control rooms, an auditorium, libraries, computing facilities, a main cafeteria, a series of conference rooms, and a small infirmary for emergency medical needs.

Industrial buildings will house limited component assembly activities, various workshops, and associated offices. Warehouses serve as receiving and storage facilities. The auxiliary support buildings—fire, rescue, site patrol, visitor services, and vehicle storage buildings—provide services to the entire complex.

SITE INFRASTRUCTURE

Adjacent to the campus is a main electrical substation, consisting of incoming high voltage electrical service, transformers, switch gear, and distribution systems. A second substation will be located on the far side of the ring. Water treatment facilities are provided for processing the water used for the SSC. Easements for utilities, including fuel and waste systems, will be needed. A road network will be needed in the campus, injector, and experimental areas as well as to connect the cluster regions and to provide access to the service areas and access points located around the 53-mile ring. Existing roads will be utilized wherever possible.

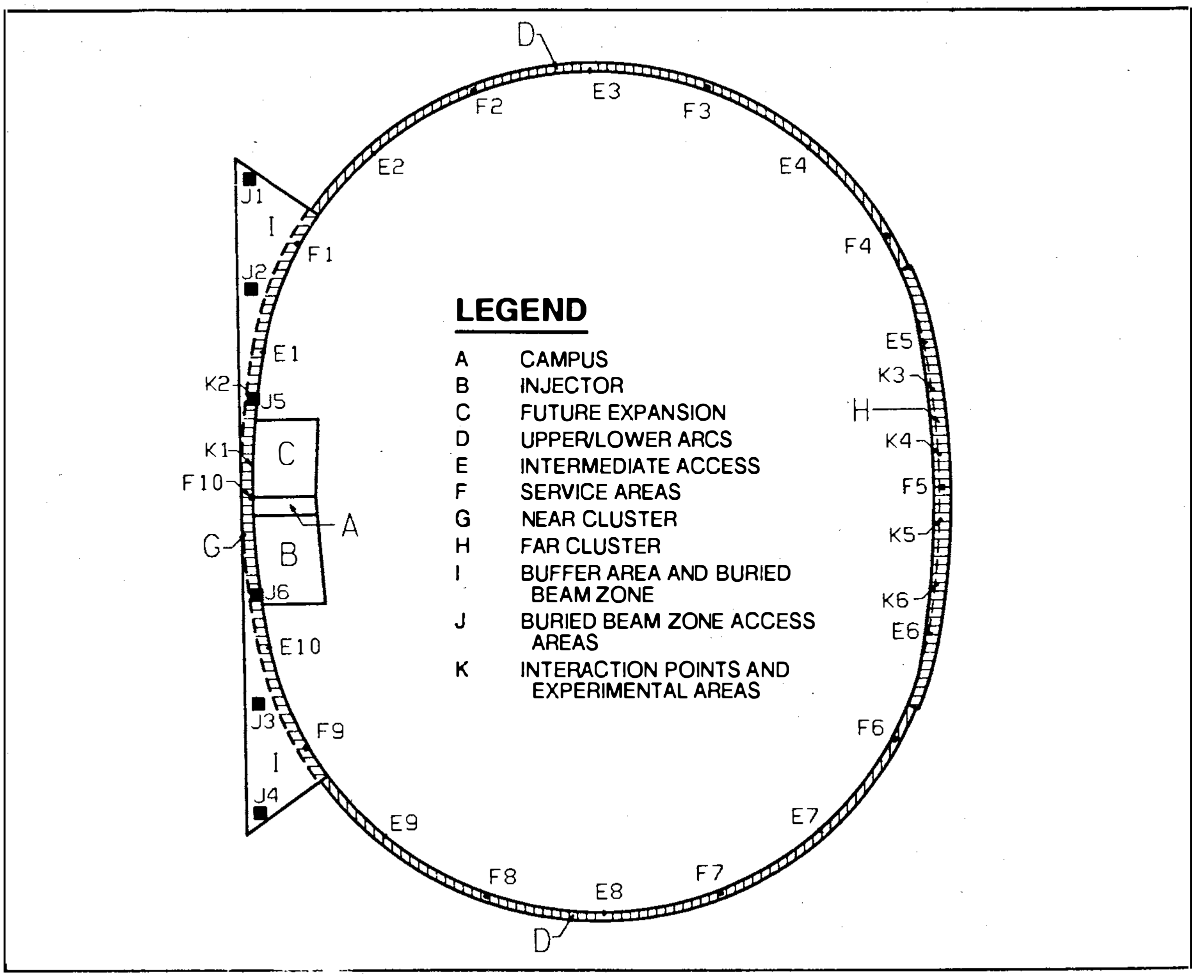
SSC LAND REQUIREMENTS

The entire SSC complex will occupy approximately 16,000 acres of land as set forth in Table B-1 of the *Invitation* and as depicted in Figure 4. The Government must have the unconditional fee simple title to all land on which permanent improvements are planned or anticipated, an area of 6,770 acres. To maintain the integrity of a deep tunnel (deeper than 50 feet) in the collider arcs and buffer area/buried beam zones (D and I areas), a stratified fee estate is sufficient. Enough land to adequately support the SSC in various types of rights-of-way for off-site roads, utilities, and communication lines will also be required, but the amount was not specified in the *Invitation* since it is site dependent.

SSC SITE SELECTION

The SSC site selection process announced by Secretary Herrington on February 10, 1987, was designed to enable a fair and open competition for states or other proposers wishing to host the SSC. The process called for the establishment of an SSC Site Task Force reporting to the Director of the Department of Energy's Office of Energy Research. The Task Force was formally organized on February 27, 1987, under the chairmanship of Dr. Wilmot N. Hess, Associate Director for the Office of High Energy and Nuclear Physics. Its membership is given in Appendix A.

Fig re 4. Land required for the SSC.



Specific activities of the Task Force have included:

- Developing site qualification and evaluation criteria and the cost considerations to be used in site selection;
- Preparing the *Invitation*;
- Screening proposals to determine which are qualified;
- Reviewing and validating the Academies' Committee report and recommended BQL site proposals;
- Conducting BQL site visits;
- Implementing the National Environmental Policy Act;
- Conducting cost analyses;
- Confirming geotechnical and other information provided by BQL site proposers; and
- Performing a comprehensive evaluation of BQL site proposals.

Table 1 highlights the important dates and events of the site selection process.

Table 1. Important SSC site selection events and dates.

October 1983	DOE news release on initial steps for the SSC.
March 1984	CDG issues *Reference Designs Study*.
December 1984	Planned site selection procedure announced.
June 1985	*Site Parameters Report* sent to all state Governors for review and comment.
March 1986	DOE issues *Conceptual Design Report.*
January 1987	President of the United States requests Congressional approval for SSC construction.
February 1987	DOE SSC Site Task Force established.
March 1987	DOE issues notice in the *Federal Register* that it intends to solicit donations of land from states and other entities for siting the SSC.
April 1987	DOE issues *Invitation for Site Proposals*.
	DOE holds SSC Preproposal Conference.
May 1987	DOE publishes Advanced Notice of Intent to prepare an Environmental Impact Statement (EIS) for the SSC.
June 1987	National Academy of Sciences/National Academy of Engineering names committee (Academies' Committee) to assist the DOE in SSC site selection process.
September 1987	DOE receives 43 site proposals, and sends 36 qualified proposals to the Academies' Committee for review.
December 1987	The Academies' Committee submits its report *(Siting the Superconducting Super Collider)* to the DOE, containing recommended "best qualified" sites.
January 1988	DOE completes its review and validation of the Academies' Committee report, and announces Best Qualified List (BQL) sites.
	DOE publishes Notice of Intent to prepare an EIS.
February 1988	DOE holds EIS Scoping Meetings at each of the seven BQL sites.
	Date for announcement of preferred site is changed to November 1988.
April-July 1988	DOE Task Force visits BQL sites: Arizona — April 18-21 Texas — May 2-5 Illinois — May 16-19 Michigan — May 31 - June 2 Tennessee — June 13-16 North Carolina — June 27-30 Colorado — July 12-15.
August 1988	DOE issues *Superconducting Super Collider Draft Environmental Impact Statement.*
September 1988	Environmental Protection Agency publishes Notice of Availability for *SSC Draft EIS* and starts 45-day comment period.
September-October 1988	Hearings on *SSC Draft EIS* held at seven BQL sites.
	BQL states make presentations to DOE Secretary.
	Task Force receives comments on *SSC Draft EIS*.
November 1988	Task Force completes report on evaluation of BQL sites.
	DOE to announce preferred site.
December 1988	DOE to issue final EIS.
January 1989	DOE to publish Record of Decision and announce final site selection.

INVITATION FOR SITE PROPOSALS

The *Invitation for Site Proposals for the SSC (Invitation)* was the initial priority of the Task Force. Significant work had been done prior to formation of the Task Force in the area of site parameters and requirements. In particular, the SSC Central Design Group (CDG) of the Universities Research Association, a DOE contractor, issued a *Reference Designs Study* in March 1984 and a *Conceptual Design Report* in March 1986 which were used as source documents for the *Invitation.* Additionally, a *Site Parameters Report* was prepared by the CDG, and sent to all state Governors in June 1985 for review and comment. Using these documents as baseline information, the Task Force developed the requirements, the qualification and evaluation criteria, and the selection guidelines which appear in the *Invitation.* On March 3, 1987, a *Federal Register* notice advised that the DOE intended to solicit proposals from states and others to provide offers of land and other contributions for siting the SSC. The final version of the *Invitation* was submitted to the Director of Energy Research who approved and issued it on April 1, 1987.

To evaluate proposals, the DOE requested data on each technical evaluation criterion and costs as they pertained to the proposed site (Section 2.2, Proposal Preparation Instructions, of the *Invitation*). Additional data needs, for BQL sites only, were included in Appendix D of the *Invitation,* "Summary of SSC National Environmental Policy Act (NEPA) Compliance Plan and Data Needs at the Best Qualified List Stage." The qualification criteria, evaluation criteria, and cost consideration information contained in the *Invitation* are provided in Appendix C of this report.

An SSC Preproposal Conference was held on April 29, 1987, at the General Services Departmental Auditorium, Washington, D.C., to familiarize prospective proposers with the SSC, to discuss siting requirements, and to answer questions related to the *Invitation.* Attendees at the conference represented states, commercial organizations, and academia, and numbered approximately 240. Addresses of the attendees indicated persons from 34 states, Canada, and West Germany were present at the Conference. The number of states planning to submit a proposal for the SSC was not known at the time.

QUALIFICATION PROCESS

In response to the *Invitation*, the DOE received 43 proposals by September 2, 1987, the latest date proposals could be received. These proposals were reviewed by the Task Force to determine if they met the five qualification criteria set forth in Section 3.2 of the *Invitation.* Seven proposals did not meet the basic qualification criteria and were disqualified. Thirty-six proposals, for sites in 25 states, met all the DOE's qualification criteria and were forwarded to the Academies' Committee on September 17, 1987. One proposal, New York, Wallkill Valley, was withdrawn by the proposer in October 1987, leaving 35 sites for evaluation by the Academies' Committee. Table 2 displays the 43 proposals received in response to the *Invitation* and indicates those that were disqualified, withdrawn, or given BQL status.

Table 2. SSC proposals received by the DOE - September 2, 1987

State	Site Name	Proposer	Location
Alaska	*Denali Site*	*State of Alaska*	*50 miles SW of Fairbanks*
ARIZONA	**MARICOPA**	**STATE OF ARIZONA**	**35 MILES SW OF PHOENIX**
Arizona	*Sierrita Site*	*State of Arizona*	*Pima County*
California	*Davis Site*	*State of California*	*Solana and Yolo Counties*
California	*Stockton Site*	*State of California*	*San Joaquin and Stanislaus Counties*
COLORADO	**DENVER SITE**	**STATE OF COLORADO**	**ADAMS AND MORGAN COUNTIES**
Florida	*Jacksonville*	*State of Florida*	*Nassau County*
Idaho	*Idaho National Engineering Lab*	*State of Idaho*	*Jefferson, Bingham, and Butte Counties*
ILLINOIS	**FERMILAB**	**STATE OF ILLINOIS**	**KANE, DUPAGE, AND KENDALL COUNTIES**
Kansas	*Topeka*	*State of Kansas*	*16 miles south of Topeka*
Louisiana	*Louisiana Site*	*State of Louisiana*	*North of Lake Pontchartrain*
Michigan	*Dundee Site*	*State of Michigan*	*Lenawee and Monroe Counties*
MICHIGAN	**STOCKBRIDGE SITE**	**STATE OF MICHIGAN**	**INGHAM AND JACKSON COUNTIES**
Mississippi	*Mississippi Site*	*State of Mississippi*	*East Central Mississippi*
Montana	*Montana Site*	*State of Montana*	*South Central Montana*
Nevada	*Nevada Site*	*State of Nevada*	*Humboldt County*
New Mexico	*Dona Ana County*	*The Rio Grande Council of Govt's and Dona Ana County*	*Dona Ana County, New Mexico*
New Mexico	*Estancia Basin*	*State of New Mexico*	*40 miles east of Albuquerque*
New York[1]	*International Site*	*State of New York*	*Franklin County, NY, and Huntingdon County, Quebec, Canada*
New York[2]	*Rochester Site*	*State of New York*	*Wayne and Monroe Counties*
New York	*St. Regis Valley Site*	*State of New York*	*St. Lawrence and Franklin Counties*
New York[3]	*Wallkill Valley Site*	*State of New York*	*Orange, Ulster, and Sullivan Counties*
N. CAROLINA	**RALEIGH/DURHAM**	**STATE OF NORTH CAROLINA**	**GRANVILLE, PERSON, AND DURHAM COUNTIES**
Ohio	*Ohio Site*	*State of Ohio*	*Marion, Union, and Delaware Counties*
Oklahoma	*Oklahoma Site*	*State of Oklahoma*	*Blaine and Kingfisher Counties*
Oregon	*Columbia River Site*	*State of Oregon*	*Morrow and Umatilla Counties*
Oregon	*University Site*	*State of Oregon*	*Benton, Lane, and Linn Counties*
South Dakota	*Northern Great Plains*	*State of South Dakota*	*Southeast South Dakota*
TENNESSEE	**TENNESSEE SITE**	**STATE OF TENNESSEE**	**CENTRAL TENNESSEE**
Texas	*Amarillo*	*State of Texas*	*Swisher, Randall, and Castro Counties*
TEXAS	**DALLAS-FORT WORTH SITE**	**STATE OF TEXAS**	**ELLIS COUNTY**
Texas[4]	*Devers Site 1*	*O. R. Amy*	*Southeast Texas*
Texas[4]	*Devers Site 2*	*Bill Leatherwood*	*Southeast Texas*
Texas	*Far West Texas Site*	*The Rio Grande Council of Govt's*	*Hudspeth County*
Texas	*Garden City Site*	*Garden City SSC Commission*	*West Central Texas*
Texas[4]	*Liberty County Site*	*Terrell G. Lara*	*Cypress Lakes Resort*
Utah	*Cedar Mountains Site*	*State of Utah*	*52 miles west of Salt Lake City*
Utah[4]	*Delta Area Site*	*Larsen Institute of Technological Evolution*	*Central Utah*
Utah	*Ripple Valley*	*State of Utah*	*69 miles west of Salt Lake City*
Washington	*Lincoln County Site*	*State of Washington*	*40 miles west of Spokane*
Washington[4]	*Mattawa*	*A-Enterprises*	*Grant County*
Wyoming	*Cheyenne*	*State of Wyoming*	*Laramie County*
N.A.[4]	*Jablonka*	*Paul Jablonka*	*Moon Area L-5*

1 Site did not meet the qualification requirement to be located entirely within the United State of America
2 Withdrawn from consideration on January 15, 1988
3 Withdrawn from consideration on ctober 15, 1987
4 Proposals not qualified. Failed to provide adequate information or data to be evaluated
BOLD = BQL sites

DETERMINATION OF BEST QUALIFIED LIST

By prior agreement, the Academies were asked by the DOE to assist in the SSC site evaluation process by providing an independent evaluation of the qualified site proposals against the set of requirements in the *Invitation* and to recommend an unranked Best Qualified List. The Academies' assistance was sought in the interest of enlisting an independent evaluation that would further the goal of a credible and objective site selection process. It was the opinion of the Department that the Academies' participation would provide a review of the proposals that met the highest standards in light of their reputation for fairness and objectivity.

The Academies' Committee formed seven working groups (one for each technical evaluation criterion and one for the life-cycle cost). Each working group included at least one member who also served on another working group.

The Academies' Committee elaborated on several of the elements within the technical evaluation criteria, subcriteria, and life-cycle cost considerations (e.g., for geology and tunneling, groundwater inflow into the tunnel and experimental halls during construction) that were considered in the evaluation of proposals. These elements are identified in the Academies' Committee report as "those items within the DOE-announced criteria and subcriteria and their relative importance, that are likely to be most critical in determining scientific productivity of the SSC laboratory." Specifically, "Because the SSC will be a very large national laboratory, its ability to recruit and retain a first-class staff is of utmost importance to its scientific success." Given the extensive experience in the management of large scientific enterprises represented on the Academies' Committee, it was well qualified to judge factors crucial to determining scientific productivity.

For each proposal meeting the qualification criteria, the Task Force prepared and furnished to the Academies' Committee a life-cycle cost estimate for the construction phase plus a 25-year operating phase. The *Invitation* stated that cost considerations were significant, but that primary emphasis was to be placed on the evaluation results of the technical evaluation criteria. The Academies' Committee considered costs, but assigned them a minor role because the estimates fell within such a narrow range.

The Academies' Committee received and discussed reports from its working groups on the strengths and weaknesses of each of the 35 proposals during its final meeting. In order to make an explicit decision to include (or not to include) each site on the BQL, the Chairman asked that the full Committee discuss each site until a consensus was reached that it should or should not be placed on the BQL. The recommended BQL was unranked. At no point did the Academies' Committee consider what would be an appropriate number of BQL sites. Geographic distribution was not a factor in the Academies' Committee decision regarding the BQL, nor did the Academies' Committee process limit BQL sites to one per state.

The Academies' Committee report, *Siting the Superconducting Super Collider*, which was forwarded to the DOE on December 24, 1987, identified eight sites that "merited inclusion" on the BQL. Listed in alphabetical order, the recommended BQL sites are:

Arizona
Colorado
Illinois
Michigan (Stockbridge)
New York (Rochester)
North Carolina
Tennessee
Texas (Dallas-Fort Worth).

The Academies' Committee expressed full confidence that the recommended BQL represented the best collective judgment of the Committee (whose members were carefully chosen for their expertise and impartiality), and reflected a selection of those sites that best met the selection considerations included in the *Invitation.*

Before release to the DOE, the Academies' Committee report was reviewed and approved by a committee of the National Research Council Governing Board to ensure that it met their quality and content standards. It was formally transmitted to the Acting Director of the Office of Energy Research by the Presidents of the Academies.

The Task Force review of the Academies' Committee recommendations is detailed in the report *Best Qualified Sites for the Superconducting Super Collider*, prepared by the Task Force in January 1988. In summary, the Task Force recommended adoption of the Academies' recommended list of sites on the BQL. Subsequently, New York withdrew the Rochester site proposal and on January 19, 1988, Secretary Herrington announced that the seven remaining sites recommended by the Academies would be the BQL for the SSC.

With the Secretary's announcement, the Task Force began its evaluation of the BQL sites, which are described in Chapter 3. The methodology used for the evaluation is summarized in Chapter 4. Chapter 5 presents the technical evaluations, and Chapter 6 presents the life-cycle cost estimates.

3

SITE DESCRIPTIONS

ARIZONA

GENERAL

The Arizona site is located approximately 35 miles southwest of Phoenix (see Figure 5). The proposed ring alignment encircles the Southern Maricopa Mountains and passes through the Northern Maricopa Mountains.

