NSP

Northern States Power Company

Before the
MN Public Utilities Commission

Application for Certificate-of-Need for Prairie Island Spent Fuel Storage Docket No. E002/CN-91-19

April, 1991

Volume 1 of 2
Application

Northern States Power Company
Law Department

Gary R. Johnson
Vice President—Law

Hollies M. Winston
Secretary

David A. Lawrence, Director—Law
Jack F. Sjoholm, Director—Law

Writer's Direct Dial Number

414 Nicollet Mall
Minneapolis, Minnesota 55401
Telephone (612)330-6600
Fax No. (612)330-7558

Attorneys
Gene R. Sommers
Ralph S. Towler
Joseph D. Bizzano, Jr.
Stephen C. Lepadat
Harold J. Bagley
James L. Altman
Donnelda L. Rice
Cheri L. Brix
Michael J. Hanson
Michael C. Connelly

April 29, 1991

Mr. Richard R. Lancaster, Executive Secretary
Minnesota Public Utilities Commission
780 American Center Building
150 East Kellogg Boulevard
St. Paul, MN 55101

RE: Application by Northern States Power Company for a Certificate of Need
Docket No. E-002/CN-91-19

Dear Mr. Lancaster:

Enclosed is an original and thirteen (13) copies of Northern States Power Company's ("NSP") Application for a Certificate of Need ("Application") for a temporary spent fuel storage facility for storing spent fuel from the Prairie Island Nuclear Generating Plant.

NSP has also served a copy of its Application on the persons on the attached service list, which was prepared by the staff of the Minnesota Public Utilities Commission.

Sincerely,

Gary R. Johnson

Gary R. Johnson
Vice President--Law

cc: with enclosures:
All Parties of Record

Prairie Island Certificate
of Need Case
Docket No. E-002/CN-91-1

Richard R. Lancaster (14)
Executive Secretary
MN Public Utilities Commission
780 American Center Building
150 E. Kellogg Blvd.
St. Paul, MN 55101

Robin Garcia (4)
Department of Public Service
790 American Center Building
160 E. Kellogg Blvd.
St. Paul, MN 55101

Scott Brockett
Department of Public Service
790 American Center Building
160 E. Kellogg Blvd.
St. Paul, MN 55101

Greg Holman
Department of Public Service
900 American Center Building
160 E. Kellogg Blvd.
St. Paul, MN 55101

Joan Peterson
Assistant Attorney General
1100 Bremer Tower
Seventh Place & Minnesota Street
St. Paul, MN 55101

Dennis D. Ahlers
Special Assistant Attorney General
Residential Utilities Division
340 Bremer Tower
Seventh Place & Minnesota Street
St. Paul, MN 55101

Linda Darland
Department of Public Safety
Emergency Management
Room B5 - Capitol Building
75 Constitution Avenue
St. Paul, MN 55155

Isaac McCrary
Department of Transportation
Room 704 Transportation Building
John Ireland Blvd.
St. Paul, MN 55155

Meri Nielsen
Pollution Control Agency
Office of Environmental Services
520 Lafayette Road
St. Paul, MN 55155

Deb McGovern
Pollution Control Agency
Office of Planning and Review
520 Layfayette Road
St. Paul, MN 55155

Timothy Donakowski
Department of Health
Radiation Control Section
925 Delaware Street SE
P.O. Box 59040
Minneapolis, MN 55449

Judith Ball
Department of Health
State Health Building
717 Delaware St. SE
Minneapolis, MN 55440

Greg Wilson
Department of Agriculture
90 W. Plato Blvd.
St. Paul, MN 55107

Gretchen Sabel (2)
Environmental Quality Board
300 Centennial Office Building
658 Cedar Street
St. Paul, MN 55155

Legislative Reference Library (2)
Attn: Zona Dewitt
645 State Office Building
St. Paul, MN 55155

Scott Johnson
Department of Natural Resources
Mississippi River System Mgmt. Team
Route 2, Box 230
Lake City, MN 55041

Minnesota Historical Society
State Historic Preservation Office
Fort Snelling History Center
St. Paul, MN 55111

Kimberly Erickson
Northern States Power Company
414 Nicollet Mall
Minneapolis, MN 55401

Michael J. Bradley
Moss & Barnett
4800 Norwest Center
90 S. 7th Street
Minneapolis, MN 55402

Frederick Dahling
County Board Chair
Goodhue County Courthouse
P.O. Box 408
Red Wing, MN 55066

Dean Massett
Council Administrator
Red Wing City Hall
315 W. Fourth Street
Box 34
Red Wing, MN 55066

Red Wing Public Library
Attn: Betsy Swartz
Third and Broad
Red Wing, MN 55066

Environmental Conservation Library
300 Nicollet Mall
Minneapolis, MN 55401

David Behm
Board of Water and Soil Resources
90 W. Plato Blvd.
St. Paul, MN 55107

Ben Wopat - Chief
US Army Corps of Engineers
Regulatory Functions Branch
1135 US PO & Custom House
St. Paul, MN 55101

William D. Frand
US Environmental Protection Agency
Chief of Environmental Review Br.
230 S. Dearborn Street
Chicago, IL 60604

US Fish and Wildlife Service
St. Paul Field Office
50 Park Square Court
400 Sibley Street
St. Paul, MN 55101

Michael Lee
MPIRG
2512 Delaware Street SE
Minneapolis, MN 55414

Dick Anderson
HC84 Box 1397B
Walker, MN 56484

Bill Galloway
Greenpeace Action
2637 Nicollet Avenue South
Minneapolis, MN 55408

Gene McDonald
Tribal Administrator
5750 Sturgeon Lake Road
Welch, MN 55089

Dale Childs
Prairie Island Tribal Council
1865 Chakya Street
Welch, MN 55089

Vine Wells
1836 Wiobata Street
Welch, MN 55089

Jim Harrison
MN/Wisc Boundary Area Commission
619 2nd Street
Hudson, WI 54014

North American Water Office
P.O. Box 174
Lake Elmo, MN 55042

Mr. Robert H. Schulte
Vice President, Rates and
Corporate Strategy
Northern States Power Company
414 Nicollet Mall
Minneapolis, MN 55401

Richard Duncan
Faegre & Benson
2200 Norwest Center
Minneapolis, MN 55402-4119

John W. Kassan
1515 South 4th Street #E104
Minneapolis, MN 55454

Hon. Allan W. Klein
Administrative Law Judge
Office of Administrative Hearings
Fifth Floor, Flour Exchange Building
310 Fourth Avenue South
Minneapolis, MN 55415

Paul Burns
Department of Agriculture
90 W. Platon Boulevard
St. Paul, MN 55107

Charlotte Cohn
Department of Natural Resources
Office of Planning
500 Lafayette Road
Box 10
St. Paul, MN 55155

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
7855.0230	General Information	I.A. (3-5); XIV. (169)	
7855.0230(A)	Applicant's complete name and address, telephone number, and standard industrial classification codes.	I.A. (3-4)	
7855.0230 (B)	Complete name, title, address, and telephone number of the official or agent to be contacted concerning the applicant's filing.	I.A. (4)	
7855.0230(C)	Brief description of nature of applicant's business and of the products that are manufactured, produced or processed, or the services rendered.	I.A. (3)	
7855.0230(D)	Brief description of proposed facility and its planned use.	I.A. (4-5)	
7855.0230(E)	Total fee for the application and the amount of the fee submitted with the application.	I.A. (5)	
7855.0230(F)	Signature and titles of applicant's officers or executives authorized to sign the application.	XIV. (169)	

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
7855.0240(A)	Schedule of Other Filings	I.D. (8-10)	2.1-2.2
7855.0240(A)	Names of all known, federal, state, or local authorities with which applicant must file.	I.D. (8-10)	
7855.0240(B)	Title of each required permit or certificate.	I.D. (8-10)	
7855.0240(C)	Date an application was filed or projected date of application for each permit or certificate.	I.D. (8-10)	
7855.0240(D)	Date of decision or anticipated date of decision for each permit or certificate.	I.D. (8-10)	
7855.0240(E)	Disposition or status of each permit or certificate for which an application has been filed.	I.D. (8-10)	
7855.0250	Need Summary	II. (11-23)	
7855.0260	Additional Considerations	XII. (161-162)	
7855.0260(A)	Socially beneficial uses of the	XII. (161)	

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
	output of the facility, including its uses to protect or enhance environmental quality.		
7855.0260(B)	Promotional activities that may have given rise to the demand for the facility.	XII. (161)	
7855.0260(C)	Effects of the facility in inducing future development.	XII. (161-162)	
7855.0270	Conservation Programs	XIII. (163-167); Appendix 1	
7855.0270(A)	Name of the committee, department, or individual responsible for applicant's energy conservation and efficiency programs.	XIII. A. (164)	
7855.0270 (B)	List of applicant's energy conservation and efficiency goals and objectives.	XIII. B. (164-165)	
7855.0270(C)	Description of the specific energy and efficiency programs the applicant has considered, a list of those that have been implemented, and the reasons why the other	XIII. C. (165-166); Appendix 1	

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
	programs have not been implemented.		
7855.0270(D)	Description of major accomplishments made with respect to energy conservation and efficiency.	XIII. D. (166)	
7855.0270(E)	Description of applicant's future plans through the forecast years with respect to energy conservation and efficiency.	XIII. E. (167); Appendix 1	
7855.0270(F)	Quantification of manner by which programs affect or help determine applicant's forecast of demand, a list of total costs by program, and a discussion of the expected effects in reducing need for new large energy facilities.	XIII. F. (167); Appendix 1	
7855.0600	Description of Proposed Nuclear Storage Facility	IV. (33-66)	Ch. 3
7855.0600 (A)	Physical description of facility	IV. A. (33-34)	3.18-3.19
(1)	Location, to fullest extent known	IV. A. (33)	3.2

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
(2)	Required land area and height of tallest structures	IV. A. (33-34)	3.18
(3)	Design capacity in cubic meters.	IV. A. (33); XI. E. (132-133)	3.24
(4)	Schematic showing major components of the facility.	IV. A. (33)	3.40, 3.39
7855.0600 (B)	Design and construction of facility	IV. A. 1. (34-44)	
(1)	Complete name and business address of engineer and firm responsible for design.	IV. A. 1. (34); IV. A. 3. (38)	
(2)	Complete name and address of company which would construct facility.	IV. A. 1. (34); IV. A. 3. (38, 42)	
(3)	Proposed date for commencing construction and the proposed in-service date.	IV. A. 1. (33-34)	
(4)	Description of construction techniques.	IV. A. 1. (33-34); IV. A. 3. (38-44)	
(5)	Estimated installed cost of facility in current dollars	IV. B. 4. (52)	

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
(6)	Estimated economic life of facility	IV. B. 4 (52); XI. E. (147-148)	
7855.0600 (C)	Operation and retirement of facility	IV. B. (44-52, 53-56); IV. F. (64-66)	
(1)	Narrative description of steps of storage process, starting at point nuclear wastes are produced.	IV. B. (44-52, 53-56)	3.21-3.24
(2)	Sources, types and amounts of nuclear waste products that would be stored, the methods of transporting these materials to the facility, and the level of radioactivity of each in curies per year.	IV. A. 2. b. (37-38); IV. B. (44-52, 53-56)	3.3-3.6; 3.21-3.24
(3)	Length of time material would be stored and method of transporting material to disposal site.	IV. F. (63-64)	3.24
(4)	Expected maintenance requirements.	IV. C. 1. (53-56); IV. D. (59)	3.24
7855.0610	Alternatives	V. (66a-115)	Ch. 5
7855.0610(A)	Location of facility, to fullest extent known.	V. (66a-115)	5.1-5.59

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
7855.0610(B)	Required land area and height of tallest structures.	V. (66a-115)	5.1-5.59
7855.0610(C)	Design capacity in appropriate units of measure.	V. (66a-115)	5.1-5.59
7855.0610(D)	Schematic showing major components of the facility.	V. (66a-115)	5.1-5.59
7855.0610(E)	Probable date for commencing construction and probable in-service date.	V. (66a-115)	5.1-5.59
7855.0610(F)	Estimated installed cost of alternative in current dollars.	V. (66a-115)	5.1-5.59
7855.0610(G)	Sources, types and amounts of nuclear waste products that would be involved in the alternative, methods of transporting these materials and level of radioactivity of each in curies per year.	V. (66a-115)	5.1-5.59
7855.0610(H)	Estimated maintenance requirements of the alternative.	V. (66a-115)	5.1-5.59
7855.0610(I)	Estimated economic life of the facilities involved in the alternative.	V. (66a-115)	5.1-5.59

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
7855.0610(J)	Reasons why alternative was rejected.	V. (66a-115)	5.1-5.59
7855.0620	Historical and Forecast Data	XI. (133-145)	
7855.0620(A)	The amount in cubic meters of the stored material produced nationally and within Minnesota during last five calendar years.	XI. A. (133-136)	
7855.0620(B)	Year end capacity in cubic meters within Minnesota and within the United States to store materials for each of last five calendar years.	XI. B. (136-138)	
7855.0620(C)	Estimate of amount in cubic meters of the stored material expected to be produced nationally and within Minnesota during first six forecast years, the 11th forecast year and 16th forecast year.	XI. C. (139-142)	
7855.0620(D)	List of all known facilities to be added during forecast years for storing the stored material.	XI. D. (143-146)	
7855.0620(E)	Expected years during which the	XI. E. (147-148)	

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
	material stored would reach ten, 25, 50 and 100 percent of the capacity of the facility.		
7855.0620(F)	Discussion of methodology, statistical techniques and data bases used in providing forecast data.	XI. F. (149)	
7855.0620(G)	Major assumptions made in supplying historical and forecast data and a discussion of sensitivity of information to changes in the assumptions.	XI. G. (149-160)	
7855.0630	Environmental Data	V. (66a-115); VI. (116); Volume 2	Ch. 4, Ch. 5
7855.0640	Description of Proposed and Alternative Sites	VII. (117-124)	Ch. 3; Ch. 5, Ch. 6A
7855.0620(A)	Nature of terrain at the site	VII. A. (117)	3.2-3.3; 6.A1
7855.0640(B)	General soil types at the site.	VII. B. (118)	
7855.0640(C)	Types and depth of bedrock underlying the site.	VII. C. (118)	
7855.0640(D)	Depth of groundwater at the site.	VII. D. (118-119)	

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
7855.0640(E)	Types of vegetation at the site	VII. E. (119)	
7855.0640(F)	Predominant types of land use at the site and the approximate percentage of each.	VII. F. (119)	3.2
7855.0640(G)	Lakes, streams, wetlands, or drainage ditches within five miles of the site or into which liquid contaminants from the site could flow.	VII. G. (120)	
7855.0640(H)	Trunk highways, airports and air traffic corridors within five miles of the site.	VII. H. (120)	
7855.0640(I)	National Natural Landmarks, National Wilderness Areas, National Wildlife Refuges, National And Wild Scenic Rivers, National Parks, National Forests, National Trails And National Waterfowl Production Areas Within Five Miles Of The Site.	VII. I. (120-121)	
7855.0640(J)	State Critical Areas, State Wildlife Management Areas, State Scientific	VII. J. (121); Appendix 5	

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
	And Natural Areas, State, Wild, Scenic, And Recreational Rivers, State Parks, State Scenic Wayside Parks, State Recreational Areas, State Forests, State Trails, State Canoe and Boating Rivers, State Zoo, Designated Trout Streams and Designated Trout Lakes Within Five Miles Of The Site As Mapped On The Inventory Of Significant Resources By The State Planning Agency.		
7855.0640(K)	National Historical Sites And Landmarks, National Monuments, National Register Historic Districts, Registered State Historic Or Archaeological Sites, State Historical Districts, Sites Listed On The National Register Of Historic Places, And Any Other Cultural Resources Within Five Miles Of the Site As Indicated By The Minnesota Historical Society.	VII. K. (122); Appendix 5	
7855.0640(L)	Areas within five miles of the site designated by regional or local authorities as having recreational,	VII. L. (122); Appendix 5	

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
	cultural, historical or scientific significance, as indicated by local units of government.		
7855.0640(M)	Estimated total population within 50 miles of the site, and a map showing the distribution of the population within 50 miles of the site.	VII. M. (122-124); Appendix 5	
7855.0650	Wastes and Emissions	IV. E. (59-63); VIII. (125); Volume II	Ch. 3, Ch. 4, Ch. 5
7855.0650(A)	Types and estimated amounts of solid, liquid and gaseous radioactive wastes that would be produced by the facility, and the level of radioactivity of each in curies per year.	IV. E. 1 (59-60)	4.1
7855.0650(B)	Analysis of human exposure to ionizing radiation attributable to operation of the facility, taking into account pathways of radioactive releases to man.	IV. E. 2 (60-62)	4.17
7855.0650(C)	Types and amounts of nonradioactive solid and liquid	IV. E. 3. (62)	4.1

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
	wastes that would be produced.		
7855.0650(D)	Types and amounts of nonradioactive gaseous and particulate emissions into the air that would occur during full operation from each emission source and the location and nature of each source.	IV. E. 4. (62)	4.1
7855.0650(E)	Locations that may be sources of fugitive dust and the nature of each source.	IV. E. 5. (62)	4.6;4.13
7855.0650(F)	Nature and estimated amount of non-radioactive discharges to water, and the locations, routes, and final receiving waters for any discharge points.	IV. E. 6. (62-63)	4.5; 4.8-4.9
7855.0650(G)	Any area from which runoff may occur, potential sources of contamination in the area and receiving waters for any runoff.	IV. E. 7. (63)	4.5; 4.8-4.9
7855.0650(H)	Sources and estimated amounts of heat rejected by the facility.	IV. E. 8. (63)	4.13

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
7855.0650(I)	Maximum noise levels in decibels, A scale, expected at the property boundary and the expected maximum increase over ambient noise levels.	IV. E. 9. (63)	4.6; 4.13
7855.0660	Pollution Control and Safeguards Equipment	IX. (126-130)	
7855.0660(A)	Provisions made for management of radioactive materials.	IX. (126)	
7855.0660(B)	Description of contingency plans to reduce the effects of an accidental release of radioactive materials.	IX. (126-127)	
7855.0660(C)	Methods to be used to recycle or dispose of solid or liquid wastes.	IX. (127-128)	
7855.0660(D)	Types of emission control and dust control devices to be used.	IX. (128)	
7855.0660(E)	Types of water pollution control and runoff control equipment to be used.	IX. (128)	4.5, 4.8-4.9
7855.0660(F)	Measures to be taken to prevent spills or leaks of pollutants or to	IX. (128-129)	

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
	minimize the effects of spills or leaks on the environment.		
7855.0660(G)	Methods to be used to reject the effects of heat rejected by the facility.	IX. (129)	
7855.0660(H)	Other equipment or measures to be used to reduce the effects of the facility on the environment.	IX. (129-130)	
7855.0660(I)	Types of environmental monitoring, if any, that are planned for the facility and a description of any relevant monitoring data already collected.	IX. (130)	
7855.0670	Estimates of Induced Development	X. (131)	4.26-4.27
7855.0670(A)	Types and amounts of vehicular traffic that would be generated by the facility due to construction activity and operational needs.	X. (131)	
7855.0670(B)	Workforces required for construction and operation of facility.	X. (131)	

Minnesota Rules, Part	Information Required	Section and page of Application	Section and page of EIS
7855.0670(C)	Extent to which the facility would create or add to the need for expanded utility or public services.	X. (132)	
7855.0670(D)	Amount of water to be apportioned and the amount to be consumed, the expected sources and uses of the water.	X. (132)	
7855.0670(E)	Amount of agricultural land that would be removed from agricultural use if the facility were constructed, and known circumstances associated with the facility that could lead to reduced productivity of surrounding agricultural land.	X. (132)	
7855.0670(F)	Number of people that would have to relocate if the facility were constructed.	X. (132)	

BEFORE THE MINNESOTA PUBLIC UTILITIES COMMISSION

Darrel Peterson	Chair
Cynthia Kitlinski	Commissioner
Dee Knaak	Commissioner
Norma McKanna	Commissioner
Patrice Vick	Commissioner

In the Matter of the Application
of Northern States Power Company
for a Certificate of Need for a Temporary
Spent Nuclear Fuel Storage Facility
for the Prairie Island Nuclear Generating Plant

Docket No. E-002/CN-91-19

APPLICATION FOR A CERTIFICATE OF NEED

Dated: April 29, 1991

TABLE OF CONTENTS

BEFORE THE MINNESOTA PUBLIC UTILITIES COMMISSION

Darrel Peterson	Chair
Cynthia Kitlinski	Commissioner
Dee Knaak	Commissioner
Norma McKanna	Commissioner
Patrice Vick	Commissioner

In the Matter of the Application
of Northern States Power Company
for a Certificate of Need for a Temporary
Spent Nuclear Fuel Storage Facility
for the Prairie Island Nuclear Generating Plant

Docket No. E-002/CN-91-19

APPLICATION FOR A CERTIFICATE OF NEED

I. INTRODUCTION

This application ("Application") by Northern States Power Company ("NSP") is for a certificate of need from the Minnesota Public Utilities Commission ("Commission") granting authority to develop additional on-site temporary storage capacity for spent nuclear fuel from the Prairie Island Nuclear Generating Plant ("PI"). More specifically, NSP seeks Commission authority to install up to 48 dry metal casks which will temporarily store spent fuel until such time as the United States Department of Energy ("DOE") removes the spent fuel for permanent storage or disposal at a federal repository. The casks will be placed in an Independent Spent Fuel Storage Installation ("ISFSI"). The casks and the ISFSI will be collectively referred to in this Application as the Dry Cask Storage Facility.

This Application is made pursuant to Minn. Stat. § 216B.243 (1990) and Minn. Rules pt. 7855 (1989). It contains the information required by the statute and rules along with additional information explaining the need for and appropriateness of the dry metal cask storage technology selected by NSP to temporarily store the spent fuel. Because of the numerous statutory and rule requirements, this Application cannot effectively be provided in a "question and answer" format. However, NSP recognizes the possibility of a contested case hearing on this Application pursuant to Minn. Stat. § 216B.243, subd. 4 (1990). Therefore, attached to this Application is the prefiled testimony by those persons who will testify in its support if there is a contested case hearing. The testimony sets forth each witness' credentials and the portions of the Application on which the witness is competent to testify. The witnesses and their areas of responsibility with regard to the Application are as follows:

Ms. Laura McCarten, NSP Project Manager, will be available to testify on the operational need for additional temporary storage capacity; the operation of the casks at PI; the selection of the dry metal cask storage technology and the designer of the technology, Transnuclear, Inc.; the cost estimates for the project; the additional regulatory proceedings which apply to the Dry Cask Storage Facility; the retirement process for the Dry Cask Storage Facility; and the alternatives to the Dry Cask Storage Facility with dry metal cask storage technology that NSP rejected.

Mr. Charles W. Pennington, Vice President, Transnuclear, Inc., will be available to testify on the design, construction and operation of the selected dry metal cask storage technology, the TN-40 cask.

Ms. Glynis A. Hinschberger, NSP Manager of Power System Strategic Planning, will be available to testify on the role of PI in providing energy within the NSP generating system.

Mr. Michael H. Schwartz, Energy Resources International, Inc., will be available to testify on DOE plans for nuclear waste storage and disposal facilities; and on national forecasts of nuclear waste production.

Mr. James H. Gamble, NSP General Manager of Electric Marketing, will be available to testify on NSP's conservation plans and efforts.

Mr. Jeffrey C. Robinson, NSP Director of Capital Asset Accounting, will be available to testify on the status and proposed use of an internal sinking fund to pay for the Dry Cask Storage Facility.

Dr. Jacob I. Fabrikant, Consultant and Professor at University of California at Berkeley, will be available to testify on radiological impacts of radioactive wastes and emissions from the Dry Cask Storage Facility. Dr. Fabrikant will also be available to testify on the Health Risk Assessment performed by the Minnesota Department of Health for the Environmental Impact Statement for the ISFSI.

NSP reserves the right, as necessary, to provide additional information or witnesses depending on the interests and concerns of the Commission and the intervenors.

A. General Information Required By Minn. Rule Pt. 7855.0230.

This Application is submitted by Northern States Power Company which has an address of 414 Nicollet Mall, Minneapolis, Minnesota 55401; the telephone number is (612) 330-5500. The Standard Industrial Code for NSP is 4911. NSP is in the business of generating and distributing electric energy to residential and business customers within NSP's assigned service territory.

The contact persons for this filing are:

Ms. Kimberly J. Erickson
Manager of Regulatory Relations
414 Nicollet Mall
Minneapolis, MN 55401
Telephone: (612) 330-7985

Mr. Michael J. Bradley
Moss & Barnett
A Professional Association
4800 Norwest Center
90 South Seventh Street
Minneapolis, MN 55402-4119
Telephone: (612) 347-0337

B. Description Of The Dry Cask Storage Facility.

To assure PI's continued full operation after January 31, 1995, NSP plans to build a Dry Cask Storage Facility on the PI site near Red Wing, Minnesota. The Dry Cask Storage Facility consists of two components. The first component is the cask, which is a large (16' 10" tall and 8' 6" wide), heavy (approximately 122 tons when loaded), fully sealed metal cask with an internal basket for holding spent fuel assemblies. The cask walls are 9½" of steel. It is called a dry cask because, in contrast to the current spent fuel pool which uses water to cool the spent fuel, the casks are filled with the inert gas helium. This Application seeks authority to construct a facility with the ability to hold 48 casks. The second component is the ISFSI, an on-site storage facility which includes two large cement pads and is enclosed by a security fence. The casks are stored on the concrete pads.

Dry storage of spent fuel is an effective way to supplement pool storage. Although pool storage will continue to be necessary for recently discharged spent fuel, dry storage is an economical and safe method for storing spent fuel which has been discharged from the reactor core and has cooled for ten or more years. Dry storage is desirable because it provides the protection and security required for public health and safety; maximizes occupational health and safety; can be used without significant changes in PI's existing plant facilities; can be accomplished without affecting power generation; is operationally efficient; is economical in comparison to other alternatives; and can be installed incrementally, on an as-needed basis.

NSP proposes to use TN-40 metal storage casks. The designation "TN" refers to Transnuclear, Inc., which designed the casks; 40 refers to each cask's capacity to store 40 PI spent fuel assemblies. A fuel assembly holds 179 uranium dioxide rods, which are used to create the nuclear reaction that produces the energy needed to create steam and generate electricity at PI.

The casks are designed to withstand severe environmental conditions and natural phenomena such as earthquakes, tornadoes, lightning, hurricanes and floods. Additionally, the casks are designed to remain safe and provide confinement of the spent fuel during loading, handling, and storage under normal and accident conditions.

Diagrams of the proposed ISFSI and the TN-40 cask are located in the Environmental Impact Statement ("EIS") in Volume 2 of this Application at pages 3.33, 3.39 and 3.40. A more complete description of the TN-40 cask design and fabrication process is provided in Section IV of this Application.

Pursuant to Minn. Rule pt. 7855.0210 (E) the total fee for processing this Application is $20,000.00, of which fifty percent is due with the Application. A draft for $10,000.00 accompanies this Application.

C. The Regulatory Review Process.

NSP is seeking regulatory approval of its Dry Cask Storage Facility from both the Commission and the United States Nuclear Regulatory Commission ("NRC"). The following briefly explains the important roles of the separate regulatory processes.

1. The Certificate-Of Need-Proceeding.

The purpose of this certificate-of-need proceeding is to obtain Commission authorization to increase PI's temporary spent fuel storage capacity by installing a Dry Cask Storage Facility which may hold up to 48 casks.

To assist the Commission in deciding whether to grant that authority, NSP is presenting, pursuant to the Commission's rules, a significant amount of information detailing why NSP needs additional storage capacity; the alternatives that have been studied to meet that need; the environmental and economic consequences of each alternative; why dry cask storage is the superior alternative; and a full description of the specific dry cask storage technology selected by NSP. In addition, to assist in evaluating the environmental concerns associated with the project, in December 1989 NSP voluntarily requested the Environmental Quality Board ("EQB") to prepare an EIS, which is attached to and incorporated into this Application as Volume 2. The EIS is an informational tool that serves an advisory function and provides an extensive environmental review and evaluation of NSP's proposed Dry Cask Storage Facility and of all significant alternatives.

In evaluating the significant alternatives for spent fuel storage, an important limitation is the Commission's rule that an alternative will not be selected:

> ...that could reasonably be expected to result in a forced shutdown of the generating facility.

Minn. Rule pt. 7855.0100. The purpose of this limitation is to narrow the scope and purpose of the certificate-of-need proceeding to the study of spent fuel storage alternatives. As a result, the need for and appropriateness of continued operation of PI is not at issue in this proceeding. Therefore, any alternative must be consistent with the continued operation of PI.

Based on this Application, as supplemented with the EIS, the proposed Dry Cask Storage Facility is the most reasonable, viable alternative which meets the need to continue operating PI in an economic and safe manner.

2. The NRC Proceeding.

While this certificate-of-need proceeding will determine whether additional temporary storage facilities are needed and the type of storage needed, the NRC is charged with the responsibility of assuring the safety and environmental integrity of NSP's proposed Dry Cask Storage Facility and related operating procedures.

The responsibilities of the NRC and of state agencies such as the Commission in regulating nuclear facilities were described by the United States Supreme Court in Pacific Gas & Electric Co. v. State Energy Resources Conservation & Development Comm'n, 461 U.S. 190, 211-12 (1982):

> Congress has preserved the dual regulation of nuclear-powered electricity generation: the Federal Government maintains complete control of the safety and "nuclear" aspects of energy generation; the states exercise their traditional authority over the need for additional generating capacity, the type of generating facilities to be licensed, land use, ratemaking and the like.

Accord NSP v. Minnesota, 447 F.2d 1143 (8th Cir. 1971), aff'd 405 U.S. 1035 (1972).

NSP filed its NRC application in August, 1990 for a 20-year Part 72 license to construct and operate a Dry Cask Storage Facility at PI. The NRC is responsible for reviewing the design of the Dry Cask Storage Facility to ensure its safety and environmental integrity, based upon a determination that the facility meets the NRC's requirements contained in 10 CFR pt. 72 with respect to design, operation, and decommissioning. The license application includes a Safety Analysis Report, which contains detailed design and analysis information for the cask and ISFSI, and an Environmental Report and Technical Specifications for the Dry Cask Storage Facility. Among other things, the safety analysis considers normal radioactive emissions and accident scenarios. The NRC review period is expected to last at least 1-1/2 years and be completed in early 1992.

3. Conclusion.

In recognition of the purpose of this certificate-of-need proceeding, the Application will focus on the need for additional temporary storage and the reasonableness of meeting that need through a Dry Cask Storage Facility. This Application will not seek a Commission ruling on issues relating to:

a) radiological safety;

b) the construction and safety of the casks;

c) safety considerations in the operation of the cask storage process.

However, NSP recognizes the Commission's and intervenors' likely interest in information related to these issues and will address these issues as appropriate.

D. Schedule Of Other Filings.

Minn. Rule pt. 7855.0240 requires a listing of all known federal, state and local agencies with which NSP must file information concerning the proposed Dry Cask Storage Facility. There are six such filings.

1) As already discussed, the NRC has been asked to grant NSP a license for the Dry Cask Storage Facility under 10 CFR pt. 72. The application to the NRC was filed on August 31, 1990. A decision on the application is pending and is expected on or about February 1, 1992.

2) NSP will file an amendment to the PI plant operating license with the NRC to reflect the upgrade of the auxiliary building crane to handle the casks. Application for an amendment will be filed on or about August 30, 1991. An NRC decision on the amendment is expected by the summer of 1992.

3) The Commission has been asked to grant a certificate-of-need, pursuant to Minn. Stat. § 216B.243 (1990). The Application to the Commission was filed in April 1991. A decision on the Application is pending and is expected later this year.

4) The EQB, with the consent of NSP, was asked to prepare an EIS on December 21, 1989. On May 17, 1990, the final scoping document was approved by the EQB. The Draft EIS was issued on November 30, 1990, and a decision on the adequacy of the Final EIS, a copy of which is contained in Volume 2 of the Application, is anticipated in May, 1991.

5) NSP will request a building permit from the City of Red Wing. Application for the permit will occur before construction begins.

6) An application may be filed with the Minnesota Department of Health ("MDH") for a construction permit. The application would be filed at least sixty (60) days before construction begins with a permit to be issued before construction begins. NSP reserves the right to challenge the validity of any MDH proceeding as not being authorized by statute

and/or in conflict with the NRC's duties to regulate nuclear generating plants and associated facilities.

II. A SUMMARY OF THE NEED FOR ADDITIONAL TEMPORARY STORAGE CAPACITY (PROVIDED PURSUANT TO MINN. RULES PT. 7855.0250).

Existing temporary storage capacity in the on-site spent fuel pool at PI is adequate to allow normal plant operation through January, 1995. Provision for additional temporary storage of spent fuel is necessary for continued plant operation after January 31, 1995. This section summarizes: 1) the major factors that justify the need for NSP to obtain additional storage capacity for its spent fuel; 2) the impact of shutting down PI if additional temporary storage capacity is not increased; 3) the key role of PI in the NSP generation system now and in the future; and 4) the characteristics and features of a Dry Cask Storage Facility.

A. Additional Temporary Storage Capacity Is Needed.

NSP operates two nuclear generating plants (PI and Monticello). As the nuclear fuel assemblies used to operate those plants exhaust their generating capabilities, it is necessary to remove the fuel assemblies from the nuclear reactors and provide temporary storage for the spent fuel. Currently, NSP uses a spent fuel pool at each reactor site to store spent fuel. The DOE is obligated under federal law to construct and operate a permanent repository for spent fuel disposal and to remove the spent fuel from PI and Monticello. Thus, NSP's need to add spent fuel storage capacity ceases once a DOE facility becomes operational and the DOE removes the spent fuel from PI.

The DOE permanent repository is not expected to be available prior to the year 2010. NSP's current temporary storage capacity is not sufficient to allow continued full operation of PI beyond January 1995. To meet its needs until the DOE permanent repository or a federal temporary storage facility (referred to as monitored retrievable storage or "MRS") is available and the DOE begins removing the spent fuel, NSP proposes to construct a Dry Cask Storage

Facility which will, depending on when DOE begins removing the spent fuel from PI, hold between 24 and 48 casks.

PI has two pressurized water nuclear reactor units ("PWR"), each holding 121 fuel assemblies. On an approximate 16-month cycle, each unit has a planned outage for the purpose of refueling. With each outage, 48 fuel assemblies (on average) are removed from the unit and replaced with new fuel assemblies. The spent fuel assemblies are moved to the spent fuel pool within the plant for temporary storage. Spent fuel assemblies are removed from the unit because they are no longer able to efficiently sustain normal reactor operation. However, useful fissionable materials remain in the spent fuel and could be recycled into new fuel. For this reason the nuclear industry originally planned, following short-term storage, to send spent fuel to nuclear fuel reprocessing facilities to extract the energy resources remaining in the spent fuel.

PI's original pool storage capacity was based on the concept that the pool would hold a 40-assembly discharge from each reactor during a 60 to 120-day holding period prior to shipment for reprocessing. In addition, there was capacity for one entire reactor's fuel (121 assemblies) in the event there was ever a need to remove all of the fuel from one reactor for equipment inspection or modification (full core discharge).

However, it became apparent in the mid 1970s that reprocessing facilities would not be available before existing storage capacity in PI's pool was exhausted. In addition, in 1977, President Carter instituted a federal policy prohibiting commercial reprocessing. In response to these events, modifications to the racks used to store spent fuel, called "reracking," were conducted at PI in 1977 and again in 1981 to increase the pool storage capacity.

Page 5.57 of the EIS contains an overhead view of the pool, showing the configuration of spent fuel storage racks within the pool and the cask set-down area. The cask set-down area must be reserved in order to permit spent fuel to be removed from the pool, either for transfer to other temporary storage or for shipment off-site for permanent disposal. PI's current NRC plant license permits long-term storage of up to 1386 spent fuel assemblies in the pool. As a result of a rod consolidation project described later in this Application, it became necessary to store portions of the old fuel assembly hardware in the pool. In addition, pool storage capacity has been reduced because some of the rack storage locations are either inaccessible or are being used to store non-fuel radioactive waste. As a result, the pool's actual capacity is 1354 spent fuel assemblies. As of April 25, 1991, 1085 spent fuel assemblies will be stored in the pool. PI anticipates needing additional storage capacity as of February 1, 1995. On that date, the pool cannot accept the spent fuel from the refueling outage of Unit 2 and that unit would be shut down. On October 4, 1995, Unit 1 would similarly be shut down because of the inability to store the spent fuel from its refueling outage in the pool.

To prevent plant shutdown, NSP must develop additional temporary storage capacity. As is explained in later sections of this Application, the best method to meet PI's additional temporary storage needs is a Dry Cask Storage Facility.

B. Financial Impact If PI Ceased Operation.

The removal of PI from the NSP generation system would significantly increase costs to NSP's ratepayers. Each PI reactor has a nominal rating 530 of MWe. These baseload units produced more than 7.6 million megawatt-hours ("MWh") of electricity in 1990, which was about 20% of NSP's total electrical needs. This contribution of the PI plant to NSP's system is typical of the contribution made each year since both units became operational. PI is one of NSP's least expensive plants to operate and so it is the first plant to be dispatched to meet customers' energy requirements when it is available.

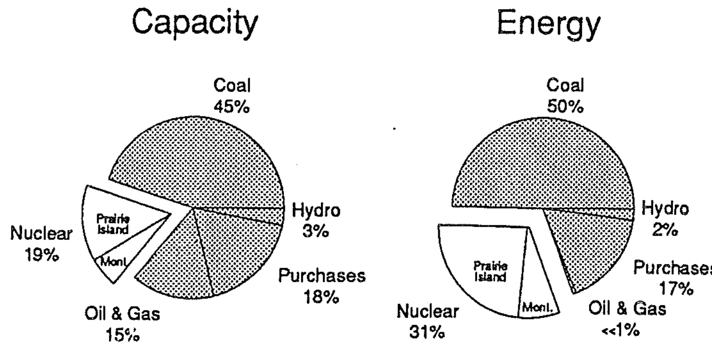
The current annual depreciation and decommissioning expense for the PI plant is approximately $40.3 million. If PI is prematurely shut down, those expenses will continue, but without the offsetting benefit of low-cost energy. Further, NSP would need to obtain replacement capacity and energy to meet customers' needs.

The full financial impact of a shutdown of the PI plant in 1995 is discussed in detail later in this Application. In summary, such a shutdown would increase NSP's future revenue requirements by more than $1 billion (present worth 1990 dollars). The $1 billion represents the estimated dual cost of purchasing replacement capacity and energy and eventually constructing and operating replacement capacity. This would represent a significant and unnecessary expense for NSP ratepayers and adversely impact the economic development of those areas served by NSP.

If PI were shut down in 1995, NSP would initially have to replace the capacity and energy provided by the plant with capacity and energy purchases from other utilities and/or accelerate construction of additional capacity and increase operation of existing fossil-fueled capacity. It is uncertain whether NSP would be able to purchase all of the energy and capacity needed to replace PI. There is increasing uncertainty about the availability of baseload capacity and energy purchases from Mid-Continent Area Power Pool ("MAPP") utilities and utilities in the surrounding region by the mid-1990s. Consequently, NSP would increase the risk of not being able to fully meet customer demand while costs would increase due to expensive energy purchases and increased reliance on existing oil and gas-fired generation. The earliest NSP could bring on line replacement baseload resources would be in the late 1990s (assuming NSP began the licensing process for new capacity in 1991). As is discussed in detail below, demand side management ("DSM") is not a viable alternative for replacing PI. NSP's aggressive DSM effort (1,000 MW by 1995) is needed to meet forecasted future growth in demand. DSM is not a replacement for PI's capacity because of PI's size and low energy cost. Additional costs would result from increased production from fossil-fueled plants and mothballing or premature decommissioning of PI. These issues are discussed further as part of the no action alternative to a Dry Cask Storage Facility. In addition, socioeconomic impacts would be felt in southeastern Minnesota if PI were shut down. NSP currently pays approximately $17 million in annual property taxes at PI. The plant employs almost 400 workers, with an annual payroll of approximately $27 million. As is demonstrated in the following subsection, PI has consistently and reliably provided safe, low-cost energy. Therefore, it is in the ratepayers' best interest for PI to continue operating.

C. Role Of PI In NSP's Generation System.

NSP's existing generation system is made up of a diverse mix of supply resources: nuclear and coal-fired baseload plants, hydro, wood and refuse-derived fuel ("RDF") plants, oil and gas-fired peaking plants, and power purchases from other utilities and non-utility power producers. Figure 1 shows the contribution of each type of resource to NSP's system in terms of capacity and annual energy production, based on actual operation in 1990.



Data based on actual 1990 operation
Coal includes wood & RDF-fired plants

Figure 1-NSP Resource Mix

NSP's nuclear generation plants generally produce electricity at a lower cost than fossil-fueled plants or energy available for purchase. Because of their low energy production cost, NSP's nuclear generation plants are dispatched before all fossil-fueled capacity and consequently are fully utilized at all times, except during outages for maintenance or refueling. This high utilization of NSP's nuclear generation plants explains why they produced 31% of NSP's energy in 1990 while comprising only 19% of NSP's capacity. PI alone accounts for almost two-thirds of NSP's nuclear capacity and in 1990 produced almost 20% of NSP's total energy requirements. Figure 2 compares the energy production cost at PI to that from other NSP plants, based on 1990 operation.

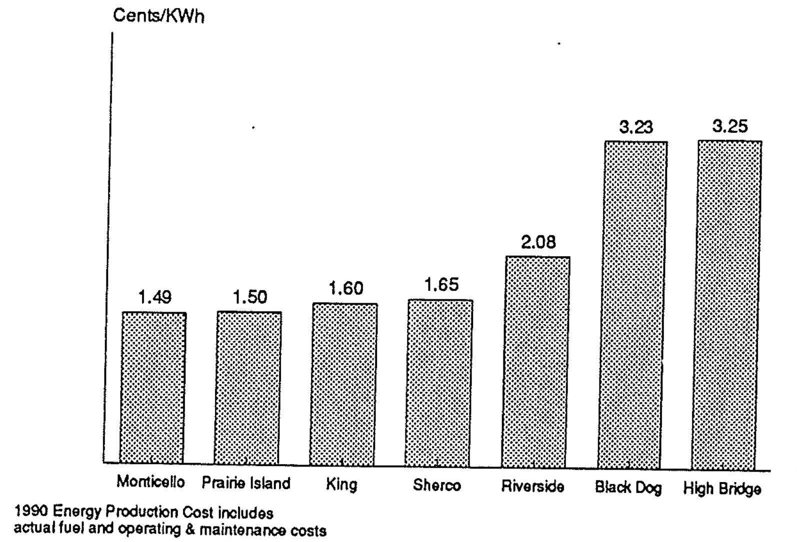


Figure 2-1990 Energy Production Cost

The PI units, since they began operation, have been world leaders in safety, efficiency, and reliability. Further, PI has maintained worker radiation exposure levels and low-level radioactive waste output volumes that are among the lowest of any operating nuclear plants in the world. Lando Zeck, former chairman of the Nuclear Regulatory Commission, said if all plants were as well run as PI, the future of nuclear power in the United States would be assured. In a recent world-wide comparison of nuclear plants done by Nuclear News magazine, there were only two reactor units in the United States that ranked in the top ten for load factor. Those two units were the two reactors at PI. (Load factor is the ratio of the average load in kilowatts carried by an electric power plant during a specific period compared to its peak load during that period. A high load factor is an indication of an efficient, reliable power plant.) PI Unit 2 ranked second in the world with a three-year average load factor of 93.0 percent, while Unit 1 ranked seventh with a load factor of 89.2 percent. The median load factor for United States nuclear units was 69.4 percent.

Nuclear plant operators from around the world, including Great Britain and the Soviet Union, have come to PI to see how the plant keeps worker radiation exposure so low year after year. In 1989, for example, PI had a per-unit cumulative worker exposure total of 71.2 person-rem. That compares to a U.S. industry average of 292 person-rem per unit.

PI also leads the industry in keeping the volume of low-level radioactive waste ("LLRW") it produces low. Compared to a U.S. industry 1989 average of 167 cubic meters a year per unit, PI produced just 50 cubic meters. Most importantly, PI consistently leads the industry in these key measures year after year. Statistics on worker exposure and LLRW production are taken from studies done by the Institute of Nuclear Power Operations ("INPO"). INPO is an industry-sponsored, self-regulating organization with the purpose of achieving excellence in nuclear plant operation.

INPO has given the two units at PI its highest rating. Only 15 units in the United States currently have that rating. PI has received this rating three times, and NSP is the first nuclear utility in the U.S. to have all its nuclear plants receive INPO's highest rating in the same year.

The NRC agrees with other outside groups in its assessment of PI's performance. In the agency's Systematic Assessment of Licensee Performance ("SALP"), both PI units consistently rank in the top quartile of all operating nuclear plants in NRC's Region 3. PI currently is tied for second among the 13 plants in Region 3.

PI's world-class performance has not come at the expense of low-cost power production. In a 1989 report on power plant operating expenses prepared by the Utility Data Institute, PI was listed as the nation's second lowest-cost electricity producer among 559 U.S. power plants from 1982 to 1986, and again in 1989. Perhaps PI's most significant aspect is its consistent excellent performance year after year for the more than 15 years the plant's reactor units have been running.

D. Forecast Of Future Resource Needs.

NSP's July 1990 long-range forecast of electric peak demand and energy requirements was filed with the EQB and the Department of Public Service ("Department") pursuant to the requirements of Minn. Stat. §§ 116C.54 and 216C.17. The forecast is composed of several scenarios which describe a range of possible outcomes for future electric use. Figure 3 graphically shows the probabilities of energy and peak demand forecasts for five scenarios. The semi-high and semi-low forecasts bound the middle 30% of probability for future sales (15% on either side of the median forecast). NSP uses the semi-low to semi-high forecast range in its planning process to capture uncertainty in future resource needs. The high and low forecasts capture 50% of the probable energy demand (with 25% band of uncertainty on either side).

The forecast shown in Figure 3 includes adjustments to account for the effects of NSP's DSM program. As is discussed below, DSM programs are expected to reduce peak demand by

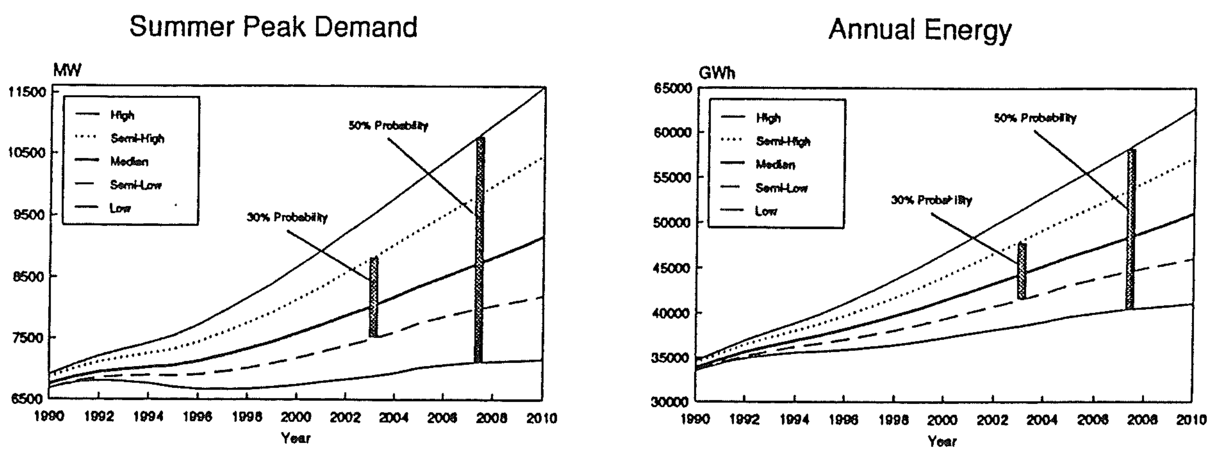


Figure 3-NSP System Range Electric Forecast (April 1990)

more than 1000 MW by 1995, and by more than 2000 MW by 2010.

Figure 4 shows how NSP's current committed capacity resources compare to requirements under the semi-low and semi-high forecast scenarios which capture a manageable range of uncertainty in future resource needs.

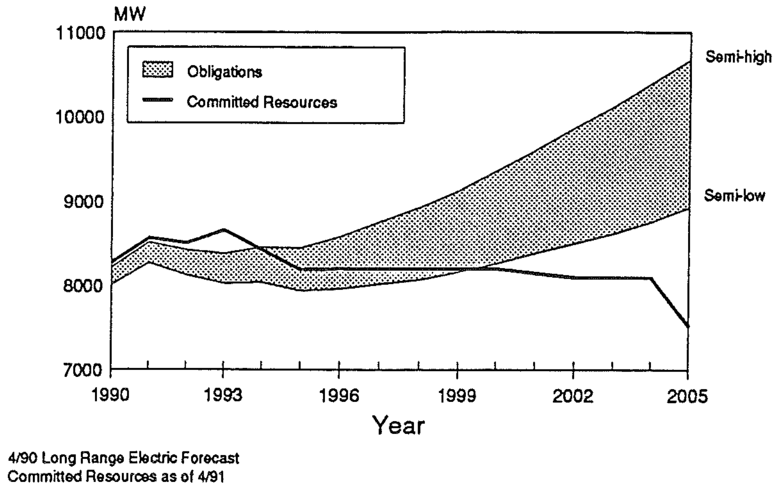


Figure 4-NSP Obligations and Committed Resources

Under each of these forecast scenarios, even after accounting for aggressive DSM programs, NSP needs long-term, on-going additional capacity resources beginning in the 1990s. Despite its DSM programs, NSP will require additional capacity resources by the mid-1990s under the semi-high forecast and by 2000 under the semi-low forecast. The following table summarizes NSP's nominal capacity resource needs for the semi-low to semi-high ranges.

Table 1

Capacity Resource Needs (in megawatts)

	1994	1998	2002
Estimated Obligations	8000-8500	8100-8900	8500-9900
Committed Resources	8400	8200	8100
Estimated Resource Need	0-100	0-700	400-1800

Since new capacity resources are likely to be required in the next decade, additional conservation would not reduce NSP's need for existing resources, such as PI. Rather, additional conservation would only continue deferring the need for new facilities. Further, additional conservation would not affect the dispatch order in which plants are called upon to provide energy. As Figure 2 demonstrates, NSP's nuclear plants are the first plants called upon to provide baseload generation because of their low production cost. Therefore, while conservation beyond NSP's DSM programs might reduce the use of existing fossil-fueled power plants or delay the need for construction of additional plants or transmission lines, it will not change the need for or use of NSP's existing nuclear plants.

E. Why NSP Selected A Dry Metal Cask Storage Technology.

The reasons for selecting a Dry Cask Storage Facility to meet NSP's additional temporary storage needs are discussed at length in the EIS, and in the section of this Application addressing alternatives to using a TN-40 cask. To summarize:

1. Dry cask storage is a proven and safe technology.

2. Dry cask storage offers an economical method of providing temporary storage.

3. Dry cask storage is operationally superior to additional spent fuel pool storage because dry metal storage casks are a completely passive storage technology with no active support systems, such as pumps, heat exchangers or water purifiers to maintain.

4. A Dry Cask Storage Facility provides optimal flexibility. NSP can order and install casks as needed to meet its storage needs.

5. Further efforts at expanding pool storage would hinder the operation of PI.

6. A Dry Cask Storage Facility is a well-established and fully approved method for temporary storage.

7. To date, most of the nuclear plants with additional temporary storage needs similar to PI's have selected an on-site ISFSI using a dry storage technology. Those electric utilities include: Virginia Power's Surry Plant; Carolina Power and Light's H.B. Robinson Plant; Duke Power's Oconee Plant; Baltimore Gas and Electric's Calvert Cliffs Plant; Consumers Power's Palisades Plant; and Wisconsin Electric Power's Point Beach Plant.

A Dry Cask Storage Facility incorporating the TN-40 casks meets all of NSP's needs for a safe, economic, flexible, operationally simple, technologically proven and temporary storage methodology. Dry cask storage even has the support of Public Citizen, a group generally opposed to nuclear power. Its September, 1989 report entitled Nuclear Legacy, states at page 14:

> If existing on-site irradiated fuel storage capacity is insufficient, the reactor should be shut down, or dry cask storage should be implemented.
>
> In the absence of a permanent solution to irradiated fuel disposal, the least

of all evils is probably the implementation of on-site fuel storage with dry cask technologies.

In summary, NSP's Prairie Island Nuclear Generating Plant is a safe, economical producer of large amounts of baseload electricity. It is, simply stated, one of NSP's workhorses. The plant needs additional temporary storage space for spent fuel because the federal government has not yet built a permanent repository. Without additional storage space, PI must shut down in 1995. While NSP's aggressive DSM programs will make a sizeable contribution to meeting future electric needs (1000 MW by 1995), conservation cannot also be relied upon to replace a large, continuously operated plant such as PI. Dry cask storage is a simple, safe, economical option to meet PI's needs. Casks can be ordered and installed as needed, thereby maintaining flexibility and minimizing costs.

III. PI NEEDS ADDITIONAL TEMPORARY SPENT FUEL STORAGE CAPACITY.

This section of the Application addresses the two factors behind NSP's need for additional temporary storage capacity: 1) NSP's existing temporary storage capacity will become inadequate in 1995; and 2) DOE has not yet developed an off-site storage facility for the PI spent fuel.

A. The Need For Additional Temporary Spent Fuel Storage Capacity.

Each PI reactor unit holds 121 fuel assemblies. Each of PI's two units operate for about 16 months before refueling. At each refueling, approximately 48 spent fuel assemblies are discharged and replaced with new fuel assemblies. In this Application, the term "cycle" refers to the period of reactor operation between refueling outages. Each fuel assembly is used for 2 or 3 cycles, until it has achieved burnup levels of 40,000 to 45,000 Megawatt days/metric tons uranium ("MWD/MTU"). As the term "burnup" implies, as the fuel is used its ability to generate a nuclear reaction at the required intensity decreases and therefore it must eventually be replaced. This process results in a spent fuel discharge rate on average of about 70 assemblies per year.

As of April 25, 1991, there will be a total of 1085 spent fuel assemblies stored in the spent fuel storage pool at PI. The plant license allows a maximum of 1386 fuel assemblies stored in the pool, but the true storage capacity is 1354 assemblies. The reduced storage capacity has resulted because some of the rack storage locations are either inaccessible or are being used to store non-fuel radioactive waste. Table 2 shows the accumulation of spent fuel with each subsequent outage.

