CHAPTER 8. NUCLEAR WASTE, DISPOSAL FACILITY, DESCRIPTION (7855.0600)

8.1 PROJECT DESCRIPTION

This chapter of our application provides a description of the Monticello Plant, the nuclear fuel used at the Plant, which is stored in the facility, and the proposed additional dry cask storage capacity at the Monticello ISFSI. It contains the information required in the Commission's application content requirement rules, Minnesota Rules, Part 7855.0600.

8.2 MONTICELLO NUCLEAR GENERATING PLANT

The Plant is owned and operated by Xcel Energy. It is a single-unit boiling water reactor rated for gross output at 671 MWe and was originally licensed by the NRC in 1970. The NRC approved a renewed license for the facility in 2006, allowing the plant to operate through 2030. As discussed in our pending 2019-2034 Upper Midwest Resource Plan, the Company intends to seek a license extension from the NRC, which would allow the Plant to operate an additional 20 years, to 2050.

The Plant is located within the city limits of Monticello, Minnesota in Wright County, on the western bank of the Mississippi River, in Section 32, T–122N, R–25W, at 45° 20' N latitude and 93° 50' W longitude, approximately 50 miles northwest of Minneapolis and St. Paul (Figure 8-1 and 8-2).

The Plant site, including both the Plant and the ISFSI, consists of approximately 2,150 acres of land owned by Xcel Energy. A portion of this land is on the eastern bank of the river in Sherburne County, and another portion is on the western bank in Wright County. Figure 8-3 shows the Plant site boundaries. Access to the Plant is restricted by a perimeter fence and other barriers.

Figure 8-4 shows an aerial photo depicting a 1-mile radius around the Plant. Figure 8-5 shows an aerial photo depicting a 2-mile radius around the Plant. Figure 8-6 shows a topographical map of the area around the Plant.