GEOLOGY

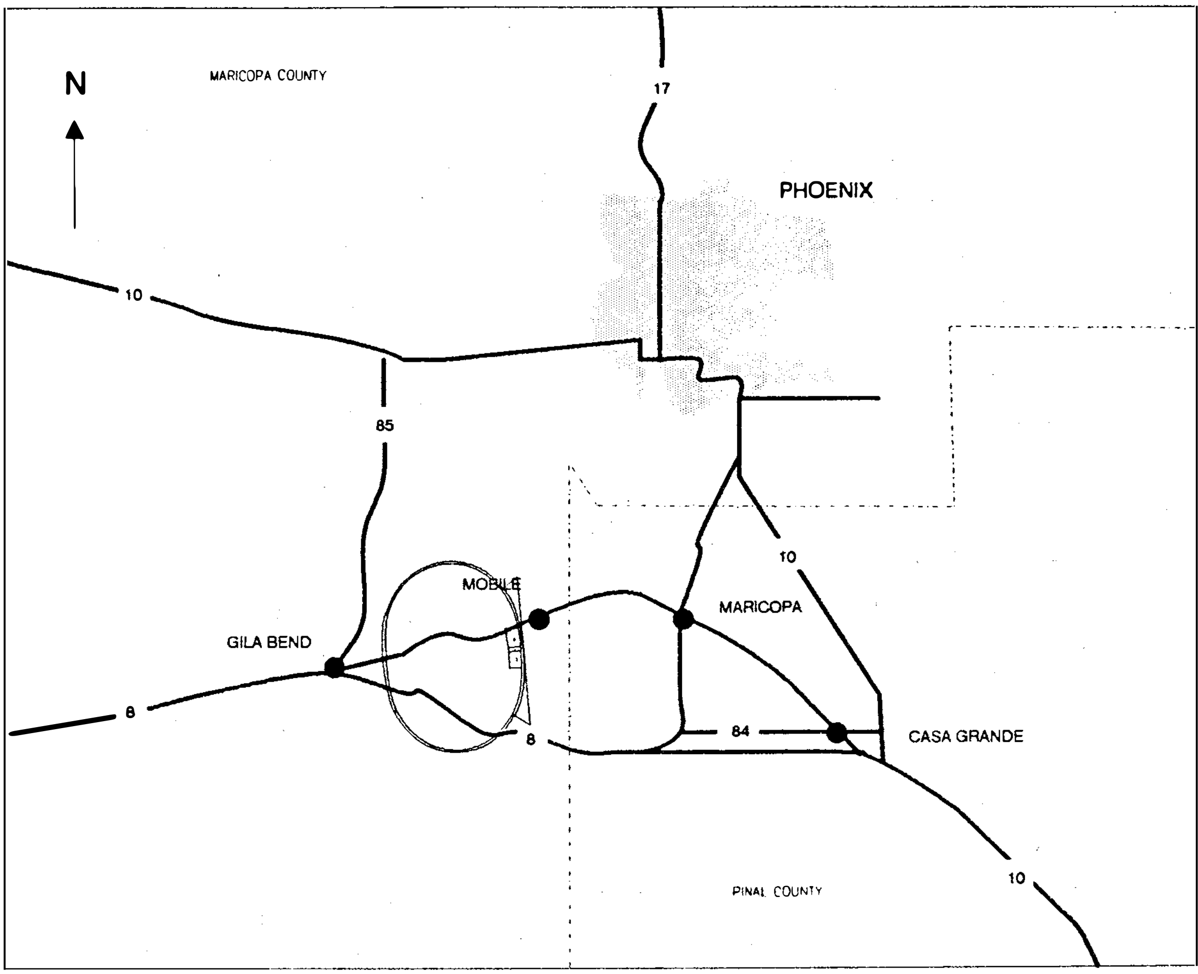
The Maricopa site lies in an area of desert plains punctuated by widely separated peaks of the Maricopa Mountains. The water table lies at a considerable depth below the proposed collider elevation. Several distinct rock groups are present at the site. Precambrian granites and schists form the mountains and are overlaid in the southern portion by a complex layered sequence of volcanics. The deep valleys between the mountain ranges are filled with weakly cemented silt, sand, and gravel (called fanglomerate). The mountains are bounded by major inactive faults; additionally, shear zones have been identified within the granites of the North Maricopa Mountains. Earthquake potential at the site is defined as moderate (Uniform Building Code (UBC) Seismic Zone 2).

Because of the occasionally rugged topography, tunnel depth varies from 40 to over 1,000 feet. Most of the tunnel (68 percent) will pass through fanglomerate. Up to 18 percent of the tunnel will be shallow enough to be completed by cut-and-cover techniques. The remainder will pass through granites and the volcanic complex. A structural lining will be required for the fanglomerate portion of the tunnel and locally through zones of fracturing in the granites. Experimental halls and the injector complex all will be constructed using cut-and-cover techniques. Hall foundations in fanglomerate will require additional supports for load distribution.

REGIONAL RESOURCES

The Phoenix metropolitan area, with approximately two million people, is one of the most rapidly growing areas in the United States. The proposed campus would be located in a remote, essentially unpopulated area more than a 45-minute drive from any sizable residential community. Sky Harbor International Airport, located 3 miles east of downtown Phoenix, will be about a 1-hour drive from the site after completion of proposed highway and road construction and improvements. The site is bounded by Interstate 10 on the north and east,

Figure 5. Arizona site vicinity.



Interstate 8 on the south, and State Road 85 on the west. A mainline railroad transects the site. The high-technology industrial base and skilled labor pool, and the construction base and trade labor pool are developing. The proposal was prepared jointly by the State, the University of Arizona, and Arizona State University, with limited local involvement.

ENVIRONMENT

The site is arid, with no perennial streams and very little surface water. Flash floods that originate in the mountains produce substantial runoff in the washes. Depth to groundwater throughout the site is generally greater than 350 feet below the surface. Groundwater quality in the major basins at the site is highly variable. The alluvial basins are a major source of groundwater in Arizona. Overdraft is not large, but the potential for overdrafting is a major water resource issue in Arizona. The site is located in an attainment area for National Ambient Air Quality Standards. The average day/night sound level is approximately 40 dBA based on present land use. The environmental setting is Sonoran desert, which is relatively pristine, although the area is widely used for recreational activities. There are no wetlands. There are seven known prehistoric sites and a total of ten known historic sites in the site vicinity. The land is essentially undeveloped.

SETTING

The site consists of 15,830 acres, 131 ownerships, 224 parcels, and six residential relocations. A majority of the property is public domain (9,748 acres) under the jurisdiction of the Bureau of Land Management (BLM). BLM has indicated general support for the project and has cooperated by temporarily withdrawing 70,000 acres for the project and by starting validation reviews of approximately 130 mining claims on the land involved. A portion of the proposed site had been nominated as a Wilderness Area. While BLM has recommended against Wilderness designation for this area, a final determination must be made by Congress. The town of Mobile is located in the north end of Area I. Other noteworthy features from the setting perspective are the historic stage route and proposed national historic trail crossing the site.

REGIONAL CONDITIONS

The site is crossed by one interstate highway and a mainline railroad. The highway is 2 miles from the nearest interaction point. The railroad crosses the ring at two points, each of which is about 0.5 mile from an interaction point. At one crossing it is only 45 feet above the tunnel. Luke Air Force Base and bombing range is south of the ring. Bombs would not be dropped closer than 14 miles from the ring. The site is quiet with few noise generators.

The monthly average maximum temperature for July is 107^{o}F. The annual mean precipitation in this desert region is 7 inches. In summer, atmospheric circulation brings moist air from the south and occasional intense rains. There is evidence of flash floods at the site.

UTILITIES

Power at this site is provided by the Arizona Public Service Co. with installed generation capacity of 3,660 MW which is 20 times the peak SSC requirement. As proposed, providing construction power will require extending a new line completely around the collider ring. Approximately 41 miles of new 230-KV transmission lines will be required to be constructed by the proposer to provide permanent power to the site. Water will be provided from existing Federally owned BLM wells located approximately 11 miles from the campus, and extended through the tunnel to the service areas. Sewage disposal will be provided by new on-site plants. Fuel (natural gas) and solid waste facilities are readily available.

COLORADO

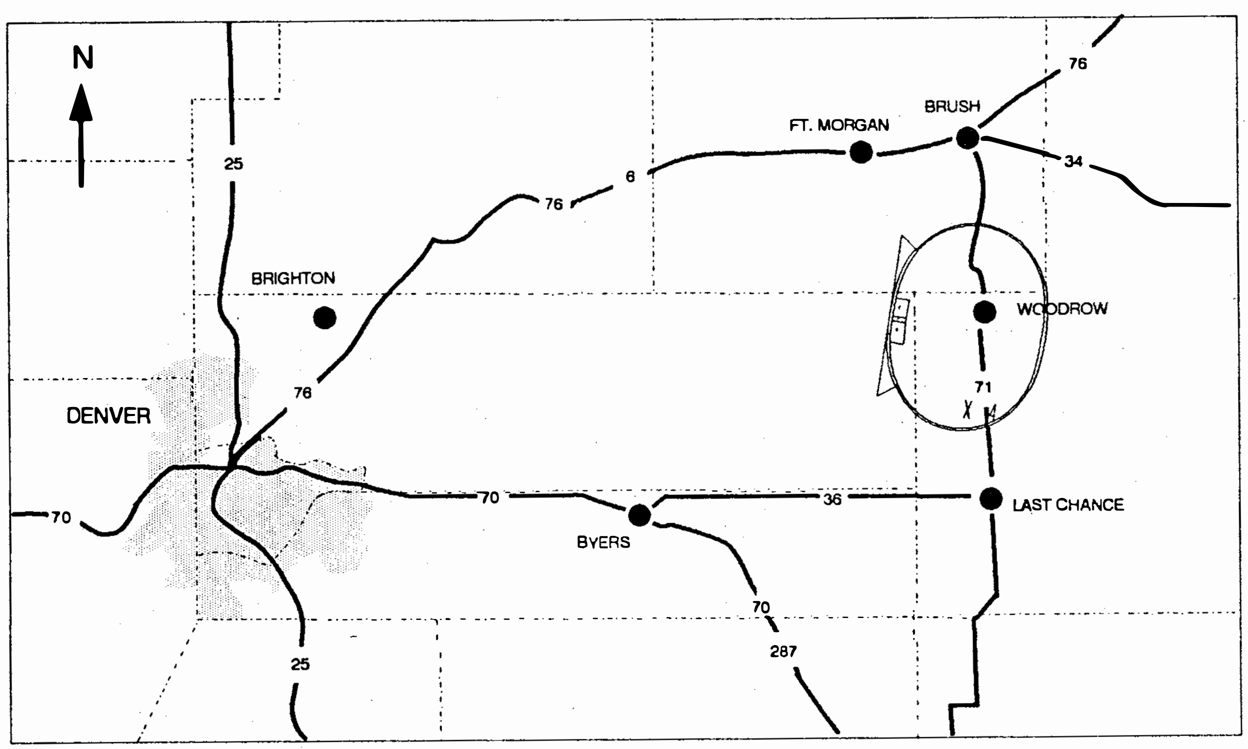
GENERAL

The Colorado site is located in a rural area approximately 65 miles east northeast of the Denver metropolitan area (see Figure 6). Colorado State Highway 71 runs through the center of the site between the communities of Brush and Last Chance. Fort Morgan, the County Seat of Morgan County, is located approximately 20 miles northwest of the site.

GEOLOGY

The Colorado site lies on the high plains east of Denver; the gentle topography at the site generally mimics the relatively flat top of the underlying Pierre Shale. The South Platte River and its intermittent tributaries are the dominant source of water in the region as the thick shale sequence is essentially impermeable. The claystone of the Pierre Shale is homogeneous and of low strength. However, the claystone is elastic and has a high slake potential (tendency to crumble when dry). Major structures (faults) are absent at this site, and the setting is within an area of low seismic risk (UBC Seismic Zone 1). Oil and gas are produced from the Dakota sandstone more than 5,000 feet below the collider ring; commercial drilling in the area dates back to the 1920's.

Figure 6. Colorado site vicinity.



The tunnel at the proposed Colorado site will be entirely within the claystone at a depth ranging up to 200 feet (average shaft depth = 125 feet). Precast segmental liners will be installed to prevent slaking of the claystone. All shafts will penetrate some thickness of alluvium, and 40 percent of them will require water control above the claystone. Similarly, the experimental halls and injector complex, which will be constructed by cut-and-cover techniques, will require water control in the alluvium. Hall foundations on the elastic claystone may require additional support for load distribution.

REGIONAL RESOURCES

The Denver metropolitan area has almost two million people. The largest towns within a 45-minute drive of the proposed campus are Fort Morgan (population approximately 9,000) and Brush (4,000). Stapleton International Airport, located in northeast Denver, is about an 80-minute drive from the site. If a new airport is built, and proposed new and improved highways and a tollway completed, driving time between the new airport and the SSC should be reduced to about 70 minutes. The site is bounded by Interstate 76 on the north and Interstate 70 to the south and is traversed by State Highway 71 connecting with I-76 to the north at Brush and, to the south, with US-36 at Last Chance, and with I-70 at Limon. The site area is served by two mainline railroads. The Denver area has a diverse, mature, high-technology base, skilled labor pool, construction base, and trade labor pool – all of which are remote from the site. The proposal was developed by the State and coordinated with local governments.

ENVIRONMENT

The Colorado site is located in a remote farming area in a rolling, semi-arid, loess-covered plain, incised by intermittent streams with narrow floodplains. The land development pattern is basically nonirrigated farmland. The site has limited surface water resources available, and the proposed water supply for the project would be from wells. Surface water is available from the Colorado Big Thompson Project to augment recharge for the groundwater supply. The tunnel would be constructed below the water table. The site is located in an attainment area for National Ambient Air Quality Standards. The average day/night sound level is approximately 50 dBA based on present land use. The environmental setting is croplands and pasture, typical of the western great plains. There are approximately 5 acres of wetlands that may be impacted. Six historic sites eligible for the National Register have been identified along the proposed access roads. There is potential for additional cultural sites, particularly prehistoric sites, to be identified along creeks.

SETTING

The site consists of 157 parcels and 67 ownerships. There would be 23 residential relocations required. Although the State plans to acquire approximately 52,520 acres of land in fee simple, only the land (15,830 acres) and estates required in the *Invitation* will be transferred to DOE, with the State retaining title and control over the remaining portions of the land they acquire. The site terrain varies from flat to slightly hilly and lies in sparsely populated grasslands used mostly for dryland wheat farming, cattle grazing, and oil exploration. There are no significant man-made or natural features.

REGIONAL CONDITIONS

A two-lane state highway, but no railroad, crosses the ring. There are some oil and gas wells in and near the ring area, and a few wells are within a few hundred feet of the tunnel.

The climate at the site is characterized by low annual precipitation (15 inches per year) and low humidity. There are occasional severe winter storms. The annual snowfall is about 30 inches.

UTILITIES

Power is provided by a combination of the Public Service Company of Colorado, the Tri-State Generation and Transmission Association, and the Morgan County Rural Electrical Association. Installed generation capacity is 4,903 MW, which is 25 times the peak SSC requirement. There are numerous 345-KV transmission lines in the vicinity of this site. As proposed, construction power will be provided for various existing service locations around the ring. Approximately 99 miles of new 230-KV transmission lines are required to be constructed by the proposer to provide permanent power to the site. Water will be provided by the Morgan County Quality Water District from a combination of new and existing wells located approximately 45 miles from the campus. The required augmentation will be provided. This augmentation requires purchase of surface water rights to replace groundwater removed from aquifers for the SSC. Sewage will be provided by new, on-site plants constructed by the SSC. Fuel (natural gas) and solid waste facilities are readily available.

ILLINOIS

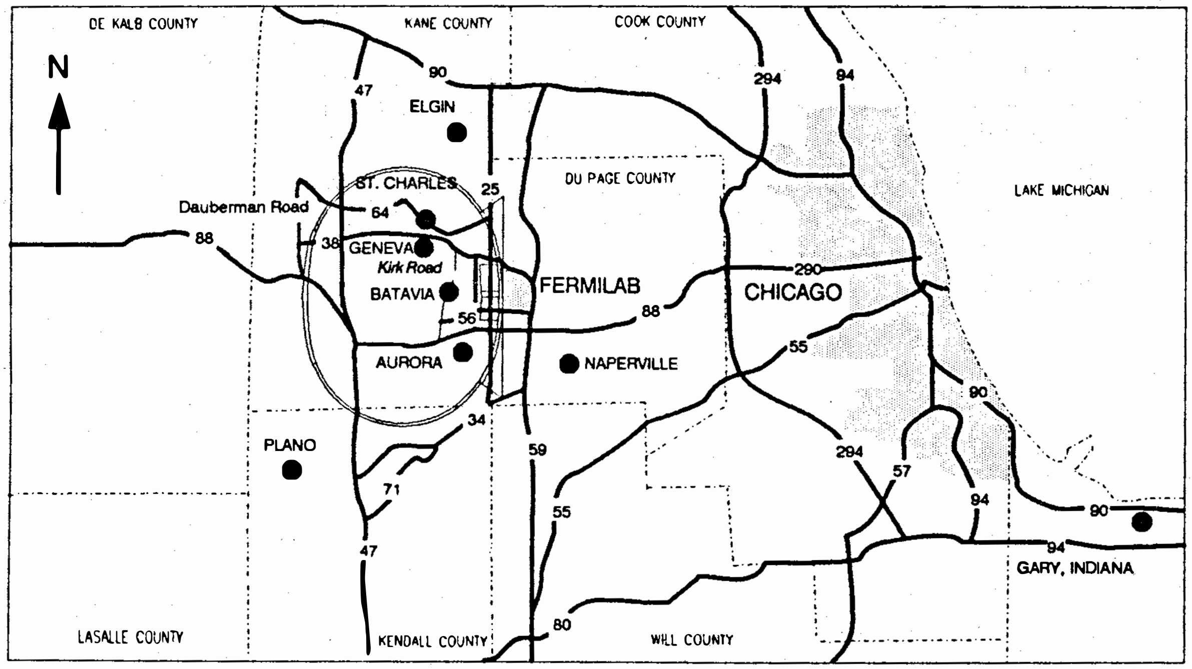
GENERAL

The Illinois site is located 40 miles west of downtown Chicago near the City of Batavia (see Figure 7). The collider ring will pass under farmlands, residential communities, and the Fox River Valley. The site also is adjacent to a growing high technology corridor.

GEOLOGY

The Illinois site is situated in a region of flat to rolling terrain. Glacial sediments form a thick mantle over a bedrock sequence of limestone, shale, and dolomite. The collider tunnel will be entirely within a uniform sequence of high-strength dolomite at an average depth of 430 feet. At this depth, the rock is essentially impermeable; however, the overlying glacial sediments and weathered bedrock carry substantial water volumes. Major structures (faults) are absent at the site, and joints in the rock are widely spaced. The setting lies within an area of low seismic risk (UBC Seismic Zone 1).

Figure 7. Illinois site vicinity.



Because of the high quality and strength of the dolomite, most of the tunnel at this site can be left unlined. All shafts will penetrate some thickness of saturated ground and will require ground support and water control prior to excavation. Shafts range in depth from 330 to 610 feet, averaging 430 feet. Experimental halls will be completed as underground caverns in the dolomite. The Illinois site would use the Tevatron at Fermilab as the injector complex. Long tunnels connecting this surface facility to the deep collider tunnel will have to be constructed.

REGIONAL RESOURCES

The Chicago metropolitan area is the third largest metropolitan area in the Nation. There are about seven million people in the six county SSC area. The SSC campus area, on the eastern side of the ring, would contain the Fermilab site and is located in a heavily populated suburban area. The western portion of the ring is located in a rural setting. O'Hare International Airport is about a 45-minute drive from the site. The site is served by an extensive network of interstate, US and state highways, tollways, and roads. The site is bounded by Interstate 90 to the north, Interstate 294 (tollway) to the east, Interstate 55 to the southeast, and Interstate 80 to the south; Interstate 88 (tollway) traverses the site in an east/west direction at the near and far cluster areas. In addition, there are several state highways traversing the site. The site area is served by an extensive network of several mainline railroads and is adjacent to one of the largest industrial and construction bases and skilled and trade labor pools in the Nation. The proposal was prepared primarily by the State.

ENVIRONMENT

The Illinois site is characterized by low rolling hills with many perennial streams that drain the site. The Fox River crosses the proposed ring location. The land development pattern is complex, i.e., intensively developed for residential, agricultural, and commercial/light industrial uses. There is currently little surface water use in the vicinity of the site; groundwater use is extensive with regional overdraft in major aquifers. The tunnel would be constructed below the water table. The site is located in counties that are designated nonattainment areas for the National Ambient Air Quality Standard for ozone. The average day/night sound level is approximately 50 dBA based on present land use. The environmental setting is a patchwork of farmland, residential development, forest, and wetlands. Forty-seven prehistoric cultural resource properties have been identified within the site area; none are listed on the National Register.

SETTING

There are 11,848 acres not presently owned by the DOE. The Illinois proposal estimates that there are 3,305 parcels and 2,750 separate ownerships. The acquisition will require approximately 219 relocations which consist of 160 residences, 46 farm complexes, 6 commercial businesses, 5 industrial, 1 school, and 1 non-profit organization. The State proposal requires connection of the SSC to the existing Tevatron at Fermilab. Additional features that affect flexibility are the Fox River, the city of Aurora, and the heavily suburbanized eastern part of the site.

REGIONAL CONDITIONS

Three railroads and eight major highways cross the ring. There are three active rock quarries near the ring. There are no nearby oil or gas wells.

The average annual precipitation is 34.7 inches. Ground frost can be expected from mid-December into March. The monthly mean temperature in January is about 20^{o}F. There are about 30 inches of snow annually; on the average, snowfalls of 6 inches or more occur twice a year.

UTILITIES

Power at this site is provided by Commonwealth Edison Company with installed capacity of 22,284 MW, which is 120 times the peak SSC requirement. As proposed, construction power will be provided from various existing service locations around the ring. Approximately 2 miles of new 345-KV transmission lines will be required to be constructed by the proposer to provide permanent power to the site. Water will be provided from the existing Fermilab well system, municipal systems, and a new well and water treatment system for the far cluster. New wells are planned for the general service areas. Sewage disposal at the campus area will be provided by the existing Warrenville Plant. At the far cluster (Area H) a new, on-site treatment plant will have to be provided by the SSC project. Fuel and solid waste disposal facilities are readily available.