Table 2

Prairie Island Nuclear Generating Plant Spent Fuel Accumulation

PI 1 CYCLE	PI 2 CYCLE	BOC DATE	EOC DATE	DISC FUEL	ACCUM FUEL
12		05/28/87	08/24/88	48	937
	12	02/13/88	03/28/89	48	985
13		09/28/88	01/02/90	48	1033
	13	04/30/89	09/10/90	52	1085
14		02/27/90	06/05/91	48	1133
	14	10/10/90	02/19/92	52	1185
15		07/02/91	11/04/92	48	1233
	15	03/25/92	09/08/93	48	1281
16		12/09/92	04/13/94	48	1329
	16	10/13/93	02/01/95	48	1377
17		06/01/94	10/04/95	48	1425
	17	03/22/95	07/24/96	48	1473
18		11/08/95	03/12/97	48	1521
	18	08/28/96	12/24/97	48	1569
19		04/16/97	08/19/98	48	1617
	19	01/28/98	05/26/99	48	1665
20		09/28/98	01/30/2000	48	1713
	20	06/30/99	10/26/2000	48	1761
21		03/10/2000	07/11/2001	48	1809
	21	11/30/2000	03/29/2002	48	1857
22		08/20/2001	12/21/2002	48	1905
	22	05/03/2002	08/30/2003	48	1953
23		01/30/2003	06/01/2004	48	2001
	23	10/04/2003	01/30/2005	48	2049
24		07/11/2004	11/12/2005	48	2097
	24	03/06/2005	07/03/2006	48	2145
25		12/22/2005	04/24/2007	48	2193
	25	08/07/2006	12/04/2007	48	2241
26		06/03/2007	10/03/2008	48	2289
	26	01/08/2008	05/06/2009	48	2337
27		11/12/2008	03/15/2010	48	2385
	27	06/10/2009	10/07/2010	48	2433
28		04/24/2010	08/26/2011	48	2481
	28	11/11/2010	03/09/2012	48	2529
29		10/05/2011	02/04/2013	48	2577
	29	04/13/2012	08/10/2013	48	2625
30		03/16/2013	07/17/2014	121	2746
	30	09/14/2013	01/11/2015	121	2867

BOC=Beginning of Cycle
EOC=End of Cycle

Because of the refueling schedules listed in Table 2, as of February 1995, NSP would be forced to cease operating one of the units because of the inability to remove spent fuel and store it in the spent fuel pool. As of October 1995, NSP would similarly be forced to shut down the second unit.

B. The DOE Will Not Have A Spent Fuel Storage or Disposal Facility Available By 1995.

The Dry Cask Storage Facility proposed by NSP is designed to provide additional temporary storage in increments of 40 fuel assemblies. This provides optimal flexibility and allows NSP to obtain only the storage needed until the DOE begins removing spent fuel from PI for shipment to a monitored retrievable storage ("MRS") facility or a permanent repository. This section of the Application explains the efforts of Congress and DOE to provide a storage or disposal facility, and explains DOE's current projections that an MRS facility will be available in 1998 and the permanent repository facility will be available in approximately the year 2010.

1. A Historical Perspective.

When the majority of the commercial nuclear power plants in the United States were being designed and built during the 1970s, it was anticipated the spent fuel would be stored in on-site spent fuel storage pools for an initial cooling period of less than two years. The spent fuel was then to be transferred to a reprocessing facility to recover the energy potential from the fissile isotopes that remain in the spent fuel. Therefore, a majority of United States nuclear power plants were built with relatively small spent fuel storage pools.

The reprocessing option was effectively eliminated during the late 1970s, when President Carter issued a ban on commercial reprocessing. This left utilities without this option for spent fuel disposal and with inadequate spent fuel storage capacities to reach the end of their nuclear power plants' designed operating lives. In October 1977, the federal government announced it would accept, take title to, and dispose of spent fuel from commercial nuclear plants for a fee. At that time, the target date to begin accepting spent fuel for disposal was 1983.

In the interim, utilities needed to develop additional temporary storage capacity. The easiest method was to replace the racks used to store spent fuel in the pools. This process came to be known as "reracking." New spent fuel storage racks incorporating smaller spacing between spent fuel assemblies replaced the older storage racks and increased spent fuel pool storage capacities. NSP initiated a reracking of its nuclear fuel at PI in 1977 and again in 1981.

In 1982, Congress passed the Nuclear Waste Policy Act ("NWPA"). It directs DOE to begin accepting spent fuel from civilian reactors for disposal in a permanent repository by 1998. The NWPA expressly states the storage of spent fuel until that time remains the responsibility of the individual utilities. In response to that directive, DOE intensified its study of various facility sites. It eventually narrowed the study to three sites. Congress amended the NWPA by passing the Nuclear Waste Policy Act Amendments in 1987 ("NWPAA"). The NWPAA directs DOE to study only one permanent repository site, Yucca Mountain in Nevada, which would be used for deep geologic disposal of spent fuel. Site specific activities at two other sites in Texas and Washington State were phased out. Subject to various conditions, the NWPAA also authorizes the siting, construction, and operation of an MRS facility to store spent fuel temporarily until the permanent repository becomes available for spent fuel disposal.

In accordance with the NWPAA, construction of an MRS facility may not begin until a license has been issued by the NRC for construction of a permanent repository. In addition, the quantity of spent nuclear fuel or high-level radioactive waste which may be stored at the

MRS facility is limited to 10,000 metric tons of heavy metal ("MTU") until the permanent repository begins accepting spent fuel. In addition, the MRS facility is limited to storing no more than of 15,000 MTU (the equivalent of 45,000 fuel assemblies, assuming an equal percentage of fuel assemblies from BWRs and PWRs) at any one time. Consequently, the MRS is inadequate to meet the nation's, and potentially PI's, spent fuel storage needs.

DOE's 1987 Draft Mission Plan established 2003 as the year the permanent repository would begin accepting spent fuel, five years later than the date established in the NWPAA. In November 1989, the Secretary of Energy announced a four-point action plan in its Report to Congress on Reassessment of the Civilian Radioactive Waste Management Program, which called for: 1) restructuring the Office of Civilian Radioactive Waste Management ("OCRWM"); 2) gaining access to Yucca Mountain for site characterization, 3) establishing an MRS facility capable of accepting waste by 1998, and 4) extending the date for the expected initial operation of a permanent repository to 2010. Under this plan, DOE anticipates it will begin accepting waste by 1998 through the use of an MRS facility. However, this is dependent upon Congress removing the requirement that a license to construct the permanent repository be obtained before the MRS may begin accepting spent fuel. It is also dependent upon locating an acceptable site for an MRS facility and constructing the facility. None of these preconditions have yet been met.

2. Prospects For The Future.

The OCRWM has made progress in implementing the Secretary of Energy's Action Plan. The OCRWM has been restructured and Dr. John Bartlett was confirmed by the Senate as Director of OCRWM on April 5, 1990. In addition, DOE has established direct reporting from the Yucca Mountain Project Office to OCRWM Headquarters. Further, Dr. Bartlett announced a new OCRWM organization structure on July 9, 1990. The new structure has been approved and is in the process of being implemented by OCRWM.

An independent assessment of OCRWM management was concluded by Booz Allen and Hamilton, Inc. in November 1989. The new OCRWM organization structure incorporates recommendations made in the independent assessment.

OCRWM issued a Management Systems Improvement Strategy ("MSIS") in August 1990. The MSIS categorizes tasks to be performed by OCRWM into physical system functions. The four major functions are: 1) accept waste; 2) transport waste; 3) store waste; and 4) dispose of waste. Other programmatic functions include such things as quality assurance, systems engineering, regulatory compliance, design, construction, operation, and program cost and schedule control.

OCRWM has already implemented management system controls including the preparation and qualification of quality assurance programs for all DOE and contractor staff. Qualification audits of quality assurance programs took place in October 1990. DOE received limited NRC acceptance of its quality assurance program for selected site characterization activities.

On August 4, 1990, Mr. David Leroy was confirmed by the Senate as the Nuclear Waste Negotiator. Mr. Leroy is a former lieutenant governor and attorney general for the State of Idaho. The role of the Nuclear Waste Negotiator is to find a state or Indian tribe willing to accept an MRS facility and/or a permanent repository.

These advancements by DOE have been offset by difficulties encountered in completing the Yucca Mountain site characterization. The State of Nevada returned to DOE its environmental permit applications and application fees to study the Yucca Mountain site. The following day, the Nevada State Attorney General filed suit in the Ninth Circuit Court of Appeals, seeking to force DOE to cease studies of the proposed Yucca Mountain site and declare the site unsuitable for a high-level radioactive waste permanent repository. The state also sought a court declaration supporting an earlier law passed by the Nevada Legislature that it claimed constituted a state veto of the waste facility.

In response to the Nevada Legislature's action rejecting the use of the Yucca Mountain site as a permanent repository and the State of Nevada's refusal to issue the environmental permits needed to properly study the Yucca Mountain site, on January 25, 1990 the Department of Justice, on behalf of DOE, filed suit in federal district court against the State of Nevada seeking to resolve three principal issues. These issues are: 1) whether the Nevada legislative action was a valid and effective notice of disapproval of the Yucca Mountain site under the NWPA; 2) whether the Nevada legislative action conflicted with and thus is preempted by the NWPA; and 3) whether Nevada's failure to act on DOE's applications for environmental permits is unlawful. DOE also sought a court order requiring the State of Nevada to act on the permit applications within a court-imposed deadline.

On September 19, 1990, the Ninth Circuit Court of Appeals issued a unanimous decision ruling that conducting a site characterization of a potential permanent radioactive-waste repository at Yucca Mountain was not unconstitutional or otherwise contrary to law. In so holding, the Court of Appeals struck down a Nevada law blocking the storage of radioactive waste within the State of Nevada and found the law preempted by the NWPA.

On March 4, 1991, the United States Supreme Court denied the State of Nevada's petition for review and allowed the decision of the Court of Appeals to stand.

In correspondence dated March 12, 1991, the Nevada Environmental Protection Agency notified DOE that it is prepared to begin processing applications for environmental permits for air quality, water appropriations and underground injections needed for the initial phases of site characterization. The District Court has directed the State of Nevada and DOE to develop a stipulation for processing and implementing permits. The permits are three of approximately thirty permits the DOE will need during the characterization process. The principal site-characterization activities at Yucca Mountain will center on scientific investigations of the suitability of the site. If the site is found unsuitable at any time during the characterization, DOE will notify Congress and will discontinue further scientific investigation at the Yucca Mountain site.

Major activities related to the design of a repository at the Yucca Mountain site will be deferred until more information is available concerning the suitability of the site. This deferral allows the DOE to concentrate on site suitability investigations.

The schedule for a permanent storage facility by 2010 is more realistic than DOE's previous schedules for repository operation. However, the scheduled operation date for the repository of 2010 is still based on optimistic assumptions about the program progress.

In addition to developing a permanent site, the DOE is developing an MRS facility. MRS facility operation by 1998 is dependent upon the success of the Nuclear Waste Negotiator in finding a state or Indian tribe willing to host the facility. The linkages between the MRS facility and the licensing and operation of the permanent repository would also have to be removed by Congress. Finally, timely licensing and construction of the MRS facility would be required.

If the Nuclear Waste Negotiator is unable to locate a volunteer state or Indian tribe by the end of his term in December 1992, the DOE will need to initiate an MRS siting process. Consequently, spent fuel acceptance at the MRS facility could be further delayed, depending on whether Congress will modify the current linkages between the MRS facility and repository operation and DOE's ability to locate, license and develop a suitable site.

Therefore, for planning purposes, the operation of an MRS facility before 2010 cannot be relied upon. However, the possibility of an MRS facility becoming available at an earlier date strongly supports the use of a Dry Cask Storage Facility because of its ability to add additional storage capacity in small increments. For example, if an MRS facility began accepting PI spent fuel in 1998, only 24 casks would be used at the PI ISFSI.

While the federal government is obligated to eventually remove the spent fuel from PI, it is clear that the date of removal is uncertain. Once fuel acceptance begins, there is also uncertainty regarding the rate at which the DOE will be able to remove spent fuel from the nuclear power plant sites. While DOE has indicated it will eventually be able to accept as much as 3,000 MTU of spent fuel (the equivalent of 9,000 fuel assemblies) per year, during the first six to ten years of operation, of either the MRS or the permanent repository, acceptance is expected to be significantly lower (e.g., 350 MTU-1,000 MTU per year, the equivalent of 1,050 to 3,000 fuel assemblies). Therefore, it is reasonable for NSP to plan for on-site temporary storage to accommodate additional spent fuel through the year 2014 (when the current plant licenses expire).

IV. A DESCRIPTION OF THE ISFSI AND TN-40 CASKS.

This section of the Application will: 1) describe the design of the ISFSI and TN-40 casks; 2) explain the operation and maintenance of the ISFSI and TN-40 casks; 3) describe any wastes and emissions produced; and 4) explain how the ISFSI and TN-40 casks affect the retirement of PI.

A. Physical Description (Provided Pursuant To Minn. Rules, Pt. 7855.0600 A and B).

The ISFSI will be located on the PI site. Page 3.31 of the EIS contains a regional map which shows the location of PI. Page 3.33 of the EIS shows the PI boundary and the proposed location of the ISFSI and access road from the ISFSI to the auxiliary building at PI. Spent fuel will be stored in TN-40 casks (16' 10" high and 8' 6" in diameter). The ISFSI uses no active controls or operator actions other than for security and monitoring. The casks provide passive criticality control, heat rejection, shielding of radiation, and confinement of the spent fuel. The design capacity of the Dry Cask Storage Facility is 1920 fuel assemblies or 312 cubic meters. The capacity of the Dry Cask Storage is described in more detail in Section XI.A. and XI.E.

Page 3.40 of the EIS shows the general arrangement of the casks on the ISFSI. As shown, the ISFSI will consist of two reinforced concrete pads, each 3 feet thick. Twenty-four casks are stored on each pad.

The top of the concrete slabs will be at an elevation of 697.0 feet mean sea level, which is above the 100-year flood level of 687.4 feet mean sea level. The cask closures and seals are well above that level and will ensure that casks are not susceptible to being submersed by flood water even in the event of a highly improbable worst case flood as calculated by the U.S. Army Corp of Engineers.

A steel framed equipment storage building (approximately 30 feet high) in the ISFSI will be used to store the cask transporter, which is a trailer for moving the cask from the auxiliary building to the ISFSI. Lighting and security monitoring equipment will be provided at the ISFSI perimeter. A security intrusion detection system inside a fenced area will surround the ISFSI. An outer fence will also be built. A monitoring panel on the outer fence will be installed to facilitate surveillance of the casks.

An earthen berm (16 feet high) will be built around all sides of the ISFSI. The berm will provide additional radiological shielding to minimize any off-site radiological dose resulting from the casks.

1. Site Design And Construction.

Grading plans, the design and specifications for installation of the concrete pads and specifications for procurement of the cask transporter, equipment storage building and other necessary facilities will be developed by Stone & Webster Engineering Corporation, P.O. Box 5406, Denver, Colorado 90217. As part of the design efforts, geotechnical investigations and analyses have been performed to confirm the stability of subsurface materials under both normal and seismic conditions. Approximately 4000 cubic yards of material will be removed per pad and replaced with more suitable fill.

The ISFSI will be in an area that is currently covered in part by a stock pile of dredged spoil material and in part by scattered trees and brush. NSP will use this dredged material, along with the material excavated for pad installation, to build the berm. Approximately 10 acres will be affected by site preparation and grading. The activities will not adversely affect any sensitive ecological or archaeological resources.

Actual construction of the ISFSI, including the installation of the concrete pads, equipment storage building, and other necessary facilities, is scheduled to commence in April 1992. NSP has not yet selected the contractors for this work.

New casks will periodically be delivered by rail to PI during the period of operation. The first cask would be moved to the ISFSI in April 1993. Additional casks would, as needed, periodically be placed in the ISFSI throughout the operating life of PI.

Minimal additional contractor support will be required during cask loading and transport from the plant to the ISFSI.

2. The TN-40 Cask.

a. Dry Cask Design Criteria.

The TN-40 cask has been designed to ensure fuel criticality is prevented, fuel temperatures remain acceptable, fuel containment is maintained and fuel damage from an accident is minimized so spent fuel can be removed from the cask if necessary. The TN-40 cask has been designed to ensure it will perform these safety functions in the event of exposure to every reasonably credible event, both natural and man-made, which might occur while in storage in the ISFSI. Table 3 provides a list of design criteria for the TN-40 cask. These criteria are established based upon NRC requirements, industry codes and standards and PI site-specific conditions.

The design criteria used for the TN-40 satisfy the NRC's requirements, contained in 10 CFR pt. 72. The requirements consider the effects of normal operation, natural phenomena and postulated accidents. The design criteria are used to establish the type and magnitude of mechanical loads that may be imposed on the cask as a result of man-made events, natural phenomena and postulated accidents.

Table 3

Design Criteria For TN-40 Casks

Maximum gross weight on auxiliary building crane	125 tons
Maximum cask height with protective cover	16 feet 10 inches
Minimum design life	25 years
Maximum k_{eff}, including bias and uncertainties	≤0.95 Normal <0.98 Accident
Fuel Assembly Capacity	40 intact PWR, 14x14 array
Maximum External Dose Rate	125 millirem/hour contact (accessible surfaces)
Spent fuel characteristics:	
a) Initial Enrichment	3.85% Uranium 235
b) Burnup (maximum)	45,000 Megawatt days/metric tons uranium (MWD/MTU)
c) Cooling Time (minimum)	10 years
d) Decay Heat	27 kilowatts (total for 40 fuel assemblies)
Max Fuel Rod Clad Temperature	340°C
Cask Cavity Atmosphere	Helium gas
Maximum Internal Pressure	100 pounds per square inch (psi)
Ambient Temperature (Min-Max)	-40° to 120°F
Maximum Solar Heat Load	135 BTU/hr-ft2
Tornado Wind	300 mph rotational 60 mph translational
Tornado Missiles	4"x12"x144"plank @ 300 mph; 4000 lb auto @ 50 mph

Cask Accident External to Plant	Drop or tip onto ISFSI pad
Seismic Design Earthquake	0.12 g horizontal 0.08 g vertical
Snow and Ice	50 pounds per square foot load

b. Spent Fuel Description.

The TN-40 cask is designed to store 40 spent fuel assemblies of the types that are used at PI. The physical characteristics of the fuel to be stored in the TN-40 casks are presented in Table 4, Fuel Assembly Information. Only spent fuel with these characteristics will be stored in the casks. Additionally, fuel assemblies for storage will be intact and have no known cladding defects or physical damage which would prevent insertion into or withdrawal from the cask.

As shown in Table 4, the spent fuel to be stored in the TN-40 casks will have been discharged from the reactor for at least 10 years. This assures the fuel has been allowed to decay and cool for a substantial period of time. When the reactor is shut down to discharge the fuel, each assembly has a decay heat rate in the range of 1000 kw. After 10 years of decay and cooling in the spent fuel pool, each assembly has a maximum decay heat rate of 0.675 kw, which is less than the heat generated by seven, 100-watt incandescent light bulbs.

Similarly, the radiation emitted by the fuel to be stored in the casks has decayed substantially from levels at the time of removal from the reactor unit. For instance, gamma radiation will have decreased by a factor of about 600 and neutron radiation will have decreased by about a factor of two. After ten years each fuel assembly will emit radiation in the approximate amount of 147,000 curies.

The storage casks, therefore, are designed to store spent fuel requiring far less cooling and shielding than would be required at the time the fuel was removed from the reactor unit.

Table 4

Fuel Assembly Information

Maximum weight	1300 lb.
Assembly dimensions	7.763" x 7.763" x 161.3"
Fuel rod array	14 x 14
Number of fuel rods	179
Fuel length	144"
Initial enrichment (maximum)	3.85% Uranium-235
Burnup (maximum)	45,000 MWD/MTU
Cooling time (minimum)	10 years
Decay heat per fuel assembly	0.675 kilowatts

3. Cask Components And Assembly.

The TN-40 cask was designed by Transnuclear, Inc., which is located at Two Skyline Drive, Hawthorne, New York 10532. The design of the TN-40 cask was developed based on three decades of experience with metal transport and storage casks for spent fuel. Since the 1970s, metal casks, weighing in the range of 120 tons, have been used to transport spent fuel around the world. Transnuclear, Inc.'s parent company, Transnucleaire, S.A. of Paris, France, has designed a family of transport casks, known as the TN-12 series, which are used to transport spent fuel from Japan to France, and from other European countries to both France and England for reprocessing. Today, approximately 100 TN-12 transport casks are used around the world.

The TN-12 casks serve a dual purpose of transport and temporary storage. After loading the spent fuel at a nuclear plant, the TN-12 casks are used to transport spent fuel by rail and ship. The casks are stored outside of the reprocessing facility on a storage pad as each cask awaits its turn for unloading. The period from loading to unloading of the cask can be several months. The TN-12 series casks have demonstrated the effectiveness of metal casks as a dry spent fuel storage technology. Based upon the experience of its parent company, Transnuclear, Inc. has developed several other storage cask systems, one of which is the TN-40 storage cask.

A schematic drawing of a TN-40 cask is contained on page 3.39 of the EIS. The TN-40 cask has several major components with specific functional purposes. These include:

- The basket assembly for structural support and criticality control of the fuel assemblies;
- The containment vessel, which encloses the basket assembly and fuel and provides containment of the radioactive material within the cask;
- The gamma shield, which provides the attenuation of gamma radiation and structural protection of the containment vessel;
- The neutron shield, which provides attenuation of neutron radiation;
- An outer shell, which covers and protects the neutron shield;
- The cask lid, which seals the cask after loading;
- A weather cover, which keeps the lid clean and protects the pressure reservoir tank of the cask seal monitoring system from the weather;
- Trunnions, which are used to lift and rotate the cask during handling operations.

Each of these components is discussed briefly below.

The basket is designed to hold 40 fuel assemblies. The basket consists of stainless steel boxes separated by heat conduction and neutron absorption plates. The plates between the boxes form a "sandwich" panel and consist of two aluminum plates which sandwich a neutron absorption plate made of a material called Boral®. One of the constituents of Boral® is boron, also referred to as B-10, which absorbs neutrons to prevent fissioning. Neutrons are necessary in order to achieve a self-sustaining nuclear reaction. Neutron absorbing material helps the TN-40 cask meet design criteria on criticality prevention. The aluminum plates also provide heat conduction paths from the fuel assemblies to the cask containment vessel.

The containment vessel of the TN-40 is the inner-most cask shell and is a welded carbon steel cylinder with an integrally welded carbon steel plate at the bottom. At the top of this cylinder is a welded flange forging which provides the recessed positioning and sealing surfaces for a bolted carbon steel lid. The lid has two penetrations which are used during loading to remove water and fill the cask interior with helium. The containment vessel lid is 10.5 inches thick and is attached to the upper vessel flange by 48 bolts. Two metallic O-rings are installed on the cask sealing flange between the cask body and the cask lid, providing a redundant and highly reliable cask seal. Once the cask has been sealed, there is no free radioactive gas or liquid inside the cask. Air is not a desirable long-term storage environment for spent fuel because of the potential for oxidation of the fuel cladding. Therefore the cask interior is filled with the inert gas helium. The cask cavity is pressurized above atmospheric pressure, so that if the cask seal were to fail, air would not enter the cask interior. The interspace between the two cask lid seals is pressurized to a level greater than the cask cavity pressure. This interspace pressure is maintained by a pressure reservoir and is monitored by a pressure sensor. Failure of either of the redundant cask lid seals would result in a decrease in the interspace pressure; if the inner seal failed, helium would leak from the interspace to the cask interior, and if the outer seal failed, helium would leak from the interspace to the outside. The drop in interspace pressure would be detected by the sensor and indicated on the cask seal monitoring system annunciator panel outside the ISFSI. The two penetrations in the cask lid are also sealed with redundant metallic seals, and the interspace pressure of both penetrations is maintained and monitored in the same manner as the interspace of the lid seals.

The gamma radiation shield is provided around the walls of the containment vessel by an independent shell of carbon steel, which is welded to a bottom shield plate and to the containment vessel closure flange, thereby completely enclosing the containment vessel inner shell and bottom plate. The gamma shield attenuates gamma radiation and protects the containment vessel from the potential impact of such things as tornado missiles.

Neutron shielding is provided by a solid resin compound that contains the same neutron absorbing material (B-10) as is contained in the basket structure. The resin compound is enclosed in long aluminum box-like containers. The resin-filled containers are arrayed vertically and surround the gamma shield. A circular neutron shield disk provides neutron shielding on the lid during storage.

The array of resin-filled containers surrounding the cask is enclosed within a smooth outer steel shell. The outer shell protects the neutron shield and serves as a heat rejection surface. The aluminum neutron shield containers conduct heat from the cask body to the outer shell. Heat is removed from the outer shell by convection and thermal radiation.

In order to keep the cask lid clean and to avoid the accumulation of water in recesses of the cask lid, a torospherical weather cover is provided above the cask lid. The protective weather cover is sealed to the cask with an elastomeric (rubber-like material) gasket. The protective weather cover gives the top of the cask a dome-shaped appearance. The pressure reservoir tank of the cask seal monitoring system is located on the cask lid, under the weather cover.

Four trunnions are attached to the cask body to allow lifting and rotation of the cask. Two trunnions are near the top of the body and two are near the lower end of the body. The lower trunnions are used for rotating the cask horizontally and vertically so the cask can be unloaded from the rail car when it is delivered to PI. The upper trunnions are used to lift the cask in all other handling operations.

The cask system has several features that provide corrosion protection. First, the cavity is evacuated to remove air and water vapor and backfilled above atmospheric pressure with the inert gas helium. In addition, the cask cavity surfaces have a sprayed metallic coating of zinc/aluminum. The outer surfaces of the cask also have the zinc/aluminum metallic coating for corrosion protection. All external surfaces of the cask body are painted to provide redundant corrosion protection and easy decontamination.

4. TN-40 Cask Fabrication.

The TN-40 cask system will be fabricated at two separate manufacturing facilities, one for the basket assembly and one for the cask body. The basket will be manufactured by U.S. Tool and Die, 475 Bustier Street, Pittsburgh, PA 15223. The cask body will be manufactured by PX Engineering Co., Inc., P.O. Box C-1019, Boston, MA 02205.

The first step in basket fabrication consists of forming fuel compartment boxes from stainless steel sheet and cutting the aluminum and neutron absorber (Boral®) plates. The stainless steel boxes and Boral® plates are prepared for welding, which involves performing a dimpling procedure on the boxes and punching the plates at the location of the fusion weld and inserting stainless steel plugs into the resulting holes. After preparation for welding, the boxes and plates are incrementally assembled using special fixtures, and welded together to form the basket structure. The welding process entails pairs of fusion welds on each face of the storage box, separated by a vertical distance of about eight inches and extending the full length of the box. After completion of the basket assembly, it will be shipped to the cask body manufacturer for installation into the cask body.

The cask body will be fabricated and assembled as a series of vessels within vessels. The containment vessel is initially a steel plate which is rolled and welded into a cylindrical structure. A bottom closure plate is welded at one end and the lid closure flange is welded at the other end. The gamma shield is similarly constructed and welded to a bottom plate. Using processes that are routinely used to fabricate petro-chemical vessels, the gamma shield is installed around the containment vessel using shrink-fit techniques to insure good thermal contact between the two vessels. The gamma shield is then welded to the containment vessel closure lid flange.

The neutron shield material is poured into the shield containers and allowed to set. The outer shell is formed by rolling two plates into half-cylinders. The neutron shield containers are arrayed around the cask body and the outer shell is welded into place around the neutron shell. This is accomplished using closure plates, welded to the gamma shell, at the top and bottom of the outer shell.

All fabrication will be controlled using a quality assurance program that has been approved by NSP, Transnuclear, Inc., and the respective fabricators. The fabrication program includes criteria, procedures, documentation, and monitoring requirements to address such considerations as traceability of materials, proper storage and inventory of materials, qualification of welders, performance and documentation of tests, performance and inspection of welds, and preparation, review, and acceptance of reports and documentation. The quality assurance process will be established and approved prior to the start of fabrication and will be monitored and reviewed regularly throughout fabrication by NSP, Transnuclear, Inc., and the respective fabricators. Additionally, all fabrication documentation is reviewed, approved and accepted prior to the loading of a cask with spent fuel. This process assures quality is maintained at a level commensurate with the safety functions performed by the cask.

B. Operating The Dry Cask Storage Facility (Provided Pursuant To Minn. Rule Pt. 7855.0600 C).

1. Fuel Selection.

The design of the TN-40 cask is based on specific spent fuel characteristics, including initial enrichment, burnup, cooling time, and physical condition. These are discussed in Section IV.A.2.b. of this Application. Only spent fuel assemblies with these characteristics will be loaded into the TN-40 casks. Almost all spent fuel generated by PI to date meets the enrichment, burnup, and physical condition requirements for storage in the TN-40 cask. Fuel not meeting these criteria will be stored in the pool until removed for shipment by DOE. There are currently only 40 fuel assemblies which are not candidates for storage in the TN-40 casks because they either have been consolidated or have sustained some physical damage.

As part of the normal fuel management and fuel accountability program at PI, all fuel assemblies have detailed records which include enrichment, isotopic composition, burnup, cooling time and location of the fuel in the pool. These records will be used by PI's Nuclear

Engineering staff to select the fuel assemblies for cask storage.

2. Fuel Handling Operations.

All fuel placed into TN-40 casks will be handled using PI's existing fuel handling equipment and procedures. Fuel assemblies will be moved from storage locations in the spent fuel storage pool to the casks using long-handled tools suspended from the pool bridge crane, in the same manner as other fuel movements associated with plant operation.

3. Cask Preparation, Loading And Positioning On Storage Pad.

Cask preparation for fuel storage begins when the cask is brought into the receiving area of the auxiliary building at PI. A general inspection of the cask is performed prior to moving the cask to the spent fuel pool. The cask lid and bolts are removed and a protective cover is installed on the cask lid sealing surface to prevent damage to the surface during loading and handling operations.

Following preparation, a lifting yoke connected to the auxiliary building crane hook is attached to the upper cask trunnions. Using this yoke, the cask is lifted to the level of the spent fuel pool. The cask is then aligned with the access door to the fuel pool enclosure, and laterally transferred north into the pool enclosure to a location above the cask set-down area. A drawing of the pool enclosure is contained on page 5.58 of the EIS. A cutaway view of the pool, which actually consists of two compartments, is contained in the EIS at page 5.55 and a picture of the configuration of the spent fuel pool is contained in the EIS at page 5.57. The cask setdown area is in the smaller compartment, referred to as Pool No. 1. The narrow slot in the ceiling of the pool enclosure prohibits any movement of the cask except in the north-south direction. This prevents the cask from being transported over Pool No. 2.

The cask is slowly lowered into Pool No. 1 until the top surface of the cask is accessible. The cask is then filled with clean pool water, which contains the neutron absorber B-10 to prevent inadvertent criticality during fuel loading. Once the cask is filled with water, it is lowered to the floor of the loading area in Pool No. 1.

After lowering the cask to the pool floor, spent fuel is loaded into the cask, using a long handled tool suspended from the spent fuel pool bridge crane and manipulated by an operator standing on the movable bridge over the pool.

After the cask is loaded, spent fuel identification numbers and storage locations will be verified to ensure the proper fuel is loaded. The cask loading will be videotaped and all fuel assemblies will be identified and verified by an operator watching a monitor displaying the image being taped. After loading, the sealing surface protective cover is removed, and the cask lid is lowered into the pool and placed on the cask. The lifting yoke is then attached to the cask and it is raised to the pool surface where the lid bolts are installed. Using the penetrations and fittings in the lid, the cask cavity is drained of water using air pressure or a drain pump. The cask is then removed from the pool and moved to the decontamination area of the plant auxiliary building.

Additionally, the cask cavity, the basket and fuel are dried using a vacuum drying system. After drying, the cavity is backfilled with helium to the designated pressure. Testing is performed to verify that the cask lid and both penetration covers are properly sealed. The lid neutron shield disk is then installed. The cask seal monitoring system is placed into operation, which involves positioning and charging the pressure reservoir, installing the pressure sensor, pressurizing the seal interspaces to design levels, and checking the system for leakage. The weather cover is bolted into place and the pressure sensor system is fed through the external fitting in the cover. The contamination levels, temperature, and radiation dose rates of the cask are checked to ensure they are within acceptable ranges.

The procedures for decontaminating the casks are the subject of an agreement between NSP, the Department of Public Service and the Environmental Quality Board, relating to this project's NRC license application. The specific procedures agreed to are as follows:

i. Normal Cask Decontamination. NSP will rinse the casks with low pressure water as the casks are removed from the pool. The casks will then be placed in the decontamination area of the auxiliary building where their entire surface will be sprayed and washed with a high pressure washer. NSP will survey the cask surface with Maslin cloths (or an equivalent or improved product) to determine if the cask is clean. For the purposes of the agreement, "clean" is defined as less than 1000 disintegrations per minute ("dpm") per 100 cm^2. If the survey indicates the cask is not clean, NSP will continue decontamination until the survey indicates it is clean. This process is as described in the Radiation Protection Implementing Procedures and Plant Operating Procedures currently in use at PI. Prior to loading any cask, NSP will develop a Radiation Protection Implementing Procedure applicable to the casks and the storage facility installation, incorporating similar procedures as described in the Radiation Protection Implementing Procedures for the plant.

ii. Procedure Validation. Upon completion of normal decontamination of each of the first two casks loaded, NSP will wipe the entire cask surface with Maslin cloth (or an equivalent or improved product) to determine if decontamination and the related survey were successful. If normal procedures for either cask incorrectly identified the cask as being clean, NSP will revise its normal procedure and repeat this procedure validation for the next two casks loaded.

iii. Reporting. NSP will report the results of procedure validation to MDH upon completion. These results may be reported separately from other documents related to NSP's PI Nuclear Generating Plant. NSP will consult with MDH prior to the decontamination of the first two (2) casks on the form of reporting of the results.

iv. Changes in Procedure. The aforementioned decontamination procedure shall not restrict or prevent NSP from implementing new procedures or practices as they become available. NSP will notify the Minnesota Department of Health prior to making changes or modifications in such procedures or practices. If NSP proposes to make changes or modifications in its dry cask decontamination and/or related procedures or practices, MDH may suggest alternative procedures or practices. NSP may adopt a) the alternative procedures or practices suggested by MDH; or b) institute the new procedures or practices originally selected by NSP; or c) institute a different procedure or practice. If NSP institutes the new procedures or practices originally selected by NSP or a different procedure or practice, NSP will provide a written statement to MDH explaining the selection and the effectiveness of the implemented procedures or practices. If NSP makes changes in its dry cask decontamination and/or related survey procedures or practices, the validation procedure described in paragraph 1.a.ii. will be repeated if requested by the EQB, the Department or MDH.

After decontamination, the cask is then moved into the rail bay where it is picked up by the cask transporter. The transporter is an A-frame type of structure designed to engage the upper handling trunnions and lift the cask about one foot above the ground. The transporter holds the cask in an upright, vertical orientation. After being loaded with the cask, the transporter is pulled to the ISFSI site by a tow vehicle. The cask is lowered onto its designated location on the storage pad. The cask seal monitoring system is connected to the ISFSI power supply and instrumentation system and functional checks are performed. After a final inspection of the cask, the cask is declared operational.

Table 5 is a flow sheet of the sequence of operations described above.

RECEIVING AREA	SPENT FUEL POOL	DECONTAMINATION AREA		STORAGE AREA
UNLOAD EMPTY CASK	LOWER CASK INTO POOL	DECONTAMINATE CASK	INSTALL PRESSURE TRANSDUCERS	UNLOAD CASK FROM TRANSFER VEHICLE
INSPECT FOR SHIPPING DAMAGE	LOAD FUEL INTO CASK	REMOVE NEUTRON SHIELD VENT PLUG	PRESSURIZE SEAL INTERSPACE	POSITION CASK ON STORAGE PAD
REMOVE WEATHER SHIELD AND INSTALL NEUTRON SHIELD VENT PLUG	PLACE LID ON CASK AFTER REMOVING PROTECTIVE PLATE	CONNECT VACUUM DRYING SYSTEM (VDS)	CHECK FOR LEAKAGE	CHECK FOR SURFACE DEFECTS
REMOVE LID AND LID BOLTS	LIFT CASK TO POOL SURFACE AND INSTALL LID BOLTS	EVACUATE AND DRY CASK CAVITY	CHECK SURFACE TEMPERATURE	CONNECT AND CHECK PRESSURE INSTRUMENTATION
INSTALL PROTECTIVE PLATE	CONNECT DRAIN LINE AND PRESSURIZE LINE	DISCONNECT VDS AND CONNECT VACUUM BACKFILL SYSTEM (VBS)	CHECK SURFACE RADIATION LEVELS	CHECK SURFACE RADIATION LEVELS
MOVE TO SPENT FUEL POOL AREA	PRESSURIZE AND DRAIN CAVITY	BACKFILL WITH HELIUM	INSTALL PROTECTIVE COVER	
	DISCONNECT DRAIN LINE AND PRESSURIZING LINE	INSTALL VENT AND DRAIN COVERS WITH SEALS AND BOLTS	LOAD CASK ON TRANSFER VEHICLE	
	MOVE CASK TO DECONTAMINATION AREA	INSTALL TOP NEUTRON SHIELD DRUM	MOVE CASK TO STORAGE AREA	

Table 5-Sequence of Operations

Procedures for monitoring the casks while at the ISFSI are also contained in NSP's agreement with the Department and EQB. Specifically, the following procedures will be used:

i. Initial Monitoring Procedure. Monitoring of each of the first two casks placed on their pads will include surface sampling with Maslin cloths (or an equivalent or improved product) at periods of one week, one month, and three months from emplacement. If the cask or pad is found not to be clean, NSP will take action necessary to clean it, use best efforts to remedy the cause, and repeat the initial monitoring procedure.

ii. Long-Term Monitoring. After placement of the first cask on its pad, NSP will continue to monitor the casks and their concrete pads for contamination. NSP will monitor the casks and concrete pads at least twice each year, with the intent to monitor quarterly. Procedures will consider concerns for occupational radiation exposure and may include sampling with Maslin cloths.

iii. Reporting. NSP will report the results of pad monitoring to MDH upon completion of the initial monitoring procedures tests. These results may be reported separately from other documents related to NSP's PI Nuclear Generating Plant. NSP will consult with MDH prior to the emplacement of the first two (2) casks on the frequency and form of reporting of the long-term monitoring results.

iv. Changes in Procedure. The aforementioned long-term monitoring procedure does not restrict or prevent NSP from implementing new procedures or practices as they become available. NSP will notify MDH prior to making changes or modifications in such procedures or practices which reduce the frequency or effectiveness of the procedures or practices. If NSP proposes to make changes or modifications in its long-term monitoring procedures or practices, MDH may suggest alternative procedures or practices. NSP may adopt a) the alternative procedures or practices suggested by MDH; b) institute the new procedures or practices originally selected by NSP; or c) institute a different procedure or practice. If NSP institutes the new procedures or practices originally selected by NSP or a different procedure or practice, NSP will provide a written statement to the MDH explaining the selection and the effectiveness of the implemented procedures or practices.

4. <u>The Estimated Installed Cost Of The Dry Cask Storage Facility</u>.

The costs to develop the Dry Cask Storage Facility and purchase 48 TN-40 casks are estimated at $ 39 million (1990 dollars). The components of this cost, the "up front" costs versus the incremental cost per cask, is available under protective order if a contested case hearing is held on this application. Annual operation and maintenance costs are estimated at $10,000.00. The selection of dry cask storage technology is not expected to have a material impact on customer rates. The estimated economic life of the Dry Cask Storage Facility is the same as the plant's licensed life. <u>See</u> Section XI.E.

In 1981, NSP obtained written approval from the Federal Energy Regulatory Commission ("FERC") and also obtained an order from the Commission to convert from a negative net salvage approach to an internal sinking fund approach for the recovery of spent nuclear fuel disposal costs. Also included in those filings was the establishment of an internal sinking fund accrual to provide for the future interim storage needs at PI. The Commission Order (Docket E002/M-81-306) took effect on August 1, 1981. As of December 31, 1990, NSP has accumulated $17.7 million in an internal reserve to provide for the interim storage requirements at PI. This fund is accumulating at $3.5 million per year and is expected to be adequate to fund the Dry Cask Storage Facility. Once the certificate-of-need process is complete and the appropriate decisions are made relating to the Dry Cask Storage Facility, NSP will review the annual depreciation accrual and if necessary adjust it through filings with the FERC and the Commission. At that time, NSP will propose a recovery requirement for interim storage at NSP's Monticello Nuclear Generating Plant. These depreciation filings will assess the total program requirements along with depreciation accumulated to date and develop a recovery requirement to be allocated over the remaining lives of these two plants.

C. Cask Performance And Maintenance During Storage.

The TN-40 cask has been designed to provide safe storage of PI spent fuel for a range of conditions which could be encountered over the storage period. The NRC process will include thorough technical reviews to assure cask safety and integrity. The following Sections provide information about the results of the performance analyses for the TN-40 design.

1. Performance Under Normal Conditions.

The TN-40 cask is designed to maintain appropriate fuel temperatures by transferring heat from the fuel to the ambient air. It also shields the radiation produced by the spent fuel. Heat is transferred from the fuel via thermal radiation and conduction to the stainless steel and aluminum structure within the basket. The basket structures, in turn, conduct and radiate the heat to the cask body where the heat is conducted from the body through the aluminum neutron shield containers to the outer shell. The outer shell is cooled by convection with ambient air and by thermal radiation.

The TN-40 cask design uses the conservative assumption that the most limiting spent fuel (i.e., the most recently discharged fuel with the greatest burnup allowed, as described in Section IV.B.2.) is stored in every fuel compartment in the cask. Additionally, it is assumed that these fuel conditions persist over the entire storage period. In fact, most of the fuel stored in the TN-40 casks will be older and have lesser burnup. In addition, spent fuel undergoes a constant process of radioactive decay, such that the radiation and heat produced by the spent fuel is constantly diminishing. Therefore, the greatest amount of heat and radiation produced by the spent fuel in a cask occurs at the beginning of storage and decays in a predictable fashion from that time forward.

To illustrate, over a 20-year period, the amount of heat produced by the spent fuel in the cask will drop by about 36%. Similarly, the gamma radiation and neutron radiation levels will drop by about 48% and 51% respectively.

As a result of the diminishing heat of the spent fuel, temperatures and pressures inside the cask system will decrease over the storage life. For instance, the peak fuel cladding temperature at the beginning of storage will be around 600°F and the internal cask pressure will be around 33 pounds per square inch ("psi"). At the end of 20 years, the peak fuel cladding temperature will be on the order of 400° F and the cask pressure will be around 28 psi. Similarly, the temperature of the outer cask shell will normally average 190° F at the beginning of storage, but will drop to an average of about 140° F after 20 years. Even these levels are conservatively high because they assume storage of the most limiting spent fuel, which is hotter and more radioactive than most of the fuel which will be stored in the casks.

The radiation levels emitted from the cask likewise decrease with the decay of the spent fuel. At the beginning of storage, average radiation dose rates on the outside surface of the cask will be about 57 millirem/hr. At the end of 20 years, average contact dose rates will be about 28 millirem/hr.

These radiation doses will occur at a cask's surface. Radiation levels drop drastically as the distance away from the casks increases. While NSP has provided different estimates of radiological impacts from the Dry Cask Storage Facility depending on the assumptions made, NSP's best estimate of the radiological impacts is that the Dry Cask Storage Facility provides a maximum annual dose rate to the nearest permanent resident of 0.42 millirem per year. The average annual dose to the nearest permanent resident is 0.34 millirem per year. (The average dose is less than the maximum dose because the maximum dose is based on the presence of 48 casks and, on average, far fewer casks will be present.) The annual dose to residents farther from the Dry Cask Storage Facility, including the Prairie Island Mdewakanton Sioux Community, is significantly lower. These very low levels should be compared with the background radiation of about 300 millirem per year at the plant site, produced by natural sources including naturally occurring radon gas.

Cask materials are slightly activated (i.e., become slightly radioactive) by the neutron radiation emitted by spent fuel contained within the cask. However, because the level of neutron radiation emitted by spent fuel is so low, there is essentially no effect on the structural integrity of the cask materials. Significant changes in the cask material properties could begin to occur if the material were exposed to a cumulative neutron exposure of 10^{19} neutrons per square centimeter (n/cm^2). However, the highest neutron level in the cask body occurs at the beginning of storage and is about $4x10^5$ n/cm^2-sec. Assuming the neutron radiation level remains constant instead of decreasing, the maximum total neutron exposure after 40 years would be about $5x10^{14}$ n/cm^2. Thus, after 40 years, the cask experiences less than .005% of the threshold value necessary to cause significant material changes.

The cask seal monitoring system is designed to maintain pressure within the interspace of the redundant cask seals at a value greater than that of the cavity pressure. The cask cavity pressure will be greater than atmospheric pressure. Therefore, if a cask seal were to fail outside air would be kept out of the cavity.

2. <u>Performance Under Off-Normal And Accident Conditions</u>.

Off-normal events are those which, while not occurring regularly, might occur on the order of once during a calendar year. Accident events are infrequent and could be reasonably expected to occur, if at all, once during the lifetime of a cask. A number of off-normal and accident events and the resulting conditions have been analyzed. The analyses included such events as peak ambient temperatures with maximum solar insolation (heat from sunshine) rates, tornadoes, earthquakes, floods, and the effect of a cask drop or tipover outside of the plant. The results of the analyses of each of these events is summarized below.

This topic is discussed at length in chapter 4.D. of the EIS at pages 4.13-4.21. The results of these analyses show that no off-normal events have any significant effect on the operation of the casks, and no accident events result in the release of any radioactive material from the cask.

a. Peak Ambient Temperature And Insolation Rate.

The average peak ambient air temperature and insolation rate are 100° F and 135 BTU/hr-ft², respectively. Under these conditions, the cask temperatures, as discussed in the EIS on page 4.16, would increase by about 50°F. These temperatures have no effect on the cask.

b. Tornado And Tornado-Driven Missiles.

During tornado winds, the TN-40 cask will remain stable and upright. No cask tipover would occur. Additionally, the impact of tornado-driven missiles against the cask will not result in cask tipover or loss of cask seal integrity.

c. Seismic Events.

Under earthquake conditions, the TN-40 cask would not tip over, the cask seal integrity would be maintained and the cask would sustain no damage.

d. ISFSI Flooding.

Under the 100-year site flood conditions, water levels would remain below the base of the cask. For the probable maximum flood condition, water levels, including associated wave run-up, would remain below the level of the cask seals. Flood water velocity would not cause cask movement or tipover. Cask seal integrity would be maintained and water would not leak into the cask.

e. External Cask Drop Or Tipover.

When a loaded TN-40 cask is moved outside of the auxiliary building, it will be handled by a cask transporter with a maximum vertical cask lift height of 18 inches. If the cask were dropped from the 18 inch height onto the concrete ISFSI pad (the hardest surface outside the auxiliary building), cask seal integrity would be maintained and the fuel basket structure within the cask would not be damaged or deformed, nor would any fuel assemblies be damaged.

No off-normal event can result in a cask tipover on the ISFSI pad. Nonetheless, a cask tipover accident on the ISFSI pad has been analyzed. The results show that the cask seal integrity would be maintained and the fuel basket structure would not suffer damage or severe deformation.

3. Sabotage.

The NRC sponsored testing and analyses of a perfectly executed sabotage scenario against a storage cask containing spent fuel assemblies. Because the casks are so massive, they will withstand attack by most types of munitions without any release of spent fuel. The only possible way to breach the cask is with large quantities of powerful explosives. Such a scenario is extremely unlikely. One reason is because sophisticated and large amounts, on the order of hundreds of pounds, of explosives would be required and such material is not easily obtained. In addition, because the casks are round, the impact must be perfect, that is within an inch of the cask center. Such accuracy is difficult to achieve, particularly for an attack launched from the outside of the ISFSI. Finally, the ISFSI is surrounded by a security fence and is monitored by security personnel. As a result, an intruder would not have an opportunity to prepare and execute a successful attack.

Crashing an aircraft into a cask might tip it over, but it would not breach the cask. The aircraft itself is a very soft projectile and most of the energy in a collision with a target as massive and robust as a TN-40 cask would be spent in disintegrating the aircraft.

D. Cask Maintenance During Storage.

Because of their passive nature, the storage casks will require little, if any, maintenance. Typical maintenance tasks could involve occasional replacement and recalibration of monitoring instrumentation and re-application to some casks of corrosion-inhibiting coatings. No special maintenance techniques are necessary.

E. Wastes And Emissions (Provided Pursuant To Minn. Rule Pt. 7855.0650).

Among other things, Minn. Rule pt. 7855.0650 requests information concerning the radioactive wastes generated by the ISFSI. (The NRC establishes the standards for radioactive wastes and emissions related to operating a nuclear power plant. The proposed Dry Cask Storage Facility is within these standards.)

1. The Types And Estimated Amounts Of Solid, Liquid, And Gaseous Radioactive Wastes That Would Be Produced By The Facility And The Level Of Radioactivity Of Each In Curies Per Year.

This topic is fully discussed at page 4.1 of the EIS. In summary, the operation of the Dry Cask Storage Facility will not generate gaseous, liquid, or solid radioactive wastes other than those resulting from the decontamination of the outside surface of the casks.

The spent fuel storage casks must be placed in the spent fuel pool to load the fuel. Spent fuel pool water is contaminated and will contaminate the surfaces of the cask. NSP will remove these contaminants by:

a. washing the cask with clean water as it is lifted out of the spent fuel pool;

b. if necessary, washing the cask with clean water in the cask decontamination area within the auxiliary building; and

c. if necessary, spot decontamination using spray cleaners and cloths.

Cask decontamination procedures were fully discussed earlier and will conform to NSP's agreement with the Department and the EQB.

Water used in decontaminating the casks will be collected by drains and routed through PI's existing radioactive waste system. Resin filters will remove any contaminants prior to water discharge. Since the wash water will contain only trace amounts of radioactive materials, the amount of resin attributable to cask decontamination, which will eventually be sent to a low-level radioactive waste burial site, is negligible.

Solid low-level radioactive waste will result from the use of throw-away protective clothing by decontamination personnel and the cloths used to remove contaminants. This volume is estimated at less than 1 cubic foot of processed solid waste per cask. Its total radioactivity will be less than .0001 curies. These amounts are negligible compared to PI's average annual radioactive waste volume of 4000 cubic feet and activity of 225 curies.

The neutron shield material of the cask is a polyester resin which, at cask operating temperatures, does produce a small amount of gas. The gases produced, helium, hydrogen and various hydrocarbons, are not radioactive.

2. <u>An Analysis Of Human Exposure To Ionizing Radiation Attributable To Operation Of The Facility, Taking Account Of The Pathways Of Radioactive Releases To Man.</u>

This topic is discussed at pages 4.17-4.19 and Chapter 6 of the EIS. The following table presents the maximum annual doses a person hypothetically could receive as a result of the Dry

Cask Storage Facility calculated using unrealistic and very conservative assumptions. The referenced off-site person inhabits the residence just to the north of the plant site boundary.

Table 6

Annual Doses Compared to Regulatory Limits

	Maximum Individual Dose (millirem)	Regulatory Limit (millirem)	Percent of Limit
Site worker	33.00	5,000	0.66%
ISFSI worker	160.00	5,000	3.20%
Off-site person	3.70	25	15.00%

Actual doses are expected to be as much as 8 times lower. The above estimates assumed all 48 casks were present and all of the spent fuel stored in the casks was the most radioactive permitted to be stored in the casks. When these assumptions are removed to reflect the actual condition of the spent fuel which will be stored in the casks, along with the fact that, for the average dose calculation, less than 48 casks will on average be stored at the ISFSI, the maximum annual dose rate to the nearest permanent resident is reduced to 0.42 millirem per year. The average annual dose rate to the nearest permanent resident is 0.34 millirem per year, which accounts for the gradual cask installation rate, and the continuing radioactive decay of spent fuel.

These very low levels should be compared with the background radiation produced by natural sources, including radon, of about 300 millirem/year at the plant site and radiation produced by masonry or construction materials. Living in a brick house results in an average annual dose of 7 millirem, while exposure from road construction materials while driving results in an average annual dose of 4 millirem.

It is also important to emphasize that the average annual dose from the ISFSI, which is well within all federal and state standards, is so low as to be unmeasurable. There are no established health effects from radiation of the level produced by the casks in the Dry Cask Storage Facility.

3. The Types And Estimated Amount Of Nonradioactive Solid And Liquid Wastes That Would Be Produced.

No nonradioactive solid or liquid wastes will be produced by the Dry Cask Storage Facility.

4. The Types And Estimated Amounts Of Nonradioactive Gaseous And Particulate Emissions Into The Air That Would Occur During Full Operation From Each Emission Source, And The Location And Nature Of The Release Point.

No nonradioactive gaseous or particulate emissions will be produced by the Dry Cask Storage Facility. The neutron shield material of the cask is a polyester resin which, at the cask operating temperatures, does produce a small amount of gas. The gases produced, helium, hydrogen and various hydrocarbons, are not radioactive. The quantities produced are minute.

5. Locations That May Be Sources Of Fugitive Dust And The Nature Of Each Source.

This topic is fully discussed at pages 4.6 and 4.13 of the EIS. Dust will be generated only when vehicles operate along the gravel road surrounding the ISFSI. This dust will not create any environmental impacts.

6. The Nature And Estimated Amount Of Nonradioactive Discharges To Water, And The Locations, Routes, And Final Receiving Waters For Any Discharge Points.

This topic is fully discussed at pages 4.5 and 4.8-4.9 of the EIS. Operation of the ISFSI will not use or discharge any water.

7. Any Area From Which Runoff May Occur, Potential Sources Of Contamination In The Area, And Receiving Waters For Any Runoff.

As indicated at pages 4.5 and 4.8-4.9 of the EIS, any precipitation runoff from the ISFSI will not be contaminated. Runoff will go to the nearby Vermillion River, which flows into the Mississippi River.

8. The Sources And Estimated Amounts Of Heat Rejected By The Facility.

This topic is fully discussed at page 4.13 of the EIS. The maximum cask surface temperature will not exceed 240° F, and would only occur in a relatively small and localized area. The total heat output from the ISFSI will be less than that from the lighting system of a typical athletic stadium.

9. The Maximum Noise Levels Expected At The Property Boundary And The Expected Maximum Increase Over Ambient Noise Levels.

This topic is fully discussed at pages 4.6 and 4.13 of the EIS. In summary, construction noise impacts will be minimal. Operational noise will be limited to those occasions when a cask is moved to or from the ISFSI. The associated noise will be minimal.

F. Cask Retirement (Provided Pursuant To Minn. Rule Pt 7855.0600C).

1. Cask Unloading.

In preparation for transferring the PI spent fuel to the DOE under the provisions of the NWPA, it will be necessary to unload each TN-40 cask and transfer the spent fuel contained therein to DOE transport casks.

NSP will transfer each cask to the auxiliary building using the cask transporter, return the cask to the fuel pool, remove the spent fuel, and place the spent fuel in empty storage locations in the spent fuel racks for later transfer to the DOE transport cask. The spent fuel would be removed from PI by rail or truck. The spent fuel is expected to remain at PI until 2010 or the date the DOE accepts the spent fuel.

The procedures used to unload a cask will essentially be a reversal of the cask loading procedure described in Section IV.B.3.

2. Cask Disposal Options.

The TN-40 cask can be easily decommissioned. At the end of its service lifetime, cask decommissioning can be accomplished by one of several options described below.

One option is the potential for a secondary market for the casks. This option involves four possible markets:

- the need for interim storage of spent fuel by DOE at the MRS facility and/or permanent repository;
- use by other utilities with compatible fuel for on-site dry storage of spent fuel;
- use by utilities and other low-level radioactive waste generators for storage of radioactive

waste;

- use for storage of hazardous or mixed wastes.

Following decontamination and refurbishment, the casks could be sold and shipped to new users. The casks would offer inexpensive, incremental storage with proven technology for a variety of radioactive, hazardous, or mixed wastes.