Figure 8-1:
50-mile radius

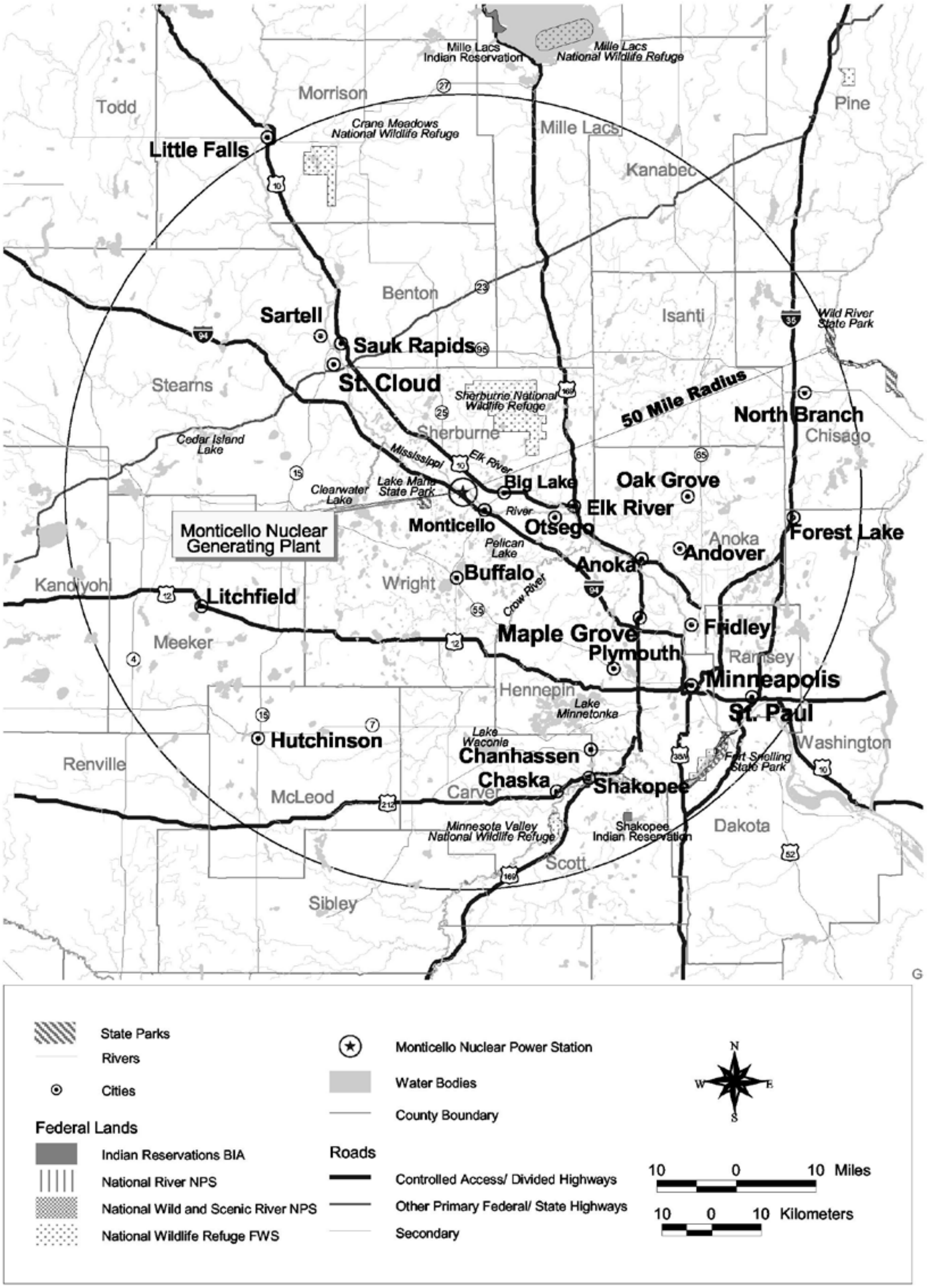


Figure 8-2:
Six-mile radius