MICHIGAN

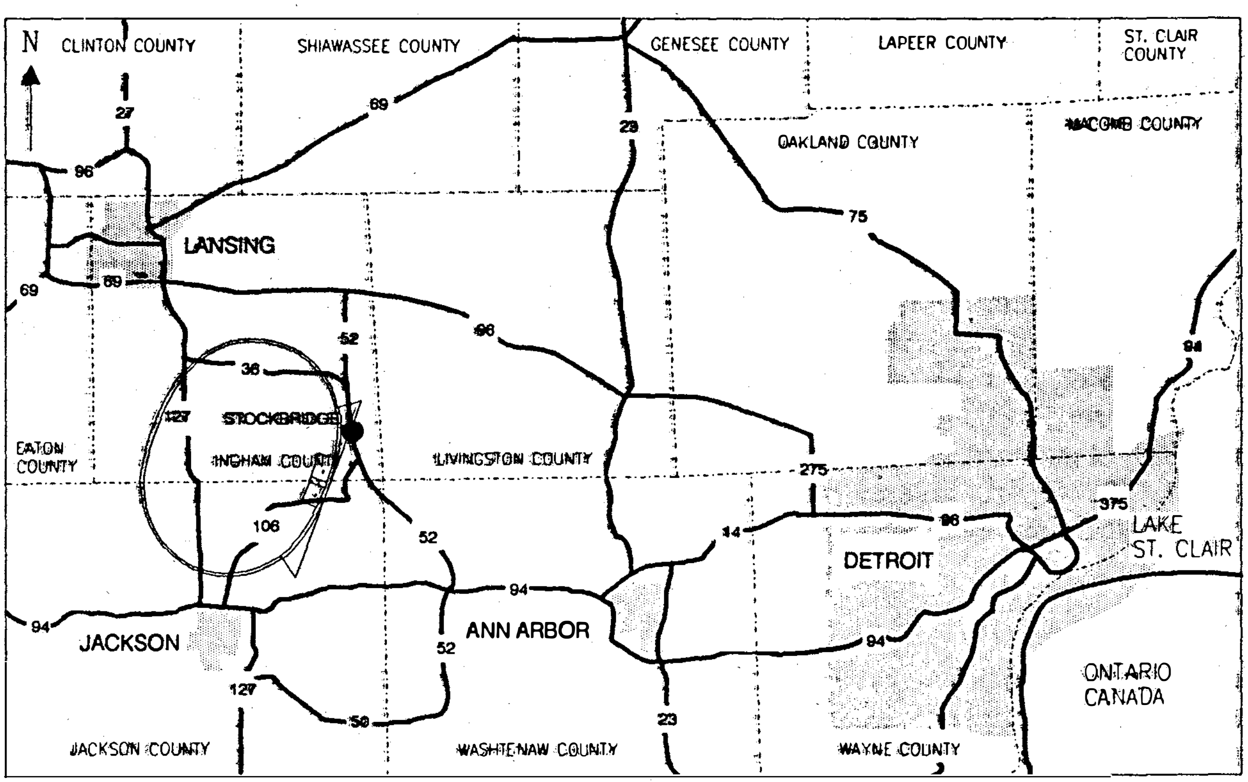
GENERAL

The Michigan site is located in a rural area in a triangle bounded by the three small metropolitan areas of Ann Arbor, Lansing-East Lansing, and Jackson, and is about 60 miles west of metropolitan Detroit (see Figure 8).

GEOLOGY

The Stockbridge site is situated in an area of glacial lowlands, with low irregular hills, lakes, and lake plains. Drainage is sluggish at the site, and there are numerous ponds and swamps. Underlying the mantle of glacial sediments, bedrock is composed of an interlayered sequence of low-strength sandstone, limestone, shale, and minor coal. Sandstones of the Saginaw Formation, while of low to moderate permeability, are a major source of groundwater for the site region. The site is without major structural features (faults), and the setting is one of low earthquake potential (UBC Seismic Zone 1).

Figure 8. Michigan site vicinity.



SITE DESCRIPTIONS

The collider tunnel will be entirely within rock at an average depth of 140 feet, and will require a waterproof liner throughout. Shaft depth ranges from 75 to 185 feet and averages 140 feet. All shafts will require significant water control measures prior to excavation, and a cast-in-place liner will be installed from surface to depth. The state proposed to construct the experimental halls with very large cut-and-cover excavations. Alternatively, it may be possible to construct two halls as underground caverns in the sandstone. In either case, significant water-control measures will be required. The high energy booster was proposed to be constructed at a depth 20 feet below the tunnel plane; alternatively, the entire injector complex can be constructed near the surface.

REGIONAL RESOURCES

The Ann Arbor, Lansing-East Lansing, and Jackson metropolitan areas' combined population within a 60-minute commuting distance of the site is in excess of 1 million. Detroit Metropolitan Wayne County Airport is about a 1-hour drive from the site. The proposed site is served by a network of interstate, U.S. and state highways and roads. The site is bounded by Interstate 96 to the north, Interstate 94 to the south, US-23 to the east, and Interstate 69/US-27 on the west, with US-127 traversing the ring alignment near the far cluster region. The area is served by two mainline railroads. There is a large industrial base and skilled labor pool and a concentration of suppliers. The proposal was developed by the State with participation by local governments and the university community.

ENVIRONMENT

The Michigan site is characterized by low, rolling hills with many perennial streams that drain the site. The ring location crosses the headwater reaches of streams, mostly within the Grand River watershed. The land development pattern is basically agricultural, but showing increasingly complex land use patterns. There are extensive surface and groundwater supplies; most municipal supplies are from wells; surface water would be used primarily for cooling towers. There is limited localized overdraft of groundwater. The tunnel would be constructed below the water table. The site is located in counties that are designated nonattainment areas for the National Ambient Air Quality Standard for ozone. The average day/night sound level is approximately 50 dBA based on land use. The environmental setting is a patchwork of farmland, forest, wetlands, and residential development. Forests provide diverse habitats, particularly at the borders between croplands, forests, and wetlands. The site is rich in wetland systems. There are several centennial historical farms in the area and prehistoric archaeological sites are likely in upland and wetland areas.

SETTING

The site contains 16,025 acres and includes 801 parcels, 687 ownerships, and 221 relocations. The relocations consist of 162 houses, 53 mobile homes, 5 commercial businesses, and 1 cemetery. The site is rural in nature although there are nearby population centers. The other noteworthy feature is the presence of wetlands near the ring.

REGIONAL CONDITIONS

One major highway crosses the ring through the north and south areas far away from interaction points. One railroad crosses the ring approximately 2.5 miles from an interaction point. There are no substantial sources of noise. There are no nearby quarries.

The site has 30 inches annual mean precipitation. The monthly mean temperature in January is 21.7°F. The annual mean snowfall is about 44 inches. Snowfalls of 10 to 18 inches generally occur once each winter.

UTILITIES

Power at this site is provided by the Consumers' Power Company and the Detroit Edison Company with installed capacity of 6,215 MW, which is 31 times the peak SSC requirement. Transmission lines rated at 345 KV and 138 KV exist within the site area. As proposed, construction power will be provided from various existing service areas around the ring. Approximately 6 miles of new 345-KV and 138-KV transmission lines are required to be constructed to provide permanent power to the site. Water will be provided by connection to the existing Stockbridge water treatment plant and new wells. Sewage disposal for the campus will be provided through a new connection to the existing Stockbridge plant, and the SSC will construct a new plant for the far cluster. Fuel (natural gas) and solid waste disposal facilities are readily available.

NORTH CAROLINA

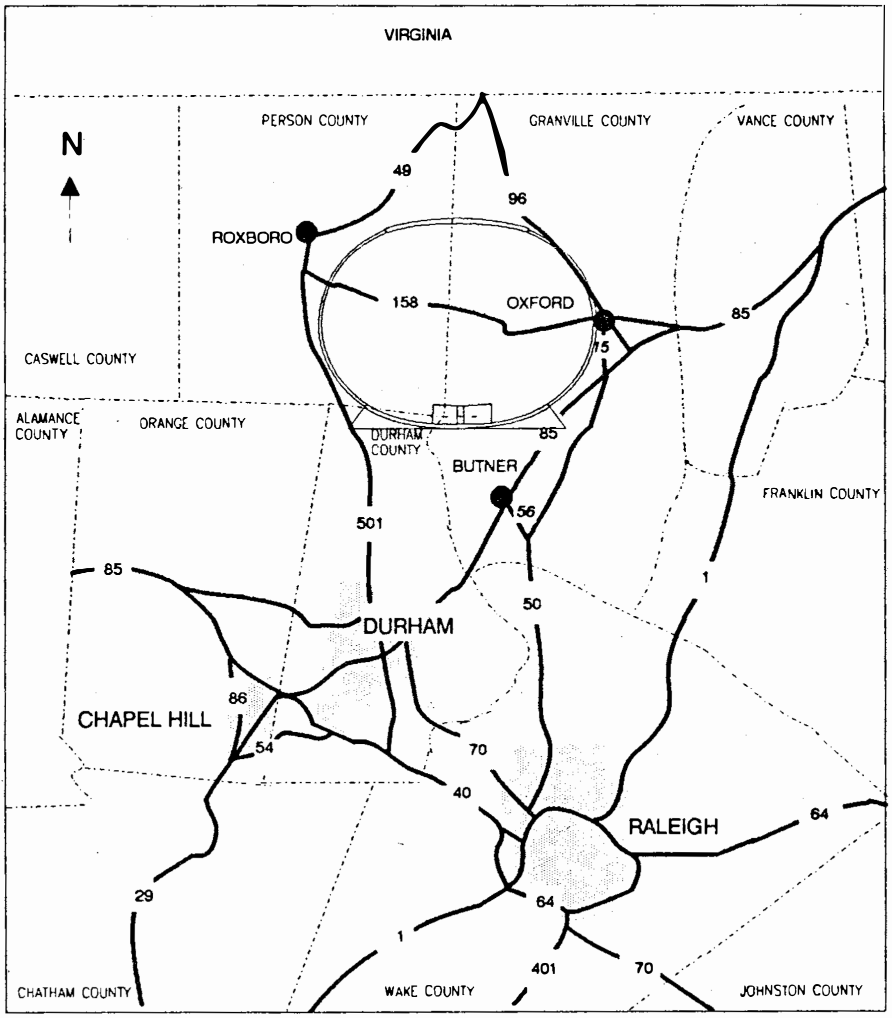
GENERAL

The North Carolina site is in a sparsely populated rural area of northern Durham, eastern Person, and western Granville Counties within 20 miles of the Raleigh-Durham metropolitan area, which includes Research Triangle Park (see Figure 9).

GEOLOGY

The site underlies flat to slightly rolling woodlands of the Piedmont Province. Thick residual soils (saprolite) grade downward into weathered bedrock and eventually to unweathered rock. The compacted residual soil tends to be a poor source of groundwater; however, the zone of weathered rock can be highly transmissive. Less weathered bedrock tends to be impermeable except along joints or fractures. The collider tunnel passes through a complex series of metamorphosed volcanic and sedimentary rocks which have been intruded by granitic bodies. However, because of similar strength and abrasiveness, this variable rock section can be considered as one engineering unit for construction. Thus the same tunnel boring machine (TBM) could be used throughout. The region has had a complex deformational history, and faults/fractures are known to occur near the contacts of the granitic plutons, and internally within the granites. This part of North Carolina lies within an area of low to moderate earthquake potential (UBC Seismic Zone 1-2).

Figure 9. North Carolina site vicinity.



Much of the collider tunnel can be left unlined in the high-strength granites and metavolcanics; however, localized heavy support and water control may be required in zones of fractures. Shafts range in depth from 70 to 275 feet, averaging 170 feet. Lining and structural support will be required through the saprolite and weathered bedrock sections. The state proposed to construct all the experimental halls as underground caverns; however, there may be insufficient thickness of unweathered bedrock to support the roofs of two halls, and cut-and-cover excavations may have to be considered. The high energy booster was proposed to be built 20 feet above the collider tunnel plane. An alternative is to construct the entire injector complex by cut-and-cover techniques at the surface.

REGIONAL RESOURCES

The Raleigh-Durham metropolitan area population in the site vicinity is over 700,000. Raleigh-Durham Airport is about a 40-minute drive from the SSC campus. The site is bounded by Interstate 85 to the east and southeast, Interstate 40 to the south, US-501 on the west, and transected by US-158 along the ring's east-west major axis. The site area is served by several local railroads which connect to arterial rail lines and then to mainlines. The area has a small high-technology skilled labor pool and a developing high-technology industrial base, construction base, and trade labor pool. The proposal was developed by the State with limited involvement from the local governments or communities.

ENVIRONMENT

The North Carolina site is characterized by low, rolling hills with many perennial streams in narrow valleys. The ring location crosses the headwater reaches of streams. The land development pattern is basically agricultural (although 65 percent forested), but shows increasingly complex land use patterns. There are extensive surface water resources; groundwater is limited to shallow bedrock. Most municipal, commercial, and irrigation supply comes from surface waters; some rural domestic and irrigation supplies are from wells. The tunnel would be constructed below the water table. The site is located in counties in an attainment area for the National Ambient Air Quality Standards. The average day/night sound level is approximately 40 dBA based on present land use. The environmental setting is a mix of extensive forest areas, farmland, and residential development. Important wetland and aquatic resources have been identified. Forests provide diverse habitats, particularly at the borders between croplands, forests, and wetlands. There are seven historic buildings in the vicinity of the project that are eligible for nomination to the National Register. An additional 31 sites require evaluation. There are several centennial historical farms in the area, and prehistoric archaeological sites are likely in upland and wetland areas.

SETTING

The site is comprised of 826 parcels and 780 ownerships. Based on the site visit, the Site Task Force estimates a total of approximately 180 relocations consisting of 5 businesses, 5 mobile homes, and 170 residences. The State has estimated a total of 111 relocations made up of 106 residences and 5 businesses. The proposed campus includes 827 acres of Camp Butner which is a State-owned, National Guard facility containing over 4,000 acres. Camp Butner was donated to the State by the United States (a former Army facility). The site has a gentle rolling topography which is sparsely populated. There are several man-made features (e.g., Camp Butner and two housing developments) which are impacted by placement of the fee simple areas.

REGIONAL CONDITIONS

Two major highways cross the ring. The closest approach to an interaction point is 3.3 miles. The Butner quarry is 7.3 miles from the closest interaction point, the Martin-Marietta quarry is under construction 4.5 miles from an interaction point, and a third quarry is also proposed west of the campus area. Two railroads pass near the ring but the minimum distance to an interaction point is 5.4 miles.

The climate is generally benign with a maximum monthly mean high temperature of 88°F and about 45 inches of precipitation per year. There are few severe storms. There are some heavy rain storms, sometimes associated with hurricanes after landfall.

UTILITIES

Power at this site is provided by Carolina Power and Light and Duke Power with joint installed capacity of 27,000 MW which is 120 times the peak SSC requirement. As proposed, construction power will be provided from various existing service locations around the ring. Approximately 4 miles of new 230-KV transmission lines will be required to be constructed by the proposer to provide permanent power to the site. Water will be provided from Lake Butner to a new SSC-constructed treatment plant for the campus area. Water will be provided from Lake Mayo to a new SSC-constructed treatment plant for the far cluster. The service areas will be served by new wells. Sewage disposal will be provided for the campus area by the Butner plant. Sewage disposal for the far cluster will be provided by a new on-site plant. Fuel (natural gas) and solid waste disposal facilities are readily available.

TENNESSEE

GENERAL

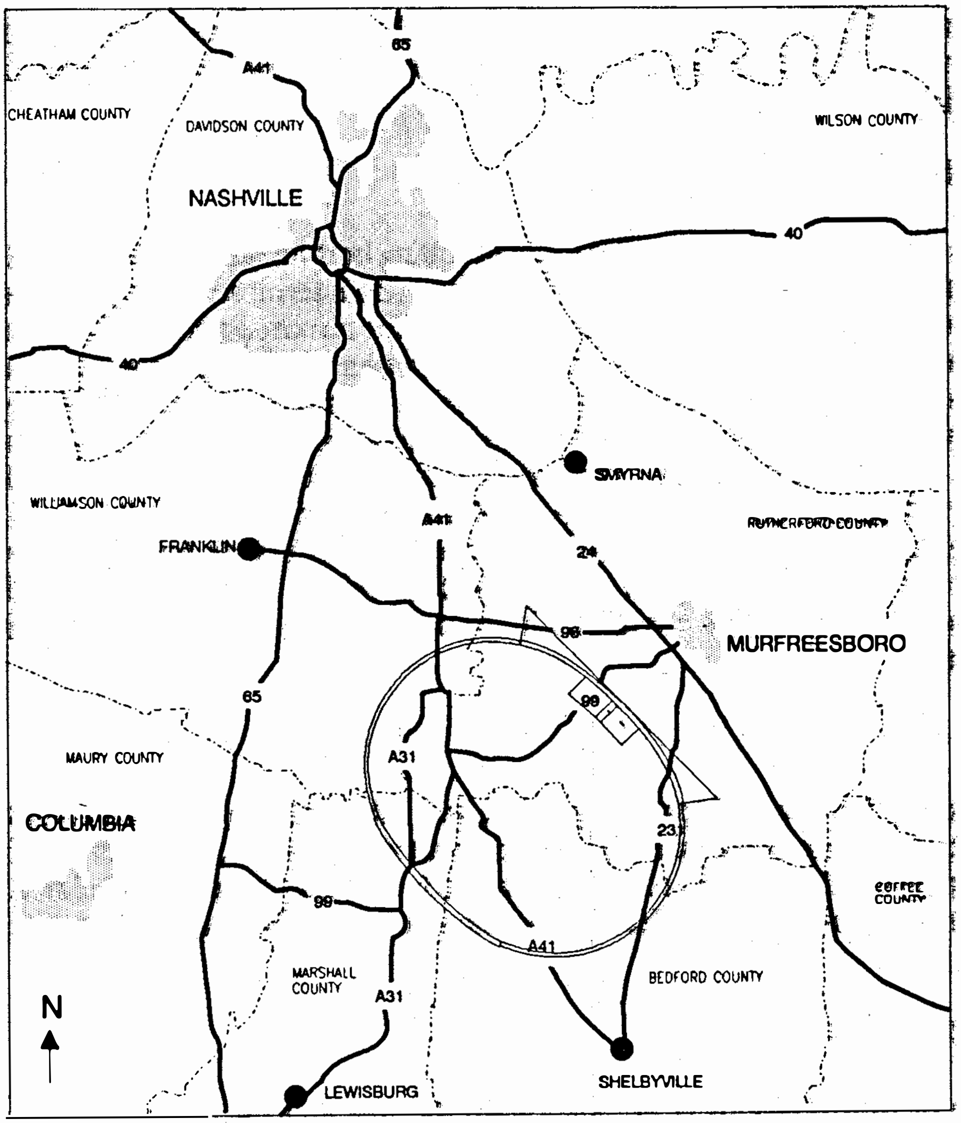
The Tennessee site is in a rural setting approximately 30 miles southeast of Nashville (see Figure 10). The site area encompasses parts of Bedford, Marshall, Rutherford, and Williamson Counties. The main campus area is about 5 miles southwest of Murfreesboro.

GEOLOGY

The Tennessee site is situated on a mature plain studded with numerous remnant knobs and hills. The underlying thick sequence of limestone is relatively soluble, and karst features (caves, widened joints, disappearing streams) are common in the shallow subsurface. The limestone is essentially impermeable, and groundwater occurs only as isolated supplies in solution cavities and channels. The limestone is uniform and predictable both vertically and laterally. Variation in the rock is limited to occasional thin shale interlayers or bands of chert (a variety of flint). No major structures disrupt the rock sequence, and the site is located in an area of low seismicity (UBC Seismic Zone 1).

The tunnel will occupy a horizontal plane in the limestone at an average depth of 405 feet. Because of the excellent quality of the rock, most of the tunnel can be left unlined. Shafts range in depth from 290 to 615 feet. The lack of any extensive soil horizon means that the shafts will be in hard rock from surface to depth. Only limited rock support is expected; most shallow karst features can either be avoided or treated. The experimental halls will be

Figure 10. Tennessee site vicinity.



excavated as deep underground caverns. The State proposed to place the high energy booster ring in a hard-rock tunnel 20 feet above the main collider ring. Alternatively, the entire injector complex can be constructed at the surface and connected to the main ring by long tunnels.

REGIONAL RESOURCES

There are approximately one million people in the site vicinity. The site is near several sizable towns. The closest principal town, Murfreesboro, is located 5 miles northeast of the campus area. Nashville Metropolitan Airport is about a 35- to 40-minute drive from the SSC campus.

The Nashville area, and the site vicinity in particular, has an extensive network of interstate, US, and state highways. The site is bounded by Interstate 40 to the north, Interstate 65 to the west and Interstate 24 to the northeast and east. The site is served by two mainline railroads. Firms, including two large automobile manufacturers, are locating in the area. The high-technology industrial base and skilled labor pool, and the construction base and trade labor pool are developing. The proposal was prepared by the State with some assistance from the Tennessee Valley Authority (TVA).

ENVIRONMENT

The Tennessee site is characterized as flat to slight rolling bottom lands, with local clusters of 350 foot high knobs. The ring crosses several perennial and intermittent streams. The area is relatively undeveloped. There are extensive surface water resources; groundwater is limited to shallow bedrock. Most municipal, industrial, and irrigation water supply comes from surface waters. The site is located in an area that is designated a nonattainment area for the National Ambient Air Quality Standard for ozone. The average day/night sound level is approximately 40 dBA based on present land use. The environmental setting is a patchwork of forest, farmland, and residential development. Agricultural production is small scale. Forests provide diverse habitats, particularly at the borders between croplands, forests, and wetlands. There are few wetlands that would be affected by the project. Several hundred historical properties more than 50 years old are known in the project area, 9 of which are listed on the National Register.

SETTING

The site consists of 807 ownerships, 898 parcels, and 128 relocations which consist of 124 residential units, 2 commercial businesses, 1 non-profit organization, and 1 school. The site terrain varies from relatively flat to hilly, and the site is generally sparsely populated. There are no man-made features which affect setting though there is hilly topography at two fee simple areas.

REGIONAL CONDITIONS

A quarry south of Murfreesboro is 1.8 miles from the ring and 2.4 miles from the nearest interaction point. Two railroads cross the site but remain more than 3,000 feet from all interaction halls. Several major highways cross the ring.

The average daily maximum temperature in July is 88°F. The annual precipitation is 48 inches, mostly in the winter and spring. There are 11 inches of snow annually. Damaging ice storms occur only about once every 5 years.

UTILITIES

Power at this site is provided by the Tennessee Valley Authority with installed capacity of 32,100 MW, which is 160 times the peak SSC requirement. As proposed, construction power will be provided from various existing service locations around the ring. Approximately 32 miles of new 161-KV transmission lines will be required to be constructed by the proposer to provide permanent power to the site. Water will be provided to the campus from the existing Rutherford County system, to the far cluster from the existing Marshall County system, and to the services areas from the nearest system (Bedford County and the town of College Grove). Sewage disposal will be provided for the campus by connection to the existing Murfreesboro plant. Sewage disposal for the far cluster will be provided by a new on-site plant. Fuel (natural gas) and solid waste disposal facilities are readily available.