A second option involves the disposal of the casks as waste. Neutrons emitted by the spent fuel interact with certain cask materials, causing a fraction of the cask material to become radioactive. This phenomenon is called "activation." The radioactive material is referred to as "radioactive isotopes." Analyses have been performed to predict the radioactivity levels in cask materials after years of storage. The results of the analyses indicate that after 20 years of storage, the radioactive isotopes in a typical cask would amount to 0.13 curies.

To evaluate the TN-40 cask and basket for disposal, the concentrations of the radioactive isotopes in the cask were calculated and compared with the limits for low-level radioactive waste in 10 CFR pt. 61.55. The calculation shows the expected concentrations are far below the limits for Class A waste, which is the classification for the least radioactive of all low-level radioactive waste. Consequently, NSP expects that after application of a simple decontamination process, which could be performed in the cask decontamination area in the auxiliary building, the radiation level would be negligible and the cask could be scrapped.

For persistent, local contamination of the cask, chemical etching using hydrochloric acid or nitric acid can be applied to remove the contaminated material. Alternatively, electropolishing could be used to achieve the same result. Any remaining contaminated portions would be shipped as low-level radioactive waste to a disposal facility. NSP will perform a detailed evaluation at the time of decommissioning to determine the appropriate mode of disposal.

V. DISCUSSION OF ALTERNATIVES TO THE USE OF DRY CASK STORAGE (PROVIDED PURSUANT TO MINN. RULE PTS. 7855.0610 AND 7855.0630).

This section of the Application discusses possible alternatives to the use of a Dry Cask Storage Facility with TN-40 casks and the environmental impacts of those alternatives. In preparing the EIS and reviewing comments received in response to the EIS, NSP and the EQB have extensively analyzed alternatives to using a Dry Cask Storage Facility. The EIS considers each alternative and provides much of the information required by the Commission's rules, including Minn. Rules, pt. 7855.0610. NSP has attached the EIS to this Application (Volume 2) and incorporates Chapter 5 of the EIS into the following discussion of alternatives. In addition, for the convenience of the Commission and Intervenors, NSP has provided citations to the pages of the EIS which discuss each alternative.

Some of the alternatives described in this Application would increase the production of low-level radioactive waste. As background, the Low-Level Radioactive Waste Policy Amendments Act of 1985 (P.L. 99-240) allows the three states that currently have low-level radioactive waste (LLRW) disposal sites to stop accepting waste from other states after 1992. Those three states are Washington, Nevada and South Carolina. All three states have indicated they will stop accepting such waste effective January 1, 1993. Every other state or congressionally approved inter-state compact must then begin to dispose of its own LLRW.

Minnesota belongs to the Midwest Compact. Michigan is the first host state for this compact and is required to build a LLRW disposal facility for the Midwest Compact member states. Michigan's present schedule shows site operations beginning in April of 1997 at the earliest.

All LLRW generators in Midwest Compact states will be forced to store their LLRW on-site from December 31, 1992, until at least April of 1997. Prairie Island's LLRW storage capacity should last about six years based on current LLRW generation levels.

The 1985 LLRW Policy Amendments Act also states that if compacts do not have sites available by 1996, each state must take title to the LLRW generated within it. The Nuclear Regulatory Commission is now taking public comments as to how to interpret and enforce this provision.

Several of the alternatives discussed in this section of the Application would generate LLRW, which would reduce PI's storage capacity to less than six years. Those impacts are discussed separately for each alternative where it is a factor. The cost estimate for disposing of LLRW comes from the Midwest Compact, which is estimating that it will charge $1,000 per cubic foot of waste when its site opens.

For convenience the following pages present a summary of the alternatives to the proposed Dry Cask Storage Facility with TN-40 casks.

	ALTERNATIVE	AVAILABILITY	POOL CAPACITY	COST	POWER SUPPLY RELIABILITY
A.	No Action	Available, Not Feasible	Through 1994	$1 Billion for Replacement Power	Increased Risk
B.	Reduce Plant Operation	Available, Not Feasible	Through 1998 at Half Capacity	$168 to $324 Million Replacement Power 1991-1998; $800 Million for Replacement Power 1999-2014	Increased Risk
C.	Conservation	Available, Not Feasible to Extent Required to Replace or Reduce Operations at PI	Through 1994	$1 Billion for Replacement Power	Increased Risk
D.	New Pool	Available	Beyond Plant License (2014)	Capital Costs $31 Million; Operating Costs $5 Million; Replacement Power 1995-1997 $70-150 Million; Decommissioning $50 Million for Disposal of LLRW	Increased Risk from 1995-1997
E.	Enlarge Current Pool	Available	Through 2005	Capital: $13 Million; Replacement Power 1991-95: $200-300 Million; Replacement Power 2005-2014: $360 Million; LLRW Disposal $6 Million	Increased Risk '91-95 and 2005-2014
F.	Rerack Current Pool	Available	Through 1998	Capital $8-10 Million; LLRW Disposal $2 Million; Replacement Power 1999-2014: $800 Million	Increased Risk 1999-2014

	ALTERNATIVE	AVAILABILITY	POOL CAPACITY	COST	POWER SUPPLY RELIABILITY
G.	Two-Tiered Racks	Available	Through 2000	Capital $12-14 Million; LLRW Disposal $1.5 Million; Replacement Power 2001-2014 $590 Million; Potentially more if NRC Delays License	Increased Risk 2001-2014
H.	Consolidation	Available	Through 2000	Consolidation $12 Million; Replacement Power 2001-2014 $590 Million	Increased Risk 2001-2014
I.	Transship to Monticello	Available, Not Feasible	Through 1998 at PI & Monticello	More than $1 Billion for Replacement Power	Increased Risk 1998 Forward
J.	Transship to Pathfinder	Not Available			
K.	Ship to other Storage Facility	Not Available			
L.	Ship to Federal Facility	Not Available			
M.	Reprocess	Available, Not Feasible	End of Plant License (2014)	At least $384 Million	
N.	Higher Burnup Fuel	Not Available			
O.	Dry Cask at Another Site	Not Available			
P.	Other Dry Storage Designs	Available	Beyond Plant License (2014)	Comparable to TN-40 Some Designs Not Incremental	Potential 1 year Risk Due to NRC Delays in Licensing
NSP's Proposed Dry Cask Storage Technology with TN-40 Dry Casks		Available	Beyond Plant License (2014)	$39 Million, Spent Incrementally	Reliability Maintained

The following are the possible alternatives to the proposed Dry Cask Storage Facility with TN-40 casks, pursuant to Minn.Rule pt. 7855.0610.

A. No Action.

This alternative is discussed in the EIS on pages 5.2-5.5. It would result in PI running out of temporary storage capacity for one of its units by February 1995, which will begin the forced shutdown of the plant. The second unit would be shut down in October 1995. Therefore, this alternative is expressly precluded by Minn. Rule pt. 7855.0100, which prevents the selection of any alternative which "could reasonably be expected to result in a forced shutdown of the generating facility." Consequently, NSP presents the following discussion only for informational purposes. This information demonstrates that the no action alternative would not solve the storage needs at PI, would increase customer costs and would jeopardize NSP's ability to meet its customers' electrical needs.

1. The Location Of The Facility.

The location of this alternative is the PI Nuclear Generating Plant at the existing facilities and within the existing plant boundaries. No construction or modification of the existing plant is required under this alternative.

2. The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns.

There is no required land area for this alternative. There are no additional structures, either above or below ground required for this alternative.

3. Its Design Capacity In The Appropriate Units Of Measure.

The design capacity of the existing PI spent fuel pools is 1582 spent fuel assemblies (1386 for normal storage and 196 for short-term storage in the area of the pool reserved for cask set-down), which is the maximum allowed under PI's current license with the NRC. However, due to the inaccessibility of some rack storage cells and the storage of other waste in the racks, the space available for normal storage has been reduced to 1354 fuel assemblies.

4. A Schematic Drawing Showing Major Components Of The Facility.

Drawings of the existing spent fuel area are contained in the EIS at pages 5.55-5.58.

5. The Probable Date For Commencing Construction And The In-Service Date.

This option does not involve construction at PI. It would result in shutdown of PI in 1995.

6. The Estimated Installed Cost Of The Alternative In Current Dollars.

This alternative results in the following incurred costs:

a. Replacement capacity and energy,

b. Additional costs to meet environmental requirements at NSP fossil-fueled plants, and

c. Mothballing or premature decommissioning.

Shutdown of PI in 1995 would require NSP to replace the capacity and energy provided by the plant. Initially, the capacity would be replaced with capacity purchases from other utilities, and/or accelerated construction of combustion turbine generators. Energy purchases and operation of existing fossil-fueled plants, including expensive peaking plants, would also increase. The risk that NSP would not be able to fully meet customer demand would increase, since baseload capacity and energy purchases available from MAPP utilities and the surrounding region may not be sufficient to meet NSP's needs. The earliest that NSP could install new baseload capacity to replace PI would be the late 1990s (assuming NSP began the licensing process for such capacity in 1991). Eventually, NSP would need to construct 1008 MW of additional baseload capacity to replace PI (based on the plant's summer capacity rating).

As was explained in Section II. of this Application, the Need Summary, the shutdown of the PI plant in 1995 would increase NSP's future revenue requirement by more than $1 billion (present worth). The $1 billion represents the estimated cost of purchasing replacement capacity and energy and eventually constructing and operating replacement capacity. This would represent a significant and unnecessary additional expense for NSP customers.

Regardless of whether NSP obtained the needed replacement energy by purchase, construction and operation of new plants, increased generation by NSP's existing fossil-fuel plants or a combination of these methods, most of the replacement energy for the foreseeable future would likely be generated by fossil-fueled plants. Those plants would have higher energy costs, and shifting from nuclear to fossil-fuel generation would increase atmospheric emissions.

A significant increase in the operation of NSP's existing fossil-fueled plants would increase emissions of sulfur dioxide (SO_2), nitrous oxides (NO_x), carbon dioxide (CO_2), and particulates. These increased emissions could cause NSP to reach emission limits established by federal regulations earlier than would otherwise occur, and would necessitate additional costs to NSP customers either to reduce emissions at NSP's fossil-fuel plants or to purchase additional emission allowances. Such costs are difficult to quantify and were not included in the costs discussed earlier with regard to the cost for replacement capacity and energy.

A shutdown of the PI plant would also require additional costs to NSP customers to: a) mothball the PI plant until an MRS or a permanent repository can be built; or b) prematurely decommission the plant.

The annual cost of operating and maintaining the existing spent fuel pools after shutdown and before decommissioning would be approximately ten percent (10%) of the current annual costs to operate and maintain PI. These additional costs would be incurred without the benefit of energy production from the plant. (They are included in the $1 billion total cost cited earlier.)

7. The Sources, Types, and Amounts of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year.

The source and type of nuclear waste products involved in this alternative are the same as for the existing plant. The amount of spent fuel and the level of radioactivity which would be involved would be that amount of spent fuel on hand (1571 fuel assemblies) as of 1995. Each fuel assembly after ten years contains radioactivity in the approximate amount of 147,000 curies. This alternative does not involve transport because the spent fuel would remain at PI in the spent fuel pools and in the reactors.

8. The Estimated Maintenance Requirements Of The Alternative.

The existing maintenance requirements for the existing pool storage would be continued until all of the spent fuel was removed by the DOE.

9. The Estimated Economic Life Of The Facilities Involved In The Alternative.

The estimated economic life of PI under this alternative is four years, until 1995 when the plant would be forced to shutdown.

10. The Reasons Why The Alternative Was Rejected.

This alternative was rejected because instead of solving the problem of spent fuel storage it creates additional and more serious problems for NSP's customers. It jeopardizes NSP's ability to assure continued service, would result in cost increases and results in a forced shutdown of PI, which violates state law (Minn. Rule pt. 7855.0100).

B. Reduce PI Operation.

This alternative was discussed at pages 5.6 and 5.7 of the EIS. The EIS analysis of this alternative assumes the DOE will begin accepting spent fuel from PI in 1998. Under this alternative, NSP would cease operation of one unit at PI in 1991 in order to reduce fuel consumption and thereby conserve storage capacity for spent fuel. This could potentially delay the date when PI runs out of storage capacity beyond January 1995. As is explained below, this has many of the same adverse consequences as the no action alternative.

1. The Location Of The Facility To The Fullest Extent Known.

The same answer given under the no action alternative applies to this alternative.

2. The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns.

The same answer given under the no action alternative applies to this alternative.

3. Its Design Capacity In The Appropriate Units Of Measure.

The same answer given under the no action alternative applies to this alternative.

4. <u>A Schematic Drawing Showing Major Components Of The Facility</u>.

The same answer given under the no action alternative applies to this alternative.

5. <u>The Probable Date For Commencing Construction And The Probable In-Service Date</u>.

The same answer given under the no action alternative applies to this alternative.

6. <u>The Estimated Installed Cost Of The Alternative In Current Dollars</u>.

Baseload-type generating plants are characterized as having high fixed costs, which are justified because baseload plants are expected to generate significant amounts of energy at a low variable cost. Because of those plant characteristics, the most reasonable method for implementing this alternative would be to shut down one of the reactors rather than run both units at less than full load.

A significant reduction in the capacity and energy production available from PI would, like the no action alternative, require the purchase of replacement baseload capacity and energy and the accelerated construction and operation of additional generating resources.

This option merely accelerates the date on which some of the costs of a no action alternative are incurred and, if an MRS is not available in 1999 for off-site storage, it merely delays the date on which a forced complete shutdown occurs and consequently potentially has many of the adverse cost effects as the no action alternative.

The EIS at page 5.7 estimates that this option would increase revenue requirements between \$168 to \$324 million (1990 dollars), based on the assumption that one reactor is shutdown between 1991 and 1998 and that the DOE begins removing fuel from PI in 1999. That estimate, however, assumes a permanent DOE storage facility will be available before 2010. While the

DOE may begin accepting spent fuel at an earlier time for temporary storage at an MRS facility, that possibility cannot replace the need for an assured temporary storage facility. More important, this proposal results in the immediate shutdown of one unit and could result in the forced complete shutdown of PI in the late 1990s, which violates the provisions of Minn. Rule pt. 7855.0100. A complete shutdown in 1999 would cause replacement energy and capacity costs of $800 million (present value revenue requirements in 1990 dollars).

7. The Sources, Types And Amounts Of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year.

The same answer given under the no action alternative applies to this alternative.

8. The Estimated Maintenance Requirements Of The Alternative.

The same answer given under the no action alternative applies to this alternative.

9. The Estimated Economic Life Of The Facilities Involved In The Alternative.

Under this option, depending on how much PI's use is curtailed, the ability to operate one reactor could be extended beyond 1995 until 1999. However, because one reactor would have to shut down, the effective full use of the plant would terminate immediately in 1991.

10. The Reasons Why The Alternative Was Rejected.

This alternative was rejected for the same reasons that the no action alternative was rejected. It does not solve PI's spent fuel storage problems, accelerates the date on which PI must be partially shut down with its attendant costs to the ratepayers, and the forced shutdown violates state law (Minn. Rule pt. 7855.0100).

C. Increase Customer Conservation.

This alternative was discussed at pages 5.7-5.12 of the EIS. It assumes that by increasing customer conservation programs, some or all of the need for operating the PI plant can be eliminated, thereby reducing fuel consumption, conserving storage capacity for spent fuel, and delaying the date when NSP expects to run out of spent fuel storage capacity at the plant past January, 1995. As is explained below, this alternative forces PI to shut down, which jeopardizes the ability to meet customer demands for service, results in increased customer rates, and is impermissible under Minn. Rule pt. 7855.0100.

1. The Location Of The Facility, To The Fullest Extent Known.

The same answer given under the no action alternative applies to this alternative to the extent the conservation is intended to replace PI. The actual conservation would take place in numerous locations across the State of Minnesota.

2. The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns.

The same answer given under the no action alternative applies to this alternative.

3. Its Design Capacity In The Appropriate Units Of Measure.

The same answer given under the no action alternative applies to this alternative.

4. A Schematic Drawing Showing Major Components Of The Facility.

The same answer given under the no action alternative applies to this alternative.

5. The Probable Date For Commencing Construction And The Probable In-Service Date

The same answer given under the no action alternative applies to this alternative.

6. The Estimated Installed Cost Of The Alternative In Current Dollars.

The full cost of this alternative is difficult to determine for several reasons: 1) the necessary conservation programs do not exist; 2) if additional programs existed were cost effective, they would be most cost effective if used to avoid construction of new capacity or operation of high-cost plants, rather than replacing or reducing operation at PI, which is one of NSP's lowest-cost baseload plants; and 3) if such programs existed, there is no evidence that they would cost less than continuing PI operation.

Conservation efforts cannot cost-effectively replace 20% of NSP's current energy requirements (PI generates approximately 20% of the electricity required by NSP's customers). Currently planned conservation efforts, which are among the most aggressive in the nation, do not even keep pace with the expected growth in NSP's customer electric energy requirements. To replace the existing energy requirements met by PI would require additional conservation during the next four years approximating three times the total conservation impact which NSP currently expects to accomplish over the next 20 years.

NSP's Conservation Improvement Plan ("CIP") is discussed further in Section XIII. of this Application. As that section explains, NSP's long-range DSM goal includes 1,000 MW of cumulative coincident peak impact system-wide by 1995. However, most DSM programs are more effective at reducing peak than in reducing baseload energy requirements. Consequently, NSP's planned energy conservation would need to increase by approximately a factor of eight by 1995 in order to replace the energy supplied by PI. There are no known programs which can economically or even feasibly reach such a goal, especially in so short a time.

Even if additional conservation programs were feasible, it would be more cost-effective to use them to avoid construction of new baseload plants, rather than shut down PI. Therefore, if it was desirable to implement additional conservation programs, economics would support installing a Dry Cask Storage Facility to keeping PI operational and delaying future plants. The appropriate forum for making such a cost/benefit analysis is in NSP's CIP filing.

7. The Sources, Types, And Amounts Of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year.

The same answer given under the no action alternative applies to this alternative.

8. The Estimated Maintenance Of The Alternative Method.

The same answer given under the no action alternative applies to this alternative.

9. The Estimated Economic Life Of The Facilities Involved In The Alternative.

The same answer given under the no action alternative applies to this alternative.

10. The Reasons Why The Alternative Was Rejected.

This alternative was rejected for the same reasons the no action/reduced operation alternatives were rejected. It does not solve PI's spent fuel storage problems, it jeopardizes NSP's ability to meet customer needs and forces the shutdown of PI, which violates state law (Minn. Rule pt. 7855.0100). No conservation programs exist which could replace Prairie Island quickly or economically.

D. Construction Of A New Pool.

This alternative is discussed at page 5.20-5.21 of the EIS. It entails constructing a building containing a new spent fuel storage pool. The new building and pool structure would be designed and constructed to the same standards as the existing auxiliary building and the existing storage pool, and would be licensed and regulated by the NRC. A new pool would be designed for older, cooler fuel. A transfer cask would be required to transfer spent fuel assemblies from the existing pool to the new pool.

As is explained below, this alternative would require a temporary shutdown of PI, offers less storage flexibility than the dry cask facility, is more complicated to operate, and is more costly than the proposed dry cask facility.

1. The Location Of The Facility, To The Fullest Extent Known.

The most likely location would be on the PI site as close to the existing spent fuel storage area as possible.

2. The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns

A building with the same capacity as the Dry Cask Storage Facility (1920 spent fuel assemblies) would have approximate dimensions of 136 feet long, 96 feet wide and 55 feet tall.

3. Its Design Capacity In The Appropriate Units Of Measure.

In contrast to TN-40 casks, which can be installed in increments to handle 40 fuel assemblies at a time, the economics of constructing a new pool would require building a single new pool large enough to handle the number of fuel assemblies which might be generated in excess of existing capacity during the remaining life of the plant.

4. A Schematic Drawing Showing Major Components Of The Facility.

An additional, new storage pool would require the same components as the existing pool. These include storage racks, pool cooling and filtration systems, pool bridge crane and fuel assembly handling tools, building ventilation system and radiation monitoring equipment and a cask decontamination area. Thus, the schematic drawing of the existing pool, found at pages 5.55-5.58 of the EIS, is representative of this alternative.

5. The Probable Date For Commencing Construction And The Probable In-Service Date

It would take an estimated three years to design a new pool building and to complete state and federal reviews and approvals. If this work began in mid-1991, construction would begin in mid-1994. Construction would last about two years. Therefore, the new pool would go into service in mid to late 1996.

6. The Estimated Installed Cost Of The Alternative In Current Dollars.

The construction costs of such a structure are estimated to be at least $31 million, while the annual operating costs are estimated at $0.5 million. Additional costs for replacement capacity and energy could range from $70 million to $150 million (present value of additional revenue requirements in 1990 dollars) for a two-year plant shutdown.

7. The Sources, Types, And Amounts Of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year.

A new storage pool would most likely be designed for fuel that has been discharged from the reactor and cooled for five or more years. Other than this restriction, there would be no difference in the spent fuel stored in the new pool from that stored in the existing pool. After five years of cooling and decay, an average PI spent fuel assembly contains about 350,000 curies of radioactivity.

Spent fuel would be transferred from the old pool to the new pool using a transfer cask. All transfer operations would take place entirely on plant property. The transfer cask would be very similar in design and operation to a storage cask. The transfer cask would be placed into the existing pool and loaded with spent fuel, decontaminated and sealed and taken to the new pool building. The transfer cask would be placed into the new pool, where spent fuel assemblies would be removed from the cask and placed into storage racks in the pool.

Operation of the new pool would generate some low-level radioactive wastes. The majority of such wastes would be used resins from the pool demineralizer and used filters from the pool filtration system. These wastes would amount to about 100 cubic feet per year and contain about 110 curies of radioactivity. Building ventilation equipment would be designed to ensure any radioactive gaseous releases would not exceed NRC standards. Insignificant amounts of nonradioactive wastes would result from operation of a new pool. Normal operation would not result in any air emissions, fugitive dust, runoff or discharges to water, or elevated noise levels.

The degree of radiation shielding provided by the pool and building structures, and by the water in the pool is such that there is essentially no increase in off-site radiation doses due to operation of the new pool. Pool operation would increase plant occupational exposures by about 1%.

The total amount of heat generated by spent fuel assemblies in the new pool would be on the order of 800 kilowatts. This heat would be transferred to the pool water and removed from the pool water by the heat exchangers in the pool cooling system.

As a new pool building would be constructed within the plant area, little environmental disturbance, if any, would result. No discharges to water would be allowed during construction. Fugitive dust and noise levels would not be a concern, given the relatively small scale of the construction, and because there are no dwellings or businesses close to the construction area.

Only a small to moderate volume of nonradioactive waste would be generated during construction, the nature of which would be the same as is generated from construction of nonnuclear facilities. Such waste would be disposed of along with other nonradioactive wastes generated by miscellaneous plant activities.

Management of the radioactive materials stored and handled in the new pool would be according to the same controls and procedures used in the plant, which comply with NRC standards. Any accidental release of solid or liquid radioactive material would occur within the building, where it could be contained and isolated from the environment. Radioactive waste generated during cleanup would be treated and shipped to a low-level radioactive waste disposal site, as is similar waste generated in the course of plant operation. In the event of a radioactive gaseous release inside the building, the NRC standards for such a release would be met.

Because new pool operation does not result in air emissions, dust, pollution, or any significant amounts of solid or liquid wastes, there would be no equipment or measures in place to control or mitigate the effects of emissions. Thorough, regular environmental monitoring of the area surrounding the plant site was initiated in the late 1960s, before plant construction began, and has continued ever since. Based on the data provided by such monitoring, one would expect no significant environmental impact due to the operation of an additional pool on the plant site.

The eventual decommissioning of the building that would house the new spent fuel pool would generate large amounts of LLRW, approximately 50,000 cubic feet. The LLRW would contain radioactivity in the approximate amount of 35 curies. Using the Midwest Compact's proposed fee for waste it would start accepting in 1997, this would amount to a $50-million decommissioning cost. LLRW would be transported by rail or truck.

8. The Estimated Maintenance Requirements Of The Alternative.

Maintenance requirements would be the same as for the existing pool. Those consist mainly of replacing the demineralizer resins about twice a year and replacing the pool water filters about four times a year, as well as routine care and repair of components of the pool support system (e.g., water cooling, building ventilation, pool bridge and cask handling cranes).

9. The Estimated Economic Life Of The Facilities Involved In The Alternative.

A new pool would have an economic life equal to the remaining life of the plant.

10. The Reasons Why The Alternative Was Rejected.

This alternative was rejected for three reasons. First, the economics of pool construction would dictate that a single large pool be installed, with an overall estimated cost of at least $31 million. Thus, it lacks the flexibility of a dry cask facility, which can be added in increments of 40 fuel assemblies. Second, dry cask storage is operationally superior for the storage of older fuel because it is a passive system that does not require pumps, filtration systems or operator actions. Third, PI would need to be shut down for up to two years during pool construction. That shutdown would create significant added energy and capacity costs for customers. And fourth, a new fuel pool eventually would require decommissioning, which would generate large amounts of LLRW which will be costly to dispose of.

E. Enlarge The Current Pool.

This alternative is discussed at page 5.20-5.21 of the EIS. It requires the existing new fuel pit to be combined with Pool No. 1, resulting in an enlarged pool with a larger total pool storage capacity. As is discussed below, this option has the same drawbacks as a new pool, plus it results in a forced shutdown of PI after the year 2005, which violates state law (Minn. Rule pt. 7855.0100).

Combining the present pool with the new fuel pit would require removing the four-foot thick concrete wall between the new fuel pit and Pool No.1, as well as removing the new fuel pit floor. This kind of construction would produce about 6,000 cubic feet of concrete rubble and steel, as well as associated equipment and material, all of which would have to be disposed of as LLRW.

1. The Location Of The Facility, To The Fullest Extent Known.

The location of the facility would be the current PI fuel pool area.

2. The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns.

The existing structures housing the current spent fuel pool would be used. Structural reinforcement of the walls of the enlarged pool would probably be required.

3. Its Design Capacity In The Appropriate Units Of Measure.

This modification would result in a storage capacity increase of approximately 500 assemblies.

4. A Schematic Drawing Showing Major Components Of The Facility.

An enlarged storage pool would resemble the schematic drawings of the existing pool contained in the EIS, pages 5.55-5.58, with the new fuel pit being converted to a spent fuel pool.

5. The Probable Date For Commencing Construction And The Probable In-Service Date

Construction could not begin until the NRC had granted an amendment to the plant operating license, which would probably be no earlier than sometime in 1992. The construction period would be about three years. Pool No. 1 could not be used for fuel storage until the construction is complete, and Pool No. 2 will be full in June 1991. Therefore, this alternative would require plant shutdown for a period of at least four years.

6. The Estimated Installed Cost Of The Alternative In Current Dollars.

The cost of enlarging the pool is estimated to be at least $13 million. In addition, it would be necessary to shut down the plant during the construction process. Pool No. 1 could not be used for spent fuel storage during construction and until this modification is completed. Pool No. 2 will be at full capacity with the next outage. Therefore, this alternative would require the plant to be shutdown for a period of approximately four years, thereby increasing customer energy and capacity costs by from $200 million to $300 million (present value of additional revenue requirements in 1990 dollars). Further, an enlarged pool would not provide sufficient storage capacity to go beyond the year 2005, long before PI's plant license expires and also before the DOE is expected to begin accepting spent fuel. The cost of replacement capacity and energy for PI after 2005 would be approximately $360 million (present value of additional revenue requirements in 1990 dollars). An additional cost is the approximately $6 million for LLRW disposal as a result of construction.

7. The Sources, Types, And Amounts Of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year.

The construction phase would generate significant nuclear waste. Removing the wall between Pool No. 1 and the new fuel pit would generate about 6,000 cubic feet of low-level radioactive waste estimated to contain about 10 curies. The majority of such waste would be the concrete and steel which form the wall. Disposal of this low-level radioactive waste could be difficult and costly given the lack of disposal capacity nationwide. Since the LLRW would be generated after 1992, it would have to be stored at PI from 1992 to 1997 and then disposed of in Michigan (if a site is available as planned). Six thousand cubic feet of LLRW would shorten the storage capacity at PI by about one year, probably necessitating the construction of additional storage space. In addition, final disposal of the material would cost about $6 million, again based on the $1,000 per cubic foot estimated fee for the Michigan site starting in 1997. When off-site storage is available, the LLRW would be transported by rail or truck in federally approved containers.

This alternative would also entail the greatest total radiation exposure to the construction workers, because the spent fuel pool area has ambient radiation levels of 1-2 millirem per hour. When compared to the existing pool configuration, an enlarged pool would present insignificant differences in operation, maintenance and radiation levels, both on-site and off-site. An enlarged pool would have an insignificant effect on plant decommissioning. There would be no difference in the type of waste stored in the enlarged pool.

8. The Estimated Maintenance Requirements Of The Alternative.

The maintenance requirements would be essentially identical to those occurring using the current pool and under the new pool alternative.

9. The Estimated Economic Life Of The Facilities Involved In The Alternative.

This would extend the economic life of the pool and thus the ability of PI to operate through the year 2001.

10. The Reasons Why The Alternative Was Rejected.

This alternative was rejected because of its lack of flexibility. In addition, this option would require a four-year shutdown during construction and then again after 2005, significantly increasing NSP's energy and capacity costs. As the alternative results in the forced shutdown of PI, it violates state law (Minn. Rule pt. 7855.0100).

F. Reracking.

This alternative is described at page 5.20 and 5.25 of the EIS. Spent fuel is stored in the pool in racks. The racks are either 7 x 7 or 7 x 8 arrays of square boxes about 14 feet long. Each box is designed to hold one fuel assembly vertically. Reracking means replacing the existing racks with racks designed to provide a more compact array of boxes, allowing more fuel to be stored in the pool. PI's racks were replaced in 1977 and again in 1981 with racks which have a much more compact design. The reracking process entails the following general sequence of installation:

1. Remove empty racks from Pool No. 1, and install new, more compact racks in Pool

No. 1.

2. Transfer spent fuel from Pool No. 2 to Pool No. 1.

3. Remove empty racks from Pool No. 2, and install new, more compact racks in Pool No. 2.

4. Transfer the remaining spent fuel from the old racks of Pool No. 2 to the new racks of Pool No. 2. Then, remove the remaining old racks and complete the installation of new racks in Pool No. 2. The old racks would be disposed of as low-level radioactive waste.

1. <u>The Location Of The Facility, To The Fullest Extent Known</u>.

The existing pool storage facility would be used.

2. <u>The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns</u>.

The existing pool storage facility would be used.

3. <u>Its Design Capacity In The Approximate Units Of Measure</u>.

It may be possible to increase the PI pool capacity by reracking. However, the maximum increase achievable by reracking is estimated to be about 20%. A 20% increase in pool capacity would support only 4 more years of operation. Additional storage capacity would be needed by 1999.

4. <u>A Schematic Drawing Showing Major Components Of The Facility</u>.

Figure 5-4 on page 5.56 of the EIS is representative of a fuel assembly in a rack of the current design.

5. The Probable Date For Commencing Construction And The Probable In-Service Date.

The licensing and manufacturing process would result in an in-service date of the first quarter of 1993.

6. The Estimated Installed Cost Of The Alternative In Current Dollars.

Reracking is estimated to cost between $8 million-$10 million. LLRW disposal costs would add about $2 million to this figure. In addition, this option requires premature shutdown of the plant in 1999 with its attendant capacity and energy replacement costs. Shut down of PI in 1999 would increase NSP's future revenue requirements by approximately $800 million (present value in 1990 dollars).

7. The Sources, Types, And Amounts Of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year.

The principal difference between this option and the existing spent fuel pool storage is that the existing rack hardware would be replaced and would need to be decontaminated and stored or shipped as additional low-level radioactive waste. The disposal of the approximately 2,000 cubic feet of low-level radioactive waste would cost about $2 million to dispose of when Michigan is ready to begin accepting waste in 1997. At that time the waste would be transported to the disposal site by truck or rail using federally approved containers. This LLRW is estimated to contain about 6 curies.

8. The Estimated Maintenance Requirements Of The Alternative.

The maintenance requirements would be the same as for the existing pool.

9. The Estimated Economic Life Of The Facilities Involved In The Alternative.

This alternative only extends the capacity of the pool until the year 1999.

10. The Reasons Why The Alternative Was Rejected.

This alternative was rejected because it is inadequate to meet the storage needs at PI. The alternative requires purchase or construction of replacement capacity at a significant incremental cost to customers. In addition, the alternative results in the forced shutdown of PI, which violates state law (Minn. Rule pt. 7855.0100).

G. Two-Tiered Racks.

This alternative is discussed at page 5.21 and 5.25 of the EIS. It entails placing a second tier of filled storage racks on top of the existing configuration of storage racks. The use of two-tiered racks would require additional supports to the fuel pool walls. This option only extends the life of PI until the year 2001. Therefore, like the reracking alternative it was rejected.

1. The Location Of The Facility, To The Fullest Extent Known.

The existing pool storage facility would be used.

2. The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns.

The existing pool storage facility would be used.

3. Its Design Capacity In The Appropriate Units Of Measure.

A storage capacity increase of more than 35% would probably result in unacceptable stress on the pool structure. Therefore, this alternative could only increase the maximum pool storage capacity increase by approximately 500 assemblies, which would be exhausted by about 2001.

4. <u>A Schematic Drawing Showing Major Components Of The Facility</u>.

The figure at page 5.57 of the EIS is representative of the current racking. Using a two-tiered method would place a second tier of racks on top of a lower tier of racks.

5. <u>The Probable Date For Commencing Construction And The Probable In-Service Date</u>.

In order to have sufficient maneuvering room to install the new racks, the installation must be completed by summer, 1992. Since no standard-design plant has been licensed by the NRC for the use of two-tier racks, there is a high potential for delays beyond that date. (The LaCrosse BWR does use two-tier racks, but it is not a standard nuclear plant design). Therefore, this option would likely result in a temporary loss or reduction of PI energy output in order to maintain the room needed to install the racks while awaiting NRC approval.

6. <u>The Estimated Installed Cost Of The Alternative In Current Dollars</u>.

Two-tiered racks are estimated to cost between $12-14 million, with an additional $1.5 million for LLRW disposal. This alternative results in shutdown of PI after 2001. To compensate for the lost baseload capacity, new fossil-fueled capacity would need to be constructed, increasing NSP's future revenue requirements by approximately $590 million. Additional costs for replacement capacity and energy could also be incurred if NRC approval of the two-tiered racks is delayed.

7. <u>The Sources, Types, And Amounts Of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year</u>.

PI's existing racks are not designed for two tiers, so they would have to be replaced and disposed of as LLRW. About 1,500 cubic feet of waste would be generated, costing about $1.5 million to dispose of at the Michigan facility, again based on the projected fee of $1,000 per cubic foot when the site opens in 1997. This LLRW is estimated to contain about 2 curies. When the Michigan site is available, the LLRW would be transported to the disposal site by truck or rail using federally approved containers.

8. The Estimated Maintenance Requirements Of The Alternative.

The maintenance requirements would be essentially the same as for the existing spent fuel pool.

9. The Estimated Economic Life Of The Facilities Involved In The Alternative.

This would not provide storage for the current license period of PI, which is 2014. Instead, it would only extend the capacity of the pool until approximately 2001, at which time the plant would shut down.

10. The Reasons Why The Alternative Was Rejected.

This plan was rejected for several reasons. First, it could cause the temporary shutdown of the plant while NRC approval was sought and construction occurred. Second, it does not provide adequate spent fuel storage and would result in the shutdown of the plant in about 2001, requiring purchase or construction of replacement capacity. Third, it results in a forced shutdown of PI, which violates state law (Minn. Rules pt. 7855.0100).

H. Fuel Rod Consolidation.

This alternative is discussed at page 5.21 and 5.25 of the EIS. It entails consolidating spent fuel rods so that more fuel can be stored in the existing pool and racks. Consolidation is a process in which all the fuel rods are removed from their fuel assemblies, reconfigured into a close-packed triangular array, and placed into a canister of about the same outside dimensions as an intact fuel assembly. The canister is stored in a rack cell formerly occupied by a single intact assembly. After the fuel rods are removed, the assembly hardware must be processed and suitably packaged for on-site storage, either in the pool or in a dry storage configuration. Fuel consolidation and hardware processing would be performed in the existing pool. Thus, no new facility is required.

In 1986, NSP decided to conduct a fuel consolidation demonstration project at PI in order to determine if consolidation was a good choice to meet PI's storage needs beyond 1994. Initial cost projections indicated that consolidation was a less costly method than dry storage to provide additional on-site storage. Also, on the basis of a licensing feasibility study available at that time, it was believed that the pool and racks could support maximum consolidation, i.e., a capacity increase of about 70%. A pool capacity increase of 70%, along with on-site dry storage of the assembly hardware, would have met NSP's storage needs to 2010.

NSP selected Westinghouse to design the consolidation process and equipment, and to perform the fuel consolidation. The fuel consolidation demonstration took place in late 1987, followed by a demonstration of assembly hardware processing in the Spring of 1988. Fuel from 36 fuel assemblies was consolidated into 18 canisters, and hardware from 13 assemblies was compacted, packaged into canisters and placed into the racks. A hardware volume reduction factor of about 5-to-1 was achieved.

While proceeding with the demonstration, NSP initiated detailed structural analysis of the pool and racks, and met with the NRC to discuss the methods and results. The result of this effort was the conclusion that the pool and racks would likely be limited by the NRC to a maximum capacity increase of 35%, or about 500 fuel assemblies (half of the original analysis). This increase would meet PI's spent fuel storage needs for about 7 additional years of operation (to the year 2001). Assuming a fuel consolidation ratio of 2-to-1 and an improved hardware compaction ratio of 7-to-1, a total of 1360 fuel assemblies would have to be consolidated to free up 485 additional rack cells.

As is explained below, this alternative was rejected because of the inability to extend the life of the pool to the date when the DOE is likely to begin removing the spent fuel, combined with the operational difficulties with this alternative.

The consolidation alternative poses occupational radiation doses that are significantly higher than dry cask storage and other alternatives. For comparison, when PI last reracked the pool, occupational exposure from the project was about 15 person-rem. The consolidation alternative,which would increase the pool's capacity by 35 percent (500 new spaces), would pose occupation exposures of about 120 person-rem.

1. <u>The Location Of The Facility, To The Fullest Extent Known</u>.

Fuel rod consolidation occurs within the pool at the Prairie Island plant.

2. <u>The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns</u>.

The existing spent fuel pool would be used for this alternative.

3. Its Design Capacity In The Appropriate Units Of Measure.

An additional 485 fuel assemblies could be stored which would extend plant operation until 2001 but not until 2010, the earliest date the DOE will likely begin accepting spent fuel from PI.

4. A Schematic Drawing Showing Major Components Of The Facility.

Page 5.57 of the EIS is representative of this process, with the principal difference being the fuel would be more closely compacted.

5. The Probable Date For Commencing Construction And The Probable In-Service Date.

This process would require NRC and Commission approval. The approval and construction processes would place the in-service date at approximately the first quarter of 1993. Like other alternatives, rod consolidation would be accomplished when the spent fuel pool and auxiliary building are not being used to receive new fuel, and to refuel the reactors. However, to keep pace with the constantly added demands to store additional spent fuel, rod consolidation would be a continuous enterprise for the remaining life of the pool (2001). This could hinder the efficient operation of PI because of the scheduling and use limitations this would impose on the pool area and the labor intensive nature of this alternative.

6. The Estimated Installed Cost Of The Alternative In Current Dollars.

Spent fuel rod consolidation would cost approximately $12 million. This option also results in the premature shutdown of the plant after the year 2001. The cost of replacement capacity and energy for PI after 2001 would be approximately $590 million (present value of additional revenue requirements in 1990 dollars).

7. The Sources, Types, And Amounts Of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year.

The waste products would be the same as for the existing pool, with the exception that the consolidation process would generate a small amount of low-level radioactive waste. All the compacted fuel assembly hardware would be delivered to the DOE, along with the consolidated spent fuel, for disposal at a permanent repository. The volume of LLRW is estimated at 600 cubic meters. The LLRW would contain radioactivity in the approximate amount of 2,500 curies. LLRW would be transported to the Michigan disposal site, when it is available, by rail or truck and using federally approved containers. The fuel assembly hardware would be shipped in DOE's containers by rail or truck when a permanent repository is available.

8. The Estimated Maintenance Requirements Of The Alternative.

The maintenance requirements would be the same as for the existing pool. The consolidation equipment would require periodic maintenance and the spent fuel pool crane would likely require more frequent maintenance due to greater use.

9. The Estimated Economic Life Of The Facilities Involved In The Alternative.

This would extend the capacity of the pool to the year 2001, after which the plant would shutdown.

10. The Reasons Why The Alternative Was Rejected.

This option was rejected for several reasons. It fails to meet the need to develop storage capability until DOE will begin accepting spent fuel, and thus has significant costs. In addition, the alternative results in the forced shutdown of PI which violates state law (Minn. Rule pt.

7855.0100). Fuel consolidation also requires intensive efforts to accomplish without interfering with the plant's daily operation. It essentially prohibits other activities in the spent fuel pool area whenever consolidation is occurring and is labor intensive. Fuel consolidation also results in greater potential occupational exposure than dry storage. Finally, even without considering the costs of obtaining replacement energy, fuel rod consolidation costs as much or more than dry cask storage.

I. Transshipment to Monticello Nuclear Generating Plant near Monticello, Minnesota.

This alternative is discussed at page 5.30 of the EIS. It entails shipping PI spent fuel to Monticello, and storing it in Monticello's spent fuel pool. As is explained below, this alternative must be rejected because it involves significant cost, requires unnecessary shipment of the spent fuel, and increases the current problems by necessitating both PI and Monticello be shutdown in the year 1998.

1. The Location Of The Facility, To The Fullest Extent Known.

The fuel would be transported to and stored in Monticello's existing spent fuel pool. The Monticello plant is located near Monticello, Minnesota.

2. The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns.

Monticello's existing spent fuel pool would be used for this alternative.

3. Its Design Capacity In The Appropriate Units Of Measure.

The storage capacity in the spent fuel pool at Monticello will be filled with Monticello spent fuel in 2005. If PI's fuel is also stored at Monticello, NSP would need additional storage capacity at both plants by approximately 1998 in order to keep both plants operating at full capacity.

4. A Schematic Drawing Showing Major Components Of The Facility.

Monticello's facilities are similar to those at PI. See the EIS Figures 5-3 through 5-5 at pages 5.55-5.57.

5. The Probable Date For Commencing Construction And The Probable In-Service Date.

This alternative would require NRC license changes for the Monticello pool. In addition, NSP would need to manufacture new racks to accept the PI fuel in the Monticello pool. Therefore, this alternative could not be implemented until 1993.

6. The Estimated Installed Cost Of The Alternative In Current Dollars.

No new facility is required so there is no cost of installation. In addition to the added costs related to shipping fuel, this alternative would substantially increase the replacement energy and capacity costs of the no action alternative. That is because it would become necessary to eventually replace 1540 MW of baseload capacity in 1998. Further, additional costs would be incurred because Monticello uses a different reactor type than PI. Monticello is a Boiling Water Reactor while PI is a Pressurized Water Reactor. Consequently, Monticello's fuel assemblies are smaller than PI's and the fuel handling tool is different. Therefore, some of Monticello's spent fuel pool racks would need to be replaced and some of the plant's fuel handling equipment modified in order to store PI spent fuel in Monticello's pool.

7. The Sources, Types, And Amounts Of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year.

The nuclear waste would be the same as for the existing pools, with the addition that, like the reracking alternative, some of the Monticello racks would be replaced and would be treated as low-level radioactive waste. LLRW would be stored on-site until the Michigan site is available in 1997 or later. The estimated amount of LLRW is the same as the alternative of two-tiered racks. The estimated radioactivity is 3 curies. At that time the LLRW would be shipped to the Michigan site by rail or truck using federally approved containers. The spent fuel would eventually be shipped by rail or truck to the DOE repository using DOE containers.

8. The Estimated Maintenance Requirements Of The Alternative.

The maintenance requirements would be the same as use for the existing pools.

9. The Estimated Economic Life Of The Facilities Involved In The Alternative.

Monticello's current pool capacity will be exhausted in 2005. If PI spent fuel is stored at Monticello, additional storage capacity will be needed at both plants by about 1998.

10. The Reasons Why The Alternative Was Rejected.

This alternative increases the existing problems, increases the cost of the reduced operating alternative and would result in the forced shutdown of PI and Monticello, which violates state law (Minn. Rule pt. 7855.0100). In addition, NSP believes the Monticello community would seriously object to storing spent fuel from another nuclear generating plant.

J. Transshipment To Pathfinder Generating Plant in Sioux Falls, South Dakota.

This alternative is discussed at page 5.30 of the EIS. Pathfinder, which was originally a nuclear generating plant, was converted to fossil-fueled generation in 1967. The conversion involved the dismantling of all reactor storage support systems, including the spent fuel storage systems. As a result, storage at Pathfinder would be the equivalent of building a new pool at a remote location. Therefore, the analysis provided for constructing a new pool applies equally to this alternative. This fact resulted in the EIS concluding at page 5.30: "Transshipment to this facility is no longer an option." NSP is currently decommissioning the nuclear portions of the plant.

K. Transshipment To Another Spent Fuel Storage Facility.

This alternative was discussed at page 5.30 of the EIS. It entails shipping PI spent fuel to a commercial spent fuel storage pool, or other facility at another site. In 1984, NSP began to ship Monticello spent fuel to a General Electric (GE) storage facility in Morris, Illinois. Shipments were completed in 1987. The GE Morris facility is now full, and there are no other commercial spent fuel storage facilities in the U.S. The only other choice is a storage pool at another nuclear plant site. This alternative requires one or more utilities to agree to store PI spent fuel in their pools until the DOE begins taking spent fuel for disposal.

No utility has evidenced any interest in accepting spent fuel from another reactor for storage in its own pool for two main reasons. First, the delays in the DOE permanent repository program could mean that all existing utilities with nuclear reactors will need their entire pool capacity for their own spent fuel, and many will need some type of additional temporary storage capacity as well. DOE currently projects the permanent repository will not be operational before 2010. By 2010, approximately 80 of the 112 reactors in the U.S. will have exhausted their pool capacities. A second reason is that utilities believe they would face vigorous public opposition to such a plan. Because this alternative is not available to NSP, it is not possible to supply the information called for by Minn. Rule pt. 7855.0610.

L. Shipment To A Federal Facility.

This topic is discussed at length at pages 5.34-5.38 of the EIS. It is also fully discussed in Section III.B. of this Application. Shipping the spent fuel to a federal facility is the long-term solution to the need for permanent storage. Unfortunately, as both the EIS and the earlier section of the Application explain, there is no federal facility which will be available in time to meet PI's temporary spent fuel storage needs. Because there is no available facility, it is not possible to provide the additional information requested by Minn. Rule pt. 7855.0610.

M. Reprocessing.

This alternative is discussed at pages 5.38-5.44 of the EIS. Reprocessing is the chemical process of dissolving spent fuel in order to extract the residual uranium and plutonium for recycling into new fuel assemblies. The remaining fission products, which are high-level radioactive waste, are concentrated and solidified into a stable form, such as glass, for storage and permanent disposal.

When PI was constructed, NSP intended to ship its spent fuel to a commercial reprocessing facility, but the reprocessing industry did not develop as expected. Then, in 1977, President Carter announced a ban on reprocessing in the United States to minimize the risk of nuclear proliferation. President Reagan rescinded the ban in 1981, but a commercial reprocessing industry has not developed in the U.S. Reprocessing services are available in France and Great Britain.

Reprocessing PI spent fuel would require NSP to contract with one of the foreign reprocessing companies to receive PI spent fuel, reprocess it, and manage the uranium and plutonium extracted. NSP would not be able to store the resulting high-level radioactive waste in its existing facilities, and would probably attempt to negotiate with the reprocessor the ability to store the HLRW on their site until a DOE repository is available.

The spent fuel would have to be shipped from PI to the east coast of the United States, either by barge along a waterway, by rail or by road. From the east coast, the spent fuel would be shipped by an ocean-going vessel to the destination country, with a later return shipment of the high-level radioactive waste. The extremely high cost of such shipping and reprocessing makes this alternative infeasible.

1. The Location Of The Facility, To The Fullest Extent Known.

France and Great Britain have the only commercial reprocessing facilities.

2. The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns.

This information is unavailable.

3. Its Design Capacity In The Appropriate Units Of Measure.

By 1992, Great Britain is expected to have the capacity to handle 1200 metric tons and France to handle 400 metric tons. Japan hopes to have a facility to handle 800 metric tons beginning in 1995.

4. A Schematic Drawing Showing Major Components Of The Facility.

A drawing of the facilities is not available.

5. The Probable Date For Commencing Construction And The Probable In-Service Date.

It would take approximately 18 months to obtain the necessary 10 CFR pt. 110 NRC license for international shipping. It is unknown how long it would take to arrange the remaining components of such an alternative (i.e., contracts, shipping requirements, HLRW storage).

6. The Estimated Installed Cost Of The Alternative In Current Dollars.

As no new facility is required there is not installed cost. The EIS, at page 5.43, estimates the cost of transport to be $12,000 per fuel assembly and the cost of reprocessing to be $200,000 to $300,000 per fuel assembly. Additional costs for disposal of the low-level radioactive waste and storage of high-level radioactive waste would exist. At this cost, even using the lower range of $200,000 per fuel assembly, the cost for reprocessing for the number of fuel assemblies stored by 48 dry casks approximates $384 million.

7. The Sources, Types, And Amounts Of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year.

This information is contained on page 5.34 of the EIS. Transport casks would be decontaminated using the same process described for decontaminating the dry casks. The resulting filter resins and other LLRW would be transported by rail or truck to the Michigan site after 1997 in federally approved containers. The HLRW would be transported by rail or truck by DOE in its containers when a permanent repository becomes available. Spent fuel shipments for reprocessing would likely require 5 or 6 cask shipments per year.

8. <u>The Estimated Maintenance Requirements Of The Alternative</u>.

Like the use of storage casks, transport casks would need to be loaded and decontaminated.

9. <u>The Estimated Economic Life Of The Facilities Involved In The Alternative</u>.

This option, if it were actually available, would possibly be adequate to extend the operating abilities of PI until DOE begins removing the spent fuel. As is explained below, however, it is very uncertain that this alternative could be successfully implemented.

10. <u>The Reasons Why The Alternative Was Rejected</u>.

This alternative was rejected for two reasons. First, the cost is many times higher than the cost of the proposed dry cask facility. Second, rail shipping and loading of the transport casks onto a ship is difficult to arrange, coordinate and consistently maintain. Using a TN-12 (12 assembly) transport cask, between 5 and 6 cask shipments would need to be made each year.

N. <u>Use Of Higher Burnup Fuel</u>.

This alternative is discussed at pages 5.44-5.46 of the EIS. If NSP could obtain higher burnup of its fuel at PI, the frequency of fuel replacement would be reduced, thus extending the life of the pool. Burnup is a measurement of how much energy a fuel assembly produced during the time it was in the reactor. For a given amount of energy production by the reactor, the number of spent fuel assemblies generated will be less if each assembly can provide more energy (i.e., if it can achieve a higher burnup). Many factors affect discharge burnup, including fuel enrichment, core design, fuel design, and reload size. The NRC has limited the allowable fuel burnup. The combination of fuel and core design currently used at PI is achieving the maximum allowable burnup.

The EIS concludes at page 5.46:

> This alternative will not be feasible unless the NRC changes the burnup which it allows. It would also not add significantly to the storage capacity of the plant (in terms of years), and so would not allow NSP to meet their objective of full operation of the PI plant through its license period.

Because PI is already accomplishing the maximum possible burnup, there is no further analysis possible under Minn. Rule pt. 7855.0100.

O. Similar Facility At Another Site Other Than PI.

The EIS did not discuss sites other than PI because there are no alternative sites. Under this alternative, a site other than the PI plant site would be selected, qualified and licensed for a Dry Cask Storage Facility like the one proposed for use at PI. As will be explained, because there are no superior sites for the dry cask facility, using a separate site significantly adds to the cost and complexity of its operation without any benefits. Therefore, this alternative should not be adopted. (See pages 3.2-3.3 of the EIS alternative sites at PI.)

1. The Location Of The Facility, To The Fullest Extent Known.

No suitable sites are known.

2. The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns.

The physical requirements would be the same as for the Dry Cask Storage Facility.

3. Its Design Capacity In The Appropriate Units Of Measure.

The design capacity would be the same as for the Dry Cask Storage Facility.

4. A Schematic Drawing Showing Major Components Of The Facility.

The drawing of the PI Dry Cask Storage Facility located at pages 3.33 and 3.40 of the EIS is representative of an alternative dry cask facility.

5. The Probable Date For Commencing Construction And The Probable In-Service Date.

Construction would be delayed while a new site was located and a determination made to do a new EIS. The total delay could be one to two years.

6. The Estimated Installed Cost Of The Alternative In Current Dollars.

The same costs applicable to the proposed Dry Cask Storage Facility would apply to an off-site dry cask facility. However, there would be significant additional costs. First, a transport cask would be required to move the fuel to the site. Second, a transfer pool and an appropriate building would need to be constructed to transfer the spent fuel from the transport cask to the TN-40. Alternatively, a different type of dry storage facility could be used which would allow a transfer without using a pool. Third, additional monitoring and security personnel would be required at any alternative site. Because there are no available alternative sites, these added costs have not been estimated.

7. The Sources, Types, And Amounts Of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year.

The nuclear wastes would be the same as for the Dry Cask Storage Facility. Transportation, whether by railroad or barge, would depend on the location of the storage site, availability of transport equipment and cost.

8. The Estimated Maintenance Requirements Of The Alternative.

The maintenance requirements would be the same as at the Dry Cask Storage Facility.

9. The Estimated Economic Life Of The Facilities Involved In The Alternative.

The economic life would be the same as for the Dry Cask Storage Facility.

10. The Reasons Why The Alternative Was Rejected.

A dry cask facility at an alternative site would look and function the same as if it were located at PI. However, additional personnel and facility resources would be required to monitor and provide security for an off-site dry cask facility. In addition, a separate transport cask would be required along with a separate pool or alternative method for transferring the fuel from the transport cask to the TN-40 storage cask. Consequently, unnecessary operational difficulties and costs would result. In addition, locating a site would be difficult; no compelling policy reasons exist that could justify using a site other than PI. In short, there are no benefits of moving the dry cask facility off-site and there are significant disadvantages from this alternative.

P. Other Designs Of Dry Spent Fuel Storage.

This alternative is discussed at pages 5.13-5.19 of the EIS. There are several different designs of dry spent fuel storage systems.

1. Modular Concrete Storage.

NUHOMS is a type of spent fuel storage which uses a modular concrete storage facility. Carolina Power and Light has a NUHOMS storage facility installed and is storing spent fuel at its H.B. Robinson plant. Duke Power has completed construction of a NUHOMS facility at its Oconee plant and began loading it with spent fuel in July 1990. Baltimore Gas and Electric plans to install a NUHOMS facility at its Calvert Cliffs plant.

The NUHOMS system has two main components: a dry storage canister which contains the spent fuel which is stored in a horizontal storage module. Each canister contains 24 spent fuel assemblies. The module is constructed of reinforced concrete and provides radiological shielding and physical protection for the canister against natural hazards like floods or tornados. The module has internal air flow passages to provide natural convection cooling for decay heat removal from the canister. The canister is welded closed to ensure the spent fuel is contained and isolated from the environment.