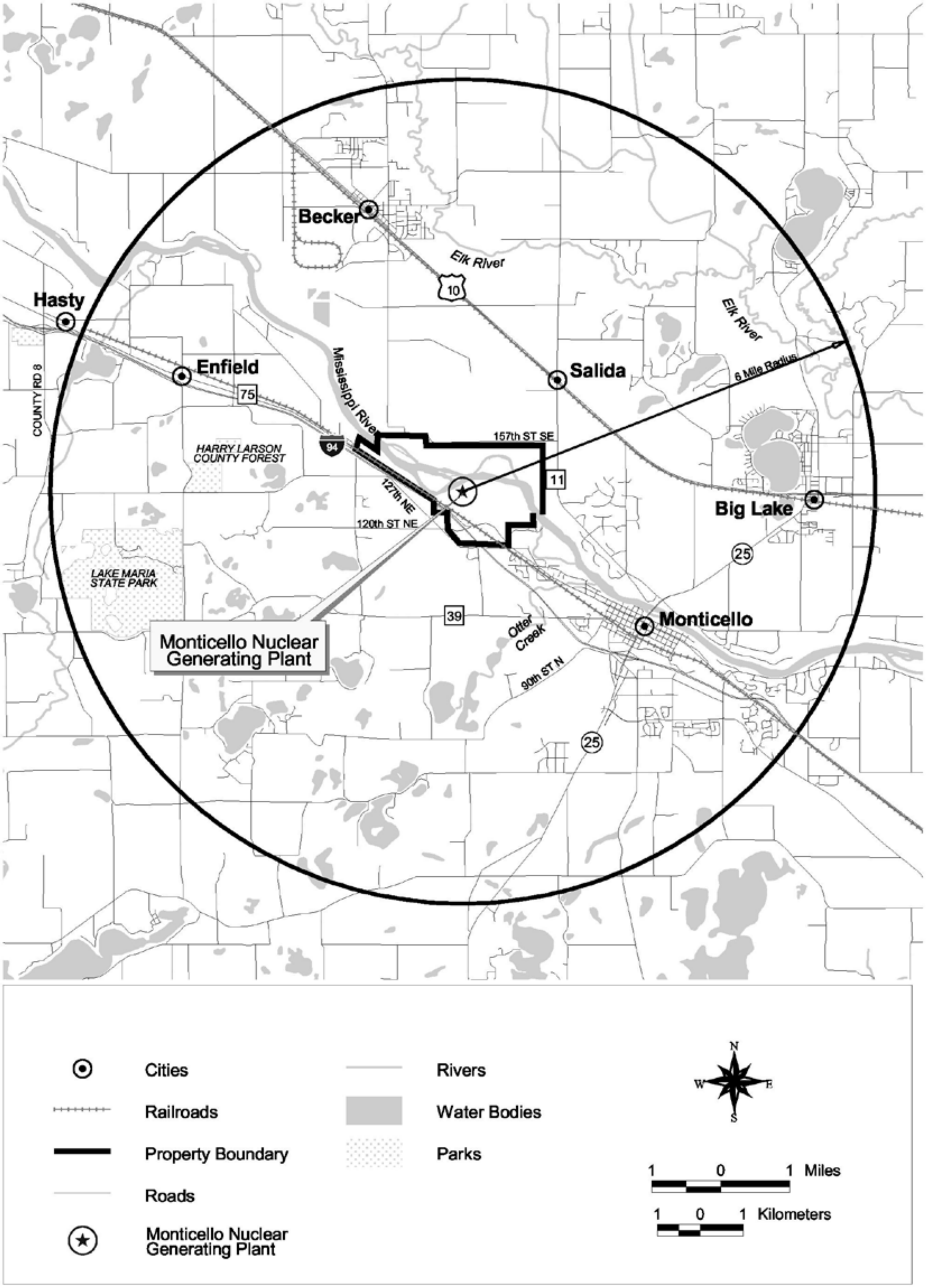


Figure 8-3:
Plant site boundaries

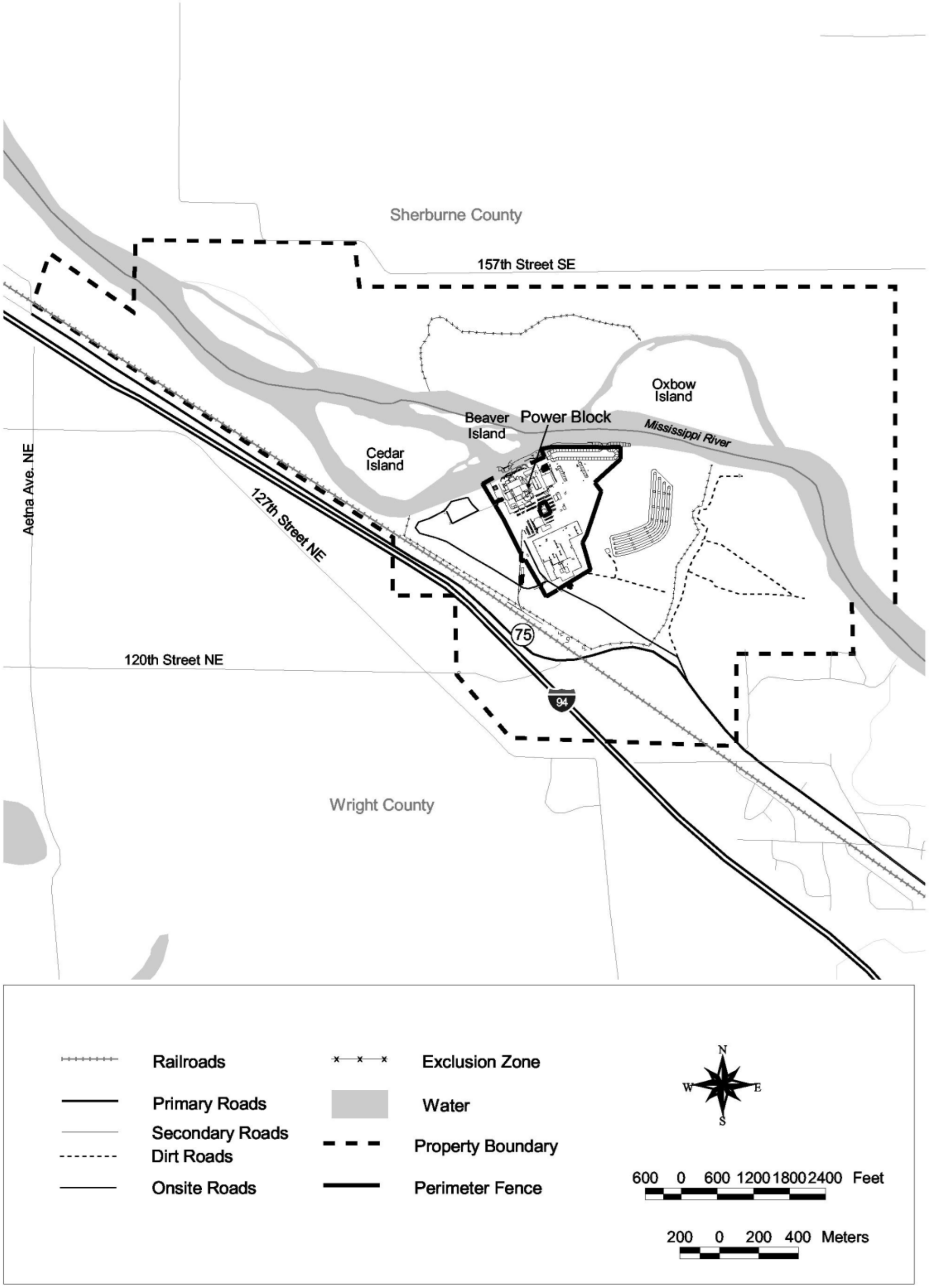