TEXAS

GENERAL

The proposed Texas site is located 25 miles south of Dallas and 35 miles southeast of Fort Worth in Ellis County (see Figure 11). This area provides a semi-rural setting with flat to gently rolling topography. The City of Waxahachie is the County Seat and is completely encircled by the ring. The main campus area will be located 5 miles southwest of the city.

GEOLOGY

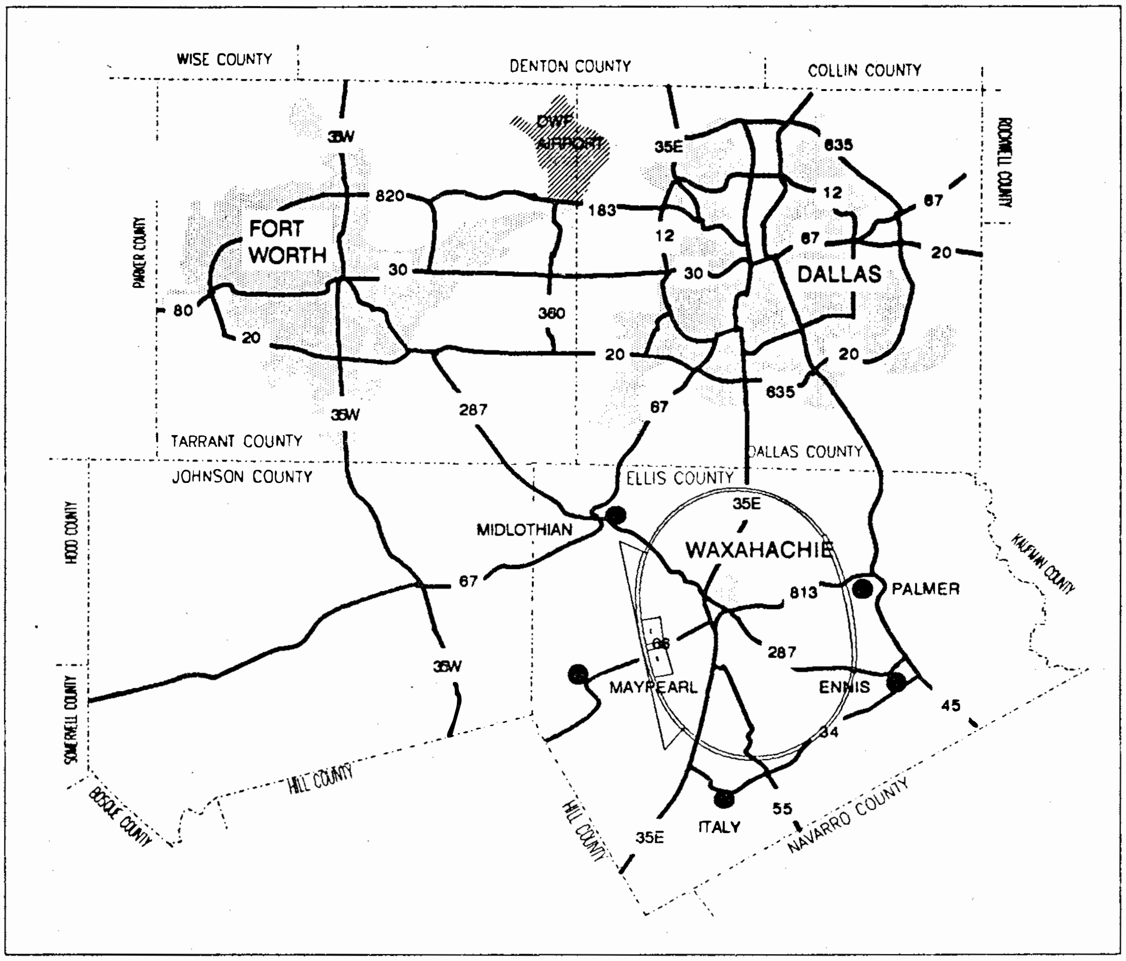
The Dallas-Fort Worth site lies in an area of flat to rolling prairies set between erosional escarpments of the underlying coastal plain strata. Thin, residual soil covers a bedrock sequence composed of the Austin Chalk, the Taylor Marl, and the Eagle Ford Shale. These rocks comprise an interlayered series of limestone, claystone, and shale, the strength of which varies directly with carbonate content and inversely with water content. Groundwater at the site is produced only from more transmissive sandstones well below the chalk and marl section, or from river gravels. At the tunnel level the rock is impermeable. Several faults related to structural readjustment of the Gulf Coast region are known to cross the ring alignment. These faults are all inactive and the site lies in a region of very low earthquake potential (UBC Seismic Zone O).

The chalk and marl at tunnel depth are soft, low-strength units which are easily tunneled. The marl (25 percent of the ring) will need to be lined to prevent slaking; the chalk will be coated with shotcrete for dust control. Shafts range in depth from 85 to 235 feet and average 150 feet. The State proposes to construct all experimental halls by deep (190 to 265 feet), open-pit excavations. Alternatively, the halls in chalk can be constructed as underground caverns. The linac and low energy booster will be constructed by cut-and-cover techniques; the medium and high energy boosters will be located at a deeper level in a tunnel bored through the chalk.

REGIONAL RESOURCES

The Dallas-Fort Worth metropolitan area is the eighth largest metropolitan area in the U.S. with a population approaching four million. Several cities are within a 30-minute commute. The Dallas-Fort Worth International Airport currently is about a 45 minute drive from the SSC site; this will be reduced to about 35 minutes after proposed highway improvements are

Figure 11. Texas site vicinity.



completed by 1996. The Dallas-Fort Worth area, and the site vicinity in particular, has an extensive network of interstate, US, and state highways. The site is bounded by Interstate 20 to the north, Interstate 35-W to the west, Interstate 45 to the east; Interstate 35-E and US 287 traverse the proposed SSC ring alignment and intersect near Waxahachie. The site area is served by an extensive rail network. There are ample industrial and construction resources, including skilled high-technology and trade labor pools. The proposal was prepared at the local level in Ellis County with support from surrounding counties and was selected by the State in a competitive process for submittal to the DOE.

ENVIRONMENT

The Texas site is characterized as a rolling plain with 50 to 70 foot relief, drained (mostly intermittently) by several creek systems. Several stream channels cross the ring location. The

Texas site is dominated by farmland. There are extensive surface water resources; however, groundwater aquifers are being overdrafted. Surface water and groundwater use is moderate for municipal, industrial, and agricultural use. The site is located in an attainment area for the National Ambient Air Quality Standards. The average day/night sound level is approximately 40 dBA based on present land use. The environmental setting is primarily cropland and pasture with a mix of woodland and residential development. There are no marshlands or swamplands in the area, although there is one important riparian wetland. No cultural resource sites are known to be affected by the project, and the potential for significant adverse impacts is low.

SETTING

The site includes 614 parcels of land held by 420 landowners. One Federal ownership is involved which is managed by the Corps of Engineers (Lake Bardwell). This site would include 175 relocations of which 120 are rural residences and the remaining 55 are manufactured houses (house-trailers). The site terrain is relatively flat to gently rolling. Other than Lake Bardwell, there are no noteworthy man-made features which affect the setting.

REGIONAL CONDITIONS

The Dallas site is crossed by five railroad lines, one of which passes only 25 feet above the ring tunnel; the closest to an interaction hall is 2,400 feet from K5. A quarry in Midlothian is about 9 miles from an interaction point. Seventeen major highways cross the ring, but none are within 600 feet of an interaction point. There are no nearby oil and gas wells. The climate is classified as continental with a monthly average high temperature of 85°F in July and an annual precipitation of 31 inches. There are occasional ice storms in winter.

UTILITIES

Power at this site is provided by the Texas Utilities Company with installed capacity of 19,500 MW, which is 100 times the peak SSC requirement. As proposed, construction power will be provided from various existing service locations around the ring. Approximately 5 miles of new 138-KV transmission lines are required to be constructed by the proposer to provide permanent power to the site. Water will be provided for the campus by connection to existing aqueducts (90 inch/72 inch) which provide water to Tarrant County from the Cherry Creek and Richland Creek Reservoirs. Potable water will be provided for the far cluster by the town of Ennis. New wells will provide industrial water to the far cluster and the service areas. Sewage disposal will be provided by new on-site plants constructed by the DOE. Fuel (natural gas) and solid waste disposal facilities are readily available.

4

METHODOLOGY

The evaluation methodology used by the Task Force was submitted to and approved by the DOE's Energy System Acquisition Advisory Board (ESAAB). That methodology requires the use of adjectival ratings of "outstanding," "good," "satisfactory," "poor," or "unsatisfactory" for each proposal on each criterion and subcriterion set forth in the *Invitation*. The technical evaluation criteria, and subcriteria within each criterion, were listed in descending order of relative importance in the *Invitation* and are reproduced in Appendix C of this report. A life-cycle cost estimate was also prepared for each qualified site for the construction phase of the SSC plus a 25-year operating phase.

TECHNICAL EVALUATIONS

Task Force assessment of proposals began in September 1987 with the review to determine which proposals met the qualification criteria. Following this review, and while the Academies' Committee was conducting its review, the Task Force was familiarizing itself with the 35 qualified proposals. To accomplish this, the Task Force assigned lead responsibility for each technical evaluation criterion and the life cycle cost to an individual Task Force member. In consultation with other Task Force members and advisors, each lead member assessed each proposal in his respective area of responsibility and reported his observations to the entire Task Force.

Following announcement of the BQL in January 1988, the Task Force began its detailed evaluation of the BQL proposals. Using the same committee structure that had been used for the proposal familiarization, the Task Force re-examined the proposals and the supplemental data submitted by all BQL sites. These data were requested to prepare the Environmental Impact Statement (EIS). From these reviews, areas requiring clarification or additional data were identified and questions were submitted to the proposers.

During February and March 1988, staff of a DOE contractor, RTK, conducted 1-week visits with a DOE representative to each site to obtain additional data needed for the EIS. Data were also gathered by RTK to assist in refinement of the life-cycle cost estimates which had previously been prepared for the Academies' Committee. Between April and July 1988, the Task Force visited each of the BQL sites. These Task Force visits permitted in-depth familiarization with the site and its vicinity and allowed members to meet with state representatives to clarify outstanding issues. At the end of each visit, questions were left with the states for response within 4 weeks, and the Task Force members documented their findings.

Following all the site visits, the Task Force continued its overview of EIS activities, prepared committee reports in the technical areas, and reviewed data submitted by the states in response to the questions left during the site visits. Meetings were then held in which the committees made oral presentations to the full Task Force. Following committee presentations, intensive meetings were held by the Task Force to review committee findings. Within a given technical criterion, such as geology and tunneling, each subcriterion was discussed until a consensus was reached on the rating to be given to each proposal on that subcriterion. Once consensus was reached on the ratings for all subcriteria within a criterion, the Task Force discussed what the overall rating should be for each proposal on that criterion. When consensus was reached on the overall criterion rating for each proposal, the Task Force proceeded to the next criterion. At the final session, all ratings were revisited. No ratings were changed during the final session. The Task Force neither developed numerical ratings nor ranked the proposals. Results of this evaluative process are summarized in Chapter 5, "Technical Evaluations."

COST ESTIMATES

The Task Force prepared a life-cycle cost analysis for each of the best qualified sites. These analyses build upon the work done for the SSC *Conceptual Design Report* in 1986 and more specifically upon the analyses prepared for all qualified sites which were reviewed by the Academies' Committee. Those life-cycle cost estimates were refined for this report utilizing the supplemental data submitted by the proposers, the site visits, and more detailed geotechnical investigations. This allowed more precise estimates in many areas, including tunneling (better definition of rock types) and utilities (better rate and load information).

The life-cycle cost for each site includes only costs for construction plus a 25-year operating period. Factors such as cost and/or benefits to the state or local communities were not included, nor were models used to project economic trends. Models were used for the construction of underground tunnels for a range of possible geotechnical properties that might be encountered and the methods required for construction. The models were adapted to incorporate the conditions at each proposed site. The site-specific data used in the models came from a number of sources, including, the state proposals, information submitted in response to supplemental data requests, reports of state and Federal agencies, technical journals, and visits to each site by DOE and DOE-contractor personnel.

Site-specific adaptations and adjustments to the base-case cost model were made because of variations in topography, geological characteristics, methods of construction, labor rates, costs of locally purchased materials and supplies, local conditions (e.g., climate), extended utility and service connections, and applicable taxes and tariffs.

A determination was made as to those items that would be acquired on a national basis (fixed costs), and what items would be purchased locally (variable costs), for both the construction and operating phases. Variable costs tend to reflect site-specific conditions or characteristics; fixed costs were assigned equally to all sites.

The factors used in developing the estimates were based, whenever possible, on the data, assumptions, and proposed construction methods shown in the site proposals, except where inconsistencies in the proposals were found or more economical construction procedures could be utilized. For example, it was assumed that the injector complex was located near the surface to permit cut-and-cover excavation for all sites. Other variations from the site proposals are listed in Chapter 6, "Life-Cycle Cost," as are discussions regarding cost credits in Illinois resulting from the Tevatron and other existing Fermilab infrastructure.

During its final session, the Task Force discussed the life-cycle cost estimates and reached consensus for each site and on the range of credits that should be used for the Illinois proposal. These estimates are summarized and discussed in Chapter 6.

ENVIRONMENTAL CONSIDERATIONS

An important part of the Task Force's effort was the development and review of environmental data which will be incorporated in the final EIS scheduled to be issued in December 1988. Environmental data were requested of all proposers in the *Invitation*. As discussed above, additional data were obtained about those sites which made the BQL. The environmental data were reviewed by the Task Force, by RTK, and by other DOE contractors, and comprised a substantial data base that was a major portion of the basis for evaluations of a number of the technical criteria. Additionally, the Task Force reviewed the *SSC Draft Environmental Impact Statement*, DOE/EIS-0138D.

EQUAL OPPORTUNITY

One of the objectives of the Task Force was to conduct a rigorous and vigorous civil rights assessment of the availability of the education, employment, and housing resources at the seven BQL sites. The purpose of these assessments was to assure that each BQL site met the Department's requirement set forth in the *Invitation* that all community resources be available on a nondiscriminatory basis.

To assure that the education, employment, and housing resources were available on a nondiscriminatory basis, an on-site civil rights examination of each site was conducted by a representative of DOE's Office of Equal Opportunity. Approximately 185 to 200 individuals were interviewed, including representatives from private industry; national minority organizations (e.g., National Urban League, National Association for the Advancement of Colored People, League of United Latin American Citizens, and the National Association of Minority Contractors); local, state and Federal agencies; educational institutions; State Senates; State Attorney General's offices; and members of the United States Congress.

To help establish a consistent and uniform base for assessing each BQL site, a questionnaire (35 questions) was developed which addressed housing, employment, education, Federal financial assistance, and enforcement. While essentially standardized, the questionnaire was refined from site to site to explore specific items contained in each proposal. The questionnaire was provided to the state proposal team at least a week before each site visit. In addition, each proposer was requested to identify an appropriate spokesperson who could address each particular section of the questionnaire and to instruct the spokesperson to complete the applicable portion of the questionnaire prior to meeting with the Task Force. Each meeting or interview was scheduled for 15 to 30 minutes to allow for focused discussion of the applicable portion of the questionnaire, and where appropriate, address allegations of discrimination. Incomplete questionnaires and requests for additional statistical data were completed by mail.

In addition to the interviewees identified by the proposer, national organization representatives were identified by the Task Force and asked to participate. These individuals were not required to complete the questionnaire. The national minority organization representatives were asked to come prepared to discuss community problems, perceived patterns of allegations of discrimination, or both. In addition, the highest ranking elected minority official in the State Senate was invited to participate, but was not asked to come with a prepared agenda. The results of this examination are discussed and summarized in Chapter 7, "Equal Opportunity."

5

TECHNICAL EVALUATIONS

ARIZONA

GEOLOGY **SATISFACTORY**

All underground portions of the facility will lie above the regional water table; thus, water control measures will not be required during construction and operation. Multiple rock types underlying the site will necessitate changes in tunnel boring machine (TBM) type and support requirements. Granitic rocks of the mountainous areas are of high strength but also are known to contain zones of shearing and fracturing which may complicate tunneling operations. Up to 18 percent of the collider tunnel in the fanglomerate can be constructed by cut-and-cover techniques. The fanglomerate has good stand-up time but will require a complete liner for long-term support. Granitic rocks of the Booth Hills and the Maricopa Mountains will provide a firm, stable foundation for three experimental halls; three other experimental hall foundations on fanglomerate will require additional support measures (e.g., drilled piles, spread footings) to distribute the load. Depths to the collider tunnel* vary from shallow (40 to 150 feet) under much of the fanglomerate to over 1,000 feet under the North Maricopa Mountains (up to 810 feet for shaft E7); the experimental halls are all at moderate depth* (average, 140 feet). The site lies in an area of moderate seismic potential (UBC Seismic Zone 2). Geologic complexity of the Maricopa site and the limited extent of geologic studies in the area (initiated largely for this project) create the potential for major, unforeseen problems to arise during construction.

Geologic Suitability *Satisfactory*

Strengths: All surface and underground facilities are located substantially above the regional water table (average depth to water = 350 feet); water inflow into excavations will not be an issue during construction.

Most of the collider tunnel (80 percent) will lie under terrain that is generally flat, allowing relatively easy development of construction access routes.

* In this report, average depths to the tunnel centerline are calculated from assumed shaft depths; depths for the experimental halls are to the excavated invert, below the tunnel centerline.

Weaknesses: Three major rock groups (granites, layered volcanics, alluvial basin fill) with differing engineering properties are found around the ring requiring multiple tunneling techniques (hard rock and mixed rock TBM's); this will increase the complexity of construction activities. Mixed-face conditions are likely in the volcanics and at the contacts of granite and fanglomerate, affecting tunnel advance rates.

The bored portion of the tunnel in fanglomerate will need to be lined throughout for long-term support. Additional structural support will likely be required across faults and shear zones (unknown number) in the Maricopa Mountains, and across contacts of fanglomerate with bedrock.

Approximately 20 percent of the collider ring (11 miles) underlies terrain that is rugged and mountainous. Sites for six shafts in this more rugged terrain will require significant grading for access and construction (E2, E7, F2, F6, F7, and F10).

Experimental halls will be constructed using deep, large, open-cut excavations. Surface dimensions of the cuts vary from approximately 180 by 360 feet (K1) to 370 by 550 (K2) feet.

Operational Stability *Satisfactory*

Strengths: The site lies within UBC Seismic Zone 2 (moderate earthquake potential), with a predicted maximum ground acceleration of 0.04 g over a 50-year time period. Earthquake recurrence interval on the Sand Tank Fault (approximately 10 miles west of the ring) is estimated at 30,000 years.

Weaknesses: Fanglomerate is a low-strength, partially cemented material (unconfined compressive strength = 300 to 1500 psi) with potential for differential settlement under the heavy loads (9 tons per square foot) that will be experienced in the experimental halls (K3, K4, and K5). Foundation supports (spread footings, drilled piles) will be required to distribute the load.

Operational Efficiency *Good*

Strengths: As much as 9.5 miles (18 percent) of the collider ring at a depth of less than 80 feet can be excavated by cut-and-cover techniques, thus simplifying that portion of construction (the actual amount of cut-and-cover tunnel installation will depend on the approach taken to cross a railroad line, a road, and two historic trails). The depth to the base of the experimental halls ranges from 120 to 170 feet, averaging 140 feet.

Weaknesses: Seven shafts are 300 feet or more in depth (E2, 300 feet; E3, 335 feet; E7, 810 feet; F3, 340 feet; F4, 380 feet; F7, 460 feet; and F8, 480 feet). Tunnel overburden under the North Maricopa Mountains (13 percent of the ring) frequently exceeds 1,000 feet.

Construction Risk *Satisfactory*

Strengths: The construction risk is relatively low for the portion of the tunnel (up to 18 percent) that is installed by cut-and-cover operations.

Weaknesses: The proposed site is in an area of complex geology with incomplete understanding of structures, contact relationships, and depth to bedrock. Reconnaissance scale mapping of the Maricopa Mountains was initiated only as part of the Arizona SSC proposal effort. The current site database includes only eight core holes, nine auger holes, two rotary holes, and short refraction seismic sections around the ring. An extensive site characterization program would be required prior to final design.

REGIONAL RESOURCES **SATISFACTORY**

With the site located in a remote desert area, there are essentially no housing supplies within a 45-minute commute of the site. However, there are ample and rapidly expanding supplies of housing and other community resources beyond a 50-minute commute, primarily in the southern Phoenix metropolitan area. Housing prices are somewhat above the national average. Primary and secondary school systems and job opportunities for family members are excellent. Air accessibility is good. There are few roads to the site from probable SSC employee residential communities or the major metropolitan area. Upgrading site vicinity roads to all-weather standards is planned to be completed by the end of 1990. Construction of a viable route to the western Phoenix metropolitan area, and upgrading the two-lane access roads to four lanes, is expected to be completed in 1996. The State will provide an on-site rail siding. The high-technology skilled labor force is minimal; the regional industrial base, trade labor force, and construction base are limited; all of the above are distant (timewise) from the site. There is very limited opposition. The institutional program is weak, and the involvement of state and local agencies in proposal-related activities has been minimal.

Community Resources *Good*

Strengths: Excellent public schools; excellent employment opportunities for spouses near attractive residential areas; and good recreational opportunities.

Weaknesses: Extremely limited housing stock within a 45-minute commute; however, an adequate supply of attractive residential communities is found after about a 50-minute drive. Limited number of research institutions in the proximity of the site.

Accessibility *Satisfactory*

Strengths: Air accessibility is considered to be good, based upon the driving time between the site and Sky Harbor International Airport and the air service between Sky Harbor and other airports which would serve the university-based, experimental, high energy physicists in the United States.

An on-site rail siding will be provided.