All canister loading and storage preparation activities take place inside the plant. A transfer cask is required to take the canister from the plant to the Dry Cask Storage Facility. The canister is transferred from the cask into a module in the facility. Maintenance and surveillance for a NUHOMS facility are similar to that required for a dry cask facility.

2. Vault.

A vault is a fixed, concrete building designed for storage of a large number of spent fuel assemblies. The basic building consists of a transfer cask receipt room, storage modules and a fuel transfer machine to take the fuel assemblies from the cask and place them into the storage module. Within the storage modules, spent fuel assemblies are stored vertically in individual, sealed storage containers. The spent fuel is cooled by air-flow around the outside of the storage container. Vault storage has been used for over 18 years in Great Britain to store spent fuel. The NRC has approved a Topical Safety Analysis Report for a vault designed to store spent fuel from reactors in the United States. Public Service of Colorado may build a vault to store spent fuel from its Fort St. Vrain plant which shut down in 1989.

3. Concrete Casks.

A concrete cask storage system is similar to NUHOMS, except the spent fuel is stored vertically rather than horizontally. There are two major components: a dry storage canister and a ventilated storage cask. Twenty-four (24) spent fuel assemblies are contained in each canister, which in turn are contained in the cask. These components perform the same functions as the canister and module of the NUHOMS system, respectively. A transfer cask is required to load the canister with spent fuel, and to transfer the canister from the pool to the concrete cask. Placing a loaded canister into a cask occurs inside the plant. The canister is moved from the plant to the ISFSI and placed onto a concrete storage pad.

This storage system is currently being reviewed by the NRC. A program to build and demonstrate concrete cask storage is underway at a DOE facility in Idaho.

4. Other Metal Casks.

Several other dry metal storage casks have been developed. Metal cask designs differ with respect to the materials used in fabricating the body and the basket which holds the assemblies, as well as capacity, weight and handling features. However, once a metal cask is loaded and sitting on a concrete pad at a facility, there is little difference among cask types. All metal storage casks are designed to the same NRC criteria and requirements.

5. Dual Purpose Casks.

These casks could be used for both storage and eventual shipment to the DOE permanent storage facility. None of the commercially available storage casks are approved for transport, but this is an area of interest and the NRC is studying the viability of this approach.

The following material responds to the requirements of Minn. Rule pt. 7855.0610 on behalf of all the dry spent fuel storage technologies. A single response is possible because of the similarities between the systems. NSP thoroughly analyzed seven dry storage system proposals prior to the selection of the TN-40 cask. This evaluation process is described in "Prairie Island Dry Spent Fuel Storage System Evaluation and Recommendation," dated July 17, 1989, which will be available under a protective order if a contested case hearing is held on this Application.

a. <u>The Location Of The Facility, To The Fullest Extent Known</u>.

Any alternative dry spent fuel storage technology would be located at PI, at the same site as the proposed Dry Cask Storage Facility.

b. <u>The Required Land Area, The Height Of The Tallest Structures, And If Applicable, The Depth And Size Of Any Underground Caverns</u>.

The required land area and height of any structure would be essentially the same as the proposed Dry Cask Storage Facility.

c. <u>Its Design Capacity In The Appropriate Units Of Measure</u>.

The alternative dry spent fuel storage technologies provide the same storage capacity. The economics of the vault and the NUHOMS system require the vault or module storage facility be constructed in larger increments than the TN-40 each providing storage capacity for about 400 spent fuel assemblies.

d. <u>A Schematic Drawing Showing Major Components Of The Facility</u>.

A drawing of the NUHOMS system is contained at page 5.53 of the EIS. Other metal casks are similar to the TN-40 cask, which is shown on page 3.39 of the EIS.

e. The Probable Date For Commencing Construction And The Probable In-Service Date.

If a different dry storage technology were selected, there could be a delay of up to two years while NSP entered into contracts and filed for an NRC approval for the alternative. Consequently, additional storage capacity might not be available until 1995, and, depending on the actual availability of additional temporary storage, one or both of the units at PI could be temporarily shut down for lack of storage.

f. The Estimated Installed Cost Of The Alternative In Current Dollars.

NSP received three responses to its request for proposals which were acceptable in terms of cost and technical feasibility. The costs of the various alternatives fall within a range of 25% of each other.

g. The Sources, Types, And Amounts Of Nuclear Waste Products That Would Be Involved In The Alternative, The Methods Of Transporting These Materials, And The Level Of Radioactivity Of Each In Curies Per Year.

Nuclear waste products would be the same as those involved with the TN-40 casks.

h. The Estimated Maintenance Requirements Of The Alternative.

The maintenance requirements would be essentially the same as for the TN-40 casks.

i. The Estimated Economic Life Of The Facilities Involved In The Alternative.

The economic life would be the same as for the TN-40 casks.

j. The Reasons Why The Alternative Was Rejected.

Alternative dry storage technologies were rejected because the TN-40 cask was determined superior on the basis of economics, operations, occupational exposure, flexibility, industry experience and vendor qualification. Once the decision was made to use dry spent fuel storage, NSP prepared a request for proposal ("RFP"). This RFP was sent to vendors that have developed dry spent fuel storage systems. The RFP went out February 20, 1989, and vendor responses were due to NSP April 12, 1989. The principle evaluation team consisted of Laura McCarten (Special Nuclear Programs), Jon Kapitz (PI), Mark Stoering (Corporate Economics) and Patrick Charais (Procurement). In addition, input was provided by PI staff (maintenance, radiation protection, security, etc.), Nuclear Engineering & Construction and Power Supply Quality Assurance (which are departments of NSP). The evaluation team recommended selection of the TN-40 cask for use at PI. The reasons for this recommendation are outlined below:

Economics: The costs of the three proposals were considered, including decommissioning costs. The TN-40 cask compares favorably to the other two proposals under this criterion. The proposals and the relative costs of the dry storage technologies are discussed in "Prairie Island Dry Spent Fuel Storage System Evaluation and Recommendation," dated July 17, 1989, which will be available under a protective order if a contested case hearing is held on this Application.

Operations: A metal cask system is, in all respects, operationally simpler than a ventilated concrete cask or module system. A metal cask does not require an on-site welding operation to achieve sealed containment of the spent fuel, as a concrete system does. Also, with metal casks there is no intermediate step necessary to transfer the sealed canister containing the spent fuel into the concrete cask. Metal casks require less surveillance during storage than do ventilated concrete systems, because they do not have air flow passages that must be kept open. Simpler operation results in less demand on plant personnel resources and a smaller risk of an off-normal event.

Occupational Exposure: The occupational exposure to NSP personnel resulting from use of a metal cask, such as the TN-40 cask, is expected to be between 25% and 50% less than that incurred from using a concrete storage system.

Flexibility: Selection of a cask storage system, as opposed to a vault or NUHOMS system, will make it easier to convert to another cask design, if it should become economically or technically advantageous. Much of the storage site and operating equipment expenditures required for a cask storage system are applicable to other cask designs, whether metal or concrete. For example, the ISFSI pad would require little or no modification to use other metal or concrete casks, and the cask transporter could be used for other casks.

Industry Experience: Metal casks and certain types of concrete storage are well understood and well demonstrated technologies. While the TN-40 cask has not yet been approved by the NRC, the NRC has reviewed and approved four metal storage cask designs: Westinghouse --MC-10; GNSI -- CASTOR V/21; NAC -- NAS-S/T, NAS-C28S/T; TN -- TN-24. The latest was the TN-24 which received NRC approval on July 5, 1989. Based on this experience, NSP has a high degree of confidence the TN-40 cask will be approved by the NRC.

Vendor Qualification: The staff of Transnuclear have a broad and in-depth background on spent fuel transport and dry spent fuel storage.

An added feature of the TN-40 cask is that it is designed to hold 40 PI spent fuel assemblies.

That compares favorably to other designs which hold only 24 fuel assemblies. Thus, use of the TN-40 requires fewer cask loadings to place a given amount of spent fuel into dry storage.

Based on the above criteria, Transnuclear's TN-40 cask design was the low-evaluated bid, including cost and operational considerations.

A dual purpose cask was not selected because: 1) the need to transport is many years into the future and the applicable cask design standards could change; 2) a dual purpose cask would cost more and NSP is already paying an annual fee to cover the DOE's future spent fuel transport costs and wishes to avoid paying such costs twice; and 3) no commercially available cask has been licensed to serve as a dual purpose cask. If a dual purpose cask becomes a feasible alternative, NSP will evaluate its use.

VI. <u>ENVIRONMENTAL IMPACT OF THE ISFSI AND OTHER ALTERNATIVES PURSUANT TO MINN. RULE PT. 7855.630</u>.

The Application must include environmental data for the Dry Cask Storage Facility and for each alternative facility. Minn. Rule pt. 7855.0630 states the information in parts 7855.0640 to 7855.0670 relating to construction and operation shall be provided for the Dry Cask Storage Facility and for each alternative to the extent "such information is reasonably available to the applicant and applicable to the particular alternative."

The information in parts 7855.0640 to 7855.0670 for the proposed Dry Cask Storage Facility is provided below in Sections VII, VIII, IX and X.

To the extent the information in parts 7855.0640 to 7855.0670 is applicable to the alternatives discussed in Section V, they are discussed in that section and in the EIS.

VII. ALTERNATIVE SITE DESCRIPTION (PRESENTED PURSUANT TO MINN. RULE PT. 7855.0640).

Minn. Rule pt. 7855.0640 requires the following information on the site of the proposed Dry Cask Storage Facility and for alternative sites. As described in the EIS at pages 3.2-3.3 and Chapter 6A, three alternative sites, in addition to the proposed ISFSI, were considered. The sites are described in Figure 3-4 on page 3-34 of the EIS. All of the sites are within the Prairie Island Nuclear Generating Plant boundary.

The information required by this rule for PI is as follows:

A. The Nature Of The Terrain At The Site.

The Dry Cask Storage Facility is proposed to be located within the boundary of PI, which encompasses about 560 acres. The facility will be located in Section 5, T113N, R15W in Goodhue County, Minnesota. The terrain at the site is fairly level to slightly rolling, ranging in elevation from 675 feet to 706 feet above mean sea level. The terrain slopes gradually toward the Mississippi River to the northeast and the Vermillion River on the southwest. Site characteristics are described in detail in the Prairie Island Nuclear Generating Plant Updated Safety Analysis Report ("USAR"). The USAR, a multi-volume document, is available for inspection at NSP and in the public documents room at the Technology & Science Department, Minneapolis Public Library, 300 Nicollet Mall, Minneapolis, Minnesota 55401. The description of the nature of the terrain at the site applies to the proposed site and the three alternative sites.

B. The General Soil Types At The Site.

The overburden materials at the site are permeable sandy alluvial soils which were deposited as glacial outwash and as recent river sedimentation. Preliminary borings have indicated that the overburden soils at the site vary from 158 to 185 feet thick. Basic geomorphology on the site is described in the Prairie Island USAR, Sections 2.5 and 2.6, and Appendix E to the USAR, and is summarized and supplemented in the Environmental Report for the Prairie Island ISFSI, Section 2.5. The description of the general soil types at the site applies to the proposed site and the three alternative sites.

C. The Types And Depths Of Bedrock Underlying The Site.

The uppermost bedrock unit at the site is sandstone and is believed to be part of the Franconia formation. Its thickness at the site is unknown, but would be less than 180 feet, which is the total measured thickness of the Franconia formation in complete sections. Underneath the Franconia formation are several hundred feet of lower Cambrian and Precambrian sandstone with minor shale horizons. Basic geomorphology on the site is described in the Prairie Island USAR, Sections 2.5 and 2.6, and Appendix E to the USAR, and is summarized and supplemented in the Environmental Report for the Prairie Island ISFSI, Section 2.5. The description of the types and depths of bedrock underlying the site applies to the proposed site and the three alternative sites.

D. The Depth Of Groundwater At The Site.

Beneath the flood plains and low terraces which border the Mississippi River, groundwater levels closely coincide with the elevations of the river surface, and vary in accordance with river fluctuations. The average groundwater gradient in these bottom lands is downstream and essentially parallel to the stream gradient. Basic hydrology on the site is described in the Prairie Island USAR, Section 2.4, and Appendix E to the USAR, and is summarized and supplemented in the Environmental Report for the Prairie Island ISFSI, Section 2.4. The description of the depth of groundwater at the site applies to the proposed site and the three alternative sites.

E. The Types Of Vegetation On The Site And The Approximate Percentage Of Each.

The ecology of the site has been extensively studied. These studies identified the quantity and quality of various habitats in the vicinity of PI. The following types of habitat were identified in the study area: oak openings, lowland forests, prairie or old fields, sand terraces, conifer plantations and marshes. Vegetation in the site area consists of prairie grass and brush, with some isolated stands of trees. The ecology of the site is described in the Environmental Report for the Prairie Island ISFSI, Section 2.2. The description of the types of vegetation on the site and the approximate percentage of each applies to the proposed site and the three alternative sites.

F. The Predominant Type Of Land Use Within Five Miles Of The Site And The Approximate Percentage Of Each.

The region within a radius of five miles of the site is devoted almost exclusively to agricultural pursuits. Principal crops grown within five miles of PI include soybeans, corn, oats, hay and some cannery crops. The nearest dairy farm is located more than three miles southwest of the plant site. Some beef cattle are raised approximately two miles southwest of the plant. Land use near the site is described in the Environmental Report for the Prairie Island ISFSI, Section 2.1. The description of the predominant type of land use within five miles applies to the proposed site and the three alternative sites.

G. Lakes, Streams, Wetlands, Or Drainage Ditches Within Five Miles Of The Site, And Any Other Lakes, Streams, Wetlands Or Drainage Ditches, Wells, Or Storm Drains Into Which Liquid Contaminants From The Site Could Flow.

There are no liquid contaminants produced by the Dry Cask Storage Facility. As a result, no liquid contaminants could or will flow into any surface waters. The principal surface waters in the vicinity of the site are the Mississippi River, Sturgeon Lake, the Vermillion River and the Cannon River. The description of water resources applies to the proposed site and the three alternative sites.

H. Trunk Highways, Airports, And Air Traffic Corridors Within Five Miles Of The Site.

Minnesota State Highway 61 runs within three miles of the site to the south. The Red Wing airport is located about seven miles southeast of the site in Bay City, Wisconsin. The runway designation is 09/27 with a 50/1 glide path. The description of the trunk highways, airports and air traffic corridors applies to the proposed site and the alternative sites.

I. National Natural Landmarks, National Wilderness Areas, National Wildlife Refuges, National And Wild Scenic Rivers, National Parks, National Forests, National Trails And National Waterfowl Production Areas Within Five Miles Of The Site As Mapped On The Inventory Of Significant Resources By The State Planning Agency.

The State Planning Agency no longer maintains an inventory of significant resources. Based on NSP's review of the area within five miles of the Site, there are no national natural landmarks, national wilderness areas, national wildlife refuges, national and wild scenic rivers, national parks, national forests, national trails or national waterfowl production areas within five miles of the Site. The description of natural resources applies to the proposed site and the three alternative sites.

J. State Critical Areas, State Wildlife Management Areas, State Scientific And Natural Areas, State, Wild, Scenic, And Recreational Rivers, State Parks, State Scenic Wayside Parks, State Recreational Areas, State Forests, State Trails, State Canoe and Boating Rivers, State Zoo, Designated Trout Streams, And Designated Trout Lakes Within Five Miles Of The Site As Mapped On The Inventory Of Significant Resources By The State Planning Agency.

The State Planning Agency no longer maintains an inventory of significant resources. Based on NSP's review of the area within five miles of the Site, there are no state critical areas, state scientific or natural areas, state wild, scenic or recreational rivers, state parks, state scenic wayside parks, state recreational areas, state trails, state canoe or boating rivers, state zoos, designated trout streams or designated trout lakes within five miles of the Site. Gores Pool Wildlife Management Area is located within five miles of the Site. Richard J. Dorer Memorial Hardwood State Forest is also located within five miles of the Site. The location of these state resources is shown in the Appendix entitled "Environmental Information." The description of state resources applies to the proposed site and the three alternative sites.

K. National Historical Sites And Landmarks, National Monuments, National Register Historic Districts, Registered State Historic Or Archaeological Sites, State Historical Districts, Sites Listed On The National Register Of Historic Places, And Any Other Cultural Resources Within Five Miles Of The Site As Indicated By The Minnesota Historical Society.

The Minnesota Historical Agency has provided NSP with lists of National Register Properties and Archaeological Sites within five miles of the Site. These lists are located in the Appendix entitled "Environmental Information." State historical sites are designated on the map in the Appendix entitled "Environmental Information. Information on the State Historical Sites is also located in the Appendix entitled "Environmental Information." The description of national and state historical resources applies to the proposed site and the three alternative sites.

L. Areas Within Five Miles Of The Site Designated By Regional Or Local Authorities As Having Recreational, Cultural, Historical, Or Scientific Significance As Indicated By Local Units Of Government.

The regional, historical, archaeological, architectural, scenic, cultural and natural features within five miles of the site are designated in response to Section VII.I-K. above. In addition, the Prairie Island Mdewakanton Sioux Indian Community is located approximately 2000 feet from the proposed site and is within the five mile radius designated by the rules. The Prairie Island Indian Community is recognized as an independent sovereign by the United States with regional, historical and cultural significance.

M. The Estimated Total Population Within Fifty Miles Of The Site, And A Map Showing The Distribution Of The Population Within Fifty Miles Of The Site.

The nearest population centers are Eagan (1986 population of 35,311), 26 miles northwest of the site; Minneapolis-St. Paul metropolitan area (1986 population of 2,118,445) 30 miles northwest of the site; and Rochester (1986 population of 62,158) 41 miles south of the site. No other population centers with more than 25,000 people lie within 50 miles of the site. Tables showing the estimated population around PI, which includes the proposed site and the three alternative sites, are located in the Appendix entitled "Environmental Information."

The provisions of Section 7855.0640 (site characteristics of alternative sites) have no application because there are no alternative sites off of PI plant property. Specifically, the alternatives of no action (Section V.A); reduced PI operation (Section V.B); and increased customer conservation (Section V.C) do not require the construction or operation of an alternative facility. These alternatives involve reduced operation of PI. The alternatives of construction of a new pool (Section V.D.); enlarging the existing pool (Section V.E); reracking (Section V.F); two-tiered racks (Section V.G); fuel rod consolidation (Section V.H); and use of higher burnup fuel (Section V.N) do not require the construction or operation of an alternative facility. These alternatives would require modification of current operations and existing equipment or facilities at PI. The alternatives of transshipment to Monticello Nuclear Generating Plant (Section V.I); transshipment to Pathfinder (Section V.J); transshipment to another spent fuel storage facility (Section V.K); shipment to a federal facility (Section V.L); and reprocessing (Section V.M) do not require the construction or operation of alternative facilities, as the alternatives would involve shipment to existing facilities. The information is not applicable to the alternative of a similar facility at another site (Section V.O) because there is no alternative site outside PI plant boundaries. Additional information is not required for the alternative of other designs of dry spent fuel storage (Section V.P) as those alternatives would be located at the same location as the proposed Dry Cask Storage Facility.

VIII. WASTES AND EMISSIONS.

Minn. Rule pt. 7855.0650 requires certain information concerning wastes and emissions resulting from the Dry Cask Storage Facility and from the other alternatives. The response to this rule for the Dry Cask Storage Facility is contained in Section IV.E. of this Application. The discussion of wastes and emissions from the proposed site also applies to the three alternative sites at PI. To the extent this rule is applicable to the alternatives, NSP's response to the rule is contained in Section V, which discusses each alternative, and in the EIS (Volume 2).

IX. POLLUTION CONTROL AND SAFEGUARDS EQUIPMENT.

Minn. Rule pt. 7855.0660 requires certain information concerning pollution control and safety for the Dry Cask Storage Facility and for the other alternatives. To the extent this rule applies to the alternatives, its requirements have been met through the EIS and this information has been provided in response to Minn. Rule pts. 7855.0600 and 7855.0650 in this Application and the EIS (Volume 2). The information on pollution control and safeguards equipment applies equally to the proposed site and the three alternative sites.

A. The Provisions That Would Be Made For Management Of Radioactive Materials.

As explained earlier, the operation of the ISFSI produces no radioactive materials other than those resulting from cask decontamination, which occurs after the casks are loaded and removed from the pool, and from decommissioning the casks at the end of their use. As previously explained, these represent normal operations and do not present unique or difficult problems.

B. A Description Of Contingency Plans To Reduce The Effects Of An Accidental Release Of Radioactive Materials.

As earlier described, the entire Dry Cask Storage Facility operation is designed to prevent an accidental release of radioactive materials. The worst postulated release would result in a one time dose at the PI boundary of only 70 millirem, which is well within the NRC standards of 5,000 millirem for an improbable accidental release. More importantly, there is no event which can cause such a release to occur. Specifically, the cladding of every fuel rod in every assembly in a cask would have to be breached--7,160 breaches. If this unlikely event occurred, coupled with failure of the cask seals, the gaseous fission products within the cladding would be released, resulting in the one-time 70 millirem dose. (Each fuel rod contains radioactive gaseous fission products, as well as solid fuel pellets. The gases are confined within the fuel rod cladding.) In the unlikely event that an accidental release of radioactive materials did occur, PI's plant emergency plan would be followed to assure the safety of the public and employees and to initiate mitigation actions.

C. <u>The Methods That Would Be Used To Recycle Or Dispose Of Solid Or Liquid Wastes</u>.

The water used for decontaminating the casks after loading will be collected by drains which route through the plant's existing radioactive waste system. Resin filters will be used to remove any contaminants prior to discharge. Since the wash water will contain only trace amounts of radioactive materials, the amount of resin attributable to cask decontamination is negligible. All contaminated resin is sent to a licensed low-level radioactive waste burial site.

Solid radioactive waste will result from the use of throw-away protective clothing by decontamination personnel and the cloths used to remove contaminants. The volume of solid waste from the Dry Cask Storage Facility is estimated at less than 1 cubic foot of processed solid waste per cask. Total radioactivity will be less than .0001 curies per cask. These amounts are negligible compared to the average annual radioactive waste volume of 4000 cubic feet and activity of 225 curies generated by PI. Low-level radioactive waste from the Dry Cask Storage Facility will be disposed of with the low-level waste from the plant.

The cask disposal options are fully discussed in Section IV.F.2., Cask Disposal Options, of this Application.

D. The Types Of Emission Control Devices And Dust Control Measures That Would Be Used.

The Dry Cask Storage Facility produces no emissions. As discussed in the EIS, at pages 4.6 and 4.13, dust production during construction will be minimal and does not require abatement measures. The neutron shield material of the cask is a polyester resin which, at the cask operating temperatures, does produce a small amount of gas. The gases produced, helium, hydrogen and various hydrocarbons, are not radioactive. The quantities produced are minute and do not require emission control equipment.

E. The Types Of Water Pollution Control Equipment And Runoff Control Measures That Would Be Used.

As discussed in the EIS on page 4.5 and 4.8-4.9, no water pollution is created and no problems due to runoff will occur.

F. The Measures That Would Be Taken To Prevent Spills Or Leaks Of Pollutants, Or To Minimize The Effects Of Spills Or Leaks On The Environment.

There is nothing to spill from the casks. The redundant cask seals provide both a very high level of assurance that there will not be a loss of cask seal and a mechanism for monitoring for potential air leaks into the cask, a desirable feature for prolonged storage periods. Even if there were a loss of cask seal, there is no free radioactive gas or liquid in the cask to leak out, and leakage would not result in the release of radioactive material to the environment. Instead, due to the differential in air pressures, air would leak into the cask. Radioactive gases could be released in the event the cask was breached and the cladding of the fuel rods in the fuel assemblies were breached. If all the fuel rod cladding were breached and all of the gasses contained within each fuel rod were released it would only result in a one time dose at the PI boundary of 70 millirem, which is well within the NRC standards of 5,000 millirem for an accidental release. More important, there is no event which could cause such an impossible breach scenario to occur. The cask and cask seals have been designed to prevent such an event, and the cladding provides yet another barrier.

G. The Methods That Would Be Used To Reduce The Effects Of Heat Rejected By The Facility.

As Section IV. of this Application explains, the casks are designed to dissipate heat generated from the spent fuel. Heat generated presents only localized impact. As the EIS states on page 4.13: "Operation of the ISFSI is not expected to affect the climate of the region. . . . The affected area will be relatively small and localized." The total heat generated will be comparable to that from a lighted athletic field. Therefore, methods to reduce the effect of the heat from the dry casks are unnecessary.

H. Any Other Equipment Or Measures, Including Noise Control Or Erosion Control, That Would Be Used To Reduce The Effects Of The Facility On The Environment.

As the EIS demonstrates, the effect of the Dry Cask Storage Facility on the environment is negligible. The cask design, the location of the site, and the use of berms to eliminate even the visual effect of the casks reduce the effects of the facility on the environment to a negligible level. No noise is produced during normal operation of the Dry Cask Storage Facility. No erosion is expected from the Dry Cask Storage Facility.

I. The Types Of Environmental Monitoring, If Any, That Are Planned For The Facility And A Description Of Any Relevant Environmental Monitoring Data Already Collected.

The Dry Cask Storage Facility radiation monitoring program will include quarterly surveillance of dose rates and contamination levels. The existing NSP Radiological and Environmental Monitoring Program ("REMP") will also monitor the Dry Cask Storage Facility using dosimeters placed on the ISFSI fence. These dosimeters will be analyzed quarterly for radiation dose at the perimeter.

X. ESTIMATES OF INDUCED DEVELOPMENT.

Minn. Rule pt. 7855.0670 requires the following information on induced development where applicable for the Dry Cask Storage Facility and for the various alternatives. To the extent this rule has any application to the alternatives it is discussed in the EIS. The following information relates to the Dry Cask Storage Facility. It applies equally to the proposed site and the three alternative sites.

A. The Types And Amounts Of Vehicular Traffic That Would Be Generated By The Facility Due To Construction Activity And Later, To Operational Needs.

As the EIS discusses on page 4.2, approximately 100 truckloads of concrete will be required for the pads in the Dry Cask Storage Facility. In addition, bulldozers and dump trucks will likely be used during the construction phase.

During operation, there will be up to 48 times when the cask transporter and tow vehicle are moved between the auxiliary building and the Dry Cask Storage Facility. The tow vehicle will move at less than 5 mph. Eventually each cask will be returned to the auxiliary building to transfer fuel into a DOE transport cask for removal from PI.

B. The Work Forces Required For Construction And For Operation Of The Facility.

As the EIS discusses on page 4.5, the peak construction force will be 20 workers. Local construction workers will be hired. No additional personnel will be required to operate the Dry Cask Storage Facility.

C. The Extent To Which The Facility Would Create Or Add To The Need For Expanded Utility Or Public Services, Including High Voltage Transmission Lines, Access Roads, And The Like.

The Dry Cask Storage Facility will not create or add any need for expanded utility or public services.

D. The Amount Of Water That Would Be Appropriated And The Amount That Would Be Consumed By The Facility, The Expected Source Of The Water, And The Uses For The Water.

Neither the construction nor the operation of the Dry Cask Storage Facility impacts on local water supplies.

E. The Amount Of Agricultural Land, Including Pasture Land, That Would Be Removed From Agricultural Use If The Facility Were Constructed, And Known Circumstances Associated With The Facility That Could Lead To Reduced Productivity Of Surrounding Agricultural Land.

The construction site is on existing PI property which is largely covered with prairie grass and weeds. The dry cask facility will have no impact on the productivity of surrounding agricultural land.

F. The Number Of People That Would Have To Relocate If The Facility Were Constructed.

Because the facility is built on PI property, no one will need to relocate.

XI. HISTORICAL AND FORECAST DATA.

The following information responds to Minn. Rule pt. 7855.0620, which requires both a historical report on nuclear waste storage and forecast data on nuclear waste storage. The Rule was written to encompass nuclear waste storage facilities that would accept nuclear waste from facilities other than the generating facility. Consequently, the Rule requires information related both to Minnesota and national nuclear waste creation and storage. Because the dry cask facility at PI will only be used for spent fuel from the two reactors at PI, the information concerning nuclear waste generated nationally and by NSP's Monticello Nuclear Generating Plant is not relevant to a determination on this certificate-of-need application. Even so, because the information is easily available, NSP is providing the requested information.

A. For Each Material That Would Be Stored In The Proposed Facility, The Amount (In Cubic Meters) Produced Nationally And Within Minnesota During Each Of The Last Five Calendar Years Preceding The Year Of Application.

This data is contained in the following Table A-1 (consisting of three tables). Data for 1986 through 1988 is based on historical data presented in the Energy Information Administration's ("EIA") report "Spent Nuclear Fuel Discharges from U.S. Reactors 1988," Table 2. Data for 1989 is based on preliminary information from the EIA for 1989. Data for 1990 is based on the DOE report, "Spent Fuel Storage Requirements 1989-2020" ("SFSR"), Table A.2a and A.2b, DOE/RL-89-30, October 1989. Data for Minnesota assumes that all Pressurized Water Reactor ("PWR") (this is the type used at PI) assemblies contain 0.360 metric tons of uranium (MTU) and all Boiling Water Reactors ("BWR") (used at Monticello) assemblies contain 0.173 MTU. On a nation-wide basis, PWR discharged assemblies are assumed to be 160 inches long with an 8.434 inch square cross section for the purpose of calculating cubic meters of spent fuel. On a nation-wide basis, BWR discharged assemblies are assumed to be 176 inches long with a 5.438 inch square cross section for the purpose of calculating cubic meters of spent fuel. PI spent fuel dimensions are assumed to be 160 inches long with a 7.76 inch square cross section. Monticello spent fuel dimensions are assumed to be 172 inches long with a 5.28 inch square cross section.

TABLE A-1
RESPONSE TO 7855.0620 - ITEM A

HISTORICAL ANNUAL SPENT FUEL DISCHARGES (NUMBER OF ASSEMBLIES)

	National			Minnesota		
YEAR	PWR	BWR	Total	Prairie Is.	Monticello	Total
1986	2,365	2,583	4,948	80	124	204
1987	2,715	3,506	6,221	44	120	164
1988	2,746	3,008	5,754	92	0	92
1989	2,795	4,464	7,259	48	128	176
1990	2,707	3,810	6,517	100	0	100

Sources:

Historical data 1986 through 1988: Energy Information Administration (EIA), "Spent Nuclear Fuel Discharges from U.S. Reactors 1988", SR/CNEAF/90-01, March 1990.

1989 data: EIA, preliminary information for the "Spent Nuclear Fuel Discharges from U.S. Reactors 1989"

1990 data: U.S. Department of Energy, "Spent Fuel Storage Requirements 1989-2020", Table A.2a, and A.2b, DOE/RL-89-30, October 1989

HISTORICAL ANNUAL SPENT FUEL DISCHARGES (METRIC TONS OF URANIUM)

	National (3)			Minnesota		
YEAR	PWR	BWR	Total	Prairie Is. (1)	Monticello(2)	Total
1986	1,030	464	1,494	29	21	50
1987	1,162	632	1,794	16	21	37
1988	1,165	545	1,710	33	0	33
1989	1,221	814	2,035	17	22	39
1990	1,137	707	1,844	36	0	36

Notes:
(1) Assumes approximately 0.360 MTU per PWR assembly.
(2) Assumes approximately 0.173 MTU per BWR assembly.
(3) Nation-wide PWR and BWR MTU data comes from sources listed below.

Sources:

Historical data 1986 through 1988: Energy Information Administration (EIA), "Spent Nuclear Fuel Discharges from U.S. Reactors 1988", SR/CNEAF/90-01, March 1990.

1989 data: EIA, preliminary information for the "Spent Nuclear Fuel Discharges from U.S. Reactors 1989"

1990 data: U.S. Department of Energy, "Spent Fuel Storage Requirements 1989-2020", Table A.2a, and A.2b, DOE/RL-89-30, October 1989

TABLE A-1
RESPONSE TO 7855.0620 - ITEM A

HISTORICAL ANNUAL SPENT FUEL DISCHARGES
(CUBIC METERS OF SPENT FUEL)

	National			Minnesota		
YEAR	PWR (3)	BWR (4)	Total	Prairie Is. (5)	Monticello(6)	Total
1986	442	220	662	13	10	23
1987	508	298	806	7	9	16
1988	514	256	769	15	0	15
1989	523	379	902	8	10	18
1990	506	324	830	16	0	16

Notes:
(3) Assumes a PWR fuel assembly 160 inches long, with a 8.434 inch square cross section.
(4) Assumes a BWR fuel assembly 176 inches long, with a 5.438 inch square cross section.
(5) Assumes a PWR fuel assembly 160 inches long, with a 7.76 inch square cross section.
(6) Assumes a BWR fuel assembly 172 inches long, with a 5.28 inch square cross section.

B. For Each Of The Last Five Calendar Years Preceding The Year Of Application, The Year-End Capacity (In Cubic Meters) Within Minnesota And Within The United States To Store The Materials Listed In Response To Item A.

This data is contained in the following Table B-1 (consisting of two tables) and Table B-2 (consisting of one table). Storage capacities are based on the licensed spent fuel storage capacities that are published in SFSR, Table A.1 and the historical discharge data from Table A-1 above. Conversion factors for calculating cubic meters of spent fuel are the same as those used in responding to subpart A of this Rule.

TABLE B-1
RESPONSE TO 7855.0620 - ITEM B

HISTORICAL YEAR-END REMAINING SPENT FUEL STORAGE CAPACITIES (NUMBER OF ASSEMBLIES)

YEAR	National			Minnesota (2)		
	PWR	BWR	Total (1)	Prairie Is.	Monticello	Total
1986	70,802	60,786	131,588	585	2,039	2,624
1987	66,966	58,071	125,037	541	1,919	2,460
1988	63,988	55,325	119,313	449	1,919	2,368
1989	59,524	52,530	112,054	401	1,791	2,192
1990	55,552	49,823	105,375	301	1,791	2,092

Notes:

(1) In addition to remaining spent fuel storage pool capacities that are included in these totals, a limited amount of spent fuel is stored in non-utility facilities such as the Generel Electric Morris Facility. These facilities are no longer accepting spent fuel from utilities for storage.

(2) Only the capacities indicated for Minnesota are accessible for storage of spent fuel discharged in Minnesota.

Sources:

Historical data 1986 through 1988: Energy Information Administration (EIA), "Spent Nuclear Fuel Discharges from U.S. Reactors 1988", SR/CNEAF/90-01, March 1990.

1989 Data: EIA, Preliminary information for the "Spent Nuclear Fuel Discharges from U.S. Reactors 1989"

1990 data and spent fuel licensed storage capacities: U.S. DOE, "Spent Fuel Storage Requirements 1989-2020", Table A.1 and A.2a, DOE/RL-89-30, October 1989

Prairie Island and Monticello year-end storage capacities are based on historical data and licensed spent fuel storage capacities.

TABLE B-1
RESPONSE TO 7855.0620 - ITEM B

HISTORICAL YEAR-END REMAINING SPENT FUEL STORAGE CAPACITIES (CUBIC METERS)

YEAR	National			Minnesota (5)		
	PWR (1)	BWR (2)	Total	Prairie Is. (3)	Monticello (4)	Total
1986	13,240	5,167	18,407	92	160	252
1987	12,523	4,936	17,459	85	151	236
1988	11,966	4,703	16,668	71	151	222
1989	11,131	4,465	15,596	63	141	204
1990	10,388	4,235	14,623	48	141	189

Notes:
(1) Assumes a PWR fuel assembly 160 inches long with a 8.434 inch square cross section.
(2) Assumes a BWR fuel assembly 176 inches long with a 5.438 inch square cross section.
(3) Assumes a PWR fuel assembly 160 inches long with a 7.76 inch square cross section.
(4) Assumes a BWR fuel assembly 172 inches long with a 5.28 inch square cross section.
(5) Only the capacities indicated for Minnesota are accessible for storage of spent fuel discharged in Minnesota.

Sources:
Historical data 1986 through 1988: Energy Information Administration (EIA), "Spent Nuclear Fuel Discharges from U.S. Reactors 1988", SR/CNEAF/90-01, March 1990.
1989 Data: EIA, Preliminary information for the "Spent Nuclear Fuel Discharges from U.S. Reactors 1989".
1990 data and spent fuel licensed storage capacities: U.S. DOE, "Spent Fuel Storage Requirements 1989-2020", Table A.1 and A.2a, DOE/RL-89-30, October 1989.
Prairie Island and Monticello year-end storage capacities are based on historical data and licensed spent fuel storage capacities.

TABLE B-2
RESPONSE TO 7855.0620 - ITEM B

CURRENT INVENTORIES AT SPENT FUEL STORAGE FACILITIES (NUMBER OF ASSEMBLIES)

Storage Facility	Current Inventory PWR	BWR	HTGR
GE Morris Facility	352	2835	0
Idaho National Engineering Laboratory	93	4	720
Ohio Battelle	1	0	0
Vallecitos Nuclear	0	1	0
Washington Hanford	5	2	0
West Valley	40	85	0

Note:
The storage facilities presented above are no longer accepting spent fuel from utilities and will, therefore, not be available as storage facilities in in the future.

C. <u>An Estimate Of The Amount (In Cubic Meters) Of Each Material Listed In Response To Item A Expected To Be Produced Nationally And Within Minnesota During The First 6 Forecast Years, The 11th Forecast Year (The 10th Year After The Year Of Application), And The 16th Forecast Year</u>.

This data is presented in Tables C-1 (consisting of three tables). Projected spent fuel discharges are based on DOE's projections from SFSR Table A.2a and A.2b. Conversion factors for calculating MTU and cubic meters are the same as those used in responding to subpart A of this Rule. The national projected spent fuel discharge data used in response to subpart C of this Rule is based on data submitted to the DOE by utilities. The data used is from the DOE document "Spent Fuel Requirements 1989-2020," which is based on spent fuel discharges as of December 31, 1988. DOE assumes that a full core reserve margin is maintained, i.e., space will be maintained in each storage pool to accept a full core discharge from the reactor, for all reactors, and utilities will increase spent fuel pool capacities to the maximum extent possible.

TABLE C-1
RESPONSE TO 7855.0620 - ITEM C

PROJECTED ANNUAL SPENT FUEL DISCHARGES (ASSEMBLIES)

YEAR	National			Minnesota		
	PWR	BWR	Total	Prairie Is.	Monticello	Total
1991	2,942	2,804	5,746	48	136	184
1992	3,526	3,496	7,022	100	0	100
1993	2,774	3,240	6,014	48	136	184
1994	2,903	3,296	6,199	48	136	184
1995	2,669	3,928	6,597	96	0	96
1996	3,138	3,658	6,796	48	136	184
2001	2,694	1,762	4,456	48	136	184
2006	2,738	4,311	7,049	48	136	184

Sources:
Projected spent fuel discharges: U.S. DOE, "Spent Fuel Storage Requirements 1989-2020", Tables A.2a and A.2b, DOE/RL-89-30, October 1989.

PROJECTED ANNUAL SPENT FUEL DISCHARGES (METRIC TONS OF URANIUM)

YEAR	National (3)			Minnesota		
	PWR	BWR	Total	Prairie Is. (1)	Monticello (2)	Total
1991	1,279	498	1,777	17	24	41
1992	1,507	625	2,132	36	0	36
1993	1,201	576	1,777	17	24	41
1994	1,247	586	1,833	17	24	41
1995	1,152	696	1,848	35	0	35
1996	1,350	653	2,003	17	24	41
2001	1,179	312	1,491	17	24	41
2006	1,189	772	1,961	17	24	41

Notes:
(1) Assumes approximately 0.360 MTU per PWR assembly.
(2) Assumes approximately 0.173 MTU per BWR assembly.
(3) Nation-wide PWR and BWR MTU projections come from sources listed below.

Sources:
Projected spent fuel discharges: U.S. DOE, "Spent Fuel Storage Requirements 1989-2020", Tables A.2a and A.2b, DOE/RL-89-30, October 1989.

TABLE C-1
RESPONSE TO 7855.0620 - ITEM C

PROJECTED ANNUAL SPENT FUEL DISCHARGES (CUBIC METERS)

YEAR	National			Minnesota		
	PWR (3)	BWR (4)	Total	Prairie Is. (5)	Monticello (6)	Total
1991	550	238	788	8	11	19
1992	659	297	957	16	0	16
1993	519	275	794	8	11	19
1994	543	280	823	8	11	19
1995	499	334	833	15	0	15
1996	587	311	898	8	11	19
2001	504	150	654	8	11	19
2006	512	366	878	8	11	19

Notes:
(3) Assumes a PWR fuel assembly 160 inches long with a 8.434 inch square cross section.
(4) Assumes a BWR fuel assembly 176 inches long with a 5.438 inch square cross section.
(5) Assumes a PWR fuel assembly 160 inches long with a 7.76 inch square cross section.
(6) Assumes a BWR fuel assembly 172 inches long with a 5.28 inch square cross section.

Source:
Projected spent fuel discharges: U.S. DOE, "Spent Fuel Storage Requirements 1989-2020", Tables A.2a and A.2b, DOE/RL-89-30, October 1989.

D. A List Of Known Facilities To Be Added In The United States During The Forecast Years, Including Locations, Design Capacities (In Cubic Meters), And In-Service Dates, For Storing The Same Types Of Materials That Would Be Stored In The Proposed Facility.

This data is provided in Tables D-1, D-2 and D-3. Known storage facilities to be added in the United States during the forecast years are based on utility dry storage facilities that have recently started operation, announced utility storage facilities and planned DOE storage facilities. The utility storage facilities will only be available to store spent fuel discharged from the designated reactors. The beginning operation dates for the DOE storage facilities are uncertain at this time as is the DOE acceptance rate for spent fuel. This is discussed further in response to subpart E of this Rule.

TABLE D-1
RESPONSE TO 7855.0620 - ITEM D

UTILITIES CURRENTLY USING DRY STORAGE TO INCREASE ON-SITE SPENT FUEL STORAGE CAPACITY

Virginia Power Company
Surry Station Independent Spent Fuel Storage Installation (ISFSI)
Surry County, Virginia:

Capacity:	1764 assembly capacity equivalent to 328.4 cubic meters
Inservice Date:	First fuel loaded in October 1986.
Comments:	Has sufficient capacity to store fuel through the end of Surry's current operating license.
Source:	NRC Docket 72-2

Carolina Power and Light Company
H.B. Robinson ISFSI
Darlington County, South Carolina:

Capacity:	56 assembly capacity equivalent to 10.4 cubic meters.
Inservice Date:	First fuel loaded in March 1989.
Comments:	The Robinson ISFSI was licensed as a demonstration project and is not designed to store any additional fuel.
Source:	NRC Docket 72-3

Duke Power Company
Oconee ISFSI
Seneca, South Carolina:

Capacity:	2112 assembly capacity equivalent to 418 cubic meters.
Inservice Date:	First fuel loaded in July 1990.
Comments:	Has sufficient capacity to store spent fuel through the end of the Oconee Units' operating licenses.
Source:	NRC Docket 72-4

TABLE D-2
RESPONSE TO 7855.0620 - ITEM D

UTILITIES THAT HAVE ANNOUNCED PLANS TO USE DRY STORAGE TO INCREASE ON-SITE SPENT FUEL STORAGE CAPACITY

Baltimore Gas and Electric Company
Calvert Cliffs Nuclear Power Plant
Calvert County, Maryland

Capacity:	2880 assembly capacity equivalent to 486 cubic meters.
Inservice Date:	Unknown at this time.
Source:	NRC Docket 72-8

Carolina Power and Light Company
Brunswick Steam Electric Plant
Southport, North Carolina

Capacity:	Unknown at this time.
Inservice Date:	Unknown at this time.
Comments:	Dry storage at Brunswick will be for the H.B. Robinson PWR fuel that is currently stored in the Brunswick spent fuel storage pools.
Source:	NRC Docket 72-6

Consumers Power Company
Palisades Nuclear Station
Covert, Michigan

Capacity:	Unknown at this time.
Inservice Date:	Unknown at this time.
Source:	NRC Docket 72-7

Public Service Company of Colorado
Fort St. Vrain
Platteville, Colorado

Capacity:	1482 assembly capacity
Inservice Date:	Unknown at this time
Source:	NRC Docket 72-9

Wisconsin Electric Power Company
Point Beach
Two Creeks, Wisconsin

Capacity:	Unknown at this time.
Inservice Date:	Unknown at this time.
Source:	NRC Docket 72-5

TABLE D-3
RESPONSE TO 7855.0620 - ITEM D

PLANNED DEPARTMENT OF ENERGY FACILITIES FOR SPENT FUEL STORAGE

Monitored Retreivable Storage Facility:	
Operator:	Department of Energy
Location:	Unknown at this time
Capacity:	10,000 MTU prior to repository operation with present legislatively mandated linkages. Maximum capacity is 15,000 MTU.
Inservice Date:	Unknown at this time. Based on an assumed repository operation date of 2010, a linked MRS facility would begin operation in 2007.
Sources:	Nuclear Waste Policy Amendments Act, 1987. DOE, "Report to Congress on Reassessment of the Civilian Radioactive Management Program", DOE/RW-0247, November 1989

Geologic Repository for Spent Nuclear Fuel and High Level Waste	
Operator:	Department of Energy
Location:	Unknown at this time. Site characterization of Yucca Mountain, Nevada is ongoing.
Capacity:	70,000 MTU prior to operation of a second repository with present legislation.
Inservice Date:	Unknown at this time. The present DOE official repository operation date is 2010.
Sources:	Nuclear Waste Policy Act, 1983. DOE, "Report to Congress on Reassessment of the Civilian Radioactive Management Program", DOE/RW-0247, November 1989

E. The Expected Years During Which The Material Stored In The Proposed Facility Would Reach 10%, 25%, 50% And 100% Of The Capacity Of The Facility.

This data is provided in Table E-1. For analysis purposes, it is assumed the DOE will begin accepting spent fuel from utilities beginning in 2015. This assumes the permanent repository will begin operations in 2015, reflecting a potential five-year change in the DOE's current scheduled operation date of 2010. The use of the year 2015 allows an analysis of the impact on the proposed Dry Cask Storage Facility should a delay occur in the DOE's acceptance of this spent fuel. Planning for spent fuel storage for the life of the plant which assumes that DOE will not begin accepting spent fuel until after the current PI operating licenses expire, is prudent because it ensures PI operations are not adversely impacted due to inadequate spent fuel storage capacity. The acceptance capacities are based on those from the DOE's 1990 Annual Capacity Report ("ACR").

The spent fuel dry storage capacities are based on PI spent fuel discharges that are consistent with those projected in response to subpart C of this Rule. Sufficient discharge capacity is assumed to be reserved in the PI spent fuel pool to accommodate a discharge capacity reserve equivalent to one full core off-load (121 assemblies) in 1990, 1991, and 1992. Beginning in 1993, the small spent fuel pool (Fuel Pool No. 1) will be reserved for dry storage cask loading operations. This will result in a reserve capacity of 266 spent fuel storage locations. The capacity of the proposed storage facility is assumed to be 1920 fuel assemblies, based on a facility for 48 storage casks that each contain 40 spent fuel assemblies. DOE's current schedule calls for spent fuel acceptance to begin in the year 2010.

The following Table E-1 goes beyond the year 2010 to reflect two possibilities: (1) DOE does not immediately begin removing fuel at a rate which eliminates the need for additional casks; and (2) DOE does not begin accepting fuel until after the year 2010. Acceptance capacities are based on the maximum acceptance schedule published in the DOE's 1990 ACR. PI spent fuel acceptance rates are based on the total DOE annual acceptance capacities and the individual acceptance rankings from the 1990 ACR (Table 2.1, 2.2 and B.1, respectively).

TABLE E-1
RESPONSE TO 7855.0620 - ITEM E

RATE AT WHICH THE PROPOSED PRAIRIE ISLAND DRY STORAGE FACILITY IS FILLED WITH SPENT FUEL

Year Spent Fuel in Dry Storage Reaches Specified Percent of Capacity	Percent of Dry Storage Capacity Utilized	Assemblies In Dry Storage
1993	10%	200
1997	25%	480
2004	48%	920
2014	79%	1520
2020	100%	1920

Assumes space is reserved for 266 spent fuel assemblies. This is the equivalent storage capacity of the small spent fuel pool at Prairie Island. One full core discharge is reserved in 1990 through 1992.

Assumes the licensed dry storage capacity is 1920 assemblies, 48 casks each with a capacity of 40 assemblies.

Assumes that DOE begins accepting spent fuel in 2015 with no MRS facility at the 1990 ACR upper-bounding acceptance capacity.

F. A Discussion Of The Methodology, Statistical Techniques And Data Bases Used In Providing The Forecast Data Required By Items C And E.

This information was provided as part of the response to subparts C and E of this Rule.

G. Any Major Assumptions Made In Supplying The Information Required By Items A To E, And A Discussion Of The Sensitivity Of The Information To Changes In The Assumptions.

This information was provided in part in the responses to subparts A through E of this Rule. In addition, several sensitivity analyses are presented in Tables G-1 through G-9. These Tables assume sufficient reserve capacity is retained in the PI spent fuel storage pool for two full core discharges of spent fuel, one for each operating unit. This forestalls any operational problems in the event both units need to be off-loaded simultaneously.

The percent of the proposed dry storage capacity utilized is highly dependent upon when the DOE begins accepting spent fuel and the rate at which the DOE accepts fuel. Table G-1 presents a comparison of different DOE spent fuel acceptance dates utilizing lower and higher 1990 ACR-based estimates of DOE acceptance capacities. The low acceptance rate, which is based on recent discussions with DOE personnel, assumes an MRS facility begins operation in 1998 and is limited to 10,000 MTU prior to repository operation.

TABLE G-1
REPONSE TO 7855.0620 -ITEM G

SENSITIVITY ANALYSIS: COMPARISON OF RATE OF SPENT FUEL STORAGE IN THE PROPOSED PRAIRIE ISLAND DRY STORAGE FACILITY

Year DOE Acceptance Begins	Annual Acceptance Capacity (1)	Year Spent Fuel in Dry Storage Reaches Specified Percent of Capacity				
		10%	25%	48%	MAX %	Reference
1998	LOW	1994	1997	2014	46%	Table G-4
2007	LOW	1994	1997	2004	67%	Table G-5
2007	HIGH	1994	1997	2004	60%	Table G-6
2010	LOW	1994	1997	2004	77%	Table G-7
2010	HIGH	1994	1997	2004	65%	Table G-8
2015	ACR	1994	1997	2004	79%	Table G-9

(1) LOW refers to the 1990 ACR Lower-bounding acceptance capacity from Table G-2. HIGH refers to the 1990 ACR Upper-bounding acceptance capacity schedule from Table G-2.

Table G-2 presents the lower end and upper end estimates as well as the spent fuel acceptance capacities that are presented in the 1990 ACR. A comparison is made assuming DOE begins accepting spent fuel in 1998 with the low acceptance rate, DOE begins accepting spent fuel in 2007 and 2010 with both the lower and upper 1990 ACR-based acceptance rates, and DOE begins accepting spent fuel in 2015.

TABLE G-2
RESPONSE TO 7855.0620 - ITEM G

DOE ANNUAL SPENT FUEL ACCEPTANCE CAPACITIES
(Metric Tons of Uranium)

YEAR	Upper-Bounding DOE Acceptance Capacity "HIGH" (1)	Lower-Bounding DOE Acceptance Capacity "LOW" (2)
1	1,200	300
2	1,200	400
3	2,000	550
4	2,000	875
5	2,700	875
6	3,000	875
7	3,000	875
[illegible]	3,000	875
9	3,000	875
10	3,000	875
11	3,000	875
12	3,000	875
13	3,000	875
Total	33,100	10,000

(1) DOE, "Annual Capacity Report", Table 2.1, DOE/RW-0294P, December 1990
(2) DOE, "Annual Capacity Report", Table 2.2, DOE/RW-0294P, December 1990

The PI specific spent fuel acceptance rates assumed in all cases are based on the data presented in Table G-3, which is a summary of Table B.1 from the 1990 ACR and presents the spent fuel acceptance ranking based on an "oldest fuel first" allocation methodology.

TABLE G-3
RESPONSE TO 7855.0620.0620 -ITEM G

DOE SPENT FUEL ACCEPTANCE RANKING BASED ON OLDEST FUEL FIRST ALLOCATION

Source of Spent Fuel	MTU	Cumulative MTU	Equivalent Prairie Island Assemblies
Other	1762.46	1,762.46	
Prairie Island	15.96	1,778.42	40
Other	383.06	2,145.52	
Prairie Island	16.03	2,161.55	40
Other	258.36	2,403.88	
Prairie Island	13.80	2,417.68	35
Other	665.24	3,069.12	
Prairie Island	14.02	3,083.13	35
Other	334.74	3,403.86	
Prairie Island	16.11	3,419.97	41
Other	733.84	4,137.70	
Prairie Island	16.04	4,153.74	40
Other	491.20	4,628.90	
Prairie Island	16.41	4,645.31	41
Other	763.77	5,392.67	
Prairie Island	16.10	5,408.77	40
Other	1,385.54	6,778.21	
Prairie Island	16.50	6,794.71	41
Other	507.38	7,285.59	
Prairie Island	16.02	7,301.61	40
Other	851.57	8,137.16	
Prairie Island	15.67	8,152.83	39
Other	420.27	8,557.43	
Prairie Island	15.55	8,572.98	41
Other	988.50	9,545.93	
Prairie Island	15.55	9,561.48	41
Other	394.71	9,940.64	
Prairie Island	15.57	9,956.21	41

TABLE G-3
RESPONSE TO 7855.0620.0620 -ITEM G

DOE SPENT FUEL ACCEPTANCE RANKING
BASED ON OLDEST FUEL FIRST ALLOCATION

Source of Spent Fuel	MTU	Cumulative MTU	Equivalent Prairie Island Assemblies
Other	946.43	10,887.07	
Prairie Island	15.50	10,902.57	41
Other	376.58	11,263.65	
Prairie Island	2.22	11,265.87	6
Other	862.61	12,126.26	
Prairie Island	20.05	12,146.31	57
Other	894.61	13,020.87	
Prairie Island	22.28	13,043.15	61
Other	860.39	13,881.26	
Prairie Island	14.73	13,895.99	41
Other	741.02	14,622.28	
Prairie Island	15.32	14,637.60	45
Other	1,330.11	15,952.39	
Prairie Island	15.95	15,968.34	40
Other	920.00	16,872.39	
Prairie Island	17.84	16,890.23	40
Other	1,318.68	18,191.07	
Prairie Island	17.80	18,208.87	40
Source: DOE, "Annual Capacity Report", Table B.1, DOE/RW-0294P, December 1990			

For the purposes of presenting a sensitivity analysis, Tables G-4 through G-9 show a detailed picture of the PI spent fuel discharge data, DOE acceptance capacities and the amount of spent fuel which must be placed in dry storage based on beginning spent fuel acceptance dates and different acceptance capacities. This data is summarized in Table G-1.

It is evident from examining the summary that if the DOE does not begin accepting spent fuel until 2015, the proposed Dry Cask Storage Facility will reach 79% of its licensed capacity. A five-year change in DOE's current scheduled operation date of 2010 is possible considering the magnitude of the work which must be accomplished in order for the permanent repository to begin operation. In addition, DOE has acknowledged that its current schedule is ambitious. The additional twenty percent margin in this case is necessary to account for any increase in operating capacities or changes in the operating schedules which may result in an increase in the spent fuel discharges.