Figure 8-4:
One-mile radius

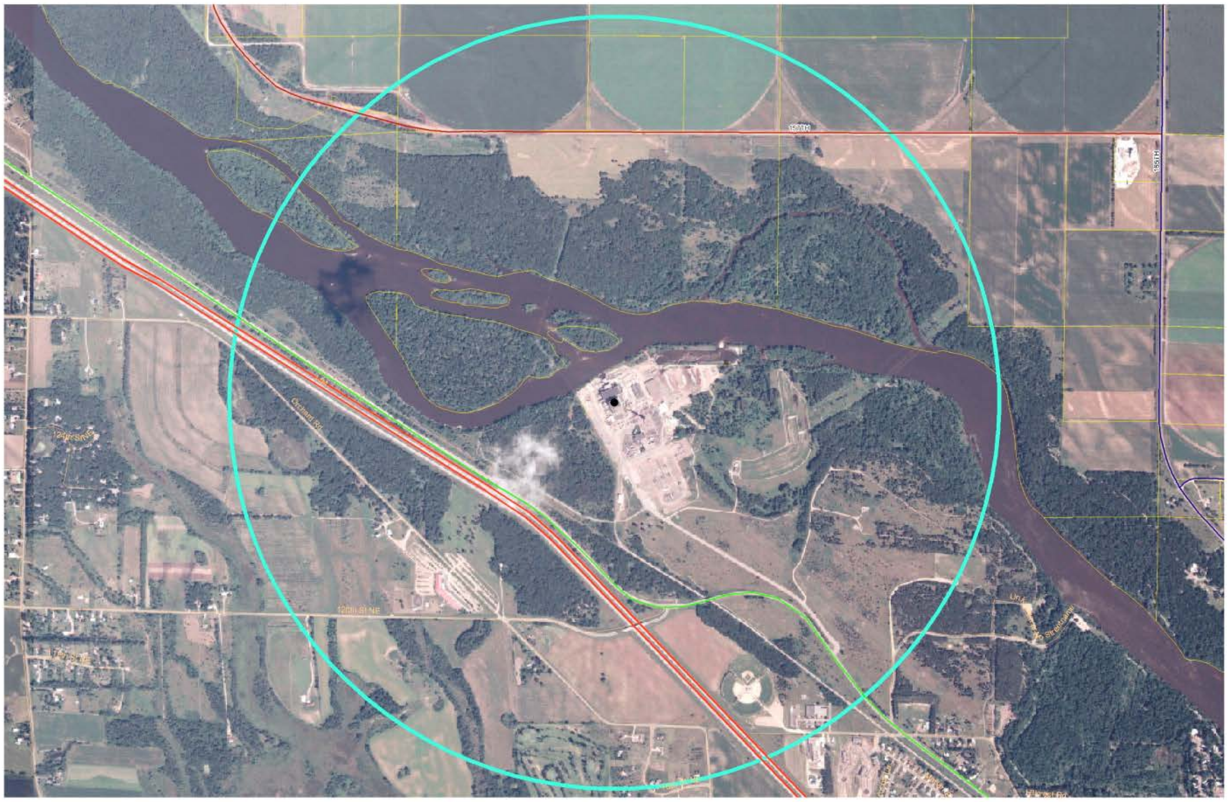


Figure 8-5:
Two-mile radius