Weaknesses: Access by road to the site from attractive residential communities will be limited to essentially one route (from the northeast) until the mid-1990's.

Near- to mid-term access by road will require a 50-minute or more commute on two-lane, paved roads—large portions of which will not meet all-weather standards until the end of 1990 or later. Road construction upgrades will probably impede traffic flow.

Waterborne and public transportation systems are very limited.

Industrial Base *Satisfactory*

Strengths: No noteworthy strengths.

Weaknesses: All resources are somewhat distant (timewise) from the site. The high-technology, skilled labor force is minimal, although growing in the electronics, semiconductors, and scientific laboratories.

The regional construction labor force and base, including materials, supplies, and operating equipment, are limited.

The high-technology industrial base is limited, although dynamic and growing.

Institutional Support *Satisfactory*

Strengths: Overall support for the SSC extends from the Governor and the legislature through to the local governments and citizens. Very limited individual opposition and no organized opposition is present.

A permits coordination role has been established through the State Department of Commerce. A number of facilities have been permitted recently by the State in the Maricopa area, such as a hazardous waste site and a large urban landfill, which provides confidence in the capabilities of the Arizona and Maricopa County permitting organizations.

Weaknesses: Until Congress decides the status of the Wilderness Study Area, the issue could provide a focus for organizing project opposition.

The institutional program is very limited, consisting primarily of a speakers bureau. No plans have been developed to support DOE in the institutional area if the Arizona SSC site is selected.

While the Arizona Department of Commerce will serve as coordinator for the SSC permits, no detailed mechanism for the permitting process has been established, such as a regulatory compliance plan. Very limited coordination has occurred between the state and local governments.

ENVIRONMENT **GOOD**

The site area contains no wetlands, farmland, or developed mineral resources. Impacts to water quality would be low. Although the number of relocations required is very small, there is a moderate potential for community disturbance impacts to the small communities near the site. The potential for the development of a groundwater overdraft is moderate to high. The proposed cut-and-cover excavation has the potential to exacerbate fugitive dust problems. Portions of the site are relatively undisturbed desert, parts of which may be considered sensitive habitat. There also is a high potential for impacts on cultural resources. Scenic/visual impacts of the project would be high.

Environmental Impact *Good*

Strengths: All surface and underground facilities would be substantially above the regional groundwater table; there is little or no potential for ground or surface water contamination. There are no wetlands, farmlands, or geologic resources near the site. Land acquisition would require only six relocations.

Weaknesses: While groundwater resources are largely undeveloped, some overdraft potential is apparent due to the limited resource. Projected elevated levels of fugitive dust and carbon monoxide are air quality concerns. There is a high potential for impacts to cultural resources which may be in the area. For example, the Butterfield Stage Route and a proposed historic trail are both considered historical resources and would be impacted by the crossing of site access roads and by the visual impact of the project on scenic views. The North Maricopa mountain area is considered a sensitive habitat because of its flora and fauna and relatively undisturbed character.

Compliance with Requirements *Good*

Strengths: The project at the proposed site is capable of meeting the requirements of applicable environmental regulatory programs.

Weaknesses: No noteworthy weaknesses.

Ability to Mitigate *Good*

Strengths: The potential for mitigating impacts regarding floodplains, noise, cultural, and scenic resources is moderate.

Weaknesses: No noteworthy weaknesses.

SETTING **GOOD**

The proposed site would require only six relocations. In addition, a majority of the property is already owned by the Federal Government, which minimizes the amount of property which must be purchased from private owners. However, the plan for acquisition of the real property has not been well developed. Arizona will utilize a private contractor, managed by the Arizona Department of Transportation, for real estate acquisition. The proposed site has several natural features (i.e., Maricopa Mountains and the Booth Hills) and one man-made feature (the town of Mobile) which could impact the designers' flexibility in shifts of the entire ring. However, the SSC designers will have very good flexibility for minor adjustments to most surface facilities. In addition, a portion of the site is currently designated as a Wilderness Study Area. While the Bureau of Land Management does not support a wilderness designation, that decision has not been made by the U.S. Congress. If designated a Wilderness Area, some impacts on construction, operations, and future expansion would occur.

Real Estate *Good*

Strengths: There are a relatively small number of parcels to acquire and there are only six relocations. The majority of the property is already Federally owned.

Weaknesses: A Wilderness Study Area, which is a portion of the BLM lands, creates the potential for delays in transfer from BLM. Plans for acquisition are not as well developed as would be desirable now, nor is the staffing as well defined as would be desirable. The degree of coordination within the State and between the State and BLM could be improved.

Flexibility *Good*

Strengths: Additional land is available, and most fee simple areas can be adjusted during final design.

Weaknesses: Potential for movement of the entire ring is limited by natural features.

Natural and Man-made Features *Good*

Strengths: The site has very few man-made features that could impact construction or operation.

Weaknesses: The Maricopa Mountains impact future access roads to service areas while the Butterfield Stage Route could impact the DOE's ability to construct or operate utilities and roads crossing the route.

REGIONAL CONDITIONS **SATISFACTORY**

There are railroad crossings of the ring within 0.5 mile of two interaction points. Projections from mathematical modeling and field vibration measurements indicate that the SSC tolerances would be met by a relatively small margin (a factor of only 2 to 4). No loss of construction or operating time would be expected due to climate; however, the high temperatures would require additional cooling capacity for the cryogenic system. Flood control would be required for potential flash floods.

Vibrations and Noise *Satisfactory*

Strengths: The only major highway crosses the ring 2 miles from the closest interaction point.

Weaknesses: A mainline railroad crosses the ring within 0.5 mile of two interaction regions. The ring is only 45 feet below the railroad at one crossing. Model projections show the vibration level is lower than the required value but only by a factor of 2 to 4; additionally, increasing the margin of safety may prove difficult.

Climate *Good*

Strengths. No loss of construction or operating time is expected due to climate.

Weaknesses: There is evidence of flash flooding, which would require flood control.

The high temperatures at the site will require additional cooling capacity for the cryogenic system.

UTILITIES **GOOD**

Ample electrical power with good stability and reliability is currently available or planned to be available at the site. An ample supply of water meeting or exceeding the standards of the *Invitation* is expected. Fuel (natural gas) is readily available. Sewage disposal and waste disposal facilities will be provided.

Electricity *Good*

Strengths: Dual service is provided.

Weaknesses: There is some exposure to outages on the 230-KV Gila Bend/Liberty line serving the SSC.

Some of the dual service would be provided by double circuits on towers.

Water *Satisfactory*

Strengths: No noteworthy strengths.

Weaknesses: Extending a water line through the tunnel from the campus presents construction and scheduling problems. The DOE will be responsible for obtaining the water source.

Other Utilities *Good*

No noteworthy strengths or weaknesses.

COLORADO

GEOLOGY **GOOD**

The host rock for the collider at the Colorado site is a thick, homogeneous sequence of claystone (the Pierre Shale) which has low abrasive character and can be easily tunneled. Earthquake potential in the region of the site is low (UBC Seismic Zone 1) and major structures (faults) are lacking. Water inflow during construction is not expected because of the very low permeability of the claystone; however, the tunnel will need to be lined completely to prevent slaking (drying out and crumbling of the claystone). The average shaft depth of 125 feet and the average experimental hall depth of 105 feet are considered desirable. The elastic nature of the claystone may necessitate additional support measures to distribute loads for experimental hall foundations (e.g., drilled piles and spread footings). The uniform, predictable nature of the geology underlying the site makes it unlikely that major problems will develop during construction.

Geologic Suitability *Good*

Strengths: The tunnel will lie entirely within a thick sequence of homogeneous, largely structureless claystone (the Pierre Shale). The claystone is easily tunneled and has low abrasive qualities.

Water inflow into the tunnel is expected to be negligible; the claystone is essentially impermeable (K* = 10^{-7} to 10^{-10} cm/sec).

Access to construction sites is good and is unhampered by topography.

Weaknesses: The tunnel will require immediate installation of a liner to prevent slaking of the claystone.

Operational Stability *Satisfactory*

Strengths: The proposed site lies within UBC Seismic Zone 1 (low earthquake potential), with a predicted maximum ground acceleration of 0.04 g over a 50-year time period.

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* K is a measure of permeability or transmissivity of water through a rock. Highly transmissive rocks have K values between 10^{-1} to 10^{-2} cm/sec. Impermeable rocks have K values smaller than 10^{-6} cm/sec.

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Weaknesses: The elastic character of the claystone creates the potential for rebound and settlement upon unloading and reloading. Foundations of experimental halls may require additional measures to redistribute loads so as to minimize unacceptable movements (e.g., drilled piles, spread footings, pretensioning).

Operational Efficiency *Outstanding*

Strengths: The average tunnel depth is 125 feet, and shafts vary in depth from 70 to 200 feet. The depth to the experimental halls ranges from 75 to 130 feet, averaging 105 feet.

Weaknesses: No noteworthy weaknesses.

Construction Risk *Outstanding*

Strengths: The site geology, consisting of one homogeneous bedrock unit (Pierre Shale), is highly uniform and laterally predictable; there are no known structural discontinuities. The unconsolidated overburden (loess, sand, and alluvium) is well characterized. There is considerable regional experience in building tunnels in the Pierre Shale (and its equivalents).

Weaknesses: No noteworthy weaknesses.

REGIONAL RESOURCES **SATISFACTORY**

With the exception of the small towns of Fort Morgan and Brush, the location of the most probable (and adequate supply of) residential communities is in the Denver suburbs and the other Front Range cities north of Denver. It will be at least a 70-minute drive to those areas. Housing prices have been significantly above the national average, but have been declining sharply in the last few years. Primary and secondary school systems are generally of good quality, and employment opportunities for family members are satisfactory. Air accessibility is good. Road access to the site is limited because of the distance plus the fact that access roads to the site will have to be improved or constructed during the next several years and will overlap significantly with site construction activities. Access to other employment centers by spouses will probably be affected by traffic congestion in the metropolitan area. The State will provide an on-site rail siding. While the Denver area has an excellent, highly diversified, mature, high-technology industry base, skilled labor pool, construction base, and trade labor pool, they are remote from the site vicinity. There is very limited opposition. A well organized institutional program is in place and is being effectively implemented.

Community Resources *Satisfactory*

Strengths: Recreational/cultural opportunities are excellent, and public school systems are good. Availability of other research institutions in the area is good.

Weaknesses: While Fort Morgan and Brush are nearby, an adequate supply of attractive residential communities is a 75-minute or more drive. Depending on the residential community chosen, access to major employment centers also may require a longer-than-average commute for family members.

Accessibility *Satisfactory*

Strengths: Air accessibility is considered to be good, based upon the driving time between the site and Stapleton International Airport or the new "Worldport" and the air service between them and other airports which would serve the university-based, experimental, high energy physicists in the United States.

An on-site rail siding will be provided.

Weaknesses: Access by road from probable residential communities, other than Fort Morgan and Brush, probably will require a 75-minute or more commute, large portions of which will be on paved, two-lane roads that will need to be improved or constructed during the next several years.

Waterborne transportation is essentially non-existent, and there is very limited public transportation outside the immediate Denver area.

Industrial Base *Good*

Strengths: The Denver area has an excellent, mature (but distant) high-technology base, including cryogenics, and skilled labor pool, with numerous, well-established distributors in electronics, computers, and other high-technology items in addition to the normal materials and supplies required to support the operation of the SSC.

The Denver area has a good (but distant) construction base including materials, supplies, and operating equipment.

Weaknesses: The construction workforce is remote from the site, as are the industrial and construction bases and the high-technology skilled labor pool.

Institutional Support *Outstanding*

Strengths: Overall support for the SSC extends from the Governor and the legislature to the local governments and to the citizens. There is very limited individual opposition. Local environmental groups have been contacted by the State and are not expected to oppose the SSC.

State agencies and consultants have been involved in preparing and implementing a well organized and active institutional program. A public relations firm was hired, and public opinion surveys were conducted and verified by the use of focus groups. Results were used to initiate new efforts including tours of high energy physics laboratories for local citizens, media, and landowners.

The Department of Local Affairs has direct responsibility for coordinating the efforts of the SSC. A Permits Management Team has been established and a permitting plan developed in concert with the responsible State agencies. Recent State experience exists for permitting facilities.

Weaknesses: No noteworthy weaknesses.

ENVIRONMENT **OUTSTANDING**

Anticipated impacts on surface water or groundwater quality would be minimal. The potential impacts to air quality, cultural resources, and scenic/visual quality are all low. There are only moderate impacts anticipated to floodplains, wetlands, sensitive habitats, and farmland. Impacts regarding relocations and noise generation would be low.

Environmental Impact *Outstanding*

Strengths: There is low potential for water quality impacts to surface or groundwaters; the tunnel would be in low permeability shale reducing the potential for groundwater contamination and low rainfall would reduce any potential for surface water contamination.

Land acquisition would necessitate only 23 relocations. Due to the rolling character of the topography, there is a low potential for scenic/visual impacts at the site. No significant noise impacts have been identified.

The site area is in compliance with air quality standards.

Weaknesses: There is a potential for a "boomtown" type of community disturbance.

There are uncertainties regarding groundwater quantities and general water availability.

Compliance with Requirements *Good*

Strengths: The project at the proposed site is capable of meeting the requirements of applicable environmental regulatory programs.

Weaknesses: No noteworthy weaknesses.

Ability to Mitigate *Good*

Strengths: The potential for mitigating impacts concerning floodplains, wetlands, and mineral and oil/gas resources is moderate.

Weaknesses: No noteworthy weaknesses.

SETTING **GOOD**

The Colorado proposed site has only 67 ownerships, 157 parcels, and 23 relocations. The State will acquire 52,520 acres which provide flexibility and future expansion potential. The real estate acquisition plan has not been thoroughly developed, and no relocation plan has been proposed. The State team did not include experienced real estate acquisition personnel, and they did not plan to utilize a state agency with acquisition experience. Instead, the State planned to hire a contractor with the requisite experience to support their efforts. Since the site is relatively flat and rural in nature with no man-made or natural features that have a significant impact on the collider placement, there is excellent flexibility left to the SSC designers for final ring positioning.

Real Estate *Satisfactory*

Strengths: There are a relatively small number of parcels to acquire and few relocations.

Weaknesses: Staffing for acquisition is undefined; there is inattention to details of acquisition requirements; no relocation plan has been developed; and there are no experienced real estate experts on the State team.

Flexibility *Outstanding*

Strengths: The site has outstanding flexibility. Surface areas can be shifted with almost no limitations. Shifts of the entire ring are possible with virtually no impediments. The State's acquisition of extra land provides ample additional land for shifting.

Weaknesses: No noteworthy weaknesses.

Natural and Man-made Features *Outstanding*

Strengths: The site is in an undeveloped, rural setting with limited man-made and natural features which have little impact on the location of the proposed collider ring or facility operation.

Weaknesses: No noteworthy weaknesses.

REGIONAL CONDITIONS **OUTSTANDING**

All vibration sources are at least an order of magnitude below the SSC vibration tolerances. No major highways cross the ring. Winter weather is relatively moderate and should cause only minor construction or operating down time.

Vibrations and Noise *Outstanding*

Strengths: The closest railroad is 10 miles from the ring. Few oil and gas wells are nearby, and they will produce a very low vibration level at the ring. A manufacturer of metal products by explosive fabrication, located 19 miles south of the ring, will not produce significant vibrations. No heavily travelled highways cross the ring.

Weaknesses: No noteworthy weaknesses.

Climate *Good*

Strengths: Winter weather is relatively moderate and should cause only minor construction or operating down time.

Weaknesses: No noteworthy weaknesses.

UTILITIES **GOOD**

Ample electrical power with good stability and reliability is currently available or planned to be available at the site. An ample supply of water meeting or exceeding the standards of the *Invitation* is expected. Fuel (natural gas) is readily available. Sewage disposal and waste disposal facilities will be provided.

Electricity *Good*

Strengths: The electric power system that would serve the site has a completely redundant dual service.

Weaknesses: Although it is planned to build extensive new power lines in the area which would provide excellent service to the SSC, the existing schedule brings such service too late for the start of SSC operation.

Water *Satisfactory*

Strengths: Sources to provide adequate and reliable supply of water to the SSC site are readily available in the area.

Weaknesses: Morgan County Quality Water District must complete a series of permitting and legal actions to provide water. Extensive new lines must be constructed for water. Extending the water line through the tunnel presents some construction and scheduling problems.

Other Utilities *Good*

No noteworthy strengths or weaknesses.

ILLINOIS

GEOLOGY — OUTSTANDING

The tunnel at the Illinois site lies entirely within a thick, uniform sequence of high-strength dolomite (430 foot average shaft depth). Because of the quality and low permeability of the rock, the tunnel can be left unlined, with only occasional rock bolting for support. Shafts which will penetrate water-bearing glacial sediments will need systematic ground support and water control prior to excavation. All experimental halls will be constructed as underground caverns (average depth, 475 feet). No major structures (faults) have been identified, and the site lies in an area of low earthquake potential (UBC Seismic Zone 1). Additionally, the dolomite will provide an excellent foundation for the experimental halls. The risk of encountering major problems during construction is considered minimal because of the uniform, predictable nature of the dolomite, the large database for the site, and the extensive experience locally in shaft sinking and tunneling.

Geologic Suitability — *Outstanding*

Strengths: The tunnel is entirely within high-strength, low abrasive dolomite of the Galena-Platteville Group. Rock properties are homogeneous and highly predictable. Long-term structural support of the tunnel is unnecessary.

There are no major faults or fracture zones crossing the ring alignment; throughgoing joints in the dolomite are widely spaced (approximately 100 feet) and are hydrologically tight.

Water inflows are expected to be minor and localized along more transmissive joints. The dolomite has low permeability (Average $K = 10^{-6}$ cm/sec).

Weaknesses: Shafts through glacial drift will require systematic support for ground and water control (up to 22 percent of total length of shafts); injector tunnels will require structural and waterproof liners through the glacial section.

Operational Stability — *Outstanding*

Strengths: The dolomite at the level of the experimental halls is a high-strength material (unconfined compressive strength = 10,000 to 12,000 psi) that will provide a stable foundation for detectors.

The proposed site is within UBC Seismic Zone 1 (low earthquake potential), with a predicted maximum ground acceleration of 0.04 g over the next 50 years.

Weaknesses: No noteworthy weaknesses.

Operational Efficiency *Poor*

Strengths. No noteworthy strengths.

Weaknesses: The tunnel will be at an average depth of about 430 feet. Caverns for experimental halls will be excavated completely underground at an average depth to the invert of 475 feet.

Construction Risk *Outstanding*

Strengths: The bedrock geology is simple and well understood, based on years of regional geologic studies, investigations for Fermilab, and more recent SSC-specific work. To an already extensive regional database, Illinois has added 30 site-specific coreholes and three rotary holes. The nature and distribution of glacial materials above the proposed site have been thoroughly studied and described. Regional experience with constructing deep tunnels in dolomite is extensive because of the Chicago Tunnel and Reservoir Project (TARP).

As provided in its proposal (Vol. 1, pg. 1.4; Vol. 3, pg. 3.60), the State of Illinois has offered to excavate the SSC tunnel and access shafts as part of its site infrastructure improvement program. Thus, the risk to the DOE for construction of these portions of the underground facility will be reduced, although DOE control of the schedule would be somewhat lessened. (No credit for the cost of the tunnel was given in the life-cycle cost.)

Weaknesses: No noteworthy weaknesses.

REGIONAL RESOURCES **OUTSTANDING**

The campus is surrounded by densely populated suburban areas. There is an abundant supply (and an excellent variety) of community resources in essentially any direction and, for the most part, within a relatively easy commute. School systems and family employment opportunities are outstanding, but these advantages are somewhat offset by the high cost of housing and the cost of living in general. Air accessibility is excellent. The site is served by an extensive network of interstate, U.S., and state highways, tollways, and roads. Traffic congestion can be a problem. In addition to the existing Fermilab rail siding in the campus area, the state has offered to construct another siding south of the far cluster area. The site is adjacent to one of the largest, most impressive industrial bases in the Nation with consistently excellent skilled and trade labor pools. While the Governor, legislature, and local governments are very supportive, and an institutional program has been implemented, there also is strong, organized opposition by affected homeowners and others. The State's approach to problems raised by CATCH is reactive.

Community Resources *Outstanding*

Strengths: Abundant and easily accessible housing; excellent public schools; excellent employment opportunities for spouses; excellent access to research institutions; excellent cultural and recreational opportunities.

Weaknesses: Housing and cost-of-living averages are above the national averages. The supply of new development housing in most communities is somewhat limited.

Accessibility *Outstanding*

Strengths: Air accessibility is considered to be excellent, based upon the driving time between the site and O'Hare International Airport and the air service between O'Hare and other airports which would serve the university-based, experimental, high energy physicists in the United States.

The site is served by an extensive network of roads, highways, tollways, and interstate highways in the site vicinity and the metropolitan area in general. Roads and highways essentially are in place now, with further improvements under way and planned.

Excellent rail accessibility will be available with one on-campus siding in place and a siding south of the far cluster area offered by the proposer.

Waterborne and public transportation systems are excellent.

Weaknesses: Some traffic congestion.

Industrial Base *Outstanding*

Strengths: There is an excellent, exceptionally mature industrial base and high-technology labor pool with numerous, well-established distributors in electronics, computers, and other high-technology items in addition to the normal materials and supplies required to support the operation of the SSC. The presence of two DOE national laboratories and other high-technology research organizations in the area is unique to this site.

The trade labor force and construction base, including materials, supplies, and operating equipment, are excellent. The expertise resulting from the construction of TARP is extensive.

Weaknesses: No noteworthy weaknesses.

Institutional Support *Satisfactory*

Strengths: The Governor, legislature and local governments are very supportive. County governments have agreed to relinquish some authority under Senate Bill 914.

The State has had several public events and mailings, and a telephone hot line has been set up. The State has prepared an impressive number and variety of public information materials for public distribution.