While the case in which DOE begins spent fuel acceptance in 1998 with an MRS facility only shows a maximum capacity for the Dry Cask Storage Facility of 46%, this is considered highly unlikely since it is dependent upon the Nuclear Waste Negotiator successfully finding a volunteer site for the MRS facility.

The cases which are based upon the upper estimated acceptance rate published in the 1990 ACR are also considered unlikely. This conclusion is based on discussions with DOE personnel which indicate the DOE will not be able to accept spent fuel at levels as high as the upper limit estimates published in the 1990 ACR, especially during the beginning years of MRS facility or repository operation. There is likely to be an initial start-up period, during which a relatively small amount of spent fuel is accepted.

TABLE G-4
REPONSE TO 7855.0620 -ITEM G

SENSITIVITY CASE: SPENT FUEL STORAGE REQUIREMENTS FOR PRAIRIE ISLAND ASSUMES: DOE ACCEPTANCE BEGINS IN 1998 WITH LOW ACCEPTANCE RATES

YEAR	Prairie Island Discharged Spent Fuel Assemblies	DOE Acceptance of Prairie Island Fuel	Remaining Licensed Storage Pool Capacity	Assemblies In Dry Storage	Percent of Dry Storage Capacity Utilized
1990	100		180		
1991	48		132		
1992	100		32		
1993	48		-161 *	80	4%
1994	48		-209	200	10%
1995	96		-305	320	17%
1996	48		-353	360	19%
1997	96		-449	480	25%
1998	48	0	-497	520	27%
1999	48	0	-545	560	29%
2000	96	0	-641	680	35%
2001	48	40	-649	680	35%
2002	96	75	-670	680	35%
2003	48	76	-642	680	35%
2004	48	81	-609	680	35%
2005	96	40	-665	680	35%
2006	48	0	-713	720	38%
2007	96	81	-728	760	40%
2008	48	39	-737	760	40%
2009	48	41	-744	760	40%
2010	96	82	-758	760	40%
2011	48	0	-806	840	44%
2012	48	47	-807	840	44%
2013	96	57	-846	880	46%
2014	242	51	-846	880	46%

* Assumes space is reserved for 266 spent fuel assemblies. This is the equivalent storage capacity of the small spent fuel pool at Prairie Island. One full core discharge is reserved in 1990 through 1992.

Assumes the licensed dry storage capacity is 1920 assemblies, 48 casks each with a capacity of 40 assemblies.

Assume that DOE begins accepting spent fuel in 1998 with an unlinked MRS facility.

TABLE G-5

REPONSE TO 7855.0620 -ITEM G

SENSITIVITY CASE: SPENT FUEL STORAGE REQUIREMENTS FOR PRAIRIE ISLAND ASSUMES: DOE ACCEPTANCE BEGINS IN 2007 WITH LOW ACCEPTANCE RATES

Year	Prairie Island Discharged Spent Fuel Assemblies	DOE Acceptance of Prairie Island Fuel	Remaining Licensed Storage Pool Capacity	Assemblies In Dry Storage	Percent of Dry Storage Capacity Utilized
1990	100		180		
1991	48		132		
1992	100		32		
1993	48		-161 *	80	4%
1994	48		-209	200	10%
1995	96		-305	320	17%
1996	48		-353	360	19%
1997	96		-449	480	25%
1998	48		-497	520	27%
1999	48		-545	560	29%
2000	96		-641	680	35%
2001	48		-689	720	38%
2002	96		-785	800	42%
2003	48		-833	840	44%
2004	48		-881	920	48%
2005	96		-977	1000	52%
2006	48		-1025	1040	54%
2007	96	0	-1121	1160	60%
2008	48	0	-1169	1200	63%
2009	48	0	-1217	1240	65%
2010	96	40	-1273	1280	67%
2011	48	75	-1246	1280	67%
2012	48	76	-1218	1280	67%
2013	96	81	-1233	1280	67%
2014	242	40	-1233	1280	67%

* Assumes space is reserved for 266 spent fuel assemblies. This is the equivalent storage capacity of the small spent fuel pool at Prairie Island. One full core discharge is reserved in 1990 through 1992.

Assumes the licensed dry storage capacity is 1920 assemblies, 48 casks each with a capacity of 40 assemblies.

TABLE G-6
REPONSE TO 7855.0620 -ITEM G

SENSITIVITY CASE: SPENT FUEL STORAGE REQUIREMENTS FOR PRAIRIE ISLAND ASSUMES: DOE ACCEPTANCE BEGINS IN 2007 WITH HIGH ACCEPTANCE RATES

Year	Prairie Island Discharged Spent Fuel Assemblies	DOE Acceptance of Prairie Island Fuel	Remaining Licensed Storage Pool Capacity	Assemblies In Dry Storage	Percent of Dry Storage Capacity Utilized
1990	100		180		
1991	48		132		
1992	100		32		
1993	48		-161 *	80	4%
1994	48		-209	200	10%
1995	96		-305	320	17%
1996	48		-353	360	19%
1997	96		-449	480	25%
1998	48		-497	520	27%
1999	48		-545	560	29%
2000	96		-641	680	35%
2001	48		-689	720	38%
2002	96		-785	800	42%
2003	48		-833	840	44%
2004	48		-881	920	48%
2005	96		-977	1000	52%
2006	48		-1025	1040	54%
2007	96	0	-1121	1160	60%
2008	48	80	-1089	1160	60%
2009	48	151	-986	1160	60%
2010	96	81	-1001	1160	60%
2011	48	161	-888	1160	60%
2012	48	129	-807	1160	60%
2013	96	204	-699	1160	60%
2014	242	120	-699	1160	60%

* Assumes space is reserved for 266 spent fuel assemblies. This is the equivalent storage capacity of the small spent fuel storage pool at Prairie Island. One full core discharge is reserved in 1990 through 1992.

Assumes the licensed dry storage capacity is 1920 assemblies, 48 casks each with a capacity of 40 assemblies.

TABLE G-7
REPONSE TO 7855.0620 -ITEM G

SENSITIVITY CASE: SPENT FUEL STORAGE REQUIREMENTS FOR PRAIRIE ISLAND
ASSUMES: DOE ACCEPTANCE BEGINS IN 2010 WITH LOW ACCEPTANCE RATES

Year	Prairie Island Discharged Spent Fuel Assemblies	DOE Acceptance of Prairie Island Fuel	Remaining Licensed Storage Pool Capacity	Assemblies In Dry Storage	Percent of Dry Storage Capacity Utilized
1990	100		180		
1991	48		132		
1992	100		32		
1993	48		-161 *	80	4%
1994	48		-209	200	10%
1995	96		-305	320	17%
1996	48		-353	360	19%
1997	96		-449	480	25%
1998	48		-497	520	27%
1999	48		-545	560	29%
2000	96		-641	680	35%
2001	48		-689	720	38%
2002	96		-785	800	42%
2003	48		-833	840	44%
2004	48		-881	920	48%
2005	96		-977	1000	52%
2006	48		-1025	1040	54%
2007	96		-1121	1160	60%
2008	48		-1169	1200	63%
2009	48		-1217	1240	65%
2010	96	0	-1313	1320	69%
2011	48	0	-1361	1400	73%
2012	48	0	-1409	1440	75%
2013	96	40	-1465	1480	77%
2014	242	75	-1465	1480	77%

* Assumes space is reserved for 266 spent fuel assemblies. This is the equivalent storage capacity of the small spent fuel pool at Prairie Island. One full core discharge is reserved in 1990 through 1992.
Assumes the licensed dry storage capacity is 1920 assemblies, 48 casks each with a capacity of 40 assemblies.

Note: Acceptance ranking for Prairie Island based on a low estimate for DOE acceptance rates.

TABLE G-8
REPONSE TO 7855.0620 -ITEM G

SENSITIVITY CASE: SPENT FUEL STORAGE REQUIREMENTS FOR PRAIRIE ISLAND ASSUMES: DOE ACCEPTANCE BEGINS IN 2010 WITH HIGH ACCEPTANCE RATES

Year	Prairie Island Discharged Spent Fuel Assemblies	DOE Acceptance of Prairie Island Fuel	Remaining Licensed Storage Pool Capacity	Assemblies In Dry Storage	Percent of Dry Storage Capacity Utilized
1990	100		180		
1991	48		132		
1992	100		32		
1993	48		-161 *	80	4%
1994	48		-209	200	10%
1995	96		-305	320	17%
1996	48		-353	360	19%
1997	96		-449	480	25%
1998	48		-497	520	27%
1999	48		-545	560	29%
2000	96		-641	680	35%
2001	48		-689	720	38%
2002	96		-785	800	42%
2003	48		-833	840	44%
2004	48		-881	920	48%
2005	96		-977	1000	52%
2006	48		-1025	1040	54%
2007	96		-1121	1160	60%
2008	48		-1169	1200	63%
2009	48		-1217	1240	65%
2010	96	80	-1233	1240	65%
2011	48	151	-1130	1240	65%
2012	48	81	-1097	1240	65%
2013	96	161	-1032	1240	65%
2014	242	129	-1032	1240	65%

* Assumes space is reserved for 266 spent fuel assemblies. This is the equivalent storage capacity of the small spent fuel pool at Prairie Island. One full core discharge is reserved in 1990 through 1992.

Assumes the licensed dry storage capacity is 1920 assemblies, 48 casks each with a capacity of 40 assemblies.

TABLE G-9
REPONSE TO 7855.0620 -ITEM E

SENSITIVITY CASE: SPENT FUEL STORAGE REQUIREMENTS FOR PRAIRIE ISLAND ASSUMES: DOE ACCEPTANCE BEGINS IN 2015 WITH HIGH ACCEPTANCE RATES

Year	Prairie Island Discharged Spent Fuel Assemblies	Remaining Licensed Storage Pool Capacity	Assemblies In Dry Storage	Percent of Dry Storage Capacity Utilized
1990	100	180		
1991	48	132		
1992	100	32		
1993	48	-161 *	80	4%
1994	48	-209	200	10%
1995	96	-305	320	17%
1996	48	-353	360	19%
1997	96	-449	480	25%
1998	48	-497	520	27%
1999	48	-545	640	33%
2000	96	-641	680	35%
2001	48	-689	760	40%
2002	96	-785	800	42%
2003	48	-833	880	46%
2004	48	-881	920	48%
2005	96	-977	1000	52%
2006	48	-1025	1120	58%
2007	96	-1121	1160	60%
2008	48	-1169	1200	63%
2009	48	-1217	1240	65%
2010	96	-1313	1320	69%
2011	48	-1361	1400	73%
2012	48	-1409	1440	75%
2013	96	-1505	1520	79%
2014	242	-1505	1520	79%

* Assumes space is reserved for 266 spent fuel assemblies. This is the equivalent storage capacity of the small spent fuel pool at Prairie Island. One full core discharge is reserved in 1990 through 1992.
Assumes the licensed dry storage capacity is 1920 assemblies, 48 casks each with a capacity of 40 assemblies.

XII. ADDITIONAL CONSIDERATIONS.

Minn. Rule pt. 7855.0260 requires the Application to contain an explanation of the relationship of the Dry Cask Storage Facility to each of the following socioeconomic considerations:

A. Socially Beneficial Uses Of The Output Of The Facility, Including Its Uses To Protect Or Enhance Environmental Quality.

The Dry Cask Storage Facility permits PI to continue in operation, providing safe, low-cost, dependable electric energy. Low-cost, dependable electric energy results in undeniable social benefits. It lights customers' homes and workplaces, makes many commercial and industrial operations possible, heats homes where alternative heating supplies are not available, and helps in the preservation of foods through refrigeration. These are only a sample of some of the benefits derived from electric energy.

B. Promotional Activities That May Have Given Rise To The Demand For The Facility.

Because the Dry Cask Storage Facility allows continued use of an existing generation plant, this is not an instance where promotional activities have an effect on the need for PI. As explained earlier, the low cost of energy makes PI one of the first plants NSP dispatches to meet baseload demand. Therefore, promotional activities have no effect on the need for the Dry Cask Storage Facility.

C. The Effects Of The Facility In Inducing Future Development.

PI provides low-cost energy, which is reflected in NSP's reasonable electric rates. NSP's relatively electric rates help the economic development of those communities served by NSP. PI is also a large employer, with nearly 400 employees. As such, it supports a portion of the greater Red Wing area economy. Further, PI is the largest property taxpayer in Goodhue County, paying $17 million in annual property taxes. The shutdown of PI would have a significant negative impact on the other taxpayers of the county, city and school district.

XIII. CONSERVATION PROGRAMS.

This section provides the information required by Minn. Rule pt. 7855.0270 on NSP's conservation programs. As noted in the Need Summary and in the discussion of conservation as an alternative, NSP is aggressively pursuing conservation. Conservation, however, cannot economically and reliably replace PI.

Aggressive conservation will displace a large part of NSP's incremental capacity required to meet growing customer needs. NSP is expanding its conservation programs to the greatest extent economically feasible to manage load growth and displace the need for new capacity. New capacity would be more costly than continued operation of PI.

The cost of NSP's conservation programs is compared to electric supply costs by recognizing the respective load factor of conservation and the equivalent capacity factor of the power plant being avoided. Conservation efforts that would replicate the availability of energy produced by NSP's baseload plants are estimated to cost in the range of $1,125-$1,500 per kilowatt of capacity, or $0.0225-$0.03 per kilowatt- hour, compared to PI's production costs of per kilowatt-hour $0.015. This range is estimated by adjusting NSP's current conservation program cost, $375/kw or $0.0075/kwh, figured at a 35% conservation load factor, to equal the 80%-90% capacity factor of PI. This cost estimate for conservation is probably low. Conservation program costs are expected to rise as NSP expands its conservation efforts in the future.

NSP's support for conservation goes beyond complying with the statutory obligation to have an approved CIP. Conservation is important to the environment, to economic development in

NSP's service areas, and it enables NSP to provide competitively priced electricity. Conservation also helps low-income and renter customers better manage their energy bills.

The adequacy of NSP's conservation efforts are independently determined pursuant to the Conservation Improvement Program ("CIP"), which has precedence over other regulatory forums for the determination of conservation program sufficiency. The Department of Public Service has approval responsibility over NSP's CIP filing.

As of the filing date of this application, NSP's 1990 CIP filing was awaiting Department approval. NSP is scheduled to file its program with the Department again in September, 1991 and every two years thereafter. In addition, in October, 1991, NSP will file with the Public Utilities Commission its first Resource Plan, pursuant to Minn. Rules pt. 7843.0100 et seq. NSP's plans, including conservation, for meeting customer needs will be reviewed in that filing. These filings are the appropriate forum for public input on conservation's role in meeting customer electricity needs.

A. The Name Of The Committee, Department Or Individual Responsible For The Applicant's Energy Conservation And Efficiency Programs.

Mr. Keith Wietecki, Vice President Electric Marketing and Sales, is responsible for all of NSP's Minnesota Electric Utility energy conservation and efficiency programs for retail customers.

B. A List Of The Applicant's Energy Conservation And Efficiency Goals And Objectives.

NSP's current short-term goal is to achieve 1,000 MW of DSM impact system-wide by

1995. This is equivalent to 91% of NSP's total peaking power plant capacity. NSP will work to achieve additional DSM impacts beyond 1995 to total 2,000 MW and 2,700 gigawatt-hours annually by 2016. To achieve this, NSP's energy efficiency program concentrates in eight major areas: Cooling, Energy Efficiency Information and Financing, Lighting, Load Management, Process/Motors, Residential and Residential Low Income, and Research, Planning and Development. NSP has a total of 34 program elements in these eight market areas.

C. A Description Of The Specific Energy Conservation And Efficiency Programs The Application Has Considered, A List Of Those That Have Been Implemented, And The Reasons Why The Other Programs Have Not Been Implemented.

Appendix 1 describes the comprehensive studies NSP conducted in 1988-90 to determine the amount of potential demand and energy efficiency available within the company's service territory. NSP's 1,000 MW DSM goal (by 1995) mentioned above includes more than two-thirds of the achievable, cost-effective conservation which, given current knowledge, is realistically possible in the next five years. By 2010, NSP hopes to achieve virtually all the known cost-effective conservation available. These studies considered a broad range of technologies for a number of end uses and customer types. The information developed in those studies, supplemented by additional, more specific development information, has been the basis for NSP's current program.

Appendix 1 to this Application also lists NSP's currently implemented program elements. A comprehensive report on this program can be found in NSP's CIP filed with the Department August 31, 1990. NSP continually refines and expands its programs as new technologies become available, as options' economies become attractive, as different sales tactics are found to be successful, and as customers' interest in an option increases.

Appendix 1 to this Application contains a partial list of programs and program elements considered but not adopted. Key reasons these efforts have not been implemented include:

- Technical infeasibility;
- Poor economics according to standard benefit-cost tests; and
- Lack of customer interest or market saturation.

D. A Description Of The Major Accomplishments That Have Been Made With Respect To Energy Conservation And Efficiency.

Since the formal beginning of NSP's energy efficiency and conservation effort in 1982 and through 1990, over 500 MW of conservation and load management have been achieved system-wide, with the Minnesota state portion comprising approximately 75% of the total. Of the impact achieved, approximately 25% is conservation, while the remainder is load management.

While many utilities are just now setting goals of this magnitude, NSP has already achieved them and expects to repeat the achievement over the next five years. NSP also expects to increase the percentage of conservation in the mix of demand side programs (conservation and load management) over the next several years.

Another notable accomplishment is the economic efficiency of NSP's efforts. NSP's program costs substantially less than programs of many other utilities. The economic assessments made for NSP's program have also been fully integrated with supply alternatives, thus accomplishing an overall low-cost total resource strategy for meeting customer needs for electric service.

E. A Description Of The Applicant's Future Plans Through The Forecast Years With Respect To Energy Conservation And Efficiency.

Appendix 1 to this Application shows the projected conservation and load management program impacts from 1990 to 2010.

F. A Quantification Of The Manner By Which These Programs Affect Or Help Determine Forecast Of Demand, A List Of Total Costs By Program, And A Discussion Of The Expected Effects In Reducing The Need For New Large Energy Facilities.

The quantification of the effect of these programs on NSP's electricity demand forecast is provided in Appendix 1 to this Application. Increased conservation reduces the base energy forecast and the forecast of peak demand, based on energy reduction accomplished at time of peak. The load management programs reduce the demand at peak, or result in a shift in the peak, and therefore reduce the peak forecast.

NSP's demand side management programs reduce the need for additional peaking and baseload electric generating facilities. Load management primarily reduces the need for additional peaking capacity. Conservation reduces the need for both peaking and baseload facilities, depending on how much energy is conserved per unit of demand reduction. The costs for programs for the years 1990 through 1992 are provided in Appendix 1 to this Application. Cost estimates beyond 1992 are unavailable and any estimate would be speculative.

NSP's DSM programs will reduce the need for new generating plants, not for existing plants such as PI. Therefore, the benefits of NSP's DSM efforts will not reduce the need for PI nor alter the forecasted need for additional temporary spent fuel storage.

XIV. CONCLUSION

Based on the preceding information presented in this Application, two basic facts are undeniably established:

1. The Prairie Island Nuclear Generating Plant needs additional temporary spent fuel storage.

2. A Dry Cask Storage Facility using TN-40 dry metal casks as needed represents the best method for meeting the need.

Therefore, NSP respectfully requests certification by the Minnesota Public Utilities Commission to authorize NSP to construct a Dry Cask Storage Facility, installing up to 48 TN-40 casks on an incremental, as-needed basis.

<u>VERIFICATION</u>

STATE OF MINNESOTA)

) ss.

COUNTY OF HENNEPIN)

Gary R. Johnson, being first duly sworn on oath, says that he is a Vice President of Northern States Power Company, a Minnesota corporation, the corporation making the foregoing Application for a Certificate of Need; that said Application has been duly authorized by Northern States Power Company; that as a duly elected officer of Northern States Power Company he is authorized to execute the same on behalf of said corporation; that he has read the foregoing Application and knows the content thereof and that the same is true and correct to the best of his knowledge, information and belief.

Gary R. Johnson
Gary R. Johnson
Vice President-Law

Subscribed and sworn to before me
this 29 day of April, 1991.

Kathleen L. Hanlin
Notary Public

KATHLEEN L. HANLIN
NOTARY PUBLIC—MINNESOTA
HENNEPIN COUNTY
My Commission Expires June 16, 1994

DEMAND-SIDE MANAGEMENT MARKET POTENTIALS
Summary Of NSP's 1988-1989 Assessment Process

Market Potentials Assessments -- Background

An essential element of any marketing product or service development is the determination of market potential. In most industries, this process is relatively straightforward because the product/service is usually narrowly defined, as is the eligible, or "target," market to which the product or service will be sold. Total market potential is basically determined by identifying the target population and estimating the ultimate acceptance level of the product or service by the target population.

Such estimates can become more complicated, however, as they are translated into achievable potential over some specified period, and further translated into annual sales goals for the marketing and sales organization. The methods used to determine both the ultimate potential and more specific achievable, annual goals vary widely. They range from simple intuitive guesses to complex computer models of the market which incorporate extensive market research, test marketing data and historical sales information.

Potentials estimates ususally begin as rough, almost subjective estimates based on some historical rule of thumb, observation of a related product/service or other educated guess. Depending on the extent of the market, historical experience, the value of the product/service and other factors, a rough estimate may be all that is necessary to attempt an initial offering, with the "street wisdom" gained from the initial offering used as a barometer for deciding whether to continue or discontinue the offering and, implicitly, gauging the remaining potential. More rigorous (though not necesarily more precise) estimates may be attempted through various means which often include market research of some sort.

Following the product/service introduction into the market, sales and other marketing information is used for tracking market saturation and reviewing remaining potential. Along with data developed through additional market research and evaluations, this information is then used to modify potentials estimates, revise the offering and help set future sales goals.

Key Differences In Demand-Side Management Potentials Assessments

The process of assessing electric demand-side management (DSM) potentials is similar to the process described above, but with important differences. The most significant difference is that the electricity market is huge and ubiquitous, unlike any other consumer market in its scope and reach in the economy. Due to this, the brief history of DSM, the lack of historical competition which drives development of market information, and other factors, good target population profile data (both baseline and on participation impacts) have been scarce.

Another key difference is that the demand for electricity is "derived." That is, electricity has no intrinsic value, unlike nearly all other market goods and services. Demand for electricity is created by the use of equipment acquired and used for its own purposes, with electricity purchased only as an operating requirement for the equipment's function. Thus, to assess the demand for electricity and the potential for DSM, one must understand both the markets for electricity-using equipment and the products or services with which that equipment is associated. Further, the technological trends associated with the evolution of the equipment must be understood as well, and technology is a fast-moving target. These are comparatively daunting requirements which drive up potentials assessment costs and greatly lengthen the time needed to fully assess the potential.

A third difference, related to the fact that demand for electricity is derived, is that most electricity consumers know almost nothing about their use of the product. They tend to care little about it because electricity is typically a small and seemingly uncontrollable part of their cost of living or business. This situation further complicates DSM potentials assessments.

These differences mean that truly comprehensive and rigorous DSM potentials assessments are practically impossible. For example, the equipment available or being developed to improve efficiency may be well-researched from a technical viewpoint, but going the required next step of determining the technical feasibility of installing such equipment in actual target facilities requires a quantum increase in data to know which facilities are technically eligible. One must next determine whether technically eligible customers are aware of a given measure, and then the likelihood of their ultimately taking appropriate action. Further, the real (not theoretical) demand, energy and economic impacts of the action must be assessed. Given the myriad technologies, possible target markets and customer decision frameworks, all of which are in constant flux, one can begin to appreciate the assessment task analysts face.

Description of NSP's DSM Potentials Assessment Process

In mid-1987, NSP management directed that a study of load management and DSM market sensitivities be conducted to contribute to optimizing DSM efforts. By 1989, two related projects had been undertaken to satisfy this directive and develop the basis for an expanded DSM goal. The first project had four basic objectives:

1) Develop a detailed market modeling capability to calculate economic and kw/kwh impacts;
2) Develop baseline market profiles (when completed these profiles included 34 residential dwelling/equipment type segments with 17 end uses per segment, and 19 commercial/industrial facility type market segments with 9 electric end uses per segment);

3) Develop technical and economic profiles for a broad spectrum of technologies to improve efficiency (over 50 measures profiled); and
4) Conduct benefit/cost and kw/kwh impact analyses across all relevant segments and electric end uses for each efficiency technology as applicable.

The model chosen was DSManager, a product developed by the Electric Power Research Institute to allow hourly simulation of baseline and DSM measure impacts against incremental hourly production and capacity costs which would be avoided by DSM. The model uses these values along with rate structures, known participant costs and expected program costs to calculate present worth values for avoided utility costs, participant and program costs, and utility revenue impacts. This model analyzes incremental impacts of individual measures or groups of measures. Measure cross impacts were accounted for in the modeling process as well. The combined results from DSManager were then passed on to NSP's integrated resource planning model, the Load Management Strategy Testing Model (LMSTM), to assess the total impact on system capacity and production dynamics.

Baseline market profiles were developed primarily using NSP's customer billing data which classify customers by building and business types, and provide monthly energy use and, where applicable, billed demand levels. For residential customers, dwelling type, size, age and key equipment ownership were the factors used to define the market segments. For the C&I sector, building type and industry type were the segmentation factors. Industry standard data for end-use energy intensities, supplemented with preliminary data from the second NSP potentials study project and a related project performed for NSP-Wisconsin, were used to determine the baseline energy profiles. Hourly demand profiles by season were developed using a combination of NSP load research data, data transferred from other research sources, and staff judgement. Appropriate rate structures were assigned to each market segment, as well as associated transmission and distribution losses.

DSM measures were profiled using a variety of source material ranging from manufacturer data to independent research test results. Most of the data were obtained through literature searches. Each technology was assessed for practicality and to determine its economic viability in each market segment. In addition, a "Delphi" survey of NSP marketing representatives was conducted to estimate customer awareness levels and likely implementation of various types of DSM actions over time assuming an NSP program. This information allowed an estimate of what the market would likely do without NSP programs. Those measures which showed a 0.9 or greater benefit/cost ratio for the "All Ratepayers" economic perspective and would not be likely to see extensive implementation without an NSP program were then included in the final integrated analysis.

All four objectives were accomplished, including model installation and training, extensive documentation of the market segments and technologies, and summary tables of impacts and economics. The final results for individual DSM measures were then summed and run through

LMSTM, to estimate the combined economics of the total package of acceptable measures. Including NSP's market-based estimate of potential load management and scaling up to the NSP system level, the results indicated an economic potential of some 1600 mw by 1995. Based on this estimate and the field accomplishments of programs then in place, NSP staff judged that about 2/3 of this economic potential, 1000 mw, would be achievable by 1995.

The second project paralleled the initial study in that it also assessed baseline market profiles, including both technical and economic decision information, and assessed the technical and economic impacts of 30 types of DSM measures. The scope of this study was confined to the C&I segments and end uses previously defined. However, it went considerably further and deeper by developing baseline market profiles and DSM recommendations for a statistically valid sample of over 1000 customers in the various C&I segments using extremely detailed energy audits and by employing state-of-the-art end-use load shape estimation modeling.

In addition, this project reassessed most of the DSM technologies examined in the initial study, including an extensive update of measure cost data, and detailed hourly load impact profiles. The results of this study were less optimistic than the initial study, partly because of the conservative nature of audit recommendations made to customers, plus a constrained analysis which excluded the residential sector and much of the industrial sector's process uses. Building envelope measures were not examined, either, and the economic criteria were more conservative. NSP thus believes this study's estimate of total DSM, 1141 mw, approximates the achievable amount of DSM on the NSP system. This result essentially corroborated the first study's estimate and gives further credibility to NSP's 1000 mw goal. It also indicates that an increase in the 1000 mw goal for 1995 or beyond is probably unrealistic unless new technical data and field experience can support such an increase.

The detailed results from the second study are being used to refine the C&I estimates made in the first study. As more information is reviewed, NSP intends to conduct periodic reviews of the potentials estimates. The existing data are being used in various ways to evaluate new program ideas and, increasingly, to set annual sales goals.

1991 CIP BUDGET FORECAST

	KW IMPACT	KWH IMPACT	PROGRAM BUDGET	PARTICIPANTS
COOLING				
Chiller Efficiency	816	1,109,260	$308,602	20
Refrigeration Efficiency	606	3,707,933	131,550	40
Rooftop Air Conditioning	1,160	1,579,000	377,151	200
	2,582	6,396,193	$817,303	260
ENERGY EFFICIENCY INFO AND FINANCING				
CACHIE	NE	NE	$3,500	500
C&I Audits	NE	NE	530,000	2,190
Community Energy Councils	NE	NE	737,600	6,300
Easy Energy Financing	NE	NE	268,800	235
Home Energy Audit	NE	NE	100,000	1,000
Quest	NE	NE	94,500	6,300
	0	0	$1,734,400	16,525
LIGHTING				
Institutional Lighting	3,840	14,480,000	$780,000	10
Lighting Efficiency	13,900	57,194,740	2,678,600	2,774
Minneapolis Electric Conservation Pilot Program - Small Businesses	NA	NA	25,000	NA
	17,740	71,674,740	$3,483,600	2,784
LOAD MANAGEMENT				
Air Cond. and Wtr Htr Load Cntrl	14,218	93,520	$3,500,000	14,000
C&I Voluntary Time of Day Rates	1,188	0	51,091	110
C&I Load Management Rate Promotion	57,750	2,310,000	1,091,860	385
Cool Storage	1,078	55,000	317,718	5
	74,234	2,458,520	$4,960,669	14,500
PROCESS/MOTORS				
Industrial DSM Incentive	2,115	2,488,170	$184,139	30
Motor Efficiency	484	3,126,500	141,000	120
	2,599	5,614,670	$325,139	150
RESIDENTIAL				
Appliance Efficiency	5,108	3,366,000	$2,715,500	26,500
Performance Plus	26	298,160	41,338	100
	5,134	3,664,160	$2,756,838	26,600
RESIDENTIAL LOW INCOME				
Elec. Cons. Brouchure - Low Income	NE	NE	$36,000	35,000
Elec. Cons. Pilot Program - Low Income	NA	NA	NA	NA
Elec. Heat Cons. Pilot Program - Low Income	NE	NE	30,050	170
Lighting Efficiency for Senior Citizens	44	88,500	33,000	750
Low Income Audit and Services	NA	NA	245,540	900
	44	88,500	$344,590	36,820
RESEARCH, PLANNING AND DEVELOPMENT				
C&I End Use Study	NA	NA	NA	NA
Demand Side Management Data Development	NA	NA	273,000	NA
Demand Side Management Planning	NA	NA	600,000	NA
Miscellaneous Program Development	NA	NA	115,000	NA
High Effic.Fluorescent Bulb Resident.Research	NA	NA	NA	NA
Information Services Subscriptions	NA	NA	17,000	NA
Market Research Data Development	NA	NA	70,000	NA
Sunscreens	NA	NA	NA	NA
Technology Transfer Development	NA	NA	NA	NA
	0	0	$1,075,000	0

31-Mar-91

CONSERVATION PROGRAM DEVELOPMENTS CONSIDERED BUT NOT ADOPTED

Following is a list of developments considered but not adopted over the last several years. This list is representative of the types of developments considered but not adopted. It is not exhaustive, however, because it does not include the many variations considered but not implemented for existing programs.

1. **Mid-level C&I Audit Services.** The C&I Audit Xencheck was considered to determine if there was a need for a "middle-" level audit. The Xencheck wasn't implemented because the audit criteria would overlap the Xencap audit and the Quick Check Walk-Thru audit.

2. **Solar Water Heating.** Solar water heating was analyzed in 1985-86 and dismissed due to the poor cost- effectiveness for the participant and NSP.

3. **Battery Energy Storage.** Battery Energy Storage was reviewed in 1989-90 as a possible Load Management program. Currently NSP is not considering this technology due to poor economics and high upfront costs. Should upfront costs lower, NSP will reconsider this technology.

4. **Freezer Rebates.** Including residential freezers as part of Appliance Rebate Program was considered and implemented, but discontinued in 1986 because energy consumption between the assorted sizes did not vary sufficiently in relation to unit price, and because the market appeared relatively saturated given the units available. Therefore, reasonable rebate amounts could not be developed.

5. **Cogeneration.** Cogeneration was considered for small C&I customers. This technology was dismissed due to poor cost-effectivness due to the low cost of electricity. Also, cogeneration is considered a form of energy supply even though it typically is implemented on the customer side of the meter.

6. **Energy Management Systems.** Energy Management Systems were also considered as a means to use customers' systems for controlling selected loads during time of system peak. This concept was rejected by the customers who wanted to retain control of their energy demand/consumption.

PROGRAMS STILL UNDER CONSIDERATION

The following lists program developments currently under consideration. Before they can be included in NSP's Conservation Improvement Program, it is necessary to determine their cost-effectiveness, likely market acceptance, various program delivery designs, and to receive the Department of Public Service's approval.

1. HVAC audits
2. Electric dehumidification (this would be in conjunction with the Rooftop AC Program).
3. Variable speed drives
4. Trees for energy conservation
5. Building design for energy conservation
6. Chiller system replacment
7. Ground source heat pumps
8. Sunscreens (pilot beyond previous research phase)
9. Industrial Cogeneration
10. Residential Cogeneration
11. High Efficiency Fluorescent Bulb Residential Research
12. Appliance Recycling

Median Scenario

Conservation Summary, Summer Peak (MW)

	Minnesota Company			Wisconsin Company			Total System		
	Net Cons	Load Mgmt	Tot.	Net Cons	Load Mgmt	Tot.	Net Cons	Load Mgmt	Tot.
1985	10	45	55	0	13	13	10	58	68
1986	21	56	77	1	17	18	22	73	95
1987	35	94	129	3	23	26	38	117	155
1988	55	147	202	10	37	47	65	184	249
1989	74	191	265	10	49	59	84	240	324
1990	106	262	368	17	64	81	123	326	449
1991	151	329	480	26	75	101	177	404	581
1992	206	385	592	36	85	121	242	470	713
1993	256	445	701	46	94	140	303	538	841
1994	300	507	807	58	100	158	359	607	966
1995	343	564	906	71	104	176	414	668	1082
1996	378	608	986	84	108	192	462	716	1179
1997	408	645	1053	96	111	207	505	756	1260
1998	438	679	1116	107	114	221	545	793	1337
1999	467	711	1178	116	117	233	583	828	1411
2000	496	741	1237	125	120	245	621	861	1482
2001	524	770	1293	132	122	254	656	892	1548
2002	551	797	1348	139	123	262	690	920	1610
2003	579	822	1401	145	124	269	724	946	1670
2004	605	846	1452	150	125	275	756	971	1727
2005	632	869	1501	155	126	281	787	995	1782
2006	657	890	1547	159	127	286	816	1017	1833
2007	682	910	1593	162	128	290	845	1038	1883
2008	707	929	1637	165	129	294	873	1058	1931
2009	732	948	1680	168	130	298	901	1078	1979
2010	758	965	1723	171	131	302	929	1096	2026

Average Annual Growth Rates (in %)

1990-1995	23.49	15.33	18.02	28.59	9.71	15.52	4.27	14.35	17.59
1990-2010	9.84	6.52	7.72	11.54	3.58	6.58	0.11	6.06	7.53

Columns may not add due to rounding
Conservation includes an estimate of historically achieved not included in other tables

APPENDIX 2

GLOSSARY

Boiling Water Reactor (BWR)-a reactor where water heated by fission circulates and turns to steam that circulates to the turbine. Monticello Nuclear Generating Plant has one boiling water reactor unit.

Cladding-hollow metal tube within which fuel pellets are loaded to create a fuel rod.

Criticality-condition under which self-sustaining nuclear reaction occurs.

Curie-unit of radioactive decay. One curie is the amount of radioactivity that decays at the rate of 3.7×10^{10} disintegrations per second (dps).

Cycle-the period of operation between scheduled outages. Prairie Island Nuclear Generating Plant is currently operating on an approximate 16-month cycle.

Decay Heat Rate-rate of heat generated by radioactive decay.

Disintegrations Per Minute (dpm)-unit of measurement of radioactive decay.

Enrichment-process whereby the percentage of uranium-235 (U-235) in nuclear fuel is increased from the approximately 1 percent naturally occurring to the 4 percent necessary for electric generation.

Fissioning-splitting or breaking apart of a heavy atom, such as uranium, into two new atoms. Fission is a chain reaction releasing energy and neutrons.

Gamma Radiation-a type of ionizing radiation. Ionizing radiation consists of gamma rays, x-rays, alpha particles, beta particles, high speed electrons, neutrons, protons and other nuclear particles.

High-Level Radioactive Waste (HLW)-highly radioactive material, including spent nuclear fuel, which must be isolated from people and the environment for long periods of time.

Independent Spent Fuel Storage Installation (ISFSI)-facility which NSP has proposed for additional temporary storage of spent nuclear fuel. The ISFSI will consist of dry metal storage casks, cement pads, security and perimeter fencing and associated buildings.

Low-Level Radioactive Waste (LLW)-materials with a low amount of radioactivity, such as discarded paper, rags, clothing, test tubes, tools and resins. Low-level radioactive waste must be isolated from people and the environment for shorter periods of time than high-level radioactive waste.

Monitored Retrievable Storage (MRS)-facility designed for the temporary storage of spent nuclear fuel and high-level waste until a permanent repository is available.

Millirem (mrem)-unit of measurement for doses of ionizing radiation. One millirem is equivalent to 0.001 rem.

Megawatt (MW(e))-unit of measurement of electricity capacity. The Prairie Island Nuclear Generating Plant produces 1,060 MW(e) of electricity with its two pressurized water reactor units.

Neutron Radiation-a type of ionizing radiation.

Nuclear Waste Policy Act of 1982 (NWPA)(Public Law 97-425, January 7, 1983)-under the NWPA the federal government assumed responsibility for radioactive waste disposal and established a plan for a permanent repository for spent nuclear fuel and high-level radioactive waste

Nuclear Waste Policy Act Amendments of 1987 (NWPAA)(Public Law 100-203, December 22, 1987)-under the NWPAA the federal government reorganized its program to establish a permanent repository and focussed site characterization activities on a proposed site at Yucca Mountain, Nevada.

Office of Civilian Radioactive Waste Management (OCRWM)-office within the United States Department of Energy created to implement the program to establish a permanent repository and monitored retrievable storage facility.

Outage-period when the reactor unit is temporarily out of service. The Prairie Island Nuclear Generating Plant has scheduled outages approximately every 16 months for refueling and maintenance.

Permanent Repository-facility for the permanent disposal of spent nuclear fuel and high-level radioactive waste.

Pressurized Water Reactor (PWR)-a reactor where water heated by fission circulates under high pressure. This heated water circulates from the reactor to a steam generator where water in a second system absorbs the heat and turns to steam that circulates to the turbine. The Prairie Island Nuclear Generating Plant has two pressurized water reactor units.

APPENDIX 3

PLANT SPECIFICATIONS

Location: The Prairie Island Nuclear Generating Plant is on a 560-acre site 28 miles southeast of Minneapolis-St. Paul in Red Wing, Minnesota, on the Prairie Island peninsula in the Mississippi River.

Features: Two independently controlled nuclear reactors, two turbines, supporting equipment and electric substations. Facilities for processing intake and discharge cooling water, nuclear fuel and radioactive wastes in gaseous, liquid and solid form.

Total cost: About $413 million.

Capacity: Unit 1 -- 530 MW

Unit 2 -- 530 MW

Reactor type: Westinghouse pressurized water reactor (PWR).

Fuel: Pellets of uranium dioxide.

Fuel loading: 120,000 pounds of uranium in 121 fuel assemblies in each reactor core,, equivalent in energy to 6 million tons of coal. Each reactor refuels 48 assemblies at a time, every 16 months, while the other reactor remains operating.

Reactor control: Absorption of free neutrons in the reactor core by 29 movable control rods, assemblies of cadmium-indium-silver alloy encased in stainless steel, plus liquid boron injected in controllable amounts into the primary coolant.

Radiation barriers: Fuel pellets themselves, zircaloy metal tubing, steel reactor vessel, steel containment vessel, air containment annulus space, concrete containment shield building and use of water barriers, storage container and filtering.

Temperatures: Maximum fuel-pellet centerline temperature is 3,500 F. Average reactor coolant temperature is 560 F. Temperature of the river water after cooling the condenser is reduced to meet discharge standards set by the Minnesota Pollution Control Agency.

Substation output: 345,000 volts and 151,000 volts.

Plant employment: About 400.

Overall design and construction responsibility: Northern States Power Company.

Architect-Engineer: Fluor Power Services, Inc., Chicago.

Reactor, steam system and turbine-generator supplier: Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

Radiological Monitoring: NSP installed at Prairie Island the Radiation Dose Assessment Computer System (RDACS), a sophisticated weather monitoring and radiation dose projection system. RDACS emergency operations involve monitoring radiation releases from the plant in order to track any releases and plan emergency response activities accordingly. Federal regulations require nuclear plants to monitor release routinely, as well as in an emergency.

Direct Testimony
Ms. Laura McCarten

Before the Public Utilities Commission of
the State of Minnesota

In the Matter of the Application of Northern States Power Company
For a Certificate of Need for a Temporary Spent Nuclear Fuel Storage Facility
for the Prairie Island Nuclear Generating Plant

Docket No. E002/CN-91-19
Exhibit___(LM-1)

April, 1991

MS. LAURA MCCARTEN
DOCKET NO. E002-CN-91-19

Q. Please state your name, business address, and position with Northern States Power Company (NSP).

A. I am Laura McCarten and my business address is Northern States Power Company, Nuclear Projects Department, 1717 Wakonade Drive East, Welch, Minnesota 55089. I am project manager for the Prairie Island Independent Spent Fuel Storage Installation.

Q. What are your present responsibilities?

A. As the project manager for the Prairie Island Independent Spent Fuel Storage Installation, I was responsible for researching and evaluating on-site spent fuel storage technologies for cost, safety, site suitability and regulatory compliance. I am responsible for developing and implementing the proposed Dry Cask Storage Facility.

Q. On what topics are you presenting your testimony?

A. I will be available to testify on those portions of the Application relating to the operational need for additional temporary storage capacity; the operation of the casks at Prairie Island; the selection of the dry metal cask storage technology and the designer of the technology, Transnuclear, Inc.; the cost estimates for the project; the additional regulatory proceedings which apply to the Dry Cask Storage Facility; the retirement process for the Dry Cask Storage Facility; and the alternatives that NSP rejected.

Q. Please describe your educational background.

A. I earned a bachelor of science in nuclear engineering from the University of Wisconsin, Madison, in 1979. I have continued my professional education by completing NSP courses in Management by Objective, Participative Management, and nuclear plant systems.

Q. Please outline your professional work experience.

A. I joined Northern States Power Company in 1979 as an engineer in the Nuclear Analysis Department, where I provided analytic support of reactor operations to the Monticello and Prairie Island plants. I worked on a team that evaluated and negotiated a contract with a fuel fabrication vendor which resulted in the award of a $30 million contract. I developed computer models of fuel types and core designs. I performed fuel cycle design analyses and planning. And I generated data for use in reactor physics testing, plant operations and vendor comparisons. By the middle of 1983 I had been promoted to the title of engineer II while performing these functions.

In 1983 I became a nuclear engineer, still in the Nuclear Analysis Department, where I performed fuel cycle design analyses and planning.

In 1985 I was promoted to consultant of NSP's Special Nuclear Programs department. In that position I managed the project in which NSP shipped spent fuel from the Monticello nuclear plant to a General Electric facility in Morris, Illinois. I have represented NSP in many industry groups active in high-level radioactive waste disposal, transportation and handling issues, including the Edison Electric Institute and the Electric Power Research Institute.

I managed the fuel consolidation pilot project at Prairie Island, which included researching and evaluating on-site spent fuel consolidation technologies for cost, safety, site suitability and regulatory compliance. I directed NSP's efforts to select a fuel consolidation vendor. I solicited and evaluated vendor bids and negotiated contracts with vendors to supply analysis to support the demonstration. I compiled and evaluated the final test and comparative data.

Q. Have you provided formal testimony in any other regulatory proceedings?
A. No, although I have periodically provided the Minnesota Public Utilities Commission with informational presentations describing NSP's high-level radioactive waste efforts, including the rod consolidation pilot program.

Q. Does that complete your testimony at this time?
A. Yes.

Direct Testimony
Mr. Charles W. Pennington

Before the Public Utilities Commission of
the State of Minnesota

In the Matter of the Application of Northern States Power Company
For a Certificate of Need for a Temporary Spent Nuclear Fuel Storage Facility
for the Prairie Island Nuclear Generating Plant

Docket No. E002/CN-91-19
Exhibit___(CWP-1)

April, 1991

MR. CHARLES W. PENNINGTON
DOCKET NO. E002-CN-91-19

Q. Please state your name, business address, and position with Transnuclear, Inc.

A. I am Charles W. Pennington, and my business address is Transnuclear, Inc., Two Skyline Drive, Hawthorne, New York 10532-2120. I am vice president of Transnuclear, Inc.

Q. What are your present responsibilities?

A. As vice president of Transnuclear, Inc., I am responsible for development of spent fuel and radioactive waste transport and storage systems. Currently the Dry Cask Storage Facility for the Prairie Island Nuclear Generating Plant falls under my responsibilities at Transnuclear.

Q. On what topics are you presenting your testimony?

A. I will be available to testify on those portions of the Application which discuss the design, construction and operation of the selected dry metal cask storage technology, the TN-40 cask, proposed for the Dry Cask Storage Facility at the Prairie Island Nuclear Generating Plant.

Q. Please describe your educational background.

A. I earned a bachelor of arts in mathematics from Duke University in 1966. I earned a master of science degree in nuclear engineering, with an economics minor, from North Carolina State University in 1974. And I earned a master's in business administration with an emphasis in marketing and finance from the University of Connecticut in 1981.

Q. Please outline your professional work experience.

A. Upon graduating from Duke in 1966, I was commissioned as an officer in the United States Navy, where I was graduated from the Nuclear Power and Nuclear Weapons Officer programs. I became a qualified nuclear reactor operator, an Engineering Officer of the Watch, a submarine officer and second officer for the engineering department of a nuclear submarine. I served in the Navy through 1971.

From 1972 through 1973 I performed post-graduate research at North Carolina State University under a grant from the Atomic Energy

Commission. I researched the radionuclide retention characteristics of prospective first-wall materials for controlled, thermonuclear (fusion) reactors.

I joined Combustion Engineering, Inc., in 1974 as a senior licensing engineer. In 1977 I became area manager of availability, and in 1978 I became manager of nuclear product marketing. In these various positions at Combustion Engineering I worked to obtain Nuclear Regulatory Commission (NRC) approval of Combustion Engineering's 80 NSSS design, the first 3800-megawatt standard plant approved by the NRC. I developed programs for government and utilities to enhance the reliability of plant systems. I was responsible for product management and marketing of a variety of products and services including nuclear fuel, Nuclear Steam Supply Systems (NSSS) equipment, and radioactive waste processing systems.

I joined Transnuclear, Inc., in 1983, and have been vice president there since 1987. My principal responsibilities have included strategic planning, consulting management and product development for spent fuel and radioactive waste transport and storage systems, including metal casks and concrete modules. I administer commercial and government contracts for the design, development and procurement of such systems. I also served as project manager on a Department of Energy funded study of spent fuel transport systems.

Q. Have you provided formal testimony in any other regulatory proceedings?
A. No.

Q. Have you published any papers in professional journals or spoken before any professional organizations?
A. Yes. A list of several of these publications follows.

"Tritium Release from Niobium," 1984, Thesis published by North Carolina State University, Department of Nuclear Engineering.

"Tritium Release from Niobium," June, 1974, Nuclear Technology, Volume 22.

"Dry Storage of Spent Fuel with Demonstrated Designs and Technology: The Transnuclear TN-24," March, 1984, American Nuclear Society and University of Arizona, Proceedings of the Symposium on Waste Management.

"Transnuclear's Dry Storage/Transport Casks," April, 1984, Institute of Nuclear Materials Management, Proceedings of the Spent Fuel Management Seminar I.

"Transnuclear, Inc. Spent Fuel Transport and Storage Activities," July, 1985, Institute of Nuclear Materials Management, Proceedings of the Twenty-Sixth Annual Meeting.

"Dry Storage Technology from Transnuclear," April, 1986, Institute of Nuclear Materials Management, Proceedings of the Spent Fuel Management Seminar III.

"A Study of Extra Large Storage Casks," December, 1986, Final Report of Work for DOE Contract DE-AC01-84RW00038, published 1987.

"Design Development and Testing of the TN-24 Dry Storage Cask," April, 1988, Proceedings of the Joint ASME-ANS Nuclear Power Conference.

"New Multipurpose Dry Cask Passes Heat and Dose Rate Tests," August, 1988, Nuclear Engineering International.

"The Independent Development of a Multi-Modal, Multi-Waste Type Transport System for Transuranic Wastes," September, 1988, American Nuclear Society, SPECTRUM '88 Proceedings.

"Conceptual Design for an On-Site Spent Fuel Transfer System," April, 1991, Final Report of Research Project 2813-25, Electric Power Research Institute (EPRI), to be published third quarter, 1991, by EPRI.

Q. Does that complete your testimony at this time?

A. Yes.

Direct Testimony
Ms. Glynis A. Hinschberger

Before the Public Utilities Commission of
the State of Minnesota

In the Matter of the Application of Northern States Power Company
For a Certificate of Need for a Temporary Spent Nuclear Fuel Storage Facility
for the Prairie Island Nuclear Generating Plant

Docket No. E-002/CN-91-19
Exhibit ___ (GAH-1)

April, 1991

Q. Please state your name, business address, and position with Northern States Power Company (NSP).

A. I am Glynis A. Hinschberger, and my business address is Northern States Power Company, 414 Nicollet Mall, Minneapolis, Minnesota 55401. I am the manager of power system strategic planing.

Q. What are your present responsibilities?

A. As the manager of power system strategic planning, I am responsible for 1) long-range generation, transmission and access policy strategies to best position NSP in the future; 2) planning and implementing appropriate capacity plans; 3) technical and sales analyses required to implement strategic positioning and to support power sales marketing; 4) securing government approvals of supply strategies needed to provide high quality service to NSP's customers while minimizing costs and environmental impacts.

Q. On what topics are you presenting testimony?

A. I will be available to testify on those portions of the Application which discuss the role of the Prairie Island Nuclear Generating Plant in providing energy to NSP's customers as part of the NSP generating system.

Q. Please describe your educational background.

A. I earned a master of science in electrical engineering from Iowa State University in 1977, after earning a bachelor of science in electrical engineering from the same university in 1976.

Q. Please outline your professional work experience.

A. I joined Northern States Power Company in 1977 as an engineer in power supply planning. From 1979 to 1982 I was an assistant planning engineer in power supply planning. In 1982 I became a planning engineer in transmission planning. In 1984 I was promoted to senior planning engineer, in 1986 I was promoted to superintendent and in 1988 to manager, all in the transmission planning area. In 1990 I became manager of power system strategic planning, my current position.

Q. Have you provided formal testimony in any other regulatory proceedings?

A. Yes, I have provided testimony before the Federal Energy Regulatory Commission on transmission services tariffs in dockets ER91-21-00 (1991) and ER90-406-000 (1990). Before the Wisconsin Public Service Commission I testifed in retail electric rate case docket 4220-UR-104 (1990), as well as Advance Plan 5, docket 05-EP-5 (1988).

Q. Have you published any papers in professional journals or through professional organizations?

A. My publications include the following:

1. Mid-continent Area Power Pool Reserve Requirements Study, 1991 MAPP Reserve Requirements Task Force.
2. "The Application of NERC/GADS Data in the Calculation of LOLE," MAPP Reserve Requirements Task Force, 1987.
3. "1985 Reserve Requirements Study Report," MAPP Reserve Requirements Task Force, 1987.

4. "Design Considerations Involved in Interfacing a Free-Space Microwave Power Transmission System and An AC Load," M.S.E.E. Thesis, Iowa State University, 1977.

Q. Do you belong to any professional associations?

A. Yes. I am a member of the Institute of Electrical and Electronic Engineers. I am a senior member and past president of the Society of Women Engineers, and I am a life member of the American Association for the Advancement of Science.

Q. Does this conclude your testimony at this time?

A. Yes.

Direct Testimony
Mr. Michael H. Schwartz

Before the Public Utilities Commission of
the State of Minnesota

In the Matter of the Application of Northern States Power Company
For a Certificate of Need for a Temporary Spent Nuclear Fuel Storage Facility
for the Prairie Island Nuclear Generating Plant

Docket No. E-002/CN-91-19
Exhibit ___ (MHS-1)

April, 1991

Q. Please state your name and business address.

A. I am Michael H. Schwartz and my business address is Energy Resources International, Inc., 1015 18th Street, N.W., Suite 500, Washington D.C. 20036.

Q. What are your present responsibilities?

A. I am a principal in the firm of Energy Resources International, Inc., which provides assistance to electric utility clients in technical and economic analyses and nuclear fuel planning and procurement.

Q. On what topics are you presenting testimony?

A. I will be available to testify on the U.S. Department of Energy's plans for nuclear waste storage and disposal facilities and on national forecasts of nuclear waste production.

Q. Please describe you educational background.

A. In 1971 I earned a bachelor of science in nuclear engineering from the University of Michigan. In 1972 I earned a master of science in nuclear engineering from the same university. Between 1974 and 1976 I completed graduate level courses in finance, economics and management at San Diego State University.

Q. Please outline your professional work experience.

A. From 1970 to 1971 I was an assistant engineer at Consumers Power Company where I performed core design and plutonium recycle studies for the Palisades and Big Rock Point nuclear power plants. I expanded the capabilities of the company's fuel accountability program and performed a variety of fuel cycle economic studies.

From 1972 to 1975 I worked for the General Atomic Company, where I performed end-of-life core physics analysis for the Peach Bottom nuclear power plant. I performed a broad range of high-temperature gas-cooled reactor physics design activities, including evaluating the safety criteria for fuel with respect to nuclear criticality and preparing the licensing topical report describing the technical basis for models used to analyze fission product release from plant cores during transient temperature excursions.

From 1975 from 1976 I was a senior fuel application engineer with General Atomic International, where I provided guidance to General Atomic's high-temperature gas-cooled reactor core physics design and fuel management activities in support of international ventures. I developed fuel cycle strategies for countries considering introduction of the high-temperature gas-cooled reactors, and I evaluated the use of alternative thorium fuel cycles.

From 1976 to 1989 I worked as a senior consultant with Pickard, Lowe and Garrick, Inc. I provided economic analyses and optimization of utility fuel cycle designs and fuel procurement plans. I provided technical and commercial evaluations of vendor proposals for fuel materials and services. I provided technical, strategic and policy support for utilities and utility-sponsored organizations in the areas of nuclear fuel and high-level radioactive wastes. I designed, developed and applied nuclear fuel management and analyses models to support utility nuclear fuel cycle activities. I prepared annual market analyses reports for nuclear fuel materials and services. I also designed, analyzed criticality for, and provided licensing support for spent fuel and new fuel storage racks. In the area of nuclear plant management and licensing, I provided supervision and direction for in-depth evaluation of the basic causes for cost increases during the construction of a commercial nuclear power plant. I directed a multi-faceted consequence analysis of the postulated release of radionuclides from an operating nuclear power plant through a liquid pathway. I was involved in a broad range of power plant technical, managerial, licensing and risk analysis activities.

Since 1989 I've been a principal with Energy Resources International, Inc., where I provide assistance to electric utilities in technical and economic analyses and nuclear fuel planning and procurement. This includes technical and commercial evaluation of vendor proposals for uranium, conversion, enrichment, fabrication and related services. I provide technical, strategic and policy support in the areas of nuclear fuel and high-level radioactive waste for utilities and utility-sponsored organizations. I prepare market analyses reports on all segments of nuclear fuel supply. I also design, develop and apply software to support these and related client activities.

Q. Have you provided formal testimony in any other regulatory proceedings?

A. Yes, here is a list of my previous testimony.

With J.K. Pickard, "Testimony on Nuclear Fuel Cycle Alternatives," presented at the California Energy Resources and Development Commission Nuclear Fuel Cycle Information Hearings, June 9, 1977.

Q. Have you published any papers in professional journals or spoken before any professional organizations?

A. Yes. Here is a list of my professional publications.

1. "Competition Still Fierce in the U.S. Fuel Fabrication Market," Nuclear Engineering International, Vol. 35, No. 433, August 1990.

2. "The U.S. Fuel Fabrication Market," Nuclear Engineering International, Vol. 34, No. 422, September 1989.

3. With J.J. Steyn, "Nuclear Fuel Procurement: History and Trends," USCEA Fuel Cycle Conference 89, April 2-5, 1989.

4. With T.B. Meade, L.A. Sonz, F.J. Diafero, Jr., "Nuclear Fuel Cycle Cost in the Face of Uncertainty," Transactions of the American Nuclear Society, Vol. 56, June 12-16, 1988.

5. With S.P. Kraft, "The Changing World Market for Uranium Enrichment Services," 1984 EPRI Fuel Supply Seminars, October 18, 1984.

6. "A Brief Overview and Projection of Nuclear Fuel Prices," prepared in support of the 1984 Update of the EPRI Technical Assessment Guide, August 14, 1984.

7. With J.M. Vallance, and S. Kaplan, "UPLAN - Application of Probabilistic Decision Theory To Optimize Fuel Ordering Strategy," Transactions of the American Nuclear Society, Vol. 35, November 16-21, 1980.

8. With W.H. Brewer, R. Hula, and M.A. Minns, "FUELMACS - A Computer-Based Nuclear Fuel Management and Accounting Systems," Transactions of the American Nuclear Society, Vol. 34, June 9-12, 1980.

Q. Are you a member of any professional organizations?
A. Yes. I am a member of the American Nuclear Society.

Q. Does this conclude your testimony?
A. Yes.

Direct Testimony
Mr. James H. Gamble

Before the Public Utilities Commission of
the State of Minnesota

In the Matter of the Application of Northern States Power Company
For a Certificate of Need for a Temporary Spent Nuclear Fuel Storage Facility
for the Prairie Island Nuclear Generating Plant

Docket No. E002/CN-91-19
Exhibit___(JHG-1)

April, 1991

Q. Please state your name, business address, and position with Northern States Power Company (NSP).

A. I am James H. Gamble and my business address is Northern States Power Company, 414 Nicollet Mall, Minneapolis, Minnesota 55401. I am general manager of electric marketing for NSP.

Q. What are your present responsibilities?

A. I am responsible for management direction, planning, evaluation, development and administration of demand-side and other marketing programs for NSP's residential, commercial and industrial customers. I am responsible for NSP's market research and analysis, and for compliance with demand-side management regulations.

Q. On what topics are you presenting your testimony?

A. I will be available to testify on those portions of the Application relating to NSP's conservation plans and efforts.

Q. Please describe your educational background.

A. In 1968 I earned a bachelor of arts degree in history from the University of Minnesota. In 1974 I earned a master's of arts degree in geography from that same university. And in 1978 I earned a master's in business administration with a focus in marketing from the University of St. Thomas.

Q. Please outline your professional work experience.

A. From 1975 to 1978 I was manager of market research for Control Data Corporation. From 1978 to 1982 I was manager of market research for West Publishing. In the utility industry, I worked for Minnegasco from 1983 to 1987 as manager of market research, analysis and systems. In 1987 I joined NSP as manager of market research. In 1989 I was promoted to general manager of electric marketing.

Q. Have you provided formal testimony in any other regulatory proceedings?

A. I provided testimony before the Minnesota Public Utilities Commission in Docket Number E002-GR-91-001 and Minnesota Resource Plan Rules Docket E-999/R-89-201.

Q. Does this conclude your testimony at this time?

A. Yes.

Direct Testimony
Mr. Jeffrey C. Robinson

Before the Public Utilities Commission of
the State of Minnesota

In the Matter of the Application of Northern States Power Company
For a Certificate of Need for a Temporary Spent Nuclear Fuel Storage Facility
for the Prairie Island Nuclear Generating Plant

Docket No. E-002/CN-91-19
Exhibit ____ (JCR-1)

April, 1991

Q. Please state your name, business address, and position with Northern States Power Company (NSP).

A. I am Jeffrey C. Robinson and my business address is Northern States Power Company, 414 Nicollet Mall, Minneapolis, Minnesota 55401. I am the manager of capital asset accounting.

Q. What are your present responsibilities?

A. As the manager of capital asset accounting, I oversee the accounting function associated with the capital assets of NSP, such as book depreciation, tax depreciation, tax normalization, plant life analysis, nuclear decommissioning, AFUDC (allowance for funds used during construction) rates, continuing property records, and the forecasting of plant investment related expenses.

Q. On what topics are you presenting testimony?

A. I will be available to testify on that protion of the Application relating to the proposed recovery of the Dry Cask Storage Facility costs using an internal sinking fund.

Q. Please describe your educational background.

A. In 1972 I earned a bachelor of science degree in mathematics from the University of Wisconsin in River Falls.

Q. Please outline your professional work experience.

A. I joined Northern States Power Company in 1972, where I worked as an operations analyst until 1974, at which time I became a tax depreciation analyst. In 1976 I became the manager of Depreciation Services. In 1981 I was promoted to manager of Depreciation and Nuclear Fuel Accounting. In 1986 I became manager of Corporate Economics and Depreciation. In 1990 I became manager of Capital Asset Accounting.

Q. Have you provided formal testimony in any other regulatory proceedings?

A. Yes. The following is a list of my previous testimony:

I've testified in four proceedings before the Federal Energy Regulatory Commission, namely: Nuclear Fuel Disposal, Docket No. ER81-651-000, 1981; Nuclear Fuel Disposal, Docket No. ER81-653-000, 1981; Tax

Normalization, Docket No. ER88-72-000, 1988; and Nuclear Decommissioning, Docket No. ER88-75-000, 1988.

Before the Ramsey County District Court in Minnesota I provided depreciation-related testimony in File No. 456710 in 1984.

Before the Minnesota Public Utilities Commission I testified on nuclear decommissioning in Docket numbers E002/GR-87-670 in 1987, and E002/GR-89-865 in 1989.

Before the North Dakota Public Service Commission I provided depreciation testimony in Docket No. 10,979 in 1987. And before the South Dakota Public Service Commission I provided testimony on nuclear decommissioning in Docket No. F-3764 in 1988.

Q. Have you published any papers in professional journals or spoken before any professional organizations?

A. Yes. The following is a list of my publications and presentations.

1. "A Sinking Fund Approach to Nuclear Fuel Disposal Recovery," Iowa State University Regulatory Conference, 1980 - Vol. 19, May, 1980.

2. "A Sinking Fund Approach to Nuclear Fuel Disposal Recovery," A.G.A. - EEI Depreciation Accounting Committee, Journal of Papers - Administration Year 1980-1981, Vol. 2, June, 1980.

3. "Mechanized Depreciation Accounting Systems," A.G.A. - EEI Depreciation Accounting Committee, Journal of Papers - Administrative Year 1980-1981, Vol 2, February, 1981.

4. "Revenue Requirements Related to Unit-Of-Production Depreciation," A.G.A. - EEI Depreciation Accounting Committee, Journal of Papers - Administrative Year 1981-1982, Vol. 3, February, 1982.

5. With Cheryl R. Hatfield, "Economic Comparison of Nuclear Decommissioning Funding Alternatives," Proceedings of the A.G.A. Depreciation and EEI Depreciation Accounting Committee, Administrative Year 1986-1987, Vol.8, September, 1987.

6. "Economic Evaluation of Power Plant Life Extension," Proceedings of the A.G.A. Depreciation and EEI Depreciation Accounting Committee, Administrative Year 1987-1988, Vol. 9, September, 1988.

Q. Are you a member of any professional associations?

A. Yes. I belong to the Depreciation Committee of the American Gas Association. I'm active in the Depreciation Accounting Committee of the Edison Electric Institute, where I served as committee chair in 1984 and 1985, and currently serve as chair of the Capital Recovery Economics subcommittee.

Q. Does this conclude your testimony at this time?

A. Yes.

Direct Testimony
Dr. Jacob I. Fabrikant

Before the Public Utilities Commission of
the State of Minnesota

In the Matter of the Application of Northern States Power Company
For a Certificate of Need for a Temporary Spent Nuclear Fuel Storage Facility
for the Prairie Island Nuclear Generating Plant

Docket No. E-002/CN-91-19
Exhibit___(JIF-1)

April, 1991

Q. Please state your name and business address.

A. I am Jacob I. Fabrikant, M.D., Ph.D. My address is the University of California-Berkeley and San Francisco, 135 Alvarado Road, Berkeley, California 94705.

Q. Please describe briefly the professional and academic activities in which you are engaged.

A. I am actively engaged, professionally and academically, in patient care, teaching and research in radiological medicine and the radiological sciences.

Q. On what topics are you presenting testimony?

A. I will be available to testify on those aspects of the Application involving radiological impacts of the Dry Cask Storage Facility. I will also be available to testify on the Health Risk Assessment performed by the Minnesota Department of Health for the Environmental Impact Statement for the Prairie Island Dry Cask Storage Facility.

Q. Where did you receive your medical training?

A. I did my post-doctoral training in surgery and pathology at Duke University Hospital in Durham, North Carolina, and trained in radiology at the Johns Hopkins Hospital and University in Baltimore, Maryland.

Q. In what medical disciplines are you certified?

A. I am certified by the American Board of Radiology in diagnostic radiology, therapeutic radiology, and nuclear medicine. I am also a Fellow of the American College of Radiology.

Q. What have been your key academic responsibilities?

A. I have been Professor and Head of the Department of Radiology, University of Connecticut School of Medicine; and Professor and Chairman, Department of Diagnostic Radiology, McGill University Faculty of Medicine in Montreal.

Q. What are your current professional and academic appointments and in which institutions are they held?

A. I am currently Professor of Radiology, University of California School of Medicine, San Francisco. I also occupy the following posts at the University of California, Berkeley - Professor of Graduate Biophysics, Senior Scientist at the Lawrence Berkeley Laboratory, and physician-in-charge of the Donner Pavilion, Cowell Memorial Hospital.

Q. What are your current responsibilities?

A. I devote all my professional and academic activities to patient care, primarily diagnostic and therapeutic radiology and nuclear medicine; to research in the radiological sciences, primarily cancer research and the neurosciences; and to teaching in radiological medicine and radiation biophysics, primarily in the radiological sciences in the medical school and in the graduate school at the University. These are all documented in my curriculum vitae which is attached to this statement.

Q. Of what international committee on radiation protection are you a member and what is the charge to that committee?

A. I serve as a member of Committee 1 of the International Commission on

Radiological Protection ("ICRP"). Committee 1 is concerned with risk estimation and the human health effects of exposure to ionizing radiations. The ICRP is the oldest expert scientific advisory body on radiation and health; it dates to 1928. The ICRP is represented by radiation and medical scientists from some 15-20 countries throughout the world with responsibilities to assess and evaluate the health risks of radiation exposure, particularly concerning radioisotopes, occupational exposure, and medical applications, to estimate the extent and magnitude of these risks, and to recommend limits on radiation exposure to worker populations, the general public, and certain selected populations.

Q. Of what national (United States) scientific committees on radiation protection are you a member and what is the charge to that committee?

A. I am a member of the National Council on Radiological Protection and Measurements ("NCRP"). This is an expert scientific advisory committee on radiation and health effects chartered by the U.S. Congress in 1964 (it is the oldest U.S. scientific body on radiation and health, dating back to 1929) with designated responsibility to collect and analyze scientific data and develop recommendations about protection against radiation and on radiation measurements, quantities and units. I serve as a member of Scientific Committee 1-2 (risk estimation and health effects (cancer and hereditary effects) of exposure to ionizing radiations). I have also served as a member or honorary member of committees of the National Radiological Protection Boards of Canada and of Great Britain.

Q. Have you ever served on committees of the United States National Academy of Sciences-National Research Council? If so, what was (were) the charge (s) to the(se) committee(s)?

A. I have served on eleven committees and boards of the National Academy of Sciences - National Research Council, notably the 1972 BEIR I, the 1976 BEIR II (vice-chairman), the 1980 BEIR III, the 1988 BEIR IV (chairman) Committees. I am currently a member of the BEIR V Committee. The BEIR Committee, i.e., the Committee on the Biological Effects of Ionizing Radiations, is mandated and its members appointed by the governing board of the National Research Council which, in turn, falls under the auspices of the National Academy of Sciences - a private, non-profit making and selfperpetuating society of scholars engaged in scientific and engineering research, which advises the federal government on scientific and technical matters. The BEIR Committee has an international reputation and is looked to for guidance by those national and international agencies which are concerned to established and maintain regulations regarding radiation and human health.

Q. How would you characterize the scientific responsibilities of the(se) committees on which you serve(d), and your own scientific responsibilities to service to the(se) committee(s)?

A. These committees, councils, and commissions (ie, ICRP, NCRP and BEIR) meet regularly and often, and have served effectively to discuss, to review, to evaluate, and to report on three important matters of societal concern: 1) to place into perspective the actual and potential harm to the health of human beings and their descendants in the present and in the future from those societal activities involving the use of ionizing radiations; 2) to develop quantitative indices of harm based on dose-response and time-response relationships to provide a scientific basis for the evaluation and estimation of somatic (ie, cancer) and genetic (ie, hereditary) risks in order to protect human populations exposed to low-level radiation; and 3) to identify the sources and levels of radiation which could cause harm, to assess their relative importance, and to provide a framework on how to reduce unnecessary radiation exposure to human populations. All these committees author scholarly scientific reports which serve as the scientific basis for regulatory guidance and standards for radiation protection.

Q. Have you ever served on national committees to evaluate the health hazards of nuclear facilities and nuclear facility safety?

A. I was Director of Public Health and Safety of the President's Commission on the Accident at Three Mile Island; I am a member of the Safety Advisory Board of Three Mile Island-2, and chairman of its Radiation Hazards Panel. I served on the U.S. Department of Energy's Committee on the Assessment of Health Consequences on Exposed Populations (Task Group on Health and Environmental Aspects of the Soviet (Chernobyl) Nuclear Accident). I currently serve as a member of the United States Department of Energy Advisory Committee on Nuclear Facility Safety.

Q. Have you published in the peer-review scientific literature, and have you submitted your curriculum vitae and list of publications?

A. I have written numerous scientific articles, reports, chapters, reviews and books in the open scientific and medical literature. They are all in the fields of the radiological sciences; medicine, radiology and surgery; radiation sciences and health, radiological protection and risks, radiobiology and radiation biophysics; cancer biology and cancer research; and related disciplines. My curriculum vitae and list of scientific publications is appended.

Q. Have you provided formal testimony in any other NSP regulatory proceedings?

A. Yes, I testified during the certificate-of-need hearings for the 1981 re-rack at Prairie Island.

Q. Does that complete your testimony at this time?

A. Yes.

CURRICULUM VITAE

JACOB I. FABRIKANT

Birth	February 9, 1928	U.S.A.

Education

1948-52	McGill University, Montreal Faculty of Arts and Science	B.Sc. (magna cum laude; Chemistry)
1952-56	McGill University, Montreal Faculty of Medicine	M.D., C.M.
1961-64	University of London, England Faculty of Science	Ph.D. (Biophysics)
1978	American College of Radiology	F.A.C.R. (Fellow, Radiology)

Academic Appointments

1956-57	Duke University Hospital and School of Medicine, Durham	Intern in Surgery
1957	Duke University Hospital and School of Medicine	Assistant in Pathology
1957-58	Duke University Hospital and School of Medicine	Fellow in Surgery
1958-61	The Johns Hopkins Hospital, Baltimore	Resident in Radiology
1958-61	The Johns Hopkins University School of Medicine, Baltimore	Fellow in Radiology
1961-64	Department of Physics Institute of Cancer Research University of London, England	Advanced Fellow in Academic Radiology of the James Picker Foundation, National Academy of Sciences-National Research Council
1964-65	The Johns Hopkins University School of Medicine and School of Hygiene and Public Health, Baltimore	Advanced Fellow in Academic Radiology of the James Picker Foundation, National Academy of Sciences-National Research Council
1964-68	The Johns Hopkins University School of Medicine	Assistant Professor of Radiology
1964-70	The Johns Hopkins Hospital	Radiologist

1965-68	The Johns Hopkins University School of Hygiene and Public Health	Assistant Professor of Radiological Science
1968-70	The Johns Hopkins University School of Medicine	Associate Professor of Radiology
1969-70	The Johns Hopkins University School of Hygiene and Public Health	Associate Professor of Radiological Science
1970-75	The University of Connecticut School of Medicine, Farmington	Professor and Head Department of Radiology
1973-75	The Royal Society London, England	Special Consultant, Advisory Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences-National Research Council
1973-75	Royal Postgraduate Medical School University of London, England	Picker Sabbatical Study Year James Picker Foundation National Academy of Sciences-National Research Council Visiting Colleague Department of Diagnostic Radiology
1973-75	Hammersmith Hospital Royal Postgraduate Medical School, London	Honorary Consultant Radiologist Department of Diagnostic Radiology
1975-78	McGill University Faculty of Medicine, Montreal	Professor of Diagnostic Radiology Department of Diagnostic Radiology
1975-78	The Montreal General Hospital Montreal	Diagnostic Radiologist-in-Chief Department of Diagnostic Radiology
1976-78	McGill University Faculty of Medicine	Professor and Chairman Department of Diagnostic Radiology
1978-	University of California San Francisco School of Medicine	Professor of Radiology
1978-80	Donner Laboratory Lawrence Berkeley Laboratory University of California, Berkeley	Scientist
1979	President's Commission on the Accident at Three Mile Island, The White House, Washington, D.C.	Director, Public Health and Safety
1980-	Donner Laboratory Lawrence Berkeley Laboratory University of California, Berkeley	Senior Scientist
1980-	University of California, Berkeley	Professor of Radiology Graduate Group in Biophysics Department of Biophysics and Medical Physics

Academic and Professional Organizations

American College of Radiology, Member, 1972-78; Fellow, 1978-
Society of Chairmen of Academic Radiology Departments, Member, 1970-75; 1976-78
Association of University Radiologists, Member, 1967-
British Institute of Radiology, Member, 1961-
Society of Nuclear Medicine, Member, The Academic Council, 1970-78
Canadian Association of Radiologists, Member, 1975-80, Committee on Basic Research, Member, 1975-78
The New England Roentgen Ray Society, Member, 1972-78
Radiological Society of Connecticut, Member, 1971-75
Radiation Research Society. Member, 1965-80, Councillor in Medicine, 1973-76
Association for Radiation Research (U.K.), Member, 1964-70
American Association for the Advancement of Science, Member, 1966-75
New York Academy of Sciences, Member, 1958-70
American Institute of Biological Science, Member, 1968-75
The Johns Hopkins Medical and Surgical Association, Member, 1965-
Connecticut State Medical Society, Member, 1971-75
Maryland Medical and Chirurgical Society, Member, 1958-70
Society of Sigma Xi, Member, 1971-
Cell Kinetics Society, Member, 1978-85
Alpha Omega Alpha Honorary Medical Society, Member, 1955-
Nu Sigma Nu Medical Fraternity, Member, 1953-

Academic Honors

Distinguished Scientist, Japan Atomic Energy Commission,
National Institute of Radiological Science, Chiba, Japan, 1989
Distinguished Visiting Lecturer in Radiation Biology and Protection,
TNO Radiobiological Institute, Rijswijk, The Netherlands, 1988
Member of The Royal Society of Medicine, Great Britain, Elected, 1984
Fellow of the American College of Radiology (F.A.C.R.), Elected, 1978
Visiting Colleague in Diagnostic Radiology, Royal Postgraduate Medical School, London, England, 1973-75
Picker Sabbatical Study Year Award of the James Picker Foundation,
National Academy of Sciences-National Research Council, 1973-75
Special Consultant, Committee on the Biological Effects of Ionizing Radiations,
National Academy of Sciences-National Research Council, The Royal Society, London, England, 1973-75
Advanced Fellow in Academic Radiology of the James Picker Foundation,
National Academy of Sciences-National Research Council, 1961-65
Wood Gold Medal, McGill University Faculty of Medicine, Montreal, 1956
Alpha Omega Alpha Honorary Medical Society, McGill University Faculty of Medicine, Montreal, 1955-

Extramural Research and Education Review Committees

Radiological Society of North America, Research and Education Fund, Distinguished Scientific Advisor, 1986-
U.S. Atomic Energy Commission, Division of Biology and Medicine, Consultant, 1968-75
U.S. Energy Research and Development Agency, Consultant, 1975-76
National Science Foundation, Division of Developmental Biology, Consultant, 1970
State of Connecticut, Commission on Higher Education, Standing Committee on Accreditation,
Connecticut Council on Higher Education, Consultant, 1971-73
Connecticut Cancer Epidemiological Program, Planning Committee, Member, Secretary, 1972-73
American Cancer Society, Connecticut Division, Board of Directors, Member, 1972-73

National Academy of Sciences-National Research Council Scientific Advisory Committees

Committee on the Biological Effects of Ionizing Radiations (BEIR V), Board of Radiation Effects Research, National Academy of Sciences-National Research Council, Member, 1986-90

Committee on the Biological Effects of Ionizing Radiations (BEIR IV), Board of Radiation Effects Research, Commission on Life Sciences, National Academy of Sciences-National Research Council, Member and Chairman, 1985-88

Board on Radiation Effects Research, Commission on Life Sciences, National Academy of Sciences-National Research Council, Member, 1983-89

Oversight Committee on the Radioepidemiologic Tables, Division of Medical Sciences, Commission on Life Sciences, National Academy of Sciences-National Research Council, Member, 1983-85

Committee to Review the Portsmouth Naval Shipyard Cytogenetics Protocol, Division of Medical Sciences, Commission on Life Sciences, National Academy of Sciences-National Research Council, Member, 1982

Board of Radioactive Waste Management, National Academy of Engineering-National Research Council, Consultant, 1981-82

Committee on Federal Research on the Biological and Health Effects of Ionizing Radiation, Division of Medical Sciences, Assembly of Life Sciences, National Academy of Sciences-National Research Council, Consultant, 1980-81

Committee on the Biological Effects of Ionizing Radiations (BEIR III), Division of Medical Sciences, Assembly of Life Sciences, National Academy of Sciences-National Research Council, Member, 1977-80; Subcommittee on Somatic Effects, Member, 1977-80; Ad hoc Subcommittee (Subcommittee on Somatic Effects), Chairman, 1979-80

Committee on the Biological Effects of Ionizing Radiations (BEIR II), Division of Medical Sciences, Assembly of Life Sciences, National Academy of Sciences-National Research Council, Member and Vice Chairman, 1973-77; Subcommittee on Medical Radiation, Chairman, 1973-77

Committee on the Biological Effects of Ionizing Radiations (BEIR I), Division of Medical Sciences, Assembly of Life Sciences, National Academy of Sciences-National Research Council, Subcommittee on Growth and Development, Member, 1969-72; Subcommittee on Somatic Effects, Consultant, 1969-72

Committee on Radiology, Division of Medical Sciences, Assembly of Life Sciences, National Academy of Sciences-National Research Council, Member, 1967-74

Additional National and International Scientific Advisory Committees

Advisory Committee on Nuclear Facility Safety, United States Department of Energy, Member, 1990-

Committee on Radiologic Units, Standards and Protection, Commission on Physics, American College of Radiology, Member, 1985-

Committee on Biological and Health Effects, Division of Diagnostic Radiology, American College of Radiology, Member, 1985-

National Council on Radiation Protection and Measurements, Member, 1985- ; Nominating Committee, Member, 1988- ; Scientific Committee 1-2, Member, 1988-

Committee on Radiological Health Effects Model, Nuclear Regulatory Commission, Harvard University School of Public Health, Advisory Committee, Member, 1982-89

Safety Advisory Board, Three Mile Island Unit-2, Member, 1981-89; Radiation Hazards Panel, Member, 1981-89, Chairman, 1985-89

International Commission on Radiological Protection, Committee 1 on Radiation Effects, Member, 1980-

President's Commission on the Accident at Three Mile Island, The White House, Director of Public Health and Safety, 1979

Committee on Federal Research into the Biological and Health Effects of Ionizing Radiation, National Institutes of Health, Department of Health, Education and Welfare, United States Public Health Service, Member, 1979-80

Committee on Radiation Risks to Space Workers (Satellite Power Systems), National Aeronautics and Space Administration, Member, 1979-81

Associate Committee on Scientific Criteria for Environmental Quality, Subcommittee on Physical Energy, National Research Council, Canada, Member, 1976-78

Committee on Medical Uses of Radiation and Radiation Exposure of Patients, National Radiological Protection Board, Great Britain, Member, 1974-75

Committee on Genetic and Carcinogenic Effects, Division of Radiotherapeutic Research, Commission on Radiation Therapy, American College of Radiology, Member, 1972-76

Medical Radiation Advisory Committee, Bureau of Radiological Health, Food and Drug Administration, Department of Health, Education and Welfare, United States Public Health Service, Member, 1969

Neurology Study Section, National Institutes of Health, Department of Health, Education and Welfare, United States Public Health Service, Member, 1969-72

X-Ray Image Production and Related Facilities Advisory Committee, Bureau of Radiological Health, Department of Health, Education and Welfare, United States Public Health Service, Member, 1968-69

Commission on Radiation and Infection, Armed Forces Epidemiological Board, Department of the Army, Member, 1965-66

University Research and Education Review Committees

University of California, Berkeley, Radioactive Drug Research Committee, Member, 1989-
University of California, Berkeley, Committee on the Protection of Human Subjects, Member, 1983-1988
Lawrence Berkeley Laboratory, University of California Berkeley, Radioactive Drug Research Committee, Member, 1979- ; Chairman, 1981-86
McGill University, Faculty of Medicine, Department of Diagnostic Radiology, Postgraduate Training Committee, Program Director, 1976-78
McGill University, Faculty of Medicine, Postgraduate Training Committee, Member, 1975-78
McGill University, Faculty of Graduate Studies and Research, Faculty Council, The Graduate Council, Councillor, 1975-78
McGill University, University Senate, Senator, 1976-78
The University of Connecticut Health Sciences Center, Radiation Control Committee, Chairman, 1970-73
The Johns Hopkins Medical Institutions, Radiation Control Committee, Member, 1966-70

Visiting Professorships and Lectureships

Bowman Gray School of Medicine, Visiting Professor of Radiology, 1968
Visiting Professor of Oncology, Georgetown University School of Medicine and Hospital, Clinical Cancer Program, 1969
American Institute of Biological Sciences, Visiting Radiation Biologist, 1969-75
University of Minnesota School of Medicine and Hospitals, William O'Brien Professor of Radiation Science, 1970

University of Vermont College of Medicine, Visiting Professor of Radiology, 1970, 1977, 1978
L.H. Gray Laboratory, Cancer Research Campaign, Mt. Vernon Hospital, England, Visiting Scientist, 1971
Cambridge University Medical School, Addenbrooke's Hospital, Cambridge, England, Visiting Lecturer, 1971
University of South Florida College of Medicine, Visiting Professor of Radiology, 1973
University of Montreal Faculty of Medicine, Visiting Professor of Radiology, 1977
Oxford University Medical School, The Radcliffe Infirmary, Oxford, England, Visiting Lecturer, 1979, 1980, 1981
University of London, Institute of Cancer Research, London, England, Visiting Lecturer, 1979, 1981
Royal Postgraduate Medical School, Hammersmith Hospital, London, England, Vesting Lecturer, 1979
National Radiological Protection Board, Harwell, England, Visiting Scientist, 1979, 1981
Middlesex Hospital Medical School, Department of Radiotherapy and Oncology, Visiting Lecturer, 1981
Brown University Division of Biology and Medicine, Providence, Visiting Professor of Radiation Medicine, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1987, 1988, 1989
Walter H. Herbst Memorial Symposium, Invited Lecturer, University of California San Francisco School of Medicine, 1981
Tartu University Faculty of Medicine, Tartu, Estonia, U.S.S.R., Visiting Lecturer, 1984
Estonian Academy of Sciences, Tallin, Estonia, U.S.S.R., Visiting Lecturer in Physics, 1984
University of California, Graduate School of Business Administration, The Berkeley Business School, Executive Program, Faculty, 1985, 1986, 1987, 1988, 1989
Shanghai Medical University, Institute of Radiation Medicine, Shanghai, China, Visiting Professor, 1986
Academy of Military Medical Sciences, Institute of Radiation Medicine, Beijing, China, Visiting Professor, 1986
Karolinska Institute, Departments of Hematology and Radiological Protection and Neurosurgery, Stockholm, Visiting Lecturer, 1987
University of Umea Faculty of Medicine, Umea, Sweden, Visiting Lecturer, 1987
University of Uppsala, University Academic Hospital, Department of Neurosurgery, Visiting Lecturer, 1987
Swedish Agricultural University, Department of Radioecology, Visiting Lecturer, 1987
TNO Radiobiological Institute, Rijswijk, The Netherlands, Distinguished Visiting Lecturer in Radiation Biology and Protection, 1988
Japan Radiation Research Society, Japan, Plenary Lecturer, 1989
Radiation Effects Research Foundation, Hiroshima, Japan, Visiting Scientist, 1989
National Institute of Radiological Science, Chiba, Japan, Distinguished Scientist of the Japan Atomic Energy Commission, 1989

Scientific Journal Review

Cell and Tissue Kinetics, 1968- ; Member, Editorial Board, 1972-85
Investigative Radiology, 1973- ; Member, Editorial Board, 1973-76
Journal of the Canadian Association of Radiologists, 1976-78; Member, Editorial Board, 1976-78
McGill Medical Journal, Member, Editorial Board, 1952-56; Managing Editor, 1954-55; Editor, 1955-56
American Journal of Roentgenology, 1966-
Radiology, 1966-
Cancer Research, 1968-
Science, 1970-
Biology of Reproduction, 1970-
Medicine, 1970-
BioScience, 1970-
Cancer, 1971-
Radiation Research, 1972-
International Journal of Applied Radiation and Isotopes, 1973-
New England Journal of Medicine, 1982-
International Journal of Radiation Oncology Biology Physics, 1987-

Hospital Appointments

1978- present	University of California Medical Center, San Francisco	Radiologist, Clinical Faculty

1978-present	Cowell Memorial Hospital University of California, Berkeley	Physician
1975-78	The Montreal General Hospital Montreal	Diagnostic Radiologist-in-Chief Department of Diagnostic Radiology
1973-75	Hammersmith Hospital London, England	Honorary Consultant Radiology Department of Diagnostic Radiology
1972-75	Mount Sinai Hospital Hartford, Connecticut	Consultant in Radiology
1971-75	William W. Backus Hospital Norwich, Connecticut	Consultant in Radiology
1971-75	New Britain General Hospital New Britain, Connecticut	Consultant in Radiology
1970-73	Veterans Administration Hospital Newington, Connecticut	Acting Chief, Department of Radiology; Consultant in Radiology
1970-75	University of Connecticut Hospital Hartford, Connecticut	Attending Radiologist Head, Department of Radiology
1964-70	The Johns Hopkins Hospital Baltimore, Maryland	Radiologist

Certification

1962	American Board of Radiology

Medical Licenses

1957	National Board of Medical Examiners (No. 36999)
1958	Maryland (No. D1511)
1971	Connecticut (No. 14808)
1973-75	Great Britain
1976-78	Quebec, Canada (No. 76-033)
1978	California (No. G 36656)

Military Service

United States Navy, World War II, Veteran

Marital Status

Irene B. Fabrikant, Wife

B.Sc.	McGill University
M.Sc.	McGill University, Bacteriology and Immunology
Ph.D.	University of Maryland, Microbiology

1966-70	Instructor, Department of Microbiology, University of Maryland School of Medicine

1970-75	Assistant Professor of Medicine, Department of Medicine The University of Connecticut School of Medicine, Honorary Research Fellow (Immunology)
1973-75	Department of Zoology and Comparative Anatomy, University College, London, England
1975-78	Assistant Professor, Department of Microbiology & Immunology Faculty of Medicine, McGill University, Montreal
1977-78	Executive Secretary, McGill University Biohazards Committee, McGill University
1978-79	Research Fellow, U.S. Public Health Service, Department of Health, Education and Welfare, Center for Disease Control, San Juan Laboratories, Puerto Rico
1979-80	Research Associate, University of California, Berkeley, School ofPublic Health, Department of Biomedical and Environmental Health Sciences
1981-82	Associate Research Immunologist, University of California, San Francisco, School of Medicine, Cancer Research Institute
1985-present	Scientific Consultant, Crosby, Heafey, Roach & May, Oakland, California

BIBLIOGRAPHY

1. Fabrikant, J.I. The Osler Society. (Editorial) McGill Med. J. 24:128, 1955.

2. Fabrikant, J.I. The Dean. (Editorial) McGill Med. J. 24:180, 1955.

3. Fabrikant, J.I. A concept of the term "anxiety". McGill Med. J. 24:201-207, 1955.

4. Fabrikant, J.I. Pediatric problems in clinical practice. (Book Review) McGill Med. J. 24:114-115, 1955.

5. Anylan, W.G., Delaughter, G.D., Jr., Fabrikant, J.I., Sullenberger, J.W. and Weaver, W.T. The management of acute venous thromboembolism. JAMA 168:725-729, 1958.

6. Anylan, W.G., Baylin, G.J., Fabrikant, J.I. and Trumbo, R.B. Studies in coronary angiography. Surgery 45:8-18, 1959.

7. Fabrikant, J.I. Colostomy--A short review. Il. Quart. 2:23-33, 1959.

8. Sullenberger, J.W., Weaver, W.T., Fabrikant, J.I. and Anylan, W.G. A study of the pressor effects of serotonin and its possible role in massive thromboembolism. Surgical Forum 9:127-130, 1959.

9. Fabrikant, J.I. Reflections on illness. Il Quart. 3:6-8, 1959

10. Fabrikant, J.I., Anylan, W.G., Baylin, G.J. and Trumbo, R.B. A comparison of various techniques for a safe and reliable method of coronary arteriography. Surgical Forum 9:233-237, 1959.

11. Fabrikant, J.I., Anylan, W.G. and Creadick, R.N. The management of radiation injuries to the intestines. South. Med. J. 52:1186-1191, 1959.

12. Fabrikant, J.I. The ileal bladder. Il. Quart. 3:43-47, 1959.

13. Fabrikant, J.I., Anylan, W.G., Baylin, G.J. and Trumbo, R.B. A comparison of techniques for visualization of the coronary arteries. Amer. J. Roentgenol., Rad. Therapy and Nuclear Med. 81:764-771, 1959.

14. Fabrikant, J.I. The wet colostomy. Il. Quart. 4:1-5, 1959.

15. Koehler, P.R., Fabrikant, J.I. and Dana E.R. Gastric retention during oral cholecystography due to underlying lesions of the stomach and duodenum. Surg. Gynec. and Obstet. 110:409-412, 1960.

16. Fabrikant, J.I., Anylan, W.G. and Creadick, R.N. Management of intestinal injuries caused by pelvic irradiation. Modern Med. 28:117-118, 1960.

17. Fabrikant, J.I. An improved ileostomy appliance. AMA Arch. Surg. 89:416-418, 1960.

18. Anylan, W.G., Baylin, G.J., Fabrikant, J.I. and Trumbo, R.B. Studies in coronary arteriography. (In) Year Book of Radiology, (Holt, J.F., Whitehouse, W.M., Jacox, H.W. and Kligerman, M.M., eds.), pp. 123-125, Year Book Medical, Chicago, 1960.

19. Fabrikant, J.I. Specialists at your service: The radiologist. II. Quart. 5:29-32, 1961.

20. Fabrikant, J.I., Richards, G.J., Jr., Brack, C.B. and Goodwin, P.N. A vaginal applicator for radium therapy of carcinoma in the vagina. Radiology 77:987-989, 1961.

21. Fabrikant, J.I., Cockey, T.B. and Goodwin, P.N. A simple pituitary localizer for radiation therapy. Amer. J. Roentgenol., Rad. Therapy and Nuclear Med. 86:649-650, 1961.

22. Fabrikant, J.I. Reflections upon illness. Nursing News 12:3-5, 1961.

23. Fabrikant, J.I., Anylan, W.G., Baylin, G.J. and Isley, J.K. Isotope studies for the evaluation of venous disease of the lower extremity. J. Nuclear Med. 2:136-148, 1962.

24. Koehler, P.R., Fabrikant, J.I. and Dickson, R.J. Observations on the behavior of testicular tumors with comments on racial incidence. J. Urol. 87:577-579, 1962.

25. Fabrikant, J.I., Richards, G.J., Jr., Tucker,, G.F., Jr. and Dickson, R.J. Contrast laryngography in the evaluation of laryngeal neoplasms. Amer. J. Roentgenol., Rad. Therapy and Nuclear Med. 87:822-835, 1962.

26. Fabrikant, J.I., Richards, G.J., Jr., Tucker, G.F., Jr. and Dickson, R.J. Aid to diagnosis of laryngeal cancer. Modern Med. 31:212, 1962.

27. Fabrikant, J.I. Cellular response and cell population kinetics under continuous irradiation. Radiologic changes in bone following irradiation. (In) James Picker Foundation, Annual Report, pp. 23-25, New York, 1962.

28. Fabrikant, J.I. and Smith, C.L.D. Radiological changes in experimental animals following the administration of bone-seeking radionuclides. (In) Radiation Effects in Physics, Chemistry, and Biology, (Ebert, M. and Howard, A., eds.), p. 472, North Holland, Amsterdam, 1963.

29. Fabrikant, J.I. Regenerating liver. (In) Report of the Institute of Cancer Research: Royal Cancer Hospital, Annual Report, p. 122, London, 1963.

30. Fabrikant, J.I., Richards, G.J., Jr., Brack, C.B. and Goodwin, P.N. Vaginal applicator for radium therapy of carcinoma in vagina. (In) Year Book of Radiology, (Holt, J.F., Whitehouse, W.M., Jacox, H.W. and Kligerman, M.M., eds.), p. 315, Year Book Medical, Chicago, 1963.

31. Fabrikant, J.I. Studies of cellular response and cell population kinetics under continuous irradiation. (In) James Picker Foundation, Annual Report, pp. 26-27, New York, 1963.

32. Fabrikant, J.I. Cell proliferation studies in normal, continuously irradiated and malignant tissues. Regenerating liver. (In) Report of the Institute of Cancer Research: Royal Cancer Hospital, British Empire Cancer Campaign for Research, Annual Report, London, 41:152-153, 1964.

33. Fabrikant, J.I. and Smith, C.L.D. Radiographic changes following the administration of bone-seeking radionuclides. Brit. J. Radiol. 37:53-62, 1964.

34. Fabrikant, J.I. and Roylance, P.J. Cinefluorographic anatomy of the larynx and hypopharynx. Proc. Anat. Soc. Great Britain and Ireland 33:25, 1964.

35. Fabrikant, J.I. Investigation of cellular response and cell population kinetics in tissues under continuous irradiation. (In) James Picker Foundation, Annual Report, pp. 28-29, New York, 1964.

36. Fabrikant, J.I. Studies of cell proliferation in the regenerating liver and the effect of prior continuous irradiation. Ph.D. Thesis, University of London, 1964.

37. Fabrikant, J.I., Dickson, R.J. and Fetter, B.F. Mechanisms of radiation carcinogenesis at the clinical level. Brit. J. Cancer 18:459-477, 1964.

38. Fabrikant, J.I. and Dickson, R.J. The use of cinefluorography for the radiological examination of the larynx and hypopharynx in cases of suspected carcinoma. Brit. J Radiol. 38:28-38, 1965.

39. Fabrikant, J.I. and Roylance, P.J. Cinefluorographic functional anatomy of the normal and diseased larynx. J. Anat. 99:209, 1965.

40. Fabrikant, J.I. and Koburg, E. Rontgen-Kontrastuntersuchungen von Larynx und Hypopharynx in Verbindung mit Bildverstarkung. HNO Wegw. f. fach. Praxis 13:16-19, 1965.

41. Fabrikant, J.I. and Lamerton, L.F. The effect of prior continuous irradiation on cell proliferation in the regenerating liver. Exc. Med. Intern. Congr. 89:347, 1965.

42. Fabrikant, J.I., Dickson, R.J. and Fetter, B.F. Mechanisms of radiation carcinogenesis at clinical level. (In) Year Book of Radiology, (Holt, J.F., Whitehouse, W.M.and Latourette, H.B., eds.), pp. 384-386, Year Book Medical, Chicago, 1966.

43. Fabrikant, J.I. and Dickson, R.J. Use of cinefluorography for radiologic examination of larynx and hypopharynx in cases of suspected carcinoma. (In) Year Book of Cancer, (Clark, R.L. and Cumley, R.W., eds.), pp. 384-387, Year Book Medical, Chicago, 1966.

44. Fabrikant, J.I. The spatial distribution of parenchymal cell proliferation during regeneration of the liver. J. Hopkins Med. J. 120:137-147, 1967.

45. Fabrikant, J.I. The effect of prior continuous irradiation on the G2, M and S phases of proliferating parenchymal cells in the regenerating liver. Radiation Res. 31:304-314, 1967.

46. Fabrikant, J.I. Radiation sterilization in man. JAMA 200:201-202, 1967.

47. Fabrikant, J.I. The accumulation of chromosome damage under continuous low dose-rate exposure. Radiology 88:767-774, 1967.

48. Fabrikant, J.I. The ileal bladder. Colorado St. Dept. Public Health, Suppl., pp. 1-4, Denver, 1967.

49. Fabrikant, J.I. Cell proliferation in the regenerating liver of continuously irradiated mice. Brit. J. Radiol. 40:487-495, 1967.

50. Fabrikant, J.I. Cell proliferation in the regenerating liver and the effect of prior continuous irradiation. Radiation Res. 32:804-826, 1967.

51. Fabrikant, J.I., Peterson, W.E. and Donner, M.W. Biographical note. (In) Russell H. Morgan, A Tribute. Fabrikant, J.I. and Donner, M.W., eds., pp. xi-xii, duPont, Wilmington, Del., 1967.

52. Fabrikant, J.I. The analysis of cell population kinetics in a conditional renewal system under continuous irradiation. (In) Russell H. Morgan, A Tribute, Fabrikant, J.I. and Donner, M.W., eds., pp. 93-100, duPont, Wilmington, Del., 1967.

53. Fabrikant, J.I. Kinetic analysis of hepatic regeneration. Growth 34:311-315, 1967.

54. Morreels, C.L, Jr., Cherry, J. and Fabrikant, J.I. Ossified arytenoid cartilage masquerading as a foreign body; A case report. Amer. J. Roentgenol., Rad. Therapy and Nuclear Med. 101:837-838, 1967.

55. Fabrikant, J.I. The kinetics of cellular proliferation in regenerating liver. J. Cell. Biol. 36:551-565, 1968.

56. Fabrikant, J.I. and Wisseman, C.L., III. In vitro incorporation of tritiated thymidine in normal and neoplastic tissues. Radiology 90:361-363, 1968.

57. Fabrikant, J.I. Rate of cell proliferation in the regenerating liver. Brit. J. Radiol. 41:71, 1968.

58. Fabrikant, J.I. Radiation effects on a conditional cell renewal system under continuous low dose rate exposure. Amer. J. Roentgenol., Rad. Therapy and Nuclear Med. 102:811-821, 1968.

59. Fabrikant, J.I. Cell proliferation in normal and malignant human tissues. (In) James Picker Foundation, Annual Report, 1967, pp. 44-45, New York, 1968.

60. Fabrikant, J.I. Cell proliferation during lymphopoiesis in normal and continuously irradiated mice. (In) Symposium on Effects of Radiation on Cellular Proliferation and Differentiation, SM-103/41, pp. 1-24, I.A.E.A., Vienna, 1968.

61. Fabrikant, J.I. Cell proliferation in the regenerating liver of continuously irradiated mice; Effect of a radiation-free interval. Brit. J. Radiol. 41: 369-374, 1968.

62. Fabrikant, J.I., Vitak, M.J. and Wisseman, C.L., III. The kinetics of cellular proliferation in human tissues. IV. Nucleic acid synthesis and the cell cycle in relation to normal, inflammatory and neoplastic growth. Radiology 54:214-224, 1968.

63. Hoopes, J.E. and Fabrikant, J.I. Objective evaluation of cleft palate speech. Plast. Reconstr. Surg. 42:214-224, 1968.

64. Fabrikant, J.I. Cell proliferation during lymphopoiesis in the thymus of continuously irradiated mice. (In) Effects of Radiation on Cellular Proliferation and Differentiation, pp. 269-393, I.A.E.A., Vienna, 1968.

65. Fabrikant, J.I., Wisseman, C.L., III, and Vitak, M.J. The kinetics of cellular proliferation in normal and malignant tissues, II. An in vitro method for incorporation of tritiated thymidine in human tissues. Radiology 92:1309-1320, 1969.

66. Fabrikant, J.I. Studies on cell population kinetics in regenerating liver. (In) Human Tumor Cell Kinetics, Nat. Cancer Inst. Monogr. No. 30:169-183, 1969.

67. Fabrikant, J.I. and Cherry, J. The kinetics of cellular proliferation in normal and malignant tissues. III. Cell proliferation in the larynx. Ann. Otol., Rhinol, Laryngol. 78:326-341, 1969.

68. Hoopes, J.E., Dellon, A.L., Fabrikant, J.I. and Soliman, H. The locus of levator veli palatini function as a measure of velopharyngeal incompetence. Plastic Reconstr. Surg. 44:155-160, 1969.

69. Fabrikant, J.I. and Foster, B.R. The kinetics of lymphoid cell proliferation during radiation lymphomogenesis in C57BL mice. Radiation Res. 39:544, 1969.

70. Fabrikant, J.I and Cherry, J. The kinetics of cellular proliferation in normal and malignant tissues. V. Analysis of labeling indices and potential doubling times in human tumor cell populations. J. Surg. Oncol. 1:27-51, 1969.

71. Fabrikant, J.I Size of proliferating pools in regenerating liver. Exp. Cell Res., 55:277-279, 1969.

72. Fabrikant, J.I. Radiation response in relation to the cell cycle in vivo. Amer. J. Roentgenol., Rad. Therapy and Nuclear Med. 105:734-745, 1969.

73. Fabrikant, J.I. Studies on cell population kinetics in radiation leukomogenesis. Assn. Univ. Radiologists 17:88, 1969.

74. Fabrikant, J.I. and Foster, B.R. Cell cycle of lymphocytes in mouse thymus. Die Naturwissenschaften 57:567, 1969.

75. Fabrikant, J.I. Cell proliferation in continuously irradiated mammals; Effect of age. (In) Radiation Biology of the Fetal and Juvenile Mammal, (Sikov, M. and Mahlum, D.D., eds.), USAEC, CONF. 690501, pp. 621-628, Oak Ridge, Tenn., 1969.

76. Fabrikant, J.I. The kinetics of cellular proliferation in the seminiferous epithelium under continuous irradiation. XII Intern. Congr. Radiology 12:98, 1969.

77. Fabrikant, J.I. Radiation effects on lymphopoiesis under continuous low dose-rate exposure. Radiology 93:877-893, 1969.

78. Fabrikant, J.I. Research on cell proliferation in normal and malignant human tissues. (In) James Picker Foundation Annual Report, 1968, pp. 45-50, New York, 1969.

79. Fabrikant, J.I. Cell proliferation in normal and malignant human tissues. (In) James Picker Foundation Annual Report, 1969, pp. 40-42, New York, 1969.

80. Fabrikant, J.I. and Wisseman, C.L., III. In vitro incorporation of tritiated thymidine in normal and neoplastic tissues. (In) Year Book of Radiology, (Holt, J.F., Whitehouse, W.M. and Latourette, H.B., eds.), pp. 383-384, Year Book Medical, Chicago, 1969.

81. Hoopes, J.E., Dellon, A.L., Fabrikant, J.I. and Soliman, A.H. Cineradiographic assessment of combined island flap pushback and pharyngeal flap in the surgical management of submucous cleft palate. Brit. J. Plast. Surg. 23:39-44, 1970.

82. Fabrikant, J.I. Thymus cell population studies during radiation leukemogenesis Amer. J. Roentgenol., Rad. Therapy and Nuclear Med. 108: 729-735, 1970.

83. Fabrikant, J.I. The kinetics of cellular proliferation in normal and malignant tissues. XI. Estimation of DNA synthesis time in human tissues. Radiology 95:691-693, 1970.

84. Hoopes, J.E., Dellon, A.H., Fabrikant, J.I. and Soliman, A.H. idiopathic hypernasality: Cineradiographic evaluation and etiologic considerations. J. Speech Hearing Dis. 35:44-50, 1970.

85. Fabrikant, J.I. and Cherry, J.I. The kinetics of cellular proliferation in normal and malignant tissues. X. Cell proliferation in respiratory epithelium of the nose and adjoining cavities. Ann. Otol., Rhinol., Laryngol. 79:572-578, 1970.

86. Fabrikant, J.I. Environmental radioactivity: Inclusion at the cellular level. Environmental Radioactivity Symposium, Clopton, J.C., ed., pp. 36-106, The Johns Hopkins University Press, Baltimore, Maryland, 1970.

87. Fabrikant, J.I. Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. Supplement 13, 1969. (Book Review) Social Biol. 17:238-241, 1970.

88. Fabrikant, J.. Human tumor cell kinetics. (In) Time and Dose Relationships in Radiation Biology as Applied to Radiotherapy, (Bond, V.P., Suit, H.D. and Marcial, V., eds.), pp. 334-337, BNL 50203(C-57) Brookhaven national Laboratory, Upton, New York, 1970.

89. Hoopes, J.E., Dellon, A.L., Fabrikant, J.I., Edgerton, M.T. and Soliman, A.H. Cineradiographic definition of the functional anatomy and pathophysiology of the velopharyn. Cleft Palate J. 7:443-454, 1970.

90. Hoopes, J.E., Dellon, A.L., Fabrikant, J.I. and Soliman, A.H. Cineradiographic definition of the anatomical variable responsible for cleft palate speech. Brit. J. Plast. Surg. 24:158-162, 1971.

91. Fabrikant, J.I. Radiation response in relation to the cell cycle in vivo. (In) Year Book of Radiology, Holt, J.F., Whitehouse, W.M. and Latourette, H.B., eds., p. 392, Year Book Medical, Chicago, 1970.

92. Fabrikant, J.I. The kinetics of cellular proliferation in human tissues. VII. Determination of duration of DNA synthesis using double labeling autoradiography. Brit. J. Cancer 24:742-749, 1970.

93. Fabrikant, J.I. The kinetics of cellular proliferation in normal and malignant tissues. XII. In vitro label. (In) The Growth Kinetics of Solid Tumors, Williamsburg, Va., February 8-11, 1971, Summary Report of the Meeting. Mendelsohn, M.L. and Shackney, S.E. The growth kinetics of solid tumors. Cell Tissue Kinet. 3:401-414, 1971.

94. Fabrikant, J.I. The kinetics of cellular proliferation in normal and malignant tissues. XV. A review of methodology and the analysis of cell population kinetics in human tissues. Amer. J. Roentgenol., Rad. Therapy and Nuclear Med. 111:700-711, 1971.

95. Delhunty, J.E. and Fabrikant, J.I. Experimental laryngeal arteriography. Ann. Otol., Rhinol., Laryngol. 80:744-749, 1971.

96. Fabrikant, J.I. Cell population kinetics in thymus lymphocytes under continuous irradiation. (In) Biological Aspects of Radiation Protection, (Sugahara, E. and Hug, O., eds.), pp. 74-80, Igaku Shoin, Tokyo, Japan, 1971.

97. Fabrikant, J.I. Spermatogonial cell renewal under continuous low dose irradiation. Invest. Radiol. 6:343, 1971.

98. Fabrikant, J.I. Radiation Biology of the Fetal and Juvenile Mammal. Proc. Ninth Ann. Hanford Biol. Symposium. (Book Review). Radiology 97:659-660, 1971.

99. Chandrasekhar, S., Shima, K., Dannenberg, A.M, Jr., Kambara, T., Fabrikant, J.I. and Roessler, W.G. Radiation, infection and macrophage function. IV. Effect of radiation on the proliferative abilities of mononuclear phagocytes in tuberculosis lesions of rabbits. Infection and Immunity 3:254-259, 1971.

100. Fabrikant, J.I., Wisseman, C.L., III and Vitak, M.J. The kinetics of cellular proliferation in normal and malignant tissues. VI Nucleic acid metabolism in relation to the cell cycle in human tissues. Growth 36:173-183, 1972.

101. Fabrikant, J.I. The effects of small doses of radiation. (In) Reduction of Radiation Dose in Diagnostic X-Ray Procedures, pp. 3-32. Proceedings of a Symposium held in Houston, Texas, July 8, 1971. Amer. Assoc. Phys. Med., USDHEW Publ. No. (FDA) 73-8009, Bureau of Radiological Health, Rockville, Md., 1972.

102. Fabrikant, J.I. Spermatogonial cell renewal under continuous low dose irradiation. Amer. J. Roentgenol., Rad. Therapy and Nuclear Med. 114:792-802, 1972.

103. Fabrikant, J.I. Radiation effects on rapidly and slowly proliferating cell renewal systems. Discussion. Front. Radiation Ther. Oncol. 6:524-526, 1972.

104. Fabrikant, J.I. and Foster, B.R. Lymphoid cell renewal under low-level irradiation. XI. The cell cycle and growth kinetics during radiation leukemogenesis of C57BL mice. Radiology 104:203-204, 1972.

105. Fabrikant, J.I. Radiation effects on rapidly and slowly proliferating cell renewal systems. (In) Frontiers of Radiation Therapy and Oncology, Vaeth, J.M., eds., Vol. 6, pp. 57-78, Karger, Basel, 1972.

106. Fabrikant, J.I. Medical Radiation Biology. (Book Review). Radiology 105:434, 1972.

107. Fabrikant, J.I. Cell population kinetics in the seminiferous epithelium under continuous low dose rate irradiation. (In) Advances in Radiation Research. Biology and Medicine. Vol II. (Duplan, J.F. and Chapiro, A., eds.), pp. 805-814, Gordon and Breach, New York, 1972.

108. Fabrikant, J.I. and Foster, B.R. Cell population kinetics in mouse and rat thymus. J. Hopkins Med. J. 130:208-215, 1972.