The Illinois legislature has eliminated the requirement for local permitting. The State SSC Interagency Task Force has been assigned the responsibility to expedite the permitting process. The State has provided a detailed regulatory compliance plan, and recent permitting experience exists.

Weaknesses: There is strong, organized opposition, led by CATCH - ILLINOIS. Perceived potential loss in home values is a key element in the opposition. While lawsuits have been filed, no delays or injunctions have occurred as a result. In some cases, local government support has started to erode. The State has been ineffective in responding to issues raised by CATCH - ILLINOIS.

ENVIRONMENT **GOOD**

There would be minimal impacts on mineral or oil/gas resources. The project would impact relatively few acres of prime farmland. Anticipated wetland and air quality impacts would be only minor. Project water use would aggravate an existing regional overdraft condition. There is a high potential for socioeconomic impacts, increased noise levels, and general community disturbance.

Environmental Impact *Good*

Strengths: Mineral and oil/gas resource impacts would be low. Many other resource category impacts would be moderate.

Relatively few acres of prime farmland (0.01 percent of regional inventory) would be affected. Wetlands that would be impacted are mainly of relatively low functional value. Floodplain impacts would be moderate.

Weaknesses: The project would contribute to an existing regional groundwater overdraft condition. Numerous residences are within the "annoying noise level" contours around the service areas. There is a moderate potential for aggravating an existing ozone air pollution problem. There is a high potential for socioeconomic impact due to the required relocations and the placement of facilities in residential communities. Numerous prehistoric cultural resource properties have been identified.

Compliance with Requirements *Good*

Strengths: The project at the proposed site is capable of meeting the requirements of applicable environmental regulatory programs.

Weaknesses: No noteworthy weaknesses.

Ability to Mitigate *Good*

Strengths: Except for a shift (for engineering considerations) of a J area out of the floodway (considered also an environmental impact avoidance), the potential for mitigating impacts concerning water quality, noise, cultural, and scenic resources is moderate.

Weaknesses: No noteworthy weaknesses.

SETTING **POOR**

The proposal estimated 219 relocations, 3,305 parcels, and 2,750 ownerships. However, the total number of parcels to be acquired could be as high as 4,000 with the actual number of ownerships as high as 3,400. In addition, there is strong landowner opposition. These two facts combine to make the real estate acquisition complicated and demand a highly experienced acquisition staff to assure that the project schedule is met. The State proposes to use the Illinois Department of Energy and Natural Resources (ENR) to manage the land acquisition. ENR plans to hire a contractor, but since ENR has no experience in land acquisition, they must rely solely on that contractor to meet all requirements of law and schedule. Illinois utilized the existing accelerator facilities at Fermilab to serve as the proposed injector for the SSC. In doing so, the designers' ability to make minor shifts of the collider ring during final design is severely limited. In addition, the large amount of development in the immediate area of the proposed collider placement has reduced the designers' flexibility in moving a number of the fee simple areas. The major concerns being some of the Service Areas (F) and the External Beam Access Area (J). There are no natural features which impact the proposed location of the collider.

Real Estate *Poor*

Strengths: No noteworthy strengths.

Weaknesses: There are 3,300 to 4,000 parcels to acquire from 2,700 to 3,400 separate ownerships. Additionally, there are 219 relocations. Continuing development in the site area will increase the number of parcels, increase values, and will further complicate the acquisition problem. The managing agency (ENR) has no experience in real estate acquisition and, therefore, will be relying extensively on the contractor to meet all requirements of law and schedule. There is strong landowner opposition which could result in resistance to sale, legal proceedings to stop the acquisition, and potential for eviction as a necessary method to relocate those required to move.

Flexibility *Satisfactory*

Strengths: Proposed Areas A, B, and C are already under the ownership of the Federal Government (DOE).

Weaknesses: There is very limited flexibility due to the regional development of the area and the State proposal to use Fermilab as the SSC injector. Many of the surface use areas required shifting by the State in their proposal to avoid impacting existing man-made features.

Natural and Man-made Features *Poor*

Strengths: No noteworthy strengths.

Weaknesses: Extensive development could impact both the construction and operation, e.g., the need to regulate and control SSC traffic in the populated areas.

REGIONAL CONDITIONS **GOOD**

Three railroads and eight major highways cross the ring; field vibration studies indicate generated displacements greater than two orders of magnitude less than SSC vibration tolerances. Three rock quarries are located relatively close to the ring. Although mathematical modeling suggests that generated vibrations should be well below SSC tolerances, no field vibration measurements were made verifying displacements from quarry blasting.

Vibrations and Noise *Good*

Strengths: Three railroads cross the ring, but all at more than 3,000 feet from any interaction point. Eight major highways cross the ring; however, vibration levels at the ring from any of these roads or railroads are well under the allowable values.

Weaknesses: Rock quarries are relatively close to the ring (4,000 to 19,000 feet). Although calculations project vibrations to be well below tolerances, no measurements were made to verify displacements from quarry blasting.

Climate *Good*

Strengths: Significant construction and operations down time is not anticipated.

Weaknesses: The winter climate is a factor. The site has an average annual snowfall of 30.3 inches, which includes an average of two snowfalls of 6 inches or more. Minor weather related construction or operating down time would be expected.

UTILITIES **GOOD**

Ample electrical power with good stability and reliability is currently available or planned to be available at the site. An ample supply of water meeting or exceeding the standards of the *Invitation* is expected. Fuel (natural gas) is readily available. Sewage disposal and waste disposal facilities will be provided.

Electricity *Good*

Strengths: A strong electrical power generation and transmission system is available.

Weaknesses: No noteworthy weaknesses.

Water *Good*

Strengths: Short connections to existing water services can be made.

Weaknesses: Although water for some areas is readily available through wells, potential for local overdraft exists.

Other Utilities *Good*

No noteworthy strengths or weaknesses.

MICHIGAN

GEOLOGY **SATISFACTORY**

The rock underlying the proposed Michigan site varies in composition both vertically and laterally, being a complex sequence of low strength sandstone, shale, and limestone. A continuous, waterproof liner will be required in the collider tunnel for both structural support and water control. Additionally, all shafts and the large open-pit excavations for the experimental halls will need systematic ground support and water control prior to excavation. Average shaft depth is 140 feet; average depth to the base of the experimental halls is 195 feet. Major structures (faults) have not been identified in the site vicinity, and the site lies in an area of low earthquake potential (UBC Seismic Zone 1). Sandstone layers at the site should provide an acceptable foundation material for the experimental halls. However, the presence of significant thicknesses of shale or coal may require additional support measures to distribute loads (e.g., piles or spread footings). The risk of encountering major problems during construction at this site is reasonably high because of the heterogeneity of the host rock, the need for extensive water control, and the relatively sparse database that currently exists.

Geologic Suitability *Satisfactory*

Strengths: Bedrock strata at the proposed site are free of major structural discontinuities (e.g., faults and shear zones). Joint sets are widely spaced (tens of feet).

The topography is rolling to flat with low hills; there is generally good access to surface facility locations.

Weaknesses: The rock at tunnel depth is variable both in composition and engineering properties. The predominant rock types (sandstone, limestone, and shale) occur in layers of varying thickness, vertical distribution, and lateral extent. Minor coal seams are also found.

Systematic ground support and water control (e.g., dewatering, caissons, slurry walls) will be required prior to excavation of shafts. All shafts will penetrate up to 110 feet of unconsolidated and variably water-bearing glacial material.

There will be a requirement for a continuous, impermeable tunnel liner for both structural support and water control. The Saginaw Formation, through which 75 percent of the tunnel passes, yields variable amounts of water ($K = 10^{-2}$ to 10^{-6} cm/sec) through both primary and secondary porosity.

The deep open cuts for the experimental halls will require significant ground support and water control prior to excavation. Experimental halls have surface excavation dimensions ranging from approximately 210 by 250 feet to 210 by 350 feet.

Operational Stability *Good*

Strengths: The proposed site lies within UBC Seismic Zone 1 (low earthquake potential) with a predicted maximum ground acceleration of 0.04 g over the next 50 years.

Weaknesses: The low-strength sandstone of the Saginaw Formation should provide a sufficient foundation for the heavy detectors in the experimental halls; however, it may be necessary to provide additional support (piles or spread footings) if significant volumes of shale or coal are encountered at the base of the excavations.

Operational Efficiency *Good*

Strengths: Shafts range in depth from 75 to 185 feet, averaging 140 feet. Experimental halls range from 160 to 235 feet deep (to the invert), averaging 195 feet.

Weaknesses: No noteworthy weaknesses.

Construction Risk *Satisfactory*

Strengths: No noteworthy strengths.

Weaknesses: Although the geology of the proposed site is not complex structurally, the rock sequence is very heterogeneous and poorly predictable. Lateral changes in composition have not been well defined. The distribution of glacial materials has been mapped only on a regional scale. Site data includes 28 coreholes, of which only 15 extend to tunnel depth and four penetrate to 600 feet. A significant site characterization program will be required prior to final design.

REGIONAL RESOURCES **OUTSTANDING**

While situated in a rural area, the Michigan site is located in a triangle bounded by the three small metropolitan areas of Ann Arbor, Lansing-East Lansing, and Jackson which are accessible within a 30-minute (Jackson) to a 45-minute (Lansing-East Lansing and Ann Arbor) commute. There is a wide range in average housing prices among the three areas, from below the national average in Jackson, at about the national average in Lansing-East Lansing, and to well above average in Ann Arbor. There are two major research universities in the immediate area. Local school systems tend to be excellent, and job opportunities for family members are good. Air accessibility is good. The site has a good network of interstate, U.S., and state highways and roads, but immediate access to the campus will be somewhat limited by a 15 to 19 mile length of two-lane roads. No on-site rail siding was offered. Being close to the Detroit metropolitan area, there is an excellent high-technology, skilled labor pool and a good, mature industrial base with ready access to suppliers. The trade labor pool and construction base are good. Due in part to excellent planning and outreach activities, there is excellent overall support and the only opposition is from a few individuals.

Community Resources *Outstanding*

Strengths: Abundant, reasonably accessible, housing supply in all directions from the site; above average mix of urban, suburban and rural settings; excellent public schools; very good employment opportunities for spouses; excellent access to research institutions; excellent cultural and recreational opportunities.

Weaknesses: Cost of living above the national average; somewhat limited supply of new development housing in most communities.

Accessibility *Good*

Strengths: Air accessibility is considered to be good, based upon the driving time between the site and Detroit Metropolitan Wayne County Airport and the air service between Detroit Metro and other airports which would serve the university-based, experimental, high energy physicists in the United States.

Waterborne transportation is readily accessible.

Weaknesses: Direct access to the campus from interstate highways and probable residential communities will require 15 to 19 miles of travel on two-lane roads. Highways in the site vicinity need major repairs during the next several years.

A rail siding will be provided inside the northwest quadrant of the ring (east of area E6) near Eden, but not on-site or near the campus area.

Local public transportation services in the area are limited.

Industrial Base *Outstanding*

Strengths: The site area is near an excellent high-technology labor pool and a good, mature industrial base with numerous, well-established distributors in electronics, computers, and other high-technology items including close-tolerance machine shop capability, in addition to the normal materials and supplies required to support the operation of the SSC.

There is a good nearby trade labor pool and construction base, including materials, supplies, and operating equipment.

Weaknesses: No noteworthy weaknesses.

Institutional Support *Outstanding*

Strengths: Overall support for the SSC extends from the Governor and the legislature through to the local governments and local citizens. Public opinion polls show that only 11 percent of the local population oppose the SSC. Very limited individual opposition and no organized opposition exists. Local environmental groups have been contacted by the State and are not expected to oppose the SSC.

An active institutional program was planned and successfully implemented by the University of Michigan. A local Citizens Advisory Council was established, polls conducted, and a tour of Fermilab included for local citizens.

A Michigan Business Ombudsman has been assigned responsibility for facilitating permits. State legislation has been passed that provides the mechanism and authority for implementing the State proposal. County involvement in permitting will be handled through the Ombudsman. The State has recent permitting experience with large industrial facilities.

Weaknesses: A regulatory compliance plan does not exist. Both State and local permitting will be required.

ENVIRONMENT **GOOD**

There should be minimal visual/scenic impacts from the project. Anticipated impacts on air quality, community disturbance and cultural resource impacts would be moderate. Water requirements would worsen a currently local groundwater overdraft situation. There also is a potential for impacts to water quality, wetlands, and floodplains. Impacts on prime farmlands are also at issue.

Environmental Impact *Good*

Strengths: Visual and scenic impacts of the project would be low. Project impacts to sensitive habitats also should be low. No economic mineral resources would be affected. Impacts on other resource categories would be moderate.

Weaknesses: Water use for the project would contribute to an existing local groundwater overdraft condition. The tunnel would be constructed through one of the major developed aquifers in the region, increasing the potential of groundwater contamination. There also is a potential of impacts to the abundant wetlands and surface waters in the area. A relatively high percentage of the prime farmland inventory (1 percent) may be impacted. There is a moderate potential for aggravating an existing ozone air pollution problem. Land acquisition would require 215 residential displacements.

Compliance with Requirements *Good*

Strengths: The project at the proposed site is capable of meeting the requirements of applicable environmental regulatory programs.

Weaknesses: No noteworthy weaknesses.

Ability to Mitigate *Good*

Strengths: The potential for mitigating impacts concerning water quality, noise, wetlands, mineral and oil/gas, and cultural resources is moderate.

Weaknesses: No noteworthy weaknesses.

SETTING **SATISFACTORY**

The site contains over 800 private parcels, which the State proposes to have acquired by a private contractor. This large number creates the potential for schedule problems. The rural nature of the site is favorable for flexibility; however, this is somewhat offset by wetlands, nearby communities, and a golf course infringing on the H area.

Real Estate *Satisfactory*

Strengths: The schedule prepared is complete and demonstrates an understanding of the scope of the real estate activities.

Weaknesses: There are a large number of parcels and relocations. Acquisition will be by a contractor with limited experience in Federal acquisition requirements.

Flexibility *Satisfactory*

Strengths: Many of the fee simple areas provide local flexibility in all directions.

Weaknesses: Limited large-scale flexibility due to numerous constraints caused by man-made and natural features.

Natural and Man-made Features *Satisfactory*

Strengths: The site is generally rural in setting.

Weaknesses: A golf course impacts on a small portion of Area H, and wetlands impact on several other fee simple areas.

REGIONAL CONDITIONS **OUTSTANDING**

Both highways and railroads site are far enough from the interaction points that any vibrations will be insignificant. There are no nearby quarries.

Vibrations and Noise *Outstanding*

Strengths: The only major highway is more than a mile from an interaction point. One railroad crosses the ring 2.5 miles from the nearest interaction point.

Weaknesses: No noteworthy weaknesses.

Climate *Good*

Strengths: Significant construction and operations down time is not anticipated.

Weaknesses: The winter climate is a factor. Mean annual snow fall is approximately 44 inches, which includes an average of one snowfall a year of 10 to 18 inches. While no significant down time is anticipated, some minor lost time on construction or operations is expected.

UTILITIES **GOOD**

Ample electrical power with good stability and reliability is currently available or planned to be available at the site. An ample supply of water meeting or exceeding the standards of the *Invitation* is expected. Fuel (natural gas) is readily available. Sewage disposal and waste disposal facilities will be provided.

Electricity *Good*

Strengths: A strong transmission service to the site is available.

Weaknesses: No noteworthy weaknesses.

Water *Good*

Strengths: Sources to provide an adequate and reliable supply of water to the SSC site are readily available in the area.

Weaknesses: Although water for service areas is readily available though wells, a limited, localized overdraft of groundwater exists.

Other Utilities *Good*

No noteworthy strengths or weaknesses.

NORTH CAROLINA

GEOLOGY **GOOD**

The Carolina Slate Belt, through which the collider tunnel at the site will pass, comprises a structurally complex series of metamorphosed volcanic, sedimentary, and granite rocks. Because of similar strength and engineering characteristics, these rocks can be considered a single construction unit for TBM design and support requirements. Most of the tunnel (average depth, 170 feet) can be left unlined, with minimal support; however, localized zones of fractures will likely be encountered which will require structural support and treatment for water inflows. The extensive depth of weathering in the site vicinity may require that some experimental halls (average depth, 215 feet) be constructed by deep open-pit excavations rather than as underground caverns. The site lies in a region of low to moderate earthquake potential (on the boundary of UBC Seismic Zones 1 and 2). The high strength of the unweathered bedrock will provide an excellent foundation for the experimental halls; however, it will be necessary to assure that excavations are sited to avoid fracture zones. The complex nature of the geology at this site, the poor predictability of fracture zones, and the variable depth of weathering create the potential for encountering problems during construction.

Geologic Suitability *Good*

Strengths: The seven rock formations found at tunnel depth, composed of metavolcanic and granitic rocks, have similar geoengineering properties and can be considered a single construction unit. Unconfined compressive strengths range from 5,000 to 15,000 psi, with lower strength correlating with more deeply weathered rock. Most of the tunnel can be left unlined.

The topography of the site is characterized by low rolling hills of the Piedmont Province. Access to construction sites is generally good.

Weaknesses: Fracture zones have been noted to occur near the contacts of granitic rock masses and surrounding units, and sporadically within individual granitic bodies. Overall rock quality around the collider ring varies widely from fair to excellent because of the common occurrence of fractures. Some fracture zones may require localized treatment for structural support and water inflow control.

A watertight lining will be required for all shafts where they penetrate highly transmissive zones within the weathered bedrock horizon ($K = 10^{-1}$ to 10^{-5} cm/sec).

Operational Stability *Good*

Strengths: The high strength of the unweathered bedrock underlying each of the experimental halls will provide stable foundation support.

The proposed site lies on the boundary of UBC Seismic Zones 1 and 2 (low to moderate earthquake potential), with a predicted maximum ground acceleration of 0.04 to 0.05 g over the next 50 years.

Weaknesses: No noteworthy weaknesses.

Operational Efficiency *Good*

Strengths: The tunnel shafts are 70 to 275 feet deep, averaging 170 feet. The depth to the base of the experimental halls ranges from 193 to 279 feet, averaging 215 feet.

Weaknesses: No noteworthy weaknesses.

Construction Risk *Satisfactory*

Strengths: No noteworthy strengths.

Weaknesses: The North Carolina site is in a complex geological setting. Rocks along the tunnel alignment have had a long history of structural deformation. There is poor predictability of fracture zones, both along the contacts of granitic and internally within the granite masses.

The weathering profile shown in the proposal was based on widely spaced measurements from boreholes and seismic profiles; more detailed work on rock mass strength at depth will have to be done prior to deciding on the construction method for the experimental halls. The site-specific database includes: 23 coreholes around the ring; four soil borings in the campus area; 18 regional water wells; and 30 seismic profiles. Detailed site investigations also will be necessary to assure that caverns for experimental halls avoid less stable fracture zones (especially near hall K2).

REGIONAL RESOURCES **GOOD**

While in a rural setting, the campus generally is within a 45-minute commute of most of the Raleigh-Durham metropolitan area, its principal employment centers, three major research universities, the Research Triangle Park, and the Raleigh-Durham Airport. Within the larger communities, average housing prices tend to range from the national average to somewhat above the national average. The public school systems are satisfactory, and a state-wide improvement program is under way. Air accessibility is good. The site area is served by interstate, U.S., and state highways, but good immediate access to the campus area will be limited for several years pending road improvements. Also, access from areas south and southeast of downtown Durham (e.g., Raleigh, Cary) may be impeded for several years until the construction of necessary connectors/interchanges is completed. The State did not propose an on-site railroad spur. The high-technology, skilled labor pool is good, but limited; the high-technology industrial base, the construction base, and the construction labor pool are also limited. The proposal was developed by the State with very little involvement from local governments or communities, which in part may have contributed to the development of strong, organized resistance, primarily by affected homeowners. The State's approach to institutional problems is reactive. Local institutional support may be eroding.

Community Resources *Outstanding*

Strengths: Very good housing availability and proximity; excellent variety of housing styles and mix of settings. Outstanding access to employment opportunities for family members as well as to research institutions. Excellent cost-of-living and medical services. Good recreational and cultural opportunities.

Weaknesses: While a major state-wide improvement program is under way, the quality of secondary school systems, as reflected by national test scores and other indicators, tends to be average.

Accessibility *Good*

Strengths: Air accessibility is considered to be good, based upon the driving time between the site and Raleigh-Durham Airport, and the air service between Raleigh-Durham and other airports which would serve the university-based, experimental, high energy physicists in the United States.

Weaknesses: Although the area is served by interstate, U.S., and state highways, immediate access roads in the campus area are somewhat limited, and proposed necessary improvements for these access roads and interstate highway interchanges in the Durham area have long-term completion schedules.

No on-site rail siding was proposed.

Waterborne transportation accessibility is very limited and the public transportation system is limited.

Industrial Base *Good*

Strengths: There is a good, but limited, high-technology skilled labor pool. The Research Triangle Park, except for computer technology, does not directly support the specific high-technology requirements of the SSC.

Weaknesses: The materials, supplies, and operating equipment resources for the high-technology industrial base and the construction base are limited (although expanding) as is the construction trade labor pool.

Institutional Support *Poor*

Strengths: Overall support for the program comes from the Governor, legislature, and local governments.

The State has conducted several public meetings. A State poll indicates that support for the SSC is two to one over those who oppose the SSC.

The Department of Commerce has been assigned responsibility for facilitating State permits. The SSC will not need to comply with the State NEPA process.

Weaknesses: Strong organized opposition has been established under the auspices of CATCH. Project support from some of the local officials does not appear to be strong and, in some cases, support may be eroding. Two local churches and associated cemeteries may have to relocate, and this has resulted in those two congregations opposing the SSC. The 111 to 180 relocations are a strong element of the opposition. One major local newspaper appears antagonistic towards the program.

The State's approach is primarily reactive to institutional problems. The local university system did not play an effective role in the institutional program. Only limited public information materials have been prepared.