109. Fabrikant, J.I., Hsu, T.H.S., Knudson, D.H. and Smith, C.L.D. LET and radiation carcinogenesis. The effects of fractionation of dose of plutonium-239, americium-241, phosphorus-32 and x-rays on the production of osteosarcomas in rats. (In) Radionuclide Carcinogenesis, 12th Hanford Biology Symposium, pp. 322-346, (Sanders, C.L., Busch, R.H., Ballou, J.E., Mahlum, D.D., eds.), CONF-720505, USAEC. Oak Ridge, Tenn., 1973.

110. Fabrikant, J.I. Radiation dosimetry of heavily irradiated sites in patients treated for ankylosing spondylitis. (In) The Effects on Populations of Exposure to Low Levels of Ionizing Radiation. Report of the Advisory Committee on Biological Effects of Ionizing Radiations, pp. 190-195. National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1972.

111. Shima, K., Dannenberg, A.M., Jr., Ando, M., Chandrasekhar, S., Seluicki, J. and Fabrikant, J.I. Macrophage accumulation, division, maturation, and digestive and microbial capacities of tritiated thymidine and their content of lysomal enzymes and bacilli. Amer. J. Pathol. 66:143, 1972.

112. Delahunty, J.E. and Fabrikant, J.I. Experimental laryngeal arteriography. Radiology 103:227, 1972.

113. Fabrikant, J.I. Public health considerations of the biological effects of small doses of medical radiation. (In) Health Physics in the Healing Arts, pp. 31-42, DHEW Publication (FDA) 73-8029, Food and Drug Administration, Bureau of Radiological Health, NTIS, Springfield, Va., 1973.

114. Fabrikant, J.I., Hsu, T.H.S., Kovar, D.H. and Smith, C.L.D. Radiation- induced osteosarcomas in rats. Delayed effects of bone-seeking radionuclides and x-rays. Invest. Radiol. 8:269, 1973.

115. Fabrikant, J.I. Lymphoid cell renewal under low level irradiation. XV. Regulation of lymphopoiesis under continuous exposure. (In) Symposium on Long-Term Effects--Low Level Radiation Doses. Proc. XIII International Congress of Radiology, p. 518, Madrid, Spain, 1973.

116. Fabrikant, J.I. Some implications of the 1972 Report of the Advisory Committee on the Biological Effects of Ionizing Radiations (The BEIR Report) of the National Academy of Sciences-National Research Council. (In) Report of the Eleventh Meeting of the Medical Radiation Advisory Committee, Bureau of Radiological Health, FDA, DHEW, Rockville, Md., September 13-14, 1973.

117. Fabrikant, J.I. The cell cycle in lymphoid tissues and the immune response. (In) The Cell Cycle in Malignancy and Immunity, (Hampton, J., ed.), Thirteenth Hanford Biology Symposium, pp. 504-530,(CONF-731005) NTIS, Springfield, Va., 1974.

118. Fabrikant, J.I. Tumor cell population kinetics under continuous irradiation. Proc. XIII Intern. Congress Radiology, Madrid, Spain, 1973, pp. 585-589, Excerpta Medica, Amsterdam, 1975.

119. Fabrikant, J.I. Medical Radiation. Second Report to the Advisory Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences-National Research Council, 59, pp., Washington, D.C., 1974.

120. Fabrikant, J.I. Concepts: cost-benefit analysis and medical radiation. Report to the Advisory Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences-National Research council, 18 pp., Washington, D.C.., 1975.

121. Fabrikant, J.I. The significance to diagnostic radiology of the effects of exposure to low levels of ionizing radiations. Clinical Radiol. 33:172-179, 1975.

122. Fabrikant, J.I. Benefit-Risk-Cost Analysis for Medical Radiation. Chapter VI. (In) Considerations of Health Benefit-Risk-Cost Analysis for Activities Involving Ionizing Radiation Exposure and Alternatives. Report of the Advisory Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences-National Research Council, 147 pp., National Academy Press, Washington, D.C., 1976.

123. Hsu, T.H.S. and Fabrikant, J.I. Spermatogonial cell renewal under continuous irradiation at 1.8 and 4.5 rads per day. (In) Biological and Environmental Effects of Low-Level Irradiation. Vol. 1, pp. 157-168.

124. Fabrikant, J.I. Benefit-cost analysis in diagnostic radiology. (In) Panel on Efficiency, Cost-Benefit Analysis and Health Resource Allocation in Radiology. James Picker Foundation Conference, The Radiologist in Society--Prospects and Problems for the 1980s. Kay Biscayne, Florida, April 1977.

125. Fabrikant, J.I. and Hilberg, A.W. Benefit-cost analysis for diagnostic radiology in medicine. (In) Symposium on Risks and Benefits in Medical Radiation Applications. XIV International Congress of Radiology, Rio de Janeiro, Brazil, 1977.

126. Fabrikant, J.I. Safety in Diagnostic Ultrasound. (In) CRC Critical Reviews in Diagnostic Imaging, Wang, Y., ed., CRC Press, Vol. 10, pp. 219-234, 1977.

127. Fabrikant, J.I. Perspectives of decision-making and estimation of risk in populations exposed to low levels of ionizing radiation. (In) Symposium on Epidemiology Studies of Low Level Radiation Exposure. AAAS Annual Meeting, Houston, Texas, January 1979.

128. Fabrikant, J.I. Cell cycle of spermatogonia in mouse testes. Invest. Radiol. 14:189-191, 1979.

129. Fabrikant, J.I. The 1979 report of the Advisory Committee on the Biological Effects of Ionizing Radiation (the BEIR Report): The Effects on Populations to Exposure to Low Levels of Ionizing Radiation. Implications for Nuclear Energy and Medical Radiation. (In) Symposium on Known Effects of Low Level Radiation Exposures, pp. 1-42, (National Cancer Institute), Pittsburgh, Pennsylvania, April 1979, Lawrence Berkeley Laboratory Report LBL-9084, University of California, Berkeley, 1979.

130. Fabrikant, J.I. Spermatogonial stem cell renewal following irradiation. (In) Symposium on Radiation and Stem Cells. VI Intern. Congr. Radiation Research. Proceedings of the Congress, Tokyo, May, 1979, Lawrence Berkeley Laboratory Report LBL-8667, University of California, Berkeley, 1979.

131. Fabrikant, J.I. Degeneration and regeneration of the spermatogonial stem- cell system after exposure to ionizing radiation. Lawrence Berkeley Laboratory Report LBL-8850, pp. 1-25, University of California, Berkeley, 1979.

132. Fabrikant, J.I. Perspectives of decision-making and estimation of risk in populations exposed to low levels of ionizing radiations. (In) Symposium on Epidemiology Studies of Low-Level Radiation Exposure, AAAS Annual Meeting, Houston, Texas, January 3-8, 1979; Lawrence Berkeley Laboratory Report LBL-8667, pp. 1-40, University of California, Berkeley, 1979.

133. Fabrikant, J.I. Fertility. Somatic Effects: Effects Other Than Cancer. The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. Chapter V, pp. 493-499, Report of the Committee on the Biological Effects of Ionizing Radiations. National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1980, Lawrence Berkeley Laboratory Report LBL-8704, University of California, Berkeley, 1979.

134. Fabrikant, J.I. Salivary Glands. Somatic Effects: Cancer. (In) The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. Chapter V, pp. 392-396, Report of the Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences- National Research Council, National Academy Press, Washington, D.C., 1980, Lawrence Berkeley Laboratory Report LBL-8708, University of California, Berkeley, 1979.

135. Fabrikant, J.I. and Lyman, J.T. Estimates of radiation doses in tissues and organs in the single-course radiotherapy patients treated for ankylosing spondylitis in England and Wales. Somatic Effects: Cancer. (In) The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. Chapter V, pp. 160-167, Report of the Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1980, Lawrence Berkeley Laboratory Report LBL-8708, University of California, Berkeley, 1979.

136. Fabrikant, J.I. and Land, C.E. Pancreas. Somatic Effects: Cancer. (In) The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. Chapter V, pp. 384-389, Report of the Committee on the Biological Effects of Radiations, National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1980, Lawrence Berkeley Laboratory Report LBL-8710, University of California, Berkeley, 1979.

137. Fabrikant, J.I. Pharynx, hypopharynx, and larynx. Somatic Effects: Cancer. (In) The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. Chapter V, pp. 389-392, Report of the Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1980, Lawrence Berkeley Laboratory Report LBL-8711, University of California, Berkeley, 1979.

138. Fabrikant, J.I. Introductory Material. Somatic Effects: Cancer. A. Mechanisms of Radiation Carcinogenesis. B. Concepts of Somatic Effects. (In) The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. pp. 1-14, Report of the Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., Lawrence Berkeley Laboratory Report LBL-8715, University of California, Berkeley, 1979.

139. Fabrikant, J.I. Ovary. Somatic Effects: Cancer. (In) The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. Chapter V, pp. 406-409, Report of the Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1980, Lawrence Berkeley Laboratory Report LBL-8743. University of California, Berkeley, 1979.

140. Fabrikant, J.I. Degeneration and regeneration of the spermatogonial stem-cell system after exposure to ionizing radiation. Presented at the Symposium on Radiation and Stem Cells, VI Intern. Congr. Radiation Research, Tokyo, Japan, May 13-19, 1979. Lawrence Berkeley Laboratory Report LBl-8850, pp. 1-25. University of California, Berkeley, 1979.

141. Fabrikant, J.I. Health effects of low-level ionizing radiation. Presented before the U.S. Senate Committee on Human Resources, Subcommittee on Health and Scientific Research. Official Record of the U.S. Senate Hearings of April 4, 1979, GPO, Washington, D.C. Lawrence Berkeley Laboratory Report LBL-9018. University of California, Berkeley, 1979.

142. Tobias, C.A., Fabrikant, J.I., Holley, W.R., and Benton, E.V. Heavy-ion radiography. Lawrence Berkeley Laboratory Report, LBL-10022, UC-48, pp. 63-67, University of California, Berkeley, 1979.

143. Holley, W.R., Henke, R.P., Gauger, G.E., Jones, B., Benton, E.V., Fabrikant, J.I., and Tobias, C.A. Heavy particle computed tomography. (In) Sixth Symposium on Computer Radiology, 1979 IEEE, pp. 64-70, 1979.

144. Fabrikant, J.I. Summary of the Public Health and Safety Task Force Report to The President's Commission on the Accident at Three Mile Island (In) Public Health and Safety Task Force Report to The President's Commission on the Accident at Three Mile Island. (Fabrikant, J.I., ed.), 32 pp., Government Printing Office, Washington, D.C., 1979.

145. Axelrod, D., Bluestone, M., Densen, P.M., Fabrikant, J.I., Fowinkle, E.W., Johnson, K.G., Jones, E.W., and Seltser, R. Technical Staff Analysis Report on Public Health and Epidemiology. (In) Public Health and Safety Task Force Report to The President's Commission on the Accident at Three Mile Island. (Fabrikant, J.I., ed.), 147 pp., Government Printing Office, Washington, D.C., 1979.

146. Abrahamson, S., Bair, W.J., Bender, M.A., Bloom, A.D., Bond, V.P., Casarett, G.W., and Fabrikant, J.I. Technical Staff Analysis Report on Report of the Radiation Health Effects Task Group. (In) Public Health and Safety Task Force Report to The President's Commission on the Accident at Three Mile Island. (Fabrikant, J.I., ed.), 98 pp., Government Printing Office, Washington, D.C., 1979.

147. Fabrikant, J.I. The BEIR-III Report and the health effects of low-level radiation. (In) Symposium on Nuclear Reactor Safety: A Current Perspective. AAAS, San Francisco, 1980. Lawrence Berkeley Laboratory Report LBL-10383, University of California, Berkeley, 1980.

148. Fabrikant, J.I. The 1979 Report of the Advisory Committee on the Biological Effects of Ionizing Radiation (The BEIR Report). The Effects on Populations of Exposure to Low Levels of Ionizing

Radiation. Implications for Nuclear Energy and Medical Radiation. (In) Known Effects of Low Level Radiation Exposure Health Implications of TMI Accident (Shrivastava, P.N., ed.), pp. 79-104. Division of Cancer Control and Rehabilitation of the National Cancer Institute, Mideast Center for Radiological Physics, Pittsburgh, Pennsylvania, April 25, 1979, NIH Publication 80-2087, 1980. Lawrence Berkeley Laboratory Report LBL-9084, University of California, Berkeley, 1980.

149. Fabrikant, J.I. The BEIR-III Report and its implications for radiation protection and public health policy. (In) Proceedings of the International Radiation Protection Association, Fifth International Congress, Jerusalem, March 9-14, 1980. Lawrence Berkeley Laboratory Report LBL-10494, Unversity of California, Berkeley, 1980.

150. Fabrikant, J.I. Current understanding of the relation between radiation exposure and the induction of developmental disabilities. (In) Symposium on Prevention of Mental Retardation: Opportunities and Obstacles 1980, III. Environmental Hazards; Special Concerns, American Association on Mental Deficiency, 104th Annual Meeting, San Francisco, 1980.

151. Fabrikant, J.I. Health effects of the nuclear accident at Three Mile Island. (In) Conference on Environmental Regulation of the Nuclear Industry: A New Decade. Atomic Industrial Forum, San Francisco, California, May 18-21, 1980.

152. Fabrikant, J.I. The BEIR-III controversy. Radiation Research Society, New Orleans, Louisiana. June 1, 1980. Lawrence Berkeley Laboratory Report LBL-11268, University of California, Berkeley, 1980.

153. Tobias, C.A., Fabrikant, J.I., Benton, E.V. and Holley, W.R. Projection radiography and tomography. (In) Biological and Medical Research with Accelerated Heavy Ions at the Bevalac 1977-1980. (Pirrucello, M. and Tobias, C.A., eds.), pp. 335-346. Lawrence Berkeley Laboratory Report LBL-11220, University of California, Berkeley, 1980.

154. Fabrikant, J.I., Tobias, C.A., Capp, M.P., Holley, W.R., Woodruff, K.H. and Sickles, S.A. Heavy-ion mammography and breast cancer. (In) Biological and Medical Research with Accelerated Heavy Ions at the Bevalac 1977-1980. (Pirruccello, M. and Tobias, C.A., eds.), pp. 347-357. Lawrence Berkeley Laboratory Report LBL-11220, University of California, Berkeley, 1980.

155. Chen, G.T.Y. Fabrikant, J.I., Holley, W.R., Tobias, C.A. and Castro, J.R. Heavy-ion radiography applied to charged particle radiotherapy. (In) Biological and Medical Research with Accelerated Heavy Ions at the Bevalac 1977-1980. (Pirruccello, M. and Tobias, C.A., eds.), pp. 359-366. Lawrence Berkeley Laboratory Report LBL-11220, University of California, Berkeley, 1980.

156. Llacer, J., Chu, W.T., Tobias, C.A., Fabrikant, J.I., and Alonzo, J.R. Active heavy-ion radiography and computerized tomography. (In) Biological and Medical Research with Accelerated Heavy Ions at the Bevalac 1977-1980. (Pirruccello, M. and Tobias, C.A., eds.), pp. 367-374. Lawrence Berkeley Laboratory Report LBL-11220, University of California, Berkeley, 1980.

157. Fabrikant, J.I, Budinger, T.F., Tobias, C.A., and Born, J.L. Focal lesions in the central nervous system. (In) Biological and Medical Research with Accelerated Heavy Ions at the Bevalac 1977-1980. (Pirruccello, M.and Tobias, C.A., eds.), pp. 399-405. Lawrence Berkeley Laboratory Report LBL-11220, University of California, Berkeley, 1980.

158. Fabrikant, J.I., Beebe, G.W., Bender, M.A., Brill, A.B., Land, C.E., Moeller, D.W., and Webster, E.W. Estimating the total cancer risk of low-dose, low-LET, whole-body radiation. (In) The Effects on Populations of Exposure to Low Levels of Ionizing Radiation, 1980.Chapter V, Section 3, pp. 176-226. Report of the Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1980.

159. Fabrikant, J.I. Health effects of the nuclear accident at Three Mile Island. Health Phys. 40:151-161, 1981. Lawrence Berkeley Laboratory Report LBL-11297, University of California, Berkeley, 1980.

160. Fabrikant, J.I. The BEIR-III controversy. Radiation Res. 84:361-368, 1980.

161. Fabrikant, J.I. The contribution of modern medical imaging technology to radiation health effects in exposed populations IEEE Transactions on Nuclear Science, Vol. NS-28, No. 1, pp. 40-46, February 1981. Lawrence Berkeley Laboratory Report LBL-11728, University of California, Berkeley, 1980.

162. Fabrikant, J.I. Public health implications and decision-making during nuclear reactor accidents---the Three Mile Island experience. (In) Proceedings, Symposium on Preparing for the Issues of the 1980's. Annual Meeting, Association of State and Territorial Health Officials, Atlanta, Georgia, 1980.

163. Fabrikant, J.I., Tobias, C.A., Capp, M.P., Benton, E.V. and Holly, W.R. Heavy-ion imaging applied to medicine. Application of Optical Instrumentation in Medicine VIII, SPIE Vol. 233, pp. 255-263, 1981. Lawrence Berkeley laboratory Report LBL-10543, University of California, Berkeley, 1981.

164. Fabrikant, JI. The BEIR-III Report: Origin of the controversy. AJR 136:209-214, 1981. Lawrence Berkeley Laboratory Report LBL-13409, University of California, Berkeley, 1981.

165. Fabrikant, J.I. and Lyman, J.T. Estimates of absolute risk of excess leukemias and cancers arising in heavily irradiated sites in the single-course radiotherapy patients treated for ankylosing spondylitis in England and Wales. Lawrence Berkeley Laboratory Report LBL-13999, University of California, Berkeley, 1981.

166. Fabrikant, J.I., Tobias, C.A., and Pirruccello, M.C. Medical imaging using heavy-ion radiography. (In) Proceedings of the Conference on Biological Imaging, Scripps Clinic and Research Foundation, La Jolla, California, November 1980. Lawrence Berkeley Laboratory Report LBL-12517, University of California, Berkeley, 1981.

167. Fabrikant, J.I. Risk estimation and decision-making: Implications of the 1980 BEIR-III Report. (In) Proceedings of the Conference on Radiation Exposure on Pediatric Dentistry, American Academy of Pedodontics, Cincinnati, Ohio, April 1981. Pediatric Dentistry, 3:400-413, 1981.

168. Fabrikant, J.I. Epidemiological studies on radiation carcinogenesis in human populations following acute exposure: Nuclear explosions and medical radiation. (In) Proceedings of the Symposium on Effects on Humans of Exposure to Low Levels of Ionizing Radiation, Yale University School of Medicine, New Haven, Connecticut, May 1981. Lawrence Berkeley Laboratory Report LBL-13416, University of California, Berkeley, 1981.

169. Fabrikant, J.I. The effects of low-level radiation on human health: Epidemiological studies. (In) The Walter W. Herbert Memorial Symposium: Is Low-dose Radiation Harmful? (In) Diagnostic Radiology 1981. (Margulis, A.R. and Gooding, G.A., eds.), pp. 451-455. University of California, San Francisco, 1981.

170. Fabrikant, J.I. and Tobias, C.A. Heavy-ion radiography and cancer. Donner Laboratory, Lawrence Berkeley Laboratory, PUB-5051, University of California, Berkeley, 1981.

171. Fabrikant, J.I. Impact of the 1980 BEIR-III Report on low-level radiation: Risk assessment. radiation protection guides, and public health policy. (In) Proceedings, Selected Topics in Reactor Health Physics, Fourth Annual HPS Summer School, Lexington, Kentucky, June 1981. NUREG/CP-0039, pp. U1-U30, USNRC, Washington, D.C., December, 1982. Lawrence Berkeley Laboratory Report LBL-13408, University of California, Berkeley, 1981.

172. Fabrikant, J.I. Biological effects of ionizing radiation: Epidemiological surveys and laboratory animal experiments. Implications for risk evaluation and decision processes. Lawrence Berkeley Laboratory Report LBL-12555, University of California, Berkeley, 1981.

173. Fabrikant, J.I. Nuclear energy, public health and public policy. Amer. Public Health Assn, Los Angeles, 1981. Lawrence Berkeley Laboratory Report LBL-13469, University of California, Berkeley, 1981.

174. Fabrikant, J.I. Influence of dose and its distribution in time on dose-response relationships for low-LET radiations. NCRP Report 64, National Council on Radiation Protection and Measurements (Book Review). Health Phys. 42:392-393, 1981.

175. Fabrikant, J.I. Mathematical models and epidemiological surveys: their value in risk assessment of the health effects on populations of exposure to low levels of ionizing radiation. Lawrence Berkeley Laboratory Report LBL-13348, University of California, 1981.

176. Fabrikant, J.I. Is nuclear energy an unacceptable hazard to public health? Lawrence Berkeley Laboratory Report LBL-13586, University of California, Berkeley, 1981.

177. Fabrikant, J.I. The BEIR-III Report and its implications for radiation protection and public health policy. (In) Radiation Protection, A Sytematic Approach to Safety, Vol. I, pp. 1213-1232, Pergamon Press, Oxford, 1981.

178. Fabrikant, J.I. Epidemiological studies on radiation carcinogenesis in human populations following acute exposure: Nuclear explosions and medical radiation. Yale J. Biol. Med. 54:457-469, 1981.

179. Holley, W.R., Tobias, C.A., Fabrikant, J.I., Llacer, J., Chu, W.T. and Benton, E.V. Computerized heavy-ion tomography. SPIE Vol. 273, pp. 283-293, Application of Optical Instrumentation in Medicine IX, 1982. Lawrence Berkeley Laboratory Report LBL-12304, University of California, Berkeley, 1982.

180. Fabrikant, J.I. Controversial issues confronting the BEIR-III Committee-implications for radiation protection. Lawrence Berkeley Laboratory Report LBL-13444, University of California, Berkeley, 1981. (In) Proceedings, Thirteenth Annual National Conference on Radiation Control, Little Rock, Arkansas, May 1981, pp 60-80, U.S. Department of Health and Human Services, USPHS, FDA, Washington, D.C., 1982.

181. Fabrikant, J.I. and Lyman, J.T. Estimates of radiation doses in tissues and organs and risk of excess cancer in the single-course radiotherapy patients treated for ankylosing spondylitis in England and Wales. Lawrence Berkeley Laboratory Report LBL-13999, University of California, Berkeley, 1982.

182. Fabrikant, J.I. and Hilberg, A.W. Cost-benefit analysis in decision making for diagnostic radiology. Lawrence Berkeley Laboratory Report LBL-14000, University of California, Berkeley, 1982.

183. Fabrikant, J.I. Radiation carcinogenesis in man: Influence of dose-response models and risk projection models in the estimation of risk coefficients following exposure to low-level radiation. Lawrence Berkeley Laboratory Report, LBL-14016, University of California, Berkeley, 1982.

184. Fabrikant, J.I. Decision-making and radiological protection at Three Mile Island: Response of the Department of Health, Education, and Welfare. Lawrence Berkeley Laboratory Report, LBL-14021, University of California, Berkeley, 1982.

185. Holley, W.R., Fabrikant, J.I., Tobias, C.A., and Benton, E.V. The physics of heavy-ion radiography and heavy-ion computerized tomography. Lawrence Berkeley Laboratory Report LBL-14316, University of California, Berkeley, 1982.

186. Fabrikant, J.I. Estimation of risk of cancer induction in populations exposed to low-level radiation. Invest. Radiol. 17:342-349, 1982.

187. Fabrikant, J.I., Holley, W.R., McFarland, E.W., and Tobias, C.A. Heavy-ion radiography and heavy-ion computed tomography. Lawrence Berkeley Laboratory Report LBL-14001, University of California, Berkeley, 1982.

188. Fabrikant, J.I. Radiation carcinogenesis in man: Influence of dose-response models and risk projection models in the estimation of risk coefficients following exposure to low-level radiation. (In) Proceedings, Third International Symposium: Radiological Protection---Advances in Theory and Practice, Vol. 1. pp. 39-47, Society for Radiological Protection, Inverness, Scotland, 1982.

189. Fabrikant, J.I., Holley, W.R., McFarland, E.W., and Tobias, C.A. Heavy-ion radiography and heavy-ion computed tomography. (In) Proceedings, Third International Symposium: Radiological Protection---Advances in Theory and Practice, Vol. 1, pp. 175-180, Society for Radiological Protection, Inverness, Scotland, 1982.

190. Fabrikant, J.I. and Lyman, J.T. Estimates of radiation doses in tissues and organs and risk of excess cancer in the patients treated for ankylosing spondylitis in England and Wales. (In) Proceedings, Third International Symposium: Radiological Protection---Advances in Theory and Practice, Vol. I, pp. 398-404, Society for Radiological Protection, Inverness, Scotland, 1982.

191. Fabrikant, J.I. and Hilberg, A.W. Cost-benefit analysis in decision making for diagnostic radiology. (In) Proceedings, Third International Symposium: Radiological Protection---Advances in Theory and Practice, Vol. I, pp. 428-435, Society for Radiological Protection, Inverness, Scotland, 1982.

192. Fabrikant, J.I. Decision-making and radiological protection at Three Mile Island: Response of the Department of Health, Education, and Welfare. (In) Proceedings, Third International Symposium: Radiological Protection---Advances in Theory and Practice, Vol. 2, pp. 756-763, Society for Radiological Protection, Inverness, Scotland, 1982.

193. Fabrikant, J.I. The health effects in women exposed to low levels of ionizing radiation. Lawrence Berkeley Laboratory Report LBL-14198, University of California, Berkeley, 1982.

194. Fabrikant, J.I. Carcinogenesis and low level ionizing radiation with special reference to lung cancer and exposure to radon daughters. Lawrence Berkeley Laboratory Report LBL-14772, University of California, Berkeley, 1982.

195. Benton, E.V., Henke, R.P., Tobias, C.A., Holley, W.R., Fabrikant, J.I., and Henshaw, D.L. Charged particle radiography and computed tomography. (In) Solid State Nuclear Track Detectors, (Fowler, P.H. and Clapham, V.M., eds.), pp. 661-666, Pergamon Press, Oxford, 1982.

196. Holley, W.R., Fabrikant, J.I., Tobias, C.A., and Benton, E.V. The physics of heavy-ion radiography and heavy-ion computed tomography. (In) Proceedings of the International Workshop on Physics and Engineering in Medical Imaging, pp. 318-327, IEEE, Computer Society Press, Los Angeles, 1982.

197. Fabrikant, J.I. Epidemiological studies on radiation carcinogenesis in human populations following acute exposure: Nuclear explosions and medical radiation. Lawrence Berkeley Laboratory Report LBL-13416 (Revised), University of California, Berkeley, 1982.

198. Tobias, C.A., Chu, W., Chatterjee, A., Benton, E.V., Fabrikant, J.I., Holley, W.R., Schmidt, J., Blakely, E., and Hayes, T.L. Special topics in heavy ion research. (In) Pion and Heavy-Ion Radiotherapy: Preclinical and Clinical Studies. pp. 169-193, Skarsgaard, L., ed. Elsevier Science Publishing, New York, 1982.

199. Fabrikant, J.I. Etudes epidemiologiques et experiences sur les animaux de laboratoire: Implications sur l'evaluation du risque et le processus de decision. (In) Evaluation des Risques et Processus de Decision, National Academy of Sciences-National Research Council (USA) et Mouvement Universel de la Responsibilite Scientifique, Orsay, France, Sciences et Devenir de l'Homme, Paris, 154:126-140, 1982.

200. Fabrikant, J.I. The effects of the accident at Three Mile Island on the mental health behavioral responses of the general population and nuclear workers. Health Phys. 45:579-586, 1983.

201. Fabrikant, J.I. Is nuclear energy an unacceptable hazard to health? Health Phys. 45:575-578, 1983.

202. Fabrikant, J.I. Nuclear energy, public health and public policy. Health Phys. 46:739-744, 1983.

203. Fabrikant, J.I. Radiation and health. West. J. Med. 138:387-390, 1983.

204. Fabrikant, J.I., Lyman, J.T., and Hosobuchi, Y. Stereotactic heavy-ion Bragg peak radiosurgery for intracranial vascular disorders: Method of treatment for deep arteriovenous malformations. Brit. J. Radiology 57:479-490, 1984.

205. Woodruff, K.H., Lyman, J.T, Lawrence, J.H., Tobias, C.A, Born, J.L., and Fabrikant, J.I. Delayed sequelae of pituitary irradiation. Human Pathol. 15:48-54, 1984.

206. Lyman, J.T., Fabrikant, J.I., and Frankel, K.A. Charged-particle stereotactic radiosurgery. Nuclear Instruments Methods in Physics B 10/11: 1107-1110, 1985.

207. Fabrikant, J.I., Lyman, J.T., and Hosobuchi, Y. Stereotactic heavy-ion Bragg peak radiosurgery for intracranial vascular disorders. (In) Neurosurgery, Wilkins, R.H., ed., pp. 1128-1132, McGraw-Hill, New York, 1985.

208. Fabrikant, J.I., Lyman, J.T., and Frankel, K.A. Heavy charged-particle Bragg peak radiosurgery for intracranial vascular disorders. Radiat. Res., 104:S-244-S-258, 1985.

209. Lyman, J.T., Kanstein, L., Yeater, F., Fabrikant, J.I., and Frankel, K.A. A helium-ion beam for stereotactic radiosurgery of central nervous system disorders. Medical Phys. 13:695-699, 1986.

210. Glicksman, A.S., Fabrikant, J.I. Analysis of post-irradiation sarcomas: correlation of clinical data with experimental results. (In) International Symposium on Biological Effects of Low Level Radiation. Wei, L., Wu, D.C., Wang, X.H., eds., pp. 4-22, Society of Radiological Medicine and Protection, Chinese Medical Association, Nanjing, China, 1986.

211. Fabrikant, J.I. Application of consensus reports used in litigation BEIR, NCRP, ICRP. (In) Basic Concepts of Radiation for Attorneys. Ricks, R., ed. REAC/TC Oak Ridge Associated Universities, Oak Ridge, Tenn., 1986.

212. Glicksman, A.S. and Fabrikant, J.I. Analysis of post-irradiation sarcomas: Correlation of clinical data with experimental results. (In) Proceedings, International Symposium on Biological Effects of Low Level Radiation. Wei, L., Wu, D.C., Wang, J.X.H., eds., pp. 124-142, Nanjing, China, 1987.

213. Fabrikant, J.I. Adaptation of cell renewal systems under continuous irradiation. Health Phys. 52:561-570, 1987.

214. Phillips, M.H., Tobias, C.A., Ludewigt, B., Wong, M. Schimmerling, W., Frankel, K.A., and Fabrikant, J.I. Multiple scattering of fast heavy ion beams for biomedical uses. (In) Third Workshop on Heavy Charged Particles in Biology and Medicine, Kraft, G., Grundinger, U., eds., GSI Report GSI-87-11, 1987.

215. Rosander, K. Frankel, K.A., Cerda, H., Fabrikant, I.B., Lyman, J.T., Fabrikant, J.I. DNA damage in the endothelial cells of the mouse brain after heavy ion irradiation. (In) Radiation Research, (Fielden, E.M., Fowler, J.F., Hendry, J.H., Scott, D., eds.), vol. 1, Taylor & Francis, London, 1987.

216. Fabrikant, J.I. The Chernobyl disaster: An international perspective. Industrial Crisis Quart., 1:1-10, 1988.

217. Noorbehest, B., Fabrikant, J.I., Enzmann, D.R. Size determination of supratentorial arteriovenous malformations of MRI, CT and angiography. Neuroradiology 29:512-518, 1987.

218. Fabrikant, J.I. Estimation of risks of radiation-induced cancer in exposed human populations --- technical difficulties and uncertainties. (In) Proceedings, International Symposium on Biological Effects of Low Level Radiation. (Wei, L., Wu, D.C., Wang, J.X.H., eds.), pp. 101-123, Nanjing, China, 1988. Lawrence Berkeley Laboratory Report LBL-24395, University of California, Berkeley, 1988.

219. Fabrikant, J.I. Radon and lung cancer risks: Implications for radiological protection. Society of Nuclear Medicine, Toronto, 1987, Lawrence Berkeley Laboratory Report LBL-24393, University of California, Berkeley, 1988.

220. Fabrikant, J.I. Application of consensus reports used in radiation litigation: 1987. (In) Basic Concepts of Radiation for Attorneys. Ricks, R., ed., REAC/TC, Oak Ridge Associated Universities, Oak Ridge, Tenn., 1987. Lawrence Berkeley Laboratory Report LBL-24391, University of California, Berkeley, 1988.

221. Fabrikant, J.I. Probability of causation: Implications for radiological protection and dose limitation. (In) Proceedings, Annual Conference, Canadian Radiation Protection Association, Saskatoon, Saskatchawan, 1987. Lawrence Berkeley Laboratory Report LBL-24392, University of California, Berkeley, 1988.

222. Fabrikant, J.I. Radiation effects on skin; Implications for radiological control and radiation protection. Health Physics Society, Salt Lake City, Utah, 1987, Lawrence Berkeley Laboratory Report LBL-24389, University of California, Berkeley, 1988.

223. Fabrikant, J.I., Frankel, K.A., Phillips, M.P., Levy, R.P., Lyman, J.T., and Foster, M.L. Heavy charged-particle Bragg peak stereotactic radiosurgery for intracranial arteriovenous malformations. (In) Third Workshop on Heavy Charged Particle in Biology and Medicine, (Kraft, G., Grundinger, U., eds.), GSI Report GSI-87-11, 1987. Lawrence Berkeley Laboratory Report LBL-24390, University of California, Berkeley, 1988.

224. Fabrikant, J.I. Health effects of radon and other internally-deposited alpha-emitters: BEIR IV. Chinese Journal of Radiation Medicine and Radiological Protection (in Chinese, transl. by Prof. Chen Xing-an), 1988.

225. Fabrikant, J.I., Ellett, W.H., Cooper, R.D., Brown, S.L. The 1987 BEIR Report: Alpha Emitting Radionuclides. (In) Radiation Research, (Fielden, E.M., Fowler, J.F., Hendry, J.H., Scott, D., eds.), Taylor & Francis, London, 1987. Lawrence Berkeley Laboratory Report LBL-24178, University of California, Berkeley, 1988.

226. Ellett, W.H., Fabrikant, J.I., Cooper, R.D. The BEIR IV Committee estimates of lung cancer mortality associated with exposure to radon progeny. (In) Proceedings, The Fourth International Symposium on the Natural Radiation Environment, December 7-11, 1987, Lisbon, 1988.

227. Marks, M.P., DeLaPaz, R.L., Fabrikant, J.I., Frankel, K.A., Phillips, M.H., Levy, R.P., Enzmann, D.R. Intracranial arteriovenous malformations: Imaging of charged-particle radiosurgery. Part I. Results of therapy. Radiology 168:447-455, 1988.

228. Marks, M.P., DeLaPaz, R.L., Fabrikant, J.I., Frankel, K.A., Phillips, M.H., Levy, R.P., Enzmann, D.R. Intracranial vascular malformations: Imaging of charged-particle radiosurgery. Part II. Complications. Radiology 168:457-462, 1988.

229. Marks, M.P., O'Donahue, J., Fabrikant, J.I., Frankel, K.A., Phillips, M.H., DeLaPaz, R.L., Enzmann, D.R. Cerebral blood flow evaluation of arteriovenous malformations with stable xenon CT. AJNR 9:1169-1175, 1988.

230. Fabrikant, J.I. The BEIR IV Report. (In) ASA Conference on Radiation and Health: Coolfont VII. (Gilbert, E.S., ed.), pp. 3-7, American Statistical Association, Arlington, VA, 1988.

231. Fabrikant, J.I., Frankel, K.A., Phillips, M.H., and Levy, R.P. Stereotactic heavy-charged Bragg peak radiosurgery for intracranial vascular malformations. (In) Cerebral Vascular Diseases in Children and Adolescents. (Edwards, M.S.B. and Hoffman, H.J., eds.), Chap. 22, Part 2, pp. 389-409, Williams & Wilkins, Baltimore, 1988.

232. Fabrikant, J.I. The health effects of the accident at Three Mile Island. (In) Population Exposure from the Nuclear Fuel Cycle. (Alpen, E.L., Chester, R.O., Fisher, D.R., eds.), pp.343-352, Gordon and Breach, New York, 1988.

233. Woodruff, K.H., Lyman, J.T., Fabrikant, J.I. Heavy charged-particle induced lesions in rabbit cerebral cortex. Int. J. Radiat. Oncol. Biol. Phys., 14:301-307, 1988.

234. Phillips, M.H., Frankel, K.A., Lyman, J.T., Fabrikant, J.I., Levy, R.P. Heavy charged particle stereotactic radiosurgery: Cerebral angiography and CT in the treatment of intracranial vascular malformations. Lawrence Berkeley Laboratory Report LBL-26030, 1988. Int. J. Radiat. Oncol. Biol. Phys. 17:419-426, 1989.

235. Lyman, J.T., Phillips, M.H., Frankel, K.A., Fabrikant, J.I. Stereotactic frame for neuroradiology and charged particle Bragg peak radiosurgery of intracranial disorders. Lawrence Berkeley Laboratory Report LBL-25666, 1988. Int. J. Radiat. Oncol. Biol. Phys., 16:1615-1621, 1989.

236. Phillips, M.H., Frankel, K.A., Lyman, J.T., Fabrikant, J.I., Levy, R.P. Comparison of different radiation types and irradiation geometries in stereotactic radiosurgery. (In) Proceedings, EULIMA Workshop, Potential Value of Light Ion Beam Therapy. (Chauvel, P., Wambersie, A., eds.), pp. 271-294, EUR 12165 EN, Commission of the European Communities. Nice, France, 1989.

237. Fabrikant, J.I., Frankel, K.A., Phillips, M.H., Levy, R.P., Lyman, J.T. Heavy-charged particle Bragg peak radiosurgery for intracranial arteriovenous malformations. (In) Proceedings, EULIMA Workshop on the Potential Value of Light Ion Beam Therapy. (Chauvel, P., Wambersie, A., eds.), pp. 233-245, EUR 12165 EN, Commission on European Communities. Nice, France, 1989.

238. Levy, R.P., Fabrikant, J.I., Frankel, K.A., Phillips, M.H., Lyman, J.T. Stereotactic heavy-charged-particle Bragg peak radiosurgery for the treatment of intracranial arteriovenous malformations in childhood and adolescence. Neurosurgery 24: 841-852, 1989.

239. Fabrikant, J.I., Levy, R.P., Frankel, K.A., Phillips, M.H., Lyman, J.T. Neurosurgical applications of ion beams. Nucl. Instrum. Methods Physics Res. B40/41: 1376-1384, 1989.

240. Fabrikant, J.I., Tokuhata, G. Health effects of the nuclear accident at Three Mile Island. (In) Proceedings, American Nuclear Society, ANS Meeting Washington, DC, 1989.

241. Fabrikant, J.I., Ellett, W.H., Cooper, R.D. The carcinogenic effects in populations of exposure to alpha-emitting radionuclides: The 1988 BEIR IV Report. (In) Low Dose Radiation - Biological Basis of Risk Assessment. 14th L.H. Gray Conference. (Baverstock, K.F., Stather, J.W., eds.), Taylor & Francis, Oxford, 1989.

242. Fabrikant, J.I., Levy, R.P., Frankel, K.A., Phillips, M.H., Lyman, J.T., Chuang, F.Y.S., Steinberg, G.K., Marks, M.P. Stereotactic helium-ion radiosurgery for the treatment of intracranial arteriovenous malformations. (In) Proceedings, International Workshop on Proton and Narrow Photon Beam Therapy, (Heikkinen, E., Kiviniitty, K., eds.), pp. 33-37, Oulu, Finland, 1989.

243. Levy, R.P., Fabrikant, J.I., Lyman, J.T., Frankel, K.A., Phillips, M.H., Lawrence, J.H., Tobias, C.A. Clinical results of stereotactic helium-ion radiosurgery of the pituitary gland at Lawrence Berkeley Laboratory. (In) Proceedings, International Workshop on Proton and Narrow Photon Beam Therapy, (Heikkinen, E., Kiviniitty, K., eds.), pp. 38-42, Oulu, Finland, 1989.

244. Lyman, J.T., Phillips, M.H., Frankel, K.A., Fabrikant, J.I., Levy R.P. Heavy-charged-particle beams for stereotactic radiosurgery. Lawrence Berkeley Laboratory Report LBL-28250, 1989. (In) Proceedings, International Workshop on Proton and Narrow Photon Beam Therapy, (Heikkinen, E., Kiviniitty, K., eds.), pp. 43-47, Oulu, Finland, 1989.

245. Fabrikant, J.I. The health risks of radon: the BEIR IV Report and beyond. Lawrence Berkeley Laboratory Report LBL-27448, University of California, Berkeley, 1989.

246. Lo, E.H., Frankel, K.A. DeLaPaz, R.L., Poljak, A., Woodruff, K., Brennan, K., Phillips, M.H., Valk, P., Steinberg, G.K., Fabrikant, J.I. Cerebrovascular and metabolic perturbations in delayed heavy charged particle radiation injury. Brain Res., 504: 168-172, 1989.

247. Frankel, K.A., Lo, E.H., Phillips, M.H., Fabrikant, J.I., Brennan, K., Valk, P., Poljak, A., DeLaPaz, R.L., Woodruff, K. Damage and repair of irradiated mammalian brain. Lawrence Berkeley Laboratory Report LBL-27582, University of California, Berkeley, 1989.

248. Lo, E.H., Frankel, K.A., Phillips, M.H., Levy, R.P., Fabrikant, J.I., Lyman, Focal heavy charged particle beams as neural probes of central nervous system physiology and pathology. Lawrence Berkeley Laboratory Report LBL-28687, University of California, Berkeley, 1989.

249. Frankel, K.A., Kjos, B., Lyman, J.T., Lo, E.H., Fabrikant, J.I. NMR imaging of irradiated rat brain. Lawrence Berkeley Laboratory Report LBID-1552. University of California, Berkeley, 1989.

250. Phillips, M.H., Frankel, K.A., Lyman, J.T., Fabrikant, J.I., Levy, R.P. Comparison of radiation types and irradiation geometries for use in stereotactic radiosurgery. Int. J. Radiat. Oncol. Biol. Phys., 8:211-220, 1990.

251. Phillips, M.H., Kessler, M., Chuang, F.A., Frankel, K.A., Lyman, J.T., Fabrikant, J.I., Levy, R.P. Image correlation of MRI, CT and cerebral angiography in the treatment planning for radiosurgery of intracranial arteriovenous malformations. Lawrence Berkeley Laboratory Report LBL-27523, 1990. Int. J. Radiat. Oncol. Biol. Phys., 1990 (in press).

252. Fabrikant, J.I. Factors that modify risks of radiation-induced cancer. Lawrence Berkeley Laboratory Report LBL-28599, 1990. Health Phys., 59:77-87, 1990.

253. Fabrikant, J.I. Radon and lung cancer: the BEIR IV Report. Lawrence Berkeley Laboratory Report LBL-28636, 1990. Health Phys., 59:89-97, 1990.

254. Fabrikant, J.I. Shelter and indoor air in the twenty-first century: Radon, smoking and lung cancer risks. (In) Environmental Health Perspectives. National Institute of Environmental Health Sciences, Research Triangle, NC, 86:275-280, 1990.

255. Fabrikant, J.I., Levy, R.P., Phillips, M.H., Frankel, K.A., Lyman, J.T., Steinberg, G.K., Marks, M.P., Chuang, F.Y.S. Clinical results of stereotactic heavy charged particle radiosurgery for intracranial arteriovenous malformations. Lawrence Berkeley Laboratory Report LBL-28252, 1989. (In) Proceedings, Radiosurgery. A Neurosurgical Approach to Intracranial Lesions, (Steiner, L., ed), Charlottesville, VA, 1990 (in press).

256. Fabrikant, J.I., Levy, R.P., Frankel, K.A., Phillips, M.H., Steinberg, G.K., Marks, M.P. Clinical-radiological evaluation of sequelae of stereotactic radiosurgery. (In) Proceedings, Radiosurgery. A Neurosurgical Approach to Intracranial Lesions, (Steiner, L., ed.), Charlottesville, VA, 1990 (in press).

257. Frankel, K.A., Phillips, M.H., Lyman, J.T., Chuang, F.Y.S., Fabrikant, J.I., Levy, R.P., Rosander, K. Treatment planning for stereotactic radiosurgery of intracranial arteriovenous malformations. Lawrence Berkeley Laboratory Report LBL-27919, 1989. (In) Proceedings, Radiosurgery. A Neurosurgical Approach to Intracranial Lesions, (Steiner, L., ed.), Charlottesville, VA, 1990 (in press).

258. Levy, R.P., Fabrikant, J.I., Phillips, M.P., Frankel, K.A., Steinberg, G.K., Marks, M.P., DeLaPaz, R.L. Chuang, F.Y.S. Stereotactic heavy-charged particle Bragg peak radiosurgery for the treatment of intracranial angiographically occult vascular malformations. (In) Proceedings, Radiosurgery. A Neurosurgical Approach to Intracranial Lesions, (Steiner, L., ed.), Charlottesville VA, 1990 (in press).

259. Lo, E.H., Frankel, K.A., Poljak, A., Phillips, M.H., Fabrikant, J.I., Levy, R.P., Woodruff, K., Brennan, K.M., Valk, P.E., DeLaPaz, R., Focal heavy charged particle irradiation of the mammalian cortex: temporal pattern of changes followed by magnetic resonance imaging and positron emission tomography. Lawrence Berkeley Laboratory Report LBL-27638, 1989. (In) Proceedings, Radiosurgery. A Neurosurgical Approach to Intracranial Lesions, (Steiner, L., ed.), Charlottsville, VA, 1990 (in press).

260. Rosander K.M., Frankel, K.A., Phillips, M.H., Lo, E.H., Fabrikant, J.I., Levy, R.P. DNA damage in mammalian cells following heavy-ion irradiation. Lawrence Berkeley Laboratory Report LBL-27918, 1989. (In) Proceedings, Radiosurgery, A Neurosurgical Approach to Intracranial Lesions, (Steiner, L., ed.), Charlottesville, VA, 1990 (in press).

261. Levy, R.P., Fabrikant, J.I., Frankel, K.A., Phillips, M.H., Steinberg, G.K., Marks, R.L., DeLaPaz, R. L., Chuang, F.Y.S. Clinical-radiological evaluation of sequelae of stereotactic radiosurgery for intracranial arteriovenous malformations. Lawrence Berkeley Laboratory Report LBL-28255, 1989. (In) Proceedings, Radiosurgery. A Neurosurgical Approach to Intracranial Lesions, (Steiner, L., ed.), Charlottesville, VA, 1990 (in press).

262. Levy, R.P., Fabrikant, J.I., Lyman, J.T., Frankel, K.A., Phillips, M.H., Lawrence, J.H., Tobias, C.A., Clinical results of stereotactic helium-ion radiosurgery of the pituitary gland at Lawrence Berkeley Laboratory. Lawrence Berkeley Laboratory Report LBL-28253, 1989. (In) Proceedings, Radiosurgery, A Neurosurgical Approach to Intracranial Lesions, (Steiner, L., ed.), Charlottesville, VA, 1990 (in press).

263. Levy, R.P., Fabrikant, J.I., Phillips, M.H., Frankel, K.A., Steinberg, G.K., Marks, M.P., DeLaPaz, R.L., Chuang, F.Y.S. Clinical results of stereotactic heavy-charged-particle radiosurgery for intracranial angiographically occult vascular malformations. Lawrence Berkeley Laboratory Report LBL-28254, 1989. (In) Proceedings, Radiosurgery, A Neurosurgical Approach to Intracranial Lesions, (Steiner, L., ed.), Charlottesville, VA, 1990 (in press).

264. Lo, E.H., Fabrikant, J.I., Levy, R.P., Phillips, M.H., Frankel, K.A., Alpen, E.L. A compartmental flow model for assessing hemodynamic response of intracranial AVMs to stereotactic radiosurgery. Lawrence Berkeley Laboratory Report LBL-28598, 1990. Neurosurgery, 1990 (submitted).

265. Phillips, M.H., Frankel, K.A., Tjoa, T., Lyman, J.T., Fabrikant, J.I., Levy, R.P. Effects of target size on the comparison of photon and charged particle dose distributions. (In) Proceedings, International Heavy Particle Therapy Workshop, (Blattman, H., ed.), pp. 24-26, Paul Scherrer Institute, Villigen, Switzerland, Sept 18-20, 1989. 1990.

266. Steinberg, G.K., Fabrikant, J.I., Marks, M.P., Levy, R.P., Frankel, K.A., Phillips, M.H., Shuer, L.M., Silverberg, G.D. Stereotactic heavy-charged-particle Bragg peak radiosurgery for intracranial vascular malformations. NEJM 323:96-101,1990.

267. Fabrikant, J.I. Modifying factors that influence the carcinogenic effects of ionizing radiation. (In) Radiation Biology, (Riklis, E., ed.), VCH, Weinheim/Deerfield Beach, FL, 1990 (in press).

268. Levy, R.P., Fabrikant, J.I., Steinberg, G.K., Frankel, K.A., Phillips, M.H., Marks, M.P., DeLaPaz, R.L., Chuang, F.Y.S., Lyman, J.T., Silverberg, G.D., Stereotactic heavy-charged-particle Bragg peak radiosurgery for the treatment of angiographically occult vascular malformations of the brain. Neurosurgery, 1990 (submitted).

269. Fabrikant, J.I. the carcinogenic risks of low-LET and high-LET ionizing radiations. Lawrence Berkeley Laboratory Report LBL-27728, 1990. J. Japan. Radiat. Res., 1990 (in press).

BOOKS AND CHAPTERS

1. Fabrikant, J.I. Studies on Cell Proliferation in the Regenerating Liver and the Effect of Prior Continuous Irradiation. Ph.D. Thesis, University of London, London, 1964.

2. Fabrikant, J.I. and Donner, M.W., eds. Russell H. Morgan, A Tribute, duPont, Wilmington, Delaware, 1967.

3. Fabrikant, J.I. The Effects of Continuous Irradiation. (In) Pathology of Irradiation. (Berdjis, C.C., ed.), Chapter 4, pp. 50-85, Williams and Wilkins, Baltimore, Maryland, 1971.

4. Fabrikant, J.I. The Effects of Irradiation on the Kinetics of Proliferation in Cell Renewal Systems. (In) CRC Critical Reviews in Radiological Sciences. (Wang, C., ed.), Vol. 2, pp. 525-576, CRC Press, Cleveland, Ohio, 1971.

5. Fabrikant, J.I. Radiobiology. Year Book Medical Publishers, Chicago, Illinois, 1972.

6. Fabrikant, J.I. The Kinetics of Cell Proliferation in Normal Tissue, Malignant Tumors of the Upper Air Passages. (In) The Biological and Clinical Basis of Radiosensitivity. (Friedman, M., ed.), Chapter 13, pp. 274-313, Charles C. Thomas Publishers, Springfield, Illinois, 1974.

7. Casarett, G., Abrahamson, S., Alpen, E.L., Baram, M.S., Brown, J.M., Comar, C.L., Eden, M., Falk, H.L., Gregg, E.C., Hutchison, G.B., Fabrikant, J.I., Krutilla, J.V., Lewis, E.B., Netschert, B.C., Rall, D.P., Rall, J.E., Russell, W.L., Smithers, O., Upton, A.C. Considerations of Health Benefit-Cost Analysis for Activities Involving Ionizing Radiation Exposure and Alternatives. A Report of Advisory Committee on the Biological Effects of Ionizing Radiations. National Research Council, National Academy of Sciences, Washington, D.C., 1977.

8. Fabrikant, J.I. Safety in Diagnostic Ultrasound. (In) CRC Critical Reviews in Diagnostic Imaging. (Wang, C., ed.), Vol. 10, pp. 219-234, CRC Press, Cleveland, Ohio, 1977.

9. Fabrikant, J.I., ed. Report of the Public Health and Safety Task Force of The President's Commission on The Accident at Three Mile Island. Government Printing Office, Washington, D.C., October 1979.

10. Fabrikant, J.I. Summary of the Public Health and Safety Task Force Report to The President's Commission on The Accident at Three Mile Island. (Fabrikant, J.I., ed.), 32 pp. Government Printing Office, Washington, D.C., 1979.

11. Axelrod, D., Bluestone, M., Densen, P.M., Fabrikant, J.I., Fowinkle, E.W., Johnson, K.G., Jones, E.W., and Seltser, R. Technical Staff Analysis Report on Public Health and Epidemiology. (In) Report of the Public Health and Safety Task Force Report to The President's Commission on The Accident at Three Mile Island. (Fabrikant, J.I., ed.), 132 pp.. Government Printing Office, Washington, D.C., 1979.

12. Abrahamson, S., Bair, W.J., Bender, M.A., Bloom, A.D., Bond, V.P., Casarett, G.W., and Fabrikant, J.I. Technical Staff Analysis Report on Report of the Radiation Health Effects Task Group. (In) Report of the Public Health and Safety Task Force Report to The President's Commission on The Accident at Three Mile Island. (Fabrikant, J.I., ed.), 98 pp. Government Printing Office, Washington, D.C., 1979.

13. Auxier, J.A., Berger, C.D., Eisenhauer, C.M., Gesell, T.F., Jones, A.R., and Masterson, M.E. Report of the Task Group on Health Physics and Dosimetry. (In) Report of the Public Health and Safety Task Force to The President's Commission on The Accident at Three Mile Island (Fabrikant, J.I., ed.), 196 pp. Government Printing Office, Washington, D.C., 1979.

14. Dohrenwend, B.P., Dohrenwend, B.S., Fabrikant, J.I., Kasl, S.V., and Warheit, G.J. Technical Staff Analysis Report on Behavioral Effects. (In) Report of the Public Health and Safety Task Force to The President's Commission on The Accident at Three Mile Island (Fabrikant, J.I., ed.) 81 pp. Government Printing Office, Washington, D.C., 1979.

15. Radford, E.P., Abrahamson, S., Beebe, G.W., Bender, M.A., Brill, A.B., Brown, R.F., Cleary, S.F., Comar, C.L., Denniston, C., Fabrikant J.I., Ingram, M., Land, C.E., Mays, C.W., Moeller, D.W., Parker, D.R., Rossi, H.H., Russell, L.B., Russell, W.L., Selby, P.B., Sloan, M.H., Trimble B.K., Webster, E.W., and Wellman, H.N. The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1980.

16. Fabrikant, J.I., Beebe, G.W., Bender, M.A., Brill, A.R., Land, C.E., Moeller, D.W., and Webster, E.W. Estimating the Total Cancer Risk of Low-Dose, Low-LET, Whole-Body Radiation. Chapter V., Section 3. (In) The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. Report of the Committee on Biological Effects of Ionizing Radiations, pp. 176-226, National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1980.

17. Lyman, J.T., Ainsworth, E.J., Alpen, E.L., Bond, V.P., Curtis, S.B., Fabrikant, J.I., Fry, R.J.M., Jackson, K.L., Nachtway, S., Sondhaus, C., and Tobias, C.A. Ionizing Radiation Risks to Satellite Power Systems (SPS) Workers in Space. DOE/NASA Satellite Power System Concept Development and Evaluation Program, LBL Berkeley, CA, DOE/ER-0094, 1980.

18. Wolff, S., Bender, M.A., Brewen, J.G., Fabrikant, J.I., Greenberg, B.G., Lagakos, S.W., Mendelsohn, M.L, Schull, W.J., and Wei, L.J.Evaluation of Portsmouth Naval Shipyard Cytogenetics and Spermatogenesis Protocol. National Academy of Sciences-National Research Council. National Academy Press, Washington, D.C., 1982.