The State did not prepare a regulatory compliance plan, and very limited information is available concerning details for compliance. The State resources allocated to support the program appeared to be the minimum. The State provided only basic information and demonstrated limited understanding of administrative support requirements.

ENVIRONMENT **GOOD**

The site is located in an air quality attainment area. There are no impacts anticipated to mineral or oil/gas resources. Visual impacts should also be low. The site transects large tracts of forested land, and there are biologically significant aquatic and upland habitats inside and adjacent to the ring. The site is also within the headwaters of three major streams and could potentially impact water quality. The project would also impact some high value wetlands. There is also a high potential for socioeconomic and cultural resource impacts.

Environmental Impact *Good*

Strengths: The proposed site is in compliance with air quality standards. No mineral resource impacts have been identified. Visual and scenic impacts of the project would be low.

Weaknesses: Some valuable wetland resources (bottomland hardwood wetlands) would be impacted. Fractured bedrock conditions increase the potential for groundwater contamination. There is a high potential for residential noise impacts and community disturbance. Numerous historic buildings have been identified. The potential for archaeological resources of concern needs to be investigated.

Compliance with Requirements *Good*

Strengths: The project at the proposed site is capable of meeting the requirements of applicable environmental regulatory programs.

Weaknesses: No noteworthy weaknesses.

Ability to Mitigate *Good*

Strengths: The potential for mitigating impacts concerning water quality, floodplains, noise, and cultural resources is moderate.

Weaknesses: No noteworthy weaknesses.

SETTING **SATISFACTORY**

The North Carolina proposed site will require acquisition of over 800 parcels and there is a proposed, available acquisition staff of only six personnel, which is an inadequate number. This is further exacerbated by organized opposition among the affected landowners. Flexibility is generally good, though somewhat limited in the campus-injector area. The only limiting man-made or natural feature is the Red Mountain subdivision which could affect operations in Area G. While flexibility and natural features are both considered good, these positive factors are offset by the problems in the real estate area, resulting in the Task Force's overall rating of satisfactory.

Real Estate *Poor*

Strengths: No noteworthy strengths.

Weaknesses: The schedule could be impacted by the Council of State review requirement. The proposed staffing, six personnel, is an inadequate number for an acquisition program of this magnitude (826 parcels; 111 to 180 relocations). The acquisition plan is poorly developed and there is no relocation plan. Local opposition by owners will increase the need for a large, well-trained staff in order to meet schedule commitments.

Flexibility *Good*

Strengths: The proposed site has good macro flexibility with the only limitation being in shifts to the west. The proposed site has outstanding local flexibility with only Areas A/B/C having limited movement potential in one direction.

Weaknesses: No noteworthy weaknesses.

Natural and Man-made Features *Good*

Strengths: The site is generally rural in setting.

Weaknesses: Red Mountain subdivision consisting of roughly 40 homesites is located on the west side of the ring and impacts Area G.

REGIONAL CONDITIONS GOOD

Both highways and railroads at the site are sufficiently distant from the interaction points that any vibrations will be insignificant. There is one existing rock quarry relatively near the site and another under construction. Although mathematical modeling (using assumed charge/delay amounts) show generated vibrations should be below SSC tolerances, no field vibration measurements are available to verify the calculations. There are no significant adverse climate conditions in the site region.

Vibrations and Noise *Satisfactory*

Strengths: All interaction points are at least 3 miles from the nearest major road and at least 5 miles from the nearest railroad.

Weaknesses: Field vibration data were not correlated with blasting at the existing quarry. A new rock quarry is being constructed relatively close to the ring. Controls on blast delays may have to be placed on this quarry to keep its vibration below the *Invitation* tolerance levels. Additionally, another new rock quarry west of the campus area is proposed and is in the permitting process.

Climate *Outstanding*

Strengths: There are no adverse climatic conditions, and there should be no loss of time in construction or operations.

Weaknesses: No noteworthy weaknesses.

UTILITIES **GOOD**

Ample electrical power with good stability and reliability is currently available or planned to be available at the site. An ample supply of water meeting or exceeding the standards of the *Invitation* is expected. Fuel (natural gas) is readily available. Sewage disposal and waste disposal facilities will be provided.

Electricity *Good*

Strengths: A strong electrical power generation and transmission system is available.

Weaknesses: No noteworthy weaknesses.

Water *Satisfactory*

Strengths: Sources to provide an adequate and reliable supply of water to the SSC site are readily available in the area.

Weaknesses: The proposer will not provide water to the service areas.

Other Utilities *Good*

No noteworthy strengths or weaknesses.

TENNESSEE

GEOLOGY **OUTSTANDING**

At the Tennessee site, all shafts and the tunnel will penetrate a thick, uniform sequence of high-strength limestone (average shaft depth, 405 feet). The site is undeformed by major structures (faults) and lies in a region of low earthquake potential (UBC Seismic Zone 1). Experimental halls will all be constructed as underground caverns in the limestone (average depth, 385 feet). The quality of the rock and its permeability are such that the tunnel, and most of the shafts, can be left unlined with only occasional rock bolts for support. Foundation conditions for the experimental halls are excellent due to the high strength of the bedded limestone. The homogeneity of the limestone, lack of structure, and the extensive regional database indicate that major problems are not likely to be encountered during construction. Karst features (solution cavities, sinkholes) are the least predictable aspect of the site. During shaft sinking there is a potential to encounter solution cavities in the upper layers of the limestone, some of which will be water-bearing and will need to be treated. However, these are expected to be of limited depth and can be easily identified during preconstruction drilling and then either treated or avoided.

Geologic Suitability *Outstanding*

Strengths: The rock beneath the Tennessee site is a thick succession of massive-to-thin bedded limestone of very good to excellent rock quality. The high-strength limestones (unconfined compressive strength = 13,000 psi) comprise a single, homogeneous construction unit. The quality of the rock is such that much of the tunnel can be left unlined.

Only minor inflows are expected along isolated, throughgoing joints. At tunnel depth the rock is essentially impermeable ($K = 10^{-3}$ to 10^{-9} cm/sec).

The site is predominantly flat with isolated hills; access to construction sites is generally good.

Weaknesses: There will be a need for detailed surveys in the areas proposed for shaft or building construction to identify caves and sinkholes.

Operational Stability *Outstanding*

Strengths: The high-strength limestone will provide a stable foundation for the detectors in the experimental halls.

The Tennessee site lies within UBC Seismic Zone 1 (low earthquake potential) with a predicted maximum ground acceleration of 0.06 g over the next 50 years.

Weaknesses: No noteworthy weaknesses.

Operational Efficiency *Poor*

Strengths: No noteworthy strengths.

Weaknesses: Shafts at this site range in depth from 290 to 615 feet, and average 405 feet. Because of the depth, caverns for the experimental halls will be constructed completely underground at an average depth to the invert of 385 feet.

Construction Risk *Good*

Strengths: The simple layered sequence of limestones at this site has widespread uniformity and good predictability. The lack of any extensive soil horizon means that shafts will be in hard rock from surface to tunnel depth, simplifying construction.

There is a large regional database resulting from deep core drilling for lead/zinc exploration. Site-specific tests include 11 core holes and 8 percussion holes.

Weaknesses: Karst features are the least predictable aspect of the site. Solution features appear to lessen in frequency and size with depth and are not expected to be a significant concern at tunnel levels. Near-surface features may have to be cleaned and filled with grout or cement prior to shaft or surface building construction.

REGIONAL RESOURCES **SATISFACTORY**

Although in a rural setting, the campus is near the city of Murfreesboro. Within an approximately 45-minute commute are the suburbs of Nashville and several sizable towns in almost any direction. While housing prices tend to be average to above average, most of the other cost of living indices are very favorable. Overall, the quality of the public school systems tend to be below average. Family employment and cultural opportunities are somewhat limited by the smaller size of the metropolitan area. Air accessibility is good. The metropolitan area and the site vicinity, in particular, are served by an extensive network of interstate, U.S., and state highways and roads. No on-site rail spur was proposed. Many new firms are moving to Tennessee since they believe it has a productive labor force. However, the high-technology skilled labor force, the industrial base (with the exception of the emerging auto industry), and the construction trade labor pool and base are limited. While there is some individual opposition and minimal organized opposition to date, the requisite planning and coordination activities with local governmental units for a successful outreach program have not been implemented, and such opposition may increase.

Community Resources *Satisfactory*

Strengths: Good housing availability and proximity; good employment opportunities with convenient access for family members; and excellent cost of living.

Weaknesses: Based upon national test scores and other indicators, public secondary schools, with few exceptions, tend to be average to below average. Approximately 20 percent of the students attend private schools and, generally, score above national averages and well above their counterparts in the local public school systems. There is limited access to research institutions. Cultural opportunities are somewhat limited.

Accessibility *Good*

Strengths: Air accessibility is considered to be good, based upon the driving time between the site and the Nashville Metropolitan Airport, and the air service between Nashville Metro and other airports which would serve the university-based, experimental, high energy physicists in the United States.

Excellent roads, highways, and interstate highway system are essentially in place with improvements planned and under way.

Excellent waterborne transportation is accessible.

Weaknesses: No on-site rail siding was proposed.

The public transportation system is limited.

Industrial Base *Satisfactory*

Strengths: No noteworthy strengths.

Weaknesses: The high-technology, skilled labor pool and the industrial base are limited (except for the newly developing auto industry).

The construction trade labor pool and construction base are limited.

Institutional Support *Good*

Strengths: The Governor, legislature, and local governments are very supportive of the program, and there appears to be very limited organized opposition.

Two public meetings have been held, and a telephone hot line has been established.

The SSC is exempted from local permits based upon a recent State law. The State SSC Regional Authority has been assigned responsibility for facilitating SSC permits, and the State has had recent permitting experience.

Weaknesses: The 128 relocations provides the basis for some individual opposition. The President of the Tennessee Chapter of the Sierra Club has taken a negative position. Only a limited outreach program is in place, and there is some indication that organized opposition may increase.

The State process for facilitating permits has not been defined. Pending national environmental legislation is considering designating caves as a natural resource, which could complicate the permitting process. The State has had only limited involvement of the local and county governments.

ENVIRONMENT **GOOD**

The project would have minimal impacts on land resources. Moderate impacts are anticipated regarding surface waters and wetlands due to spoil disposal placement. The project's use of a large fraction of the excess water supply also is considered a moderate impact. Impacts concerning socioeconomics and noise are also considered moderate. There is, however, a higher potential for impacting sensitive habitats, cultural resources, and aggravating an existing air quality problem.

Environmental Impact *Good*

Strengths: The area contains a negligible amount of designated prime farmland actually in cultivation; commercial forests comprise one-third of the area. The project would also have low impacts on other land resources. Many other resource category impacts would be moderate. Potential for scenic/visual impacts is minimal.

Weaknesses: There is the potential for aggravating the existing nonattainment air quality problem for ozone. Karst aquifers which underlie the site are sensitive to contamination. There is the potential for some impact to sensitive habitats such as cedar glades and downstream cave systems. Project impacts on cultural resources, such as historic properties, are of concern.

Compliance with Requirements *Good*

Strengths: The project at the proposed site is capable of meeting the requirements of applicable environmental regulatory programs.

Weaknesses: No noteworthy weaknesses.

Ability to Mitigate *Good*

Strengths: The potential for mitigating impacts concerning water quality, floodplains, noise, wetlands, cultural, and scenic resources is moderate.

Weaknesses: No noteworthy weaknesses.

SETTING **OUTSTANDING**

The State has an experienced acquisition team and a good acquisition plan. There are a total of 898 parcels, 807 ownerships, and 128 relocations. The large number of parcels creates some schedule risk. The site provides the SSC designers with outstanding flexibility allowing minor shifts of the collider as a whole and adequate shifting of the individual surface use areas. There are no man-made or natural features which have a significant impact on the proposed collider placement. Although the real estate task is fairly complex, this is mitigated by the size and quality of the real estate acquisition team. In addition, the other two subcriteria are outstanding. It was felt by the Task Force that the flexibility and natural and man-made features ratings overcame the good rating for real estate and resulted in an overall rating of outstanding.

Real Estate *Good*

Strengths: The State is utilizing an experienced acquisition team to acquire the property, and plans and schedules are well thought out. The number of personnel who can be called upon to perform the functions are adequate for the number of parcels to be acquired.

Weaknesses: The site involves a large number of parcels, ownerships, and relocations; this does create some risk to meeting the schedule requirements.

Flexibility *Outstanding*

Strengths: The site offers outstanding flexibility for surface use areas and very good flexibility for shifting the entire ring. Additional land is readily available adjacent to the site.

Weaknesses: No noteworthy weaknesses.

Natural and Man-made Features *Outstanding*

Strengths: The site is located in a rural setting with few natural or man-made obstructions.

Weaknesses: No noteworthy weaknesses.

REGIONAL CONDITIONS **OUTSTANDING**

Geologic conditions of the proposed site serve to reduce the amplitude of vibrations from surface sources. Vibration survey field data indicate that displacements generated by roads, railroad, or nearby quarries would be more than an order of magnitude below SSC tolerances. Additionally, there are no significant adverse climate conditions in the site region.

Vibrations and Noise *Outstanding*

Strengths: All railroad crossings are greater than 3,000 feet from interaction points and will produce vibrations at least 10 times smaller than the *Invitation* criterion. Data from nearby quarries show small vibrations.

Weaknesses: No noteworthy weaknesses.

Climate *Outstanding*

Strengths: There should be no loss of time in construction or operations due to climate.

Weaknesses: No noteworthy weaknesses.

UTILITIES **GOOD**

Ample electrical power with good stability and reliability is currently available or planned to be available at the site. An ample supply of water meeting or exceeding the standards of the *Invitation* is expected. Fuel (natural gas) is readily available. Sewage disposal and waste disposal facilities will be provided.

Electricity *Good*

Strengths: A strong electrical power generation and transmission system is available.

Weaknesses: No noteworthy weaknesses.

Water *Good*

Strengths: The State SSC Regional Authority will act as coordinator for all SSC water usage.

Weaknesses: No noteworthy weaknesses.

Other Utilities *Good*

No noteworthy strengths or weaknesses.

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TEXAS

GEOLOGY — OUTSTANDING

The chalk and marl underlying the proposed Texas site form a sequence of easily tunneled and structurally competent rock. Although the marl will require a lining for structural support and to prevent slaking, both the chalk and marl are impermeable; water control during construction and operation will not be a problem. Inactive faults of limited displacement cross the collider ring in several places, and the site lies in an area of very low earthquake potential (UBC Seismic Zone 0). Three experimental halls which may be founded on more elastic shale or marl may require additional support (e.g., drilled piles) to assure stability under detector loads. The low-strength chalk, however, should provide acceptable, stable foundation conditions for the remaining three halls. The average depth of the tunnel is 150 feet, and of the experimental halls, 220 feet. Deep open-pit excavations will be required for hall construction. The chances of running into unforeseen problems at this site are minimal since the geology is highly uniform and predictable, and the database is well developed.

Geologic Suitability — *Outstanding*

Strengths: The site lies within a simple layered sequence of chalk and marl with uniform and well characterized material properties. The rocks have relatively low strength (unconfined compressive strength = 400 psi [marl], and 2,200 psi [chalk]) and low abrasiveness. Tunneling characteristics are excellent.

The topography of the site is flat to rolling, and access to construction areas is good.

Only small volume inflows are expected along discrete fractures which can be controlled by grouting or a final waterproof liner. The chalk and marl are essentially impermeable ($K = 10^{-8}$ to 10^{-9} cm/sec [chalk], and 10^{-8} [marl]).

Weaknesses: The section of the tunnel in the marl (25 percent of the ring) will require a liner for structural support and to prevent slaking of the rock.

The experimental halls are proposed to be constructed with large cut-and-cover operations. Surface dimensions of these excavations range from approximately 250 feet by 430 feet to 630 feet by 710 feet.

Operational Stability — *Good*

Strengths: The Texas site lies within UBC Seismic Zone 0 (very low earthquake potential) with a predicted maximum ground acceleration of 0.04 g over the next 50 years.

The Austin Chalk has sufficient compressive strength (up to 3,800 psi) to provide a stable base for three experimental hall foundations.

Weaknesses: As proposed, two experimental halls (K1 and K2) will bottom on the Eagle Ford Shale, and one hall (K6) will bottom on marl. Differential settlement or rebound during loading and unloading of the detectors on these elastic materials may require measures to redistribute the heavy foundation loads (e.g., piles and spread footings). Alternatively, Texas proposed a symmetrical shift of the injector and future expansion areas to place the foundations of K1 and K2 on the more stable chalk.

Operational Efficiency *Good*

Strengths: Tunnel depth ranges from 85 to 235 feet, and averages 150 feet. Halls range in depth to the invert from 190 to 265 feet; average depth is 220 feet.

Weaknesses: At two points where the collider ring passes beneath drainages (Red Oak Creek near F3 and Waxahachie Creek near E2), the depth to tunnel center-line is less than 35 feet.

Construction Risk *Outstanding*

Strengths: The proposed site is underlain by a simple layered sequence of chalk and marl which has been confirmed by 39 project-specific borings. Structural features are minor, and the geology is considered to be highly predictable. Regional experience with tunneling in the Austin Chalk and Taylor Marl is extensive due to storm water tunnel projects in the Austin area.

Weaknesses: No noteworthy weaknesses.

REGIONAL RESOURCES **OUTSTANDING**

The site is in a rural setting with the city of Waxahachie (18,000) located inside the ring. The campus is within an easy commute of other attractive residential areas of the Dallas-Fort Worth metropolitan area, as well as several smaller cities and towns in the site vicinity. Family members will have ready access to employment centers. Housing prices and the cost of living are very attractive. The public school systems tend to be average. Air accessibility is excellent. The metropolitan area and the site vicinity, in particular, are served by an extensive and excellent network of interstate, US, and state highways and roads. No on-site rail spur was proposed. The site area has an excellent supply of skilled, high-technology and construction trades labor and a good industrial and construction base. Coordination of all appropriate local and state governmental units was effectively implemented, and there is a high level of public support.

Community Resources *Outstanding*

Strengths: Excellent supply and variety of easily accessible housing at below national average prices; good employment opportunities with excellent access for family members; good recreational/cultural opportunities; and excellent cost of living.

Weaknesses: The quality of public secondary school systems, as reflected by national test scores and other indicators, tend to be average.

Accessibility *Outstanding*

Strengths: Air accessibility is considered to be excellent, based upon the driving time between the site and the Dallas-Fort Worth International Airport and the air service between Dallas-Fort Worth and other airports which would serve the university-based, experimental, high energy physicists in the United States.

The site is served by an excellent network of roads, highways, and interstate highways in the site vicinity and metropolitan area, in general.

Roads and highways are essentially in place with further improvements planned and under way.

There is an excellent railroad network.

Weaknesses: Waterborne transportation accessibility is very limited.

No on-site rail siding was proposed.

Industrial Base *Outstanding*

Strengths: There are excellent, skilled high-technology and construction trade labor pools.

There is a good, mature, high-technology industrial base with numerous, well-established distributors in electronics, computers, and other high-technology items in addition to the normal materials and supplies required to support the operation of the SSC. The construction base, including materials, supplies, and operating equipment, is good.

Weaknesses: No noteworthy weaknesses.

Institutional Support *Outstanding*

Strengths: Overall support for the Texas SSC site extends from the Governor and State of Texas legislature through to the local governments and communities.

Very limited individual opposition and no organized opposition are present. Local environmental organizations were approached and did not object to the program.

A sophisticated institutional organization and a plan were established and effectively implemented by the State of Texas. An Ellis County Environmental Review Board has been established, public meetings conducted, and the affected landowners dealt with in a direct manner. Public information materials have been prepared and mailings conducted.

A regulatory compliance plan has been prepared and a one-stop permitting process established. Responsibilities and authorities are defined and written agreements have been developed.

Weaknesses: No noteworthy weaknesses.

ENVIRONMENT **OUTSTANDING**

The site is located in an area where the natural ecology has already been highly modified through the extensive development of the land for pasture and farming. There will be minimal impact to surface or groundwater resources, wetlands, or ecological resources.

Environmental Impacts *Outstanding*

Strengths: The tunnel would be excavated above the groundwater table. The potential for water quality impacts to surface or groundwater is low. Project water use would be only a small increment of excess surface water supply.

The site is within an air quality attainment area. No impact on mineral resources is expected. Prime farmlands which may be impacted are a relatively low 0.02 percent of the inventory of the site region. The potential for cultural impacts is low.

Weaknesses: One important riparian wetland/floodway may be impacted. Project use of groundwater resources would contribute to an existing overdraft condition. Land acquisition would require 175 relocations. There is a potential for socioeconomic impact.

Compliance with Requirements *Good*

Strengths: The project at the proposed site is capable of meeting the requirements of applicable environmental regulatory programs.

Weaknesses: No noteworthy weaknesses.

Ability to Mitigate *Good*

Strengths: A shift (for engineering considerations) of a J area out of the floodway/riparian wetland is considered also an environmental impact avoidance. The potential for mitigating impacts concerning water quality, noise, cultural, and scenic resources is moderate.

Weaknesses: No noteworthy weaknesses.

SETTING **OUTSTANDING**

The Texas site has 614 parcels which will be acquired by the Texas Department of Transportation. There will be about 175 relocations. Adequate, experienced staff are available, and a strong management team is assembled to assure timely acquisition. Flexibility is good, though Lake Bardwell places some limitation on the use of Area H, since about 100 acres is within a Corps of Engineers flowage easement which would restrict construction. The Task Force considered that the strength of the real estate plan more than overcame the minor weaknesses in flexibility and natural and man-made resources, thereby resulting in an outstanding rating.

Real Estate *Outstanding*

Strengths: There is a highly experienced management team and staff, and the acquisition plan and schedule are well conceived and very feasible. The relocations plan is excellent, and the acquisition team shows good sensitivity to landowners. There is excellent support from Federal, State, and local governments as well as landowner support of the project.