19. Mosteller F., Fabrikant, J.I., Fry, R.J.M., Lagakos, S.W., Miller, A.B., Saenger, E.L., Schottenfeld, D., Scott, E.L. Van Ryzin, J.R., and Webster, E.W. Assigned Share for Radiation as a Cause of Cancer. Review of Assumptions and Methods for Radioepidemiologic Tables. National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1984.

20. Mosteller, F., Fabrikant, J.I., Fry, R.J.M., Lagakos, S.W., Miller, A.B.,Saenger, E.L., Schottenfeld, D., Scott, E.L., Van Ryzin, J.R., and Webster, E.W. Assigned Share for Radiation as a Cause of Cancer. Review of Radioepidemiologic Tables Assigning Probabilities of Causation. National Academy of Sciences-National Research Council,National Academy Press, Washington, D.C., 1985.

21. Goldman, M., Anspaugh L., Catlin, R.J., Fabrikant, J.I., and Gudiksen, P. The Nuclear Reactor Accident at Chernobyl. Interim Report of the Committee on Assessment of Radiological Effects and Consequences. Prepared for the Office of Health and Environmental Research, U.S. Department of Energy, Washington, D.C., 1986.

22. Goldman, M., Anspaugh, L., Catlin, R.J., Fabrikant, J.I., and Gudiksen, P. Assessment of the Dosimetric and Health Implications of the Chernobyl Reactor Accident. Interim Report of The Committee on the Assessment of Radiological Effects and Consequences (CAREC). Prepared for The Office of Health and Environmental Research, U.S. Department of Energy, Washington, D.C., 1986.

23. Goldman, M., Anspaugh, L., Catlin, R.J., Fabrikant, J.I., and Gudiksen, P. Health and Environmental Consequences of the Chernobyl Nuclear Power Plant Accident. Report to the United States Department of Energy from the Interlaboratory Task Group on Health and Environmental Aspects of the Soviet Nuclear Accident. Prepared by the Committee on the Assessment of Health Consequences in Exposed Populations. U.S. Department of Energy, Washington, D.C., 1987.

24. Fabrikant, J.I., BEIR IV. The Effects on Populations of Exposure to Internally Deposited Alpha-Emitters. A Report to the International Commission on Radiological Protection, Como, Italy, 1987. Lawrence Berkeley Laboratory Report LBL-24173, UC-48, University of California, Berkeley, 1987.

25. Fabrikant, J.I., Bair, W.J., Bender, M.A., Borek, C., Groer P., Lubin, J., Muir, D., Pierce, D. Roesch, W., Samet, J., Schlenker, R., and Waxweiler, R. The Health Effects of Radon and Other Internally Deposited Alpha-Emitters: BEIR IV. National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1988.

26. Fabrikant, J.I., Frankel, K.A., Phillips, M.H., and Levy, R.P. Stereotactic heavy charged particle Bragg peak radiosurgery for intracranial vascular malformations. (In) Cerebral Vascular Diseases in Childhood and Adolescence. (Edwards, M.S.B and Hoffman, H.J., eds.), Chap. 22, Part 2, pp. 389-409, Williams & Wilkins, Baltimore, Maryland, 1989.

27. Barendsen, G.W., Fabrikant, J.I., Field, S.B., Hahn, F.F., Kellerer, A.M., Stather, J.W. RBE for Deterministic Effects. International Commission on Radiological Protection, Annals of the ICRP, ICRP Publication 58, Vol. 20, No. 4, Pergamon Press, Oxford, 1990 (in press).

28. Upton, A.C., Becker, B.B., Clifton, K.H., Denniston, C., Epp, E.R., Fabrikant, J.I., Grahn, D., Hall, E.J., Harte, D.L., Herbert, D.E., Hoel, D.G., Howe, G.H., Jablon, S., Kennedy, A.R., Knudson, A.G., Jr., Thomas, D.C. The Health Effects of Exposure to Low Levels of Ionizing Radiation, BEIR V. National Academy Press, Washington D.C., 1990.

29. Rodriquez, A., Levy, R.P., Fabrikant, J.I. Experimental central nervous system injury from charged particles. (In) Radiation Injury to the Nervous System. (Gutin, P.H., Leibel, S.A., Sheline, G.E., eds.) , Chap. 9, Williams & Wilkins, Baltimore, 1990 (in press).

30. Levy, R.P., Fabrikant, J.I., Frankel, K.A., Phillips, M.H. Charged particle radiosurgery. (In) Neurosurgery Clinics of North America, (Friedman, W., ed.), W.B. Saunders, Philadelphia, 1990 (in press).

31. Fabrikant, J.I., Levy, R.P., Frankel, K.A., Phillips, M.H. Stereotactic heavy-charged-particle radiosurgery for the treatment of intracranial vascular malformations. (In) Neurosurgery Clinics of North America, (Lunsford, L.D., ed.), W.B. Saunders, Philadelphia, 1990 (in press).

National Register Properties

Property	County	Street Address	City/Township	Date Listed	Construction Date
Barn Bluff	Goodhue	Jct. of U.S. 61 and U.S. 63	Red Wing	08/03/90	
Bartron Site	Goodhue		Burnside Twp.	10/15/70	
Baslington, George, Farmhouse	Goodhue	off U.S. Hwy. 52	Pine Island Twp.	02/12/80	1850s
Bridge No. 12	Goodhue	Twp. Rd. 43 over Bullard Creek	Hay Creek Twp.	11/06/89	1908
Bringgold, Jacob, House	Goodhue	314 S.W. 2nd St.	Pine Island	02/12/80	1906
Cannon Falls Elementary School	Goodhue	115 W. Minnesota St.	Cannon Falls	02/12/80	1893, 1912
Carlson, Gustaf A., Lime Kiln	Goodhue	E. 5th St.	Red Wing	09/27/76	1882
Chicago Great Western Depot	Goodhue	Main St.	Red Wing	06/04/80	1906
Church of the Redeemer (Episcopal)	Goodhue	123 N. 3rd St.	Cannon Falls	02/12/80	1867
Cross of Christ Lutheran Church	Goodhue	Mn. Hwy. 61	Welch Twp.	02/12/80	1878
Dammon Round Barn	Goodhue	Mn. Hwy. 61	Wacouta Twp.	02/12/80	1914
District School No. 20	Goodhue	Mn. Hwy. 58	Hay Creek Twp.	02/12/80	1889
Ellsworth Hotel Livery Stable	Goodhue	4th St.	Cannon Falls	02/12/80	1871
Firemen's Hall	Goodhue	206 W. Mill St.	Cannon Falls	02/12/80	1888
First Congregational Church	Goodhue	455 East Ave.	Zumbrota	02/12/80	1862
Fort Sweeney Site	Goodhue		Welch Twp.	08/05/70	
Fryk Barn	Goodhue	off Mn. Hwy. 61	Hay Creek Twp.	02/12/80	1872
Gellett, Charles, House	Goodhue	311 N. 6th St.	Cannon Falls	02/12/80	1860
Gladstone Building	Goodhue	309 Bush St.	Red Wing	11/14/79	1886
Gronvold, Just C., House	Goodhue	Co. Hwy. 8	Wanamingo Twp.	04/23/73	1873-1895
Gunderson, Martin T., House	Goodhue	107 2nd St.	Kenyon	06/10/75	1895
Hall, Orrin I., House	Goodhue	206 W. 3rd St.	Zumbrota	02/12/80	1884
Hauge Lutheran Church	Goodhue	off Mn. Hwy. 60	Kenyon Twp.	02/12/80	1871-1888
Hewitt Laboratory	Goodhue	216 Dakota St.	Red Wing (also in Red Wing Residential Historic District)	11/15/79	1866
Holden Lutheran Church Parsonage	Goodhue	Co. Hwy. 8	Wanamingo Twp.	02/12/80	1861
Hoyt, E.S., House	Goodhue	300 Hill St.	Red Wing (also in Red Wing Residential Historic District)	06/10/75	1913
Immanuel Lutheran Church	Goodhue	off Mn. Hwy. 58	Hay Creek Twp. (Hay Creek)	02/12/80	1897
Kappel Wagon Works	Goodhue	221 W. 3rd St.	Red Wing	11/14/79	1875
Kenyon Opera House	Goodhue	Main St.	Kenyon	02/12/80	1890
Keystone Building	Goodhue	409 Main St.	Red Wing	11/14/79	1867
Lawther, James L., House	Goodhue	927 W. 3rd St.	Red Wing (also in Red Wing Residential Historic District)	05/21/75	1857, 1870
Mendota to Wabasha Military Road: Cannon River Section	Goodhue	Cannon River Rd.	Red Wing	02/07/91	1854

National Register Properties

Property	County	Street Address	City/Township	Date Listed	Construction Date
Miller, Harrison, Farmhouse	Goodhue	Mn. Hwy. 19	Stanton Twp.	05/22/78	1869
Miller, John, Farmhouse	Goodhue	Co. Hwy. 1	Leon Twp.	02/12/80	1860s
Minnesota Stoneware Company	Goodhue	1997 W. Main St.	Red Wing	12/26/79	1883, 1901
Nelson, Julia B., House	Goodhue	219 5th St.	Red Wing	11/15/79	ca. 1880
Old Frontenac Historic District	Goodhue	Co. Hwy. 2	Florence Twp.	06/04/73	1854-1900
Opera House Block	Goodhue	Main St.	Pine Island	02/12/80	1895
Oxford Mill Ruin	Goodhue	off Co. Rd. 24	Stanton Twp.	02/12/80	1878
Pine Island City Hall and Fire Station	Goodhue	Main and 3rd Sts.	Pine Island	02/12/80	1909
Pratt-Taber House	Goodhue	706 W. 4th St.	Red Wing (also in Red Wing Residential Historic District)	11/14/79	ca. 1875
Red Wing City Hall	Goodhue	W. 4th St.	Red Wing	11/14/79	1905, 1906
Red Wing Iron Works	Goodhue	401 Levee St.	Red Wing	11/14/79	1874
Red Wing Mall Historic District	Goodhue	vicinity of East and West Aves. and Broadway	Red Wing	01/08/80	
Red Wing Residential Historic District	Goodhue	vicinity of Dakota, Cedar, W. 5th and 3rd Sts.	Red Wing	04/15/82	1855-1935
Roscoe Butter and Cheese Factory	Goodhue	Co. Hwy. 11	Roscoe Twp. (Roscoe)	02/12/80	1920's
Roscoe Store	Goodhue	Co. Hwy. 11	Roscoe Twp. (Roscoe)	02/12/80	1907
Saint James Hotel Complex	Goodhue	Bush and Main Sts.	Red Wing	01/08/82	1874-1923
Sheldon, T.B., Memorial Auditorium	Goodhue	443 W. 3rd St.	Red Wing (also in Red Wing Mall Historic District)	06/03/76	1904
Sheldon, Theodore B., House	Goodhue	805 W. 4th St.	Red Wing (also in Red Wing Residential Historic District)	06/07/76	1875
State Training School Historic District	Goodhue	E. 7th St.	Red Wing	06/04/73	1889
Third Street Bridge	Goodhue	3rd St. over Cannon River	Cannon Falls	11/06/89	1909
Tower View	Goodhue	U.S. Hwy. 61	Red Wing	04/13/77	1916
Towne-Akenson House	Goodhue	1121 W. 3rd St.	Red Wing (also in Red Wing Residential Historic District)	11/15/79	1875
Vasa Historic District	Goodhue	off Mn. Hwy. 19	Vasa Twp. (Vasa)	05/30/75	1860-1900
Wallauer, Fred, Farmhouse	Goodhue	Mn. Hwy. 58	Hay Creek Twp.	02/12/80	1882
Wanamingo Township Hall	Goodhue	Co. Hwy. 1	Wanamingo Twp. (Aspenlund)	02/12/80	ca. 1860
Yale Hardware Store	Goodhue	139 N. 4th St.	Cannon Falls	02/12/80	1887
Yale, Darwin E., House	Goodhue	421 N. 6th St.	Cannon Falls	02/12/80	1879
Zumbrota Covered Bridge	Goodhue	off Mn. Hwy. 58	Zumbrota	02/20/75	1869

ARCHAEOLOGICAL SITES

Inventory Number	Site#	Name	Description	Quarter Section	Sec.	Twp.	Rng.	Correct Context	NR	Ex	Reference	Region
** County GOODHUE												
		Black Oak	Ghost Town			113	15	HE			MHS(GTF)	3e
		Union	Ghost Town			113	15	HE			MHS(GTF)	3e
	5	Eggleston	Md(5)	SE	1	113	15	W		E		3e
	148		Hab	S-SW-SW	4	113	15	W		E		3e
	149		Hab	S-NW-NW	4	113	15	W-Ot				3e
	59	NSP #2	Md(6)	SE-SE	5	113	15	W		E		3e
	62		Md	SW-SE	5	113	15	P				3e
	60		Md(3)-LS	SE-NE	6	113	15	P				3e
	63		Md	SW-NE	6	113	15	P				3e
	64		Md	NE-NE	6	113	15	P				3e
	58-61	NSP #1-Birch Lake	Md(8)	N-NE	8	113	15	W		E		3e
	1	Nauer	Md(51)	NW	9	113	15	W		E		3e
	2	Bartron	Hab	NW-NW	9	113	15	Ot	O	E		3e
	181	Pickerel Slough	Hab	C-E-NW-SE	9	113	15	W				3e
	20		Md(6)	C-NW-SE	16	113	15	P				3e
	50		Md	SW-SE-SE	16	113	15	P				3e
	111	Kenneth Anderson	Hab	NW-SE-SE	16	113	15	P				3e
	127		LS	C-S-S	16	113	15	P				3e
				C-N-N	21							
	19		Md(3)	NW-NE	19	113	15	P				3e
	129		LS	N-NW-SE-SW	19	113	15	P				3e
	142		LS	SW-NE-NE	19	113	15	P				3e
				NW-NW-SE-NE								
	46		Md(15)	S-SW-SE	20	113	15	P				3e
				N-NW-NE	29							
	48		Md(7)	C-N-N-NE	21	113	15	P				3e
	49		Md(2)	SW-NW-NE	21	113	15	P				3e
	168		LS	S-SE-SW	21	113	15	P				3e
	128		LS	N-NW-NW	21	113	15	P				3e
				N-NE-NE	20							
	3	Silvernale	Hab	C-S-NW	22	113	15	Sn		E		3e
	17		Md(226+)	N-SW	22	113	15	EM				3e
				NW-SE								
	182	Cannon River Drive	Hab-Md(7)	C-N-SE	22	113	15	EM				3e

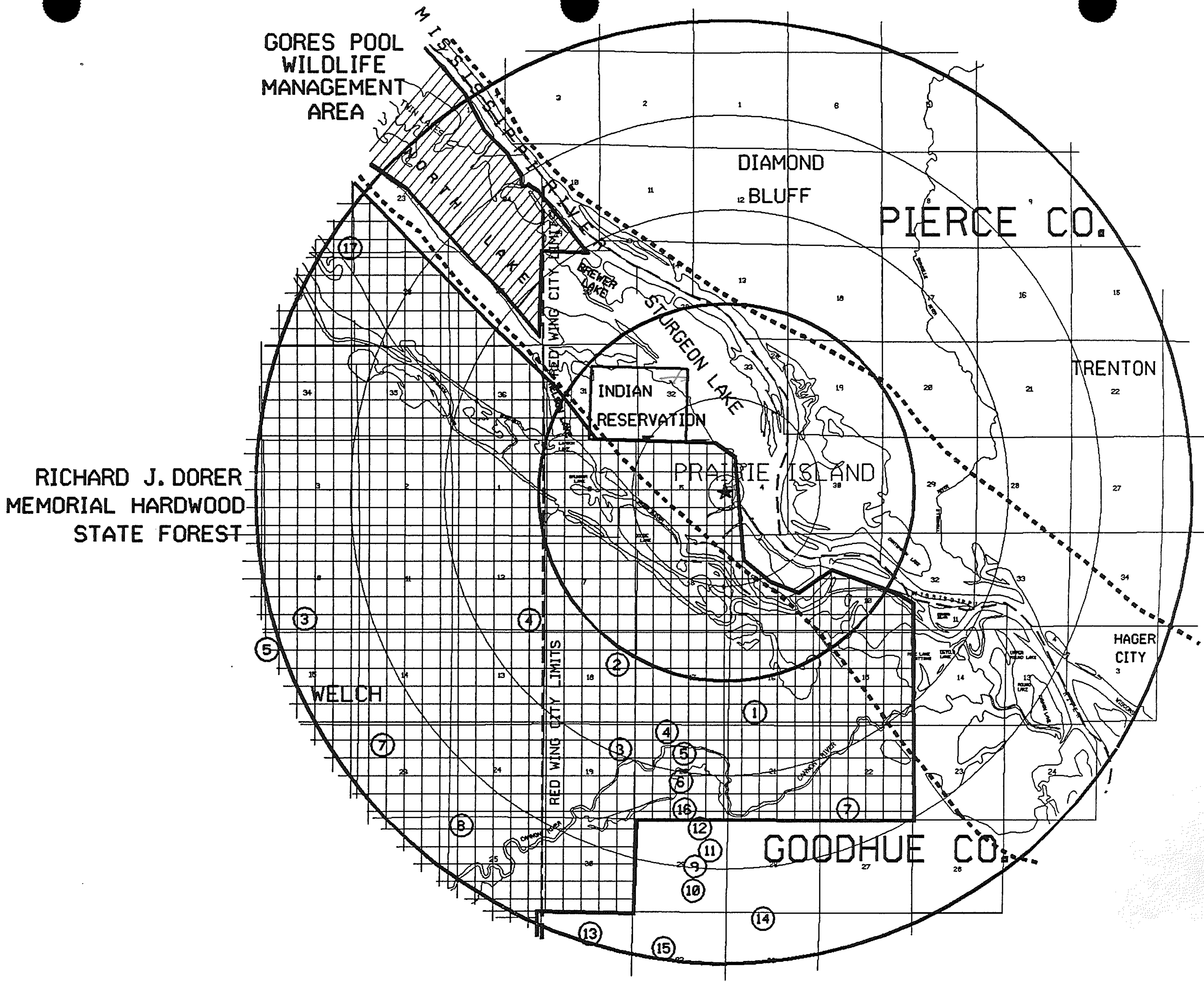
Inventory Number	Site#	Name	Description	Quarter Section	Sec.	Twp.	Rng.	Correct	Context	NR	Ex	Reference	Region
	22		Md(91)	SW-SW	22	113	15		P				3e
				SE-SE	21								
	16		Md(25+)	S	22	113	15		EM				3e
				N	27								
	4	Bryan	Hab	S-SW	22	113	15		Sn		E		3e
				N-NW	29								
	25		Md(5)	SW	23	113	15		P				3e
	24		Md(3)	NW-SW	25	113	15		P				3e
	56		Md(2)	SE-SW	25	113	15		P				3e
	89	Red Wing Pottery Dump	Dmp	N-SE	25	113	15		HE		E		3e
	18		Md(15)	SE-NE	26	113	15		P				3e
	21		Md(2)	SW-SE	26	113	15		P				3e
	116	Chicago Great Western	Hab	NE-NW	26	113	15		P				3e
	23		Md(3)	SW-NE	27	113	15		P				3e
	27		Md(3)	SW-NW	27	113	15		P				3e
	29		Md	NE-SW	27	113	15		P				3e
	37		Md(11)	NW-SW	27	113	15		P				3e
	38		Md(20)-LS	S-SW	27	113	15		EM				3e
	54		Md(14)	W-SW-SW	27	113	15		P				3e
	165		LS	SW-NW-NE	27	113	15		P				3e
			Md(4)	SE-NE	27	113	15		P			Lewis 2	3e
		Howe	Mill	SW-SW	27	113	15		HE			Andreas	3e
	26		Md(4)	NE-SW	28	113	15		P				3e
	41	Aiton's	StnMd	SE-NE	28	113	15		P		A		3e
	155	Charlson	LS	NE-NE-SE	28	113	15		P				3e
	161		Hab	W-W-SW	28	113	15		P				3e
	33-159		Md(4)	NW-SE	29	113	15		P				3e
			Hab	NW-NE-SE									
	34		Md(2)	SW-NE	29	113	15		P				3e
	35		Md(5)	SW-NW	29	113	15		P				3e
	53		Md(8)	SE-SE	29	113	15		P				3e
	85		Md(2)	NE-SW	29	113	15		P				3e
	119	Klobuchar	Md(3)	NE-NE	29	113	15		P		E		3e
	160		Hab	C-E-W-SE	29	113	15		P				3e
	164		LS	NE-SW-SE-NE	29	113	15		P				3e

ARCHAEOLOGICAL SITES

Inventory Number	Site#	Name	Description	Quarter Section	Sec.	Twp.	Rng.	Correct	Context	NR	Ex	Reference	Region
	52-158	Temple Mound-Energy Park	Md(64)-Hab	NE-NE	29	113	15		P	DOE			3e
				N-N-NW-NW	28								
	36		Md	SE-NE	30	113	15		P				3e
	51		Md(26)-LS	N-NW	30	113	15		P				3e
	FS04		pt	S-SE-NE	30	113	15		P				3e
	45		Md(173)	NE	30	113	15		P				3e
				N	29								
	166		LS	W-SE-SE	31	113	15		P				3e
	162		Hab	S-SW-SW-NW	32	113	15		P				3e
	163		LS	E-NW-NE	32	113	15		P				3e
	44-96-167	Sell	Md(20)-Hab	NW-NE	32	113	15		P				3e
				NE-NW-NE	32								
				SW-SE	29								
				SE-SW	29								
	30		Md(3)-Ptrgl	C-NW	33	113	15		P				3e
	31		Md(7)-LS	NW-SE	33	113	15		P				3e
				C-W-SW-NE									
	32		Md(5)	N-NE	33	113	15		P				3e
	91	Much	Hab	N-NW	33	113	15		P				3e
	99	Nygren	Hab	SW-NE	33	113	15		P				3e
	109	Olander	Hab	NE	33	113	15		P				3e
	169		Hab	C-S	33	113	15		Ot				3e
	39		StnMd(3)	N-SW	34	113	15		P				3e
	40		StnMd(4)	SW-NE	34	113	15		P				3e
	55		Md(2)-LS	SE-NW	34	113	15		P				3e
				C-E-SW-NW									
	95	Strusz Village	Hab	C-S-N-N	34	113	15		P				3e
	124	Strusz Mound	Md(5)	C-E-W-NW	34	113	15		P				3e
			StnMd( )	N-SW	34	113	15		P			Brower	3e
	42		Md(23)	SW-NW	36	113	15		P				3e
	43		Md	NW-NW	36	113	15		P				3e
		City	Mill	C-S-SW	36	113	15		HE			Andreas	3e

ARCHAEOLOGICAL SITES

Inventory Number	Site#	Name	Description	Quarter Section	Sec.	Twp.	Rng.	Correct Context	NR	Ex	Reference	Region
** County GOODHUE												
	170		Hab	NE-SE-SE	1	113	16	W-Ot				3e
	71-114	Brink	Md(4)	NE-NE	12	113	16	P				3e
	143		Md	SW-NW-NE-SE	25	113	16	P				3e
	65		Md(3)	SE-SE	26	113	16	P				3e
	66		Md(4)	SW-SE	26	113	16	P				3e
	67		Md(3)	SE-SW	26	113	16	P				3e
	68		Md	SW-SW	26	113	16	P				3e
	86	Fort Sweeny	Hab-Md(5)	SE	28	113	16	W-Ot	O	E		3e
	144		LS	S-NE	28	113	16	P				3e
	69		Md	NW-SW	29	113	16	P				3e
	145		Hab	NW-NE-SW	29	113	16	P				3e
	FS06		scpr	SE-SE-SW	30	113	16	P				3e
	146		LS	C-W-E-SW	31	113	16	P				3e
	147		LS	NE	32	113	16	P				3e
	73		Md	NE-SE	34	113	16	P				3e
	130	Belle Creek Junction #	Hab	N-N-NE	34	113	16	LW-Ot				3e
				S-S-SE	27							
	70		Md(3)	E-NW	35	113	16	P				3e
	72		Hab-Md(67)	NE	35	113	16	P				3e


GORES POOL WILDLIFE MANAGEMENT AREA
MISSISSIPPI RIVER
NORTH LAKE
DIAMOND BLUFF
PIERCE CO.
BREWER LAKE
STURGEON LAKE
RED WING CITY LIMITS
INDIAN RESERVATION
PRAIRIE ISLAND
TRENTON
RICHARD J. DORER MEMORIAL HARDWOOD STATE FOREST
WELCH
HAGER CITY
CANNON RIVER
GOODHUE CO.

Historic Name:

Common Name:

Owner's Name and Address:

Classification: *Farmhouse*

Building________ Structure________ Object ________ District____

Condition:

Excellent ______ Good ______ Fair ______ Deteriorated ______

Open to the Public:

Yes No

Visible from the road:

Yes No

Occupied:

Yes No

Present Use:

History:

Date Constructed:

Original Owner:

Architect/Builder:

Original Use:

Description:

Significance:

County:

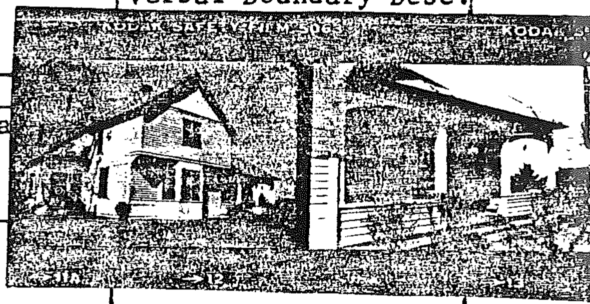
Community: *Welch twp*

Address/Legal Desc.:

Acreage: -

02352

Verbal Boundary Desc.



UTM Reference:

Level of Significance:

Local____________

State____________

Nation____________

Status:

Survey	Date
Local	________
State	________
Nat'l. Reg.	________
Nat'l. Land.	________
HABS/HAER	________

Theme/s:

Primary ____________

Secondary ____________

Other ____________

Local Contact/Org.:

Prepared by and date:

GMZ '78

Historic Name:

Common Name:

Legal Description:

Owner's name and address:

Classification:
Building ____ Structure ____ Object ____

Abandoned Farmhouse

Open to public
Yes No

Visible from road:
Yes No

Occupied:
Yes No

Present use:

History:
Date constructed ____

Original owner ____ Original use ____

Architect/Builder ____

Description -- describe present and original appearance

Significance -- explain why this property is significant in the history of the community, state or nation

Source of Information:

County:

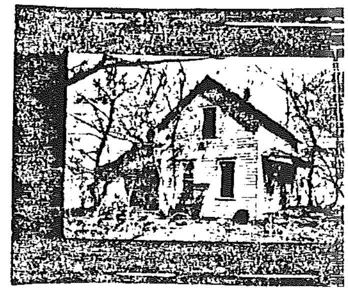
Community: Welch Twp

Address:

Local contact/ organization:

Photo - note view and direction

Contact sheet # 02386



Sketch site plan - note north arrow

Status:

	Date
Local survey	____
State survey	____
HABS/HAER	

Theme:
Primary ____

Secondary ____

Other ____

Form prepared by:
BMZ '78

Staff review and comments:

Common Name: Cross of Christ Lutheran Church

Owner's Name and Address: Swedish Evangelical Lutheran Congregation
Welch, Minnesota 55089

Classification:

Building X Structure ____ Object ____ District ____

Condition:

Excellent X Good ____ Fair ____ Deteriorated ____

Open to the Public:	Visible from the road:
Yes X No	Yes X No

Occupied:	Present Use:
Yes X No	Religious

History:

Date Constructed: 1878 Original Owner: Swedish Ev. Lutheran Congregation

Architect/Builder: Charles E. Johnson Original Use: Religious

Description:

The Cross of Christ Lutheran Church is located on the southeast corner of the intersection of U.S. Route 61 and Goodhue County Highway 7, in the northwest quarter of the northwest quarter of Section 15, Welch Township.

The Cross of Christ Lutheran Church is a one-story, wood-frame structure measuring 40 by 70 feet. It has a gable roof with its end oriented to the street. Its facade is three bays wide, with a pair of narrow, Gothic-arched windows framing a square, projecting tower in the center. Entry to the church is through paneled double doors in the front of the tower, with a transom surmounted by a wide, Gothic-arched window. The upper section of the tower is embellished by a lancet in front and quatrefoils on either side. The tower is capped off by a bellcast hip roof surmounted by an octagonal belfry,

(continued)

Significance:

The Cross of Christ Lutheran Church is significant as an example of the type of churches the Swedish settlers built in southeastern Minnesota, once they had passed through the pioneer phase of development.

Along with the Norwegians, the Swedes were the largest group to settle the rural areas to the south of the Twin Cities in the decades after 1850. In many districts, they predominated. In Goodhue County, for example, there were 3,224 foreign-born Swedes in 1900, compared to 3,056 Norwegians and 1,926 Germans. Wherever Swedish farms would cluster, their Lutheran Churches appeared in their midst as their religious and cultural centers.

The Cross of Christ Lutheran Church is an outstanding example of such a structure. Located in Welch Township, one of the most solidly Swedish districts in the region, its congregation was organized in 1873 by the Rev. Eric Norelius, the father of the Swedish Lutheran Church in Minnesota. In 1878, the congregation built the present commodious structure with its characteristically Swedish steeple, thereby indicating the growing numbers and

(continued)

Community: Welch Township

Address/~~Legal Desc~~.:
Highway 61, west of Red W

Acreage:

5 acres

Verbal Boundary Desc.:
The north half of the NW¼ of the NW¼ of the NW¼ of sec. 15, T113N, R16W.

UTM Reference:

15 / 521450 / 4938350
Red Wing Quadrangle

Level of Significance:

Local X
State ____
Nation ____

Status:

Survey	Date
Local	
State	5/78
Nat'l. Reg.	
Nat'l. Land.	
HABS/HAER	

Theme/s:

Primary Religious
Secondary Ethnic
Other ____

Local Contact/Org.:
Mrs. R.H. Nelson
Red Wing, MN 55066

Prepared by and date:
B. Michael Zuckerman
August 1978

S. 23 MINNESOTA HISTORIC PROPERTIES INVENTORY FORM

Historic Name: School #6

Common Name:

Owner's Name and Address:

County:

Community: Welch Twp

Address/Legal Desc.:

Classification: Abandoned Schoolhouse

Building____ Structure____ Object ____ District____

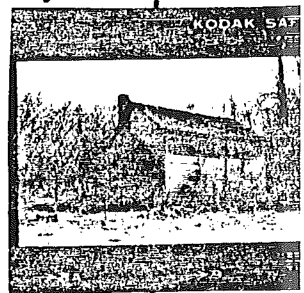
Acreage:

02352

Condition:

Excellent ____ Good ____ Fair ____ Deteriorated ____

Verbal Boundary Desc.



Open to the Public:

Yes No

Visible from the road:

Yes No

Occupied:

Yes No

Present Use:

History:

Date Constructed: 1886

Original Owner:

Architect/Builder:

Original Use:

UTM Reference:

Description:

Level of Significance:

Local____

State____

Nation____

Status:

Survey	Date
Local	
State	
Nat'l. Reg.	
Nat'l. Land.	
HABS/HAER	

Significance:

Theme/s:

Primary ____

Secondary ____

Other ____

Local Contact/Org.:

Prepared by and date:

BMZ '78

GD-WLC-008 (8)

5.25 MINNESOTA HISTORIC PROPERTIES INVENTORY FORM

Historic Name:

Common Name:

Owner's Name and Address:

County:

Community: Welch twp

Address/Legal Desc.:

Classification: Farmhouse

Building____ Structure____ Object ____ District____

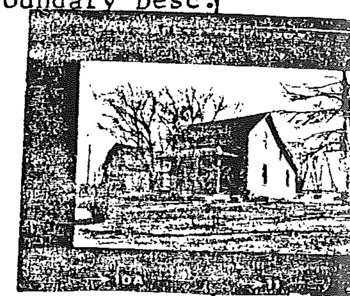
Acreage:

02352

Condition:

Excellent ____ Good ____ Fair ____ Deteriorated ____

Verbal Boundary Desc.



Open to the Public:

Yes No

Visible from the road:

Yes No

Occupied:

Yes No

Present Use:

History:

Date Constructed:

Original Owner:

Architect/Builder:

Original Use:

UTM Reference:

Description:

Level of Significance:

Local____

State____

Nation____

Status:

Survey	Date
Local	
State	
Nat'l. Reg.	
Nat'l. Land.	
HABS/HAER	

Significance:

Theme/s:

Primary ____

Secondary ____

Other ____

Local Contact/Org.:

Prepared by and date:

BRR '78

GD-WLC-017 (17)

S. 26 (T 114, R 16) MINNESOTA HISTORIC PROPERTIES INVENTORY FORM

Historic Name: Upper Island School (District #119)

Common Name:

Owner's Name and Address:

County:

Community: Welch twp Prairie Island

Address/Legal Desc.:

Classification: Schoolhouse

Building ______ Structure ______ Object ______ District ______

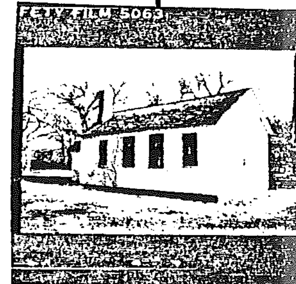
Acreage:

02366

Condition:

Excellent ______ Good ______ Fair ______ Deteriorated ______

Verbal Boundary Desc.:



Open to the Public:

Yes No

Visible from the road:

Yes No

Occupied:

Yes No

Present Use:

History:

Date Constructed: 1872

Original Owner:

Architect/Builder:

Original Use:

UTM Reference:

Description:

Level of Significance:

Local ______

State ______

Nation ______

Status:

Survey	Date
Local	
State	
Nat'l. Reg.	
Nat'l. Land.	
HABS/HAER	

Significance:

Theme/s:

Primary ______

Secondary ______

Other ______

Local Contact/Org.:

Prepared by and date:

BMz '78

Historic Name:

Common Name:

Legal Description:

County:

Community: Burnside twp

Address:

Owner's name and address:

Local contact/ organization:

Classification:

Building ____ Structure ____ Object ____

Farmhouse & Barn

Photo - note view and direction

Contact sheet # 02376

Open to public

Yes No

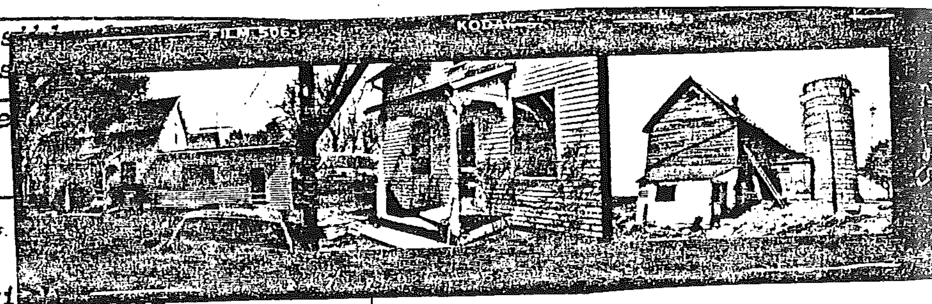
Vi...

Yes

Occupied:

Yes No

Pre...



History:

Date constructed House - 1900, Ba...

Original owner ____________ Ori...

Architect/Builder ____________

Description -- describe present and original appearance

Sketch site plan - note north arrow

Status:

	Date
Local survey	________
State survey	________
HABS/HAER	

Significance -- explain why this property is significant in the history of the community, state or nation

Theme:

Primary ____________

Secondary ____________

Other ____________

Form prepared by:

BMZ '78

Staff review and comments:

Source of Information:

Historic Name:

Common Name:

Legal Description:

County:

Community: Burnside twp

Address:

Owner's name and address:

Local contact/ organization:

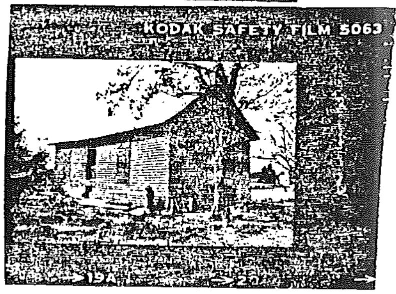
Classification:

Building ______ Structure ______ Object ______

Schoolhouse

Photo - note view and direction

Contact sheet # 02375



Open to public
Yes No

Visible from road:
Yes No

Occupied:
Yes No

Present use:

History:

Date constructed ____________

Original owner ____________ Original use ____________

Architect/Builder ____________

Description -- describe present and original appearance

Sketch site plan - note north arrow

Status:

	Date
Local survey	______
State survey	______
HABS/HAER	

Significance -- explain why this property is significant in the history of the community, state or nation

Theme:

Primary ____________

Secondary ____________

Other ____________

Form prepared by:

G??? '78

Staff review and comments:

Source of Information:

Historic Name:

Common Name: Bridge # 4773

Legal Description:

Owner's name and address:

Classification:
Building _____ Structure _____ Object _____

Open to public
Yes No

Visible from road:
Yes No

Occupied:
Yes No

Present use:

History:
Date constructed 1931

Original owner ________ Original use ________

Architect/Builder ________

Description -- describe present and original appearance

Significance -- explain why this property is significant in the history of the community, state or nation

Source of Information:

County:

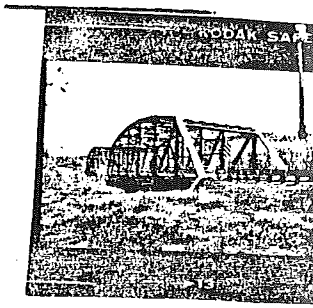
Community: Burnside Twp

Address:

Local contact/
organization:

Photo - note view and direction

Contact sheet # 02376



Sketch site plan - note north arrow

Status:

	Date
Local survey	
State survey	
HABS/HAER	

Theme:
Primary ________
Secondary ________
Other ________

Form prepared by:
BAZ '79

Staff review and comments:

Historic Name:

Common Name:

Legal Description:

Owner's name and address:

Classification:

Building _____ Structure _____ Object _____

Bridge

Open to public

Yes No

Visible from road:

Yes No

Occupied:

Yes No

Present use:

History:

Date constructed 1921

Original owner _____ Original use _____

Architect/Builder _____

Description -- describe present and original appearance

SOON TO BE REMOVED

SEE J340 & O-897

9-1-82

Significance -- explain why this property is significant in the history of the community, state or nation

Source of Information:

County:

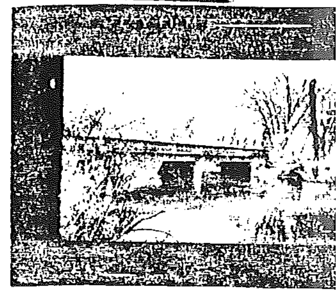
Community: Burnside twp

Address:

Local contact/organization:

Photo - note view and direction

Contact sheet # 02376



Sketch site plan - note north arrow

Status:

	Date
Local survey	
State survey	
HABS/HAER	

Theme:

Primary _____

Secondary _____

Other _____

Form prepared by:

CAZ '78

Staff review and comments:

Historic Name:

Common Name:

Legal Description:

County:

Community: Burnside Twp

Address:

Owner's name and address:

Local contact/ organization:

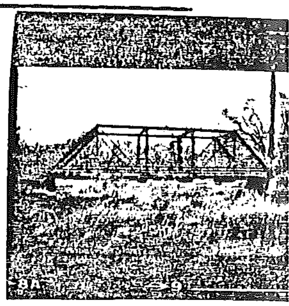
Classification:

Building ______ Structure ______ Object ______

Bridge

Photo - note view and direction

Contact sheet # 62376



Open to public

Yes No

Visible from road:

Yes No

Occupied:

Yes No

Present use:

History:

Date constructed 1915

Original owner R

Original use ______

Architect/Builder M. A. Adams - Mpls.

Description -- describe present and original appearance

Sketch site plan - note north arrow

Status:

	Date
Local survey	______
State survey	______
HABS/HAER	

Significance -- explain why this property is significant in the history of the community, state or nation

Theme:

Primary ______

Secondary ______

Other ______

Form prepared by:

BAZ '78

Staff review and comments:

Source of Information:

Historic Name:

Common Name:

Legal Description:

County:

Community: Burnside Twp

Address:

Owner's name and address:

Local contact/ organization:

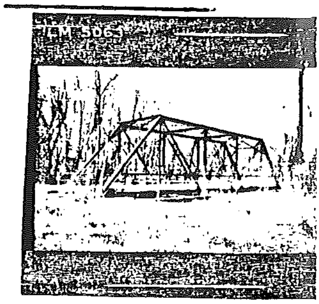
Classification:

Building _____ Structure _____ Object _____

Bridges

Photo - note view and direction

Contact sheet # 03376



Open to public

Yes No

Visible from road:

Yes No

Occupied:

Yes No

Present use:

History:

Date constructed _____

Original owner _____ Original use _____

Architect/Builder _____

Description -- describe present and original appearance

Sketch site plan - note north arrow

Status:

	Date
Local survey	_____
State survey	_____
HABS/HAER	

Significance -- explain why this property is significant in the history of the community, state or nation

Theme:

Primary _____

Secondary _____

Other _____

Form prepared by:

GAL '78

Staff review and comments:

Source of Information:

Historic Name: Barn from County Poor Farm

Common Name:

Legal Description:

County:

Community: Burnside twp

Address:

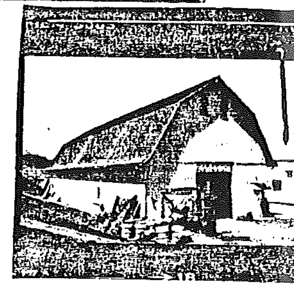
Owner's name and address:
Goodhue County Highway Dept.

Local contact/ organization:

Classification:
Building _____ Structure _____ Object _____

Photo - note view and direction

Contact sheet # 02376



Open to public
Yes No

Visible from road:
Yes No

Occupied:
Yes No

Present use:

History:
Date constructed _____

Original owner _____ Original use _____

Architect/Builder _____

Description -- describe present and original appearance

Sketch site plan - note north arrow

Status:

	Date
Local survey	_____
State survey	_____
HABS/HAER	

Significance -- explain why this property is significant in the history of the community, state or nation

Theme:
Primary _____
Secondary _____
Other _____

Form prepared by:
BAL '78

Staff review and comments:

Source of Information:

Historic Name:

Common Name:
Legal Description:

County:

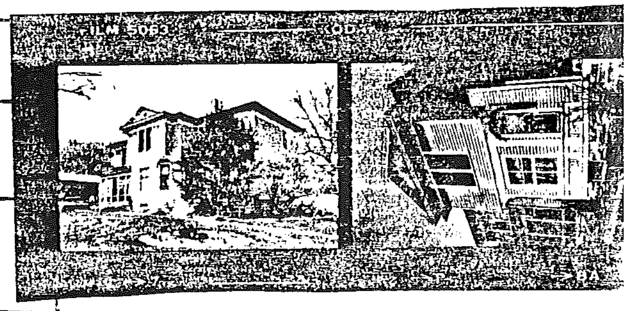
Community: Barnside Twp
Address:

Owner's name and address:

Local contact/
organization:

Classification:
Building ______ Structure ______ Object ______
Farmhouse

Photo - note view and direction
Contact sheet # 02402



Open to public
Yes No

Visible from road:
Yes No

Occupied:
Yes No

Present use:

History:
Date constructed ____________
Original owner ________________ Original use ____________
Architect/Builder ______________

Description -- describe present and original appearance

Sketch site plan - note north arrow

Status:
Date
Local survey ____________
State survey ____________
HABS/HAER

Significance -- explain why this property is significant in the history of the community, state or nation

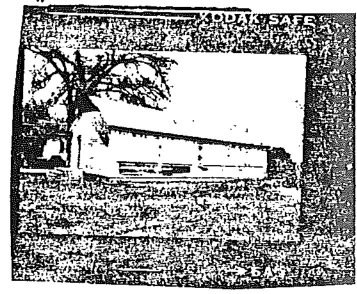
Theme:
Primary ____________
Secondary ____________
Other ____________

Form prepared by:
BMZ '78

Staff review and comments:

Source of Information:

2

Historic Name:	County:
Common Name: Town Hall	Community: Burnside Twp
Legal Description:	Address:
Owner's name and address:	Local contact/ organization:
Classification: Building ____ Structure ____ Object ____ Schoolhouse, converted into a Town Hall	Photo - note view and direction Contact sheet # 02402
Open to public: Yes No Visible from road: Yes No	
Occupied: Yes No Present use:	
History: Date constructed ____ Original owner ____ Original use ____ Architect/Builder ____	
Description -- describe present and original appearance Now used for storage - since Burnside's absorption by Red Wing	Sketch site plan - note north arrow
	Status: Date Local survey ____ State survey ____ HABS/HAER
Significance -- explain why this property is significant in the history of the community, state or nation	Theme: Primary ____ Secondary ____ Other ____
	Form prepared by: BRL '78
	Staff review and comments:
Source of Information:	

Historic Name: Burnside School, District #3

Common Name:

Legal Description:

County:

Community: Burnside Twp

Address:

Owner's name and address:

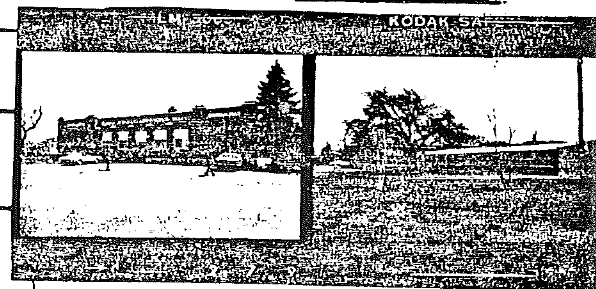
Local contact/ organization:

Classification:

Building ______ Structure ______ Object ______

Photo - note view and direction

Contact sheet # 02402



Open to public

Yes No

Visible from road:

Yes No

Occupied:

Yes No

Present use:

History:

Date constructed 1931 + Later Additions

Original owner ______ Original use ______

Architect/Builder ______

Description -- describe present and original appearance

Sketch site plan - note north arrow

Status:

	Date
Local survey	______
State survey	______
HABS/HAER	

Significance -- explain why this property is significant in the history of the community, state or nation

Theme:

Primary ______

Secondary ______

Other ______

Form prepared by:

R.M. '79

Staff review and comments:

Source of Information:

MINNESOTA HISTORIC PLACES SURVEY

Historic Name:

Common Name: Vasa Childrens Home

Legal Description:

County:

Community: Burnside Twp

Address:

Owner's name and address:

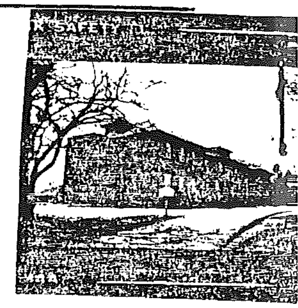
Local contact/ organization:

Classification:

Building ______ Structure ______ Object ______

Photo - note view and direction

Contact sheet # 02396



Open to public

Yes No

Visible from road:

Yes No

Occupied:

Yes No

Present use:

History:

Date constructed 1926

Original owner ______ Original use ______

Architect/Builder ______

Description -- describe present and original appearance

Sketch site plan - note north arrow

Status:

	Date
Local survey	
State survey	
HABS/HAER	

Significance -- explain why this property is significant in the history of the community, state or nation

Theme:

Primary ______

Secondary ______

Other ______

Form prepared by:

BAZ '78

Staff review and comments:

Source of Information:

Historic Name:

Common Name:

Legal Description:

Owner's name and address:

County:

Community: Burnside Twp

Address:

Local contact/ organization:

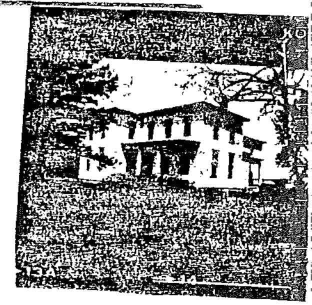
Classification:

Building ____ Structure ____ Object ____

Farmhouse

Photo - note view and direction

Contact sheet # 03376



Open to public

Yes No

Visible from road:

Yes No

Occupied:

Yes No

Present use:

History:

Date constructed ____________

Original owner ________________ Original use ____________

Architect/Builder ______________

Description -- describe present and original appearance

Sketch site plan - note north arrow

Status:

	Date
Local survey	
State survey	
HABS/HAER	

Significance -- explain why this property is significant in the history of the community, state or nation

Theme:

Primary ____________

Secondary ____________

Other ____________

Form prepared by:

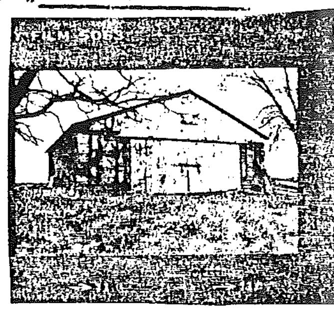
Roz '78

Staff review and comments:

Source of Information:

S. 31 MINNESOTA HISTORIC PLACES SURVEY

13

Historic Name: Common Name: Legal Description:	County: Community: Burnside twp Address:
Owner's name and address:	Local contact/ organization:
Classification: Building ____ Structure ____ Object ____ Barn made from two Buses	Photo - note view and direction Contact sheet # 0240
Open to public Yes No Visible from road: Yes No	
Occupied: Yes No Present use:	
History: Date constructed ____ Original owner ____ Original use ____ Architect/Builder ____	
Description -- describe present and original appearance	Sketch site plan - note north arrow
	Status: Date Local survey ____ State survey ____ HABS/HAER
Significance -- explain why this property is significant in the history of the community, state or nation	Theme: Primary ____ Secondary ____ Other ____
	Form prepared by: BAL '78
	Staff review and comments:
Source of Information:	

5.33 MINNESOTA HISTORIC PLACES SURVEY

(14)

Historic Name:

Common Name:

Legal Description:

Owner's name and address:

County:

Community: Burnside Twp

Address:

Local contact/
organization:

Classification:
Building _____ Structure _____ Object _____
Farmhouse & Barn

Photo - note view and direction

Contact sheet # [illegible]

Open to public
Yes No

Visible from road:
Yes No

Occupied:
Yes No

Present use:

History:
Date constructed Barn - 1887; House - 'about as old'

Original owner ______________ Original use ______________

Architect/Builder ______________

Description -- describe present and original appearance

Sketch site plan - note north arrow

Status:

	Date
Local survey	
State survey	
HABS/HAER	

Significance -- explain why this property is significant in the history of the community, state or nation

Theme:
Primary ______________
Secondary ______________
Other ______________

Form prepared by:
[illegible]

Staff review and comments:

Source of Information:

S. 3

MINNESOTA HISTORIC PLACES SURVEY

(15)

Historic Name:

Common Name:

Legal Description:

Owner's name and address:

County:

Community: Garnside Twp

Address:

Local contact/ organization:

Classification:

Building _____ Structure _____ Object _____

Farmhouse Barn

Photo - note view and direction

Contact sheet # 03402

Open to public

~~Yes~~ No

Visible from road:

Yes No

Occupied:

Yes No

Present use:

History:

Date constructed _____

Original owner _____ Original use _____

Architect/Builder _____

Description -- describe present and original appearance

Sketch site plan - note north arrow

Status: Date

Local survey _____

State survey _____

HABS/HAER

Significance -- explain why this property is significant in the history of the community, state or nation

Theme:

Primary _____

Secondary _____

Other _____

Form prepared by:

Staff review and comments:

Source of Information:

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

NATIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

FOR NPS USE ONLY
RECEIVED
DATE ENTERED

(16)

SEE INSTRUCTIONS IN *HOW TO COMPLETE NATIONAL REGISTER FORMS*
TYPE ALL ENTRIES -- COMPLETE APPLICABLE SECTIONS

1 NAME

HISTORIC
Tower View

AND/OR COMMON
Tower View

2 LOCATION

STREET & NUMBER
NE¼, Section 29, ~~T112~~ 113N, R15W
__NOT FOR PUBLICATION

CITY, TOWN
X VICINITY OF Red Wing

CONGRESSIONAL DISTRICT
First

STATE
Minnesota
CODE
27
COUNTY
Goodhue
CODE
049

3 CLASSIFICATION

CATEGORY	OWNERSHIP	STATUS	PRESENT USE	
__DISTRICT	__PUBLIC	__OCCUPIED	__AGRICULTURE	__MUSEUM
X BUILDING(S)	X PRIVATE	X UNOCCUPIED	__COMMERCIAL	__PARK
__STRUCTURE	__BOTH	__WORK IN PROGRESS	__EDUCATIONAL	__PRIVATE RESIDENCE
__SITE	**PUBLIC ACQUISITION**	**ACCESSIBLE**	__ENTERTAINMENT	__RELIGIOUS
__OBJECT	__IN PROCESS	__YES: RESTRICTED	__GOVERNMENT	__SCIENTIFIC
	X BEING CONSIDERED	__YES: UNRESTRICTED	__INDUSTRIAL	__TRANSPORTATION
		X NO	__MILITARY	X OTHER: unoccupied

4 OWNER OF PROPERTY

NAME
Mr. and Mrs. Frank Chesley

STREET & NUMBER
300 Hill Street

CITY, TOWN
Red Wing
__ VICINITY OF
STATE
Minnesota

5 LOCATION OF LEGAL DESCRIPTION

COURTHOUSE, REGISTRY OF DEEDS, ETC.
Goodhue County Courthouse

STREET & NUMBER

CITY, TOWN
Red Wing
STATE
Minnesota

6 REPRESENTATION IN EXISTING SURVEYS

TITLE
Statewide Historic Sites Survey

DATE
1973
__FEDERAL X STATE __COUNTY __LOCAL

DEPOSITORY FOR SURVEY RECORDS
Building 25, Fort Snelling -- Minnesota Historical Society

CITY, TOWN
Saint Paul
STATE
Minnesota

ESTIMATED 1985/1986 POPULATION DISTRIBUTION AROUND THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT

(MILES)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0-1	3	0	0	0	0	0	0	6	0	0	0	0	18	101	6	40	174
1-2	50	123	10	8	3	0	0	6	3	3	6	0	41	34	3	0	290
2-3	81	23	18	13	32	0	0	6	12	34	35	25	10	32	3	0	324
3-4	13	18	21	11	53	106	0	795	43	68	13	41	19	10	6	5	1,222
4-5	21	51	32	64	34	215	209	829	307	9	26	26	26	22	3	0	1,874
5-10	28[illegible]	492	708	438	279	1,405	11,132	692	188	370	305	271	531	1,330	469	271	19,170
10-20	10,700	1,836	1,713	1,598	1,294	1,539	1,120	1,290	1,834	1,291	1,616	4,428	2,146	12,575	14,564	2,056	61,398
20-30	3,840	5,212	4,174	2,945	2,920	3,191	3,995	2,224	6,125	2,258	3,418	16,225	8,867	17,135	120,508	21,879	224,918
30-40	11,259	3,192	4,987	9,864	4,943	4,851	4,206	7,041	11,225	3,577	17,277	8,046	13,363	342,639	675,752	79,936	1,198,158
40-50	6,738	7,275	4,193	11,229	5,662	2,931	3,676	46,030	35,469	5,259	26,552	8,380	13,116	150,662	339,696	19,039	685,907
TOTAL	32,994	18,020	15,853	26,170	15,220	14,238	24,338	58,919	55,206	12,869	49,248	37,442	38,137	524,540	1,151,010	119,226	2,193,433