Weaknesses: No noteworthy weaknesses.

Flexibility *Good*

Strengths: The site offers outstanding flexibility for most surface use areas.

Weaknesses: The flexibility to shift the ring is limited by Lake Bardwell and the town of Ennis.

Natural and Man-made Features *Good*

Strengths: The site is basically rural in nature with few natural or man-made obstructions.

Weaknesses: Approximately 100 acres in the northwestern corner of Area H will have limited use because they are located in a 100-year floodplain, which has a flowage easement that constricts construction.

REGIONAL CONDITIONS **GOOD**

Road and quarry generated vibrations would be an order of magnitude below SSC tolerances. The site is crossed by five railroad lines; the closest to an interaction hall is less than the recommended minimal distance. Vibration levels obtained by the extrapolation of field data indicate that generated displacements would be below SSC tolerances at the interaction halls. One railroad line passes only 20 to 25 feet above the ring tunnel. The generally favorable climate is such that no lost time in construction or operation is anticipated.

Vibrations and Noise *Good*

Strengths: Vibration monitoring near the railroad closest to an interaction point (2,400 feet) shows vibration levels ten times below the *Invitation* limit at that interaction point. All roads are further than 600 feet from an interaction point. A quarry 8 miles from interaction point K1 shows small vibration values.

Weaknesses: A railroad line crosses the ring at a point at which the tunnel is only 20 to 25 feet below. Data indicate vibration levels lower than the required SSC tolerances by only a factor of 2 to 4; however, this margin could easily be improved by increased track maintenance, a better cushioning layer, or both.

Climate *Outstanding*

Strengths: There are no significant adverse climate conditions. There should be no loss of construction or operational time due to climate.

Weaknesses: No noteworthy weaknesses.

UTILITIES **GOOD**

Ample electrical power with good stability and reliability is currently available or planned to be available at the site. An ample supply of water meeting or exceeding the standards of the *Invitation* is expected. Fuel (natural gas) is readily available. Sewage disposal and waste disposal facilities will be provided.

Electricity *Good*

Strengths: A strong electrical power generation system is available with a dual service.

Weaknesses: No noteworthy weaknesses.

Water *Good*

Strengths: Sources to provide adequate and reliable supply of water to the SSC site are readily available in the area.

Weaknesses: No noteworthy weaknesses.

Other Utilities *Good*

No noteworthy strengths or weaknesses.

6

LIFE-CYCLE COST

Life-cycle cost estimates were determined using the methodology discussed in Chapter 4. The factors used to develop these estimates were based, whenever possible, on the data, assumptions, and proposed construction methods shown in the site proposals, except where inconsistencies in the proposals were found or more economical construction procedures could be utilized. For example, it was assumed that the injector complex was located near the surface to permit cut-and-cover excavation for all sites. Other variations from the site proposals are listed below by state.

ARIZONA Reduced the percentage of cut-and-cover excavation from the State proposal of 22 percent* to 11 percent to limit the cut-and-cover excavation depth to 80 feet and to avoid impacts of ring construction on a mainline railroad crossing, Maricopa Road, the historic Butterfield Stage Route, and the Juan Bautista de Anza Trail. The cost estimate is based upon a more conservative approach to avoid the above mentioned crossings.

COLORADO Assumed a 6-inch precast liner instead of sealer, shotcrete or a slipform liner (all with spot bolting, as needed). Precast liner is conventionally used by tunnel contractors.

ILLINOIS No changes.

MICHIGAN Assumed two experimental halls as open cut excavations and two experimental halls as rock caverns rather than four open cut excavations. The two rock caverns are feasible in the proposed rock, resulting in less surface disruption at no additional cost.

Assumed a gasket precast liner throughout instead of a variety of liner and support methods suggested by the proposer. Precast liner is conventionally used as a single liner and support system rather than multiple systems.

Located the injector near the surface rather than locating the HEB and MEB below the collider ring, as proposed.

* In the technical evaluation, the Task Force assumed only 18 percent cut-and-cover excavation using a maximum 80-foot excavation depth (per Arizona's proposal, Volume III, page 40).

NORTH CAROLINA	Assumed two halls as open-cut excavation and two as rock caverns rather than four halls as caverns. This assumption was made because it was felt that the two caverns would be technically risky due to the limited thickness of good rock above the hall roof.
TENNESSEE	Located the injector near the surface rather than near the tunnel.
TEXAS	Assumed a 6-inch precast liner in marl instead of shotcrete coatings. Precast liner is conventionally used. Assumed two experimental halls as rock caverns, rather than four halls as cut-and-cover excavations; the two rock caverns are feasible in the proposed rock resulting in less surface disruption at no additional cost. Located the HEB and MEB nearer the surface for cut-and-cover excavation rather than deeper tunnel excavation.

A determination was made as to those items that would be acquired on a national basis (fixed costs), and what items would be purchased locally (variable costs), for both the construction and operating phases.

There are special cost savings considerations which would result if the SSC is sited at Fermilab because of the presence of the Tevatron which meets many of the injector requirements of the SSC. The Department estimates a saving on injector construction in the range of $240 to $312 million and a saving on site and infrastructure, campus, and other construction of $22 million (1988 dollars). The range of injector cost savings results from the presently unresolved technical issue of whether the Fermilab 150-GeV main ring (which would be the MEB for the SSC) needs to be replaced. An operating cost savings in the range of $233 to $699 million (1988 dollars) is also projected for such items as personnel, power, materials, supplies, and improvements. A range of operating cost savings is given because of the great uncertainty in projecting the lifetime for a viable and productive Tevatron program after SSC comes into operation. This analysis assumed a 5- to 15-year operating lifetime for the Tevatron. It is estimated that locating the SSC at Fermilab would result in cost savings in the range of $495 million to $1.033 billion (1988 dollars).

The life-cycle cost estimates for all BQL sites are provided in Table 3. The Task Force believes that the estimates are accurate on the order of 10 percent.

The estimates range from a low of $10.4 billion to a high of $11.5 billion, a variance from low to high of 10.5 percent. The average of the cost estimates is $11.0 billion. Maximum variance from the average is ±5 percent.

Because of the limitations in the accuracy of the life-cycle cost estimates and the relatively narrow range of those estimates, costs are not considered to be a strong discriminator among the sites.

Table 3. SSC life-cycle cost estimates for construction plus a 25-year operating period (in billions of 1988 dollars).

State	Fixed Costs	Variable Costs	Total Life Cycle Cost	Variance from the Average ($11.0 billion)
Arizona	5.7	5.8	11.5	+5%
Colorado	5.7	5.5	11.2	+2%
Illinois	5.7	5.7	10.4 to 10.9[a]	-5 to -1%
Michigan	5.7	5.8	11.5	+5%
North Carolina	5.7	5.0	10.7	-3%
Tennessee	5.7	5.0	10.7	-3%
Texas	5.7	5.1	10.8	-2%

[a] The Illinois life-cycle cost estimate is $11.4 billion minus the credit given for Fermilab facilities. The credit ranges from $495 million to $1.033 billion, resulting in the cost range shown.

7

EQUAL OPPORTUNITY

The *Invitation* required that all community resources be available on a nondiscriminatory basis. This was viewed as a critical element of the selection process. To ascertain whether the education, employment, and housing resources were available on a nondiscriminatory basis, an on-site civil rights examination was conducted by a representative of DOE's Office of Equal Opportunity (see Chapter 4). The results of that examination are summarized below.

Allegations of discrimination were raised in the education, employment, and housing resources at each state. It is difficult to suggest that the allegations were more strenuous in one state than another. While it was important to place the allegations into perspective, the overall goal of the assessments was to try to determine if mechanisms were available to provide all individuals with an equal opportunity to a particular resource. In response to allegations presented to the Task Force, processes in place were examined to determine if there were mechanisms in place at the local level to resolve them. One of the objectives was to determine if the institutionalized procedure included the following aspects: (a) an opportunity for the alleged injured party to file a complaint, (b) an examination of the allegation to determine if there was a basis for the complaint, (c) an investigation to collect the facts, and (d) a decision step. If such a mechanism was found to be in place and was being utilized, it was concluded that a safety net existed to provide due process.

Allegations of discrimination raised in the *Educational Resources* area included:

- Different admission standards for minorities
- Lower test scores on the SAT/ACT examinations for minorities
- Examinations given to deny certification to minority teachers
- Segregated and dual school systems
- Imbalance in student enrollment by race
- Lack of upward mobility within the faculty hierarchy because of race.

These and similar allegations were examined to determine if mechanisms existed to provide due process. In some instances, affirmative actions by a state were precipitated by court action or proposed action.

Allegations of discrimination in the area of *Employment Resources* included:

- Unfair/illegal hiring practices
- Minorities being denied an opportunity to participate in the Labor Union Apprenticeship programs

- Lack of iocal ordinances and resolutions outlawing discrimination against minorities on the basis of race, color, creed, national origin, sex, age, or handicap
- Unequal pay for women and minorities for similar work.

Some of these concerns were raised not only by the minorities, but by civil rights organizations that were responsible for enforcing the regulations in this area. The lack of subpoena powers during the investigatory and conference stages sometimes caused the responsible enforcement offices to operate with less than effective enforcement means.

Allegations of discrimination in the area of *Housing Resources* included:

- Use of restrictive covenants in propery deeds
- Refusal to rent to single heads of households
- Difficulty in acquiring housing because of the lack of resolutions or ordinances which prohibit discrimination on the basis of race, color, national origin, sex, age, or handicap.

In states where such allegations occurred, there appears to be a concerted effort to resolve such impediments.

During the assessment of the seven BQL sites it became apparent that mechanisms vary from state to state. Some mechanisms are more effective than others and, therefore, the degree of availability of these resources differed. Some states had visible and effective mechanisms in place. In several states the educational resources were subject to active court orders or decrees. While the need for such a legal remedy indicates a weakness, its presence was viewed as an insurance policy since it helps to ensure compliance and establishes a viable mechanism.

While concerns still exist in the various states, there are continuing efforts to improve the mechanisms to resolve them. Accordingly, the Task Force concluded, based upon the available information, that: (a) each state has met the minimum requirements of the *Invitation*, (b) the community resources are available on a nondiscriminatory basis, and (c) systematic mechanisms are in place to provide due process should a problem arise.

APPENDIX A

SUPERCONDUCTING SUPER COLLIDER SITE TASK FORCE MEMBERS

The Site Task Force is a Department-wide group of senior personnel reporting to the Director, Office of Energy Research, and providing expertise in the areas of physics, engineering, cost analysis, project management, construction, real estate, environment, law, procurement, business management, and public administration.

Dr. Wilmot N. Hess, Chairman

Dr. Hess is Associate Director for High Energy and Nuclear Physics, U.S. Department of Energy. Prior to joining the Department, he was Director, National Center for Atmospheric Research. He received a B.S. in Electrical Engineering from Columbia University, an M.A. in Physics from Oberlin College, and a Ph.D in Physics from the University of California. He is a member of the National Academy of Engineering, the American Association for the Advancement of Sciences, the American Meterological Society, and the American Geophysical Union.

Dr. Lewis E. Temple, Jr., Executive Director

Dr. Temple is Director, Construction, Environment, and Safety Division, Office of Energy Research, U.S. Department of Energy. Prior to joining the Department, he was employed by the General Electric Company in San Jose, California. He received an A.B. in Physics and Mathematics from Kansas Wesleyan, an M.S. and Ph.D in Nuclear Engineering from the University of California. He is a member of the American Physical Society.

Mr. Richard H. Nolan*, Deputy Executive Director

Mr. Nolan is Special Assistant to the Manager, San Francisco Operations Office, U.S. Department of Energy. Prior to joining the Department, he was employed by the U.S. Energy Research and Development Administration and the U.S. Atomic Energy Commission. He received a B.S. and M.S. in Public Administration from San Diego State University.

Mr. Warren D. Black

Mr. Black is an Environmental Protection Specialist with the Office of Environment, Safety and Health, U.S. Department of Energy. He is the Lead for the Environment and Regional Conditions Committees. Prior to joining the Department, he was an Environmental/ Biological Scientist with the U.S. Environmental Protection Agency. He holds a B.S. in Biology and is pursuing graduate studies in Environmental Management.

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*Non-voting members

Mr. Robert L. Forst*

Mr. Forst is Deputy Assistant General Counsel for Procurement, U.S. Department of Energy. Prior to joining the Department, he was employed by the U.S. Energy Research and Development Administration and the U.S. Atomic Energy Commission. He received a B.A. in History and Government from the City College of New York and a LL.B. from Columbia University.

Dr. Earle C. Fowler

Dr. Fowler is Chief, Facilities Operations Branch, Division of High Energy Physics, Office of Energy Research, U.S. Department of Energy. He is the Lead for the Utilities Committee and a member of the Regional Resources Committee. Prior to joining the Department, he was a Professor of Physics at Purdue University. He received a B.S. in Chemistry from the University of Kentucky and an M.A. and Ph.D in Physics from Harvard University. He is a member of the American Physical Society.

Mr. Daniel R. Lehman

Mr. Lehman is an Engineer for the Construction, Environment, and Safety Division, Office of Energy Research, U.S. Department of Energy. He is the Lead for the Geology and Tunneling and Life Cycle Cost Committees. Prior to joining the Department, he was a Civil Engineer with Bechtel Power Corporation. He received a B.S. in Civil Engineering from the University of Maryland. He is a licensed, professional engineer and a member of the American Society of Civil Engineers.

Mr. Howard K. Mitchell

Mr. Mitchell is a Policy Analyst in the Office of Policy, Procurement and Assistance Management Directorate, U.S. Department of Energy. He is a member of the Regional Resources Committee. Prior to joining the Department, he was employed by the U.S. Energy Research and Development Administration and the U.S. Atomic Energy Commission. He is a Certified Professional Contract Manager of the National Contract Management Association. He received an A.B. in Economics from Whitman College and a M.B.A. from the University of Washington.

Mr. Donald G. Trost

Mr. Trost is the Chief, Real Property Branch, Office of Project and Facilities Management, U.S. Department of Energy. He is the Lead for the Setting Committee. He has been involved in real estate in the Federal sector since 1963, working for the U.S. Army Corps of Engineers and the U.S. Postal Service. He is currently the President of the Federal Real Property Association. He received an A.B. degree in Political Science from the University of California at Berkeley.

Mr. Robert A. Zich

Mr. Zich is the Director, Division of Acquisition and Assistance Management, Office of Energy Research, U.S. Department of Energy. He is the Lead for the Regional Resources Committee. Prior to joining the Office of Energy Research, he was employed by the U.S. Energy Research and Development Administration and the U.S. Atomic Energy Commission. He received a B.S. in Economics and Business Administration from West Virginia Wesleyan College and has taken graduate courses in industrial management at the University of New Mexico.

APPENDIX B

SSC SITE TASK FORCE TECHNICAL SUPPORT AND ADVISORS

Mr. William C. Adams
Realty Officer and Program Manager
Office of Project and Facilities Management
Assistant Secretary, Management and Administration

Mr. Ira M. Adler
Acting Director
Office of Management
Office of Energy Research

Mr. Thomas A. Baillieul
Staff Geologist
Chicago Operations Office

Ms. Regina Borchard
Executive Director
Superconducting Super Collider Coordination
Office of the Deputy Secretary

Mr. Prentis Cook, Jr.
Attorney Advisor
Office of General Counsel

Ms. Arlene deBlanc
Utilities Specialist
Division of Construction, Environment, and Safety
Office of Energy Research

Dr. Robert E. Diebold
Director
Superconducting Super Collider Division
Office of Energy Research

Dr. Tom Elioff
Physicist
Division Head of Project Planning and Management
SSC/Central Design Group

Dr. Raymond L. Fricken
Executive Officer
Superconducting Super Collider Division
Office of Energy Research

Mr. Alan G. Gann
General Engineer
Office of Project and Facilities Management
Assistant Secretary, Management and Administration

Mr. Barry W. Haley
Manager of Federally Assisted Programs
Office of Equal Opportunity
Assistant Secretary, Management and Administration

Mr. Jay O. Hunze
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Mr. John B. King
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Dr. Jerry J. Nelsen
Environmental Engineer
Environment, Safety, and Health Division
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Mr. Raymond Pelletier
Director of Environmental Guidance
Assistant Secretary for Environment, Safety and Health

Mr. Gary L. Pitchford
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Dr. G. Mack Riddle
SSC Project Manager
RTK Joint Venture

Dr. James R. Sanford
Physicist
Head, Conventional Facilities Division
SSC/Central Design Group

Mr. G. John Scango
Project Engineer
Superconducting Super Collider Division
Office of Energy Research

Mr. F. Berndt Schine
Director of Intergovernmental Affairs
Office of External Affairs
Assistant Secretary, Congressional, Intergovernmental and Public Affairs

Mr. Robert C. Selby
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Mr. Paul J. Sherry*
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Office of General Counsel

Mr. Jeffrey L. Sherwood
Public Information Officer
Press Office
Office of the Press Secretary

Mr. Robert H. Strickler
Group Leader
Office of NEPA Project Assistance
Assistant Secretary, Environment, Safety and Health

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Technology Management Division
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Dr. William A. Wallenmeyer*
Director
High Energy Physics Division
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Mr. Robert C. Wunderlich
Program Manager
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* No longer employed by the DOE

APPENDIX C

QUALIFICATION CRITERIA, TECHNICAL EVALUATION CRITERIA, AND COST CONSIDERATIONS

This Appendix reproduces for the convenience of the reader the qualification criteria, technical evaluation criteria, and cost considerations set forth in the *Invitation for Site Proposals for the SSC* (DOE/ER-0315) and used by the Task Force during its evaluation process.

QUALIFICATION CRITERIA

The following qualification criteria for Section 3.2 of the *Invitation* were used to qualify the proposals received in September 1987.

1. Location entirely in the United States of America.

2. Land size and configuration to accommodate the SSC facility as specified in the *Invitation*, including Figure 1-2 and Table B-1 in the *Invitation*.

3. Absence of cost to the Government for land acquisition.

4. Capability of providing at least 250 MW of electrical power with at least 500 gpm of industrial water or 200 MW of power with 2,200 gpm of industrial water, or an appropriate interpolated combination.

5. Absence of known unacceptable environmental impacts from siting, constructing, operating, and decommissioning the SSC. Reasonable mitigation measures may be taken into consideration.

TECHNICAL EVALUATION CRITERIA

Those sites that met the qualification criteria were evaluated against the following six technical evaluation criteria, which were listed in descending order of importance in the *Invitation* (Section 3.3), as were the subcriteria within each criterion.

1. Geology and Tunneling

   a. Suitability of the topography, geology, and associated geohydrology for efficient and timely construction of the proposed SSC underground structures.

   b. Stability of the proposed geology against settlement and seismicity and other features that could adversely affect SSC operations.

   c. Installation and operational efficiency resulting from minimal depths for the accelerator complex and experimental halls.

d. Risk of encountering major problems during construction.

2. Regional Resources

a Proximity of communities within commuting distance of the proposed SSC facilities capable of supporting the SSC staff, their families, and visitors. Adequacy of community resources—e.g., housing, medical services, community services, educational and research activities, employment opportunities for family members, recreation, and cultural resources—all available on a non-discriminatory basis.

b. Accessibility to the site, e.g., major airport(s), railroads, and highway systems serving the vicinity and site.

c. Availability of a regional industrial base and skilled labor pool to support construction and operation of the facility.

d. Extent and type of state, regional, and local administrative and institutional support that will be provided, e.g., assistance in obtaining permits and unifying codes and standards.

3. Environment

a. Significance of environmental impacts from siting, constructing, operating, and decommissioning the SSC.

b. Projected ability to comply with all applicable, relevant, and appropriate Federal, state, and local environmental/safety requirements within reasonable bounds of time, costs, and litigation risk.

c. Ability of the proposer, the DOE, or both to reasonably mitigate adverse environmental impacts to minimal levels.

4. Setting

a. Ability of the proposer to deliver defendable title, in accordance with the provision of Section 2.2.2.4 of the *Invitation*, for land and estates in land that will adequately protect the Government's interest and the integrity of the SSC during construction and operation.

b. Flexibility to adjust the position of the SSC in the nearby vicinity of the proposed location.

c. Presence of natural and man-made features of the region that could adversely affect the siting, construction, and operation of the SSC.

5. Regional Conditions

   a. Presence of man-made disturbances, such as vibration and noise, that could adversely impact the operation of the SSC.

   b. Presence of climatic conditions that could adversely impact construction and operation of the SSC.

6. Utilities

   a. Reliability and stability of the electric power generating and transmission grid systems. Flexibility for future expansion.

   b. Reliability, quality, and quantity of water to meet the needs of the facility.

   c. Availability of fuel, waste disposal, and sewage disposal.

COST CONSIDERATIONS

Section 3.5 of the *Invitation*, as amended, stated:

> Cost considerations are important to the selection process and will be used in conjunction with the technical evaluation criteria in selecting the most desirable site. The cost and schedule for constructing the SSC will depend upon site features, such as geological and geohydrological conditions. The tunnels, access shafts, and experimental halls are major cost elements of the project. The availability of usable buildings and facilities on the proposed site would favorably affect both cost and schedule.
>
> Annual operating costs, including those related to local wage scales, utility rates, site accessibility, etc., must be considered. Operation and construction costs must be evaluated over the long term to achieve an optimum balance. Environmental mitigation costs may also be an important consideration for both construction and operation.
>
> For each proposal meeting the qualification criteria, a life-cycle cost estimate will be prepared for the construction phase plus a 25-year operating phase. The cost of land to the proposer will not be considered in determining the life-cycle cost. The NAS/NAE will take into consideration the life-cycle cost in determining the merits of proposed sites.
>
> Any financial or other incentives offered by the proposer will not be considered in the evaluation of proposals. However, proposers may chose to include financial incentives in their proposals. Such financial incentives shall be described in Volume 2, Section 2.2.2.5 of proposals.

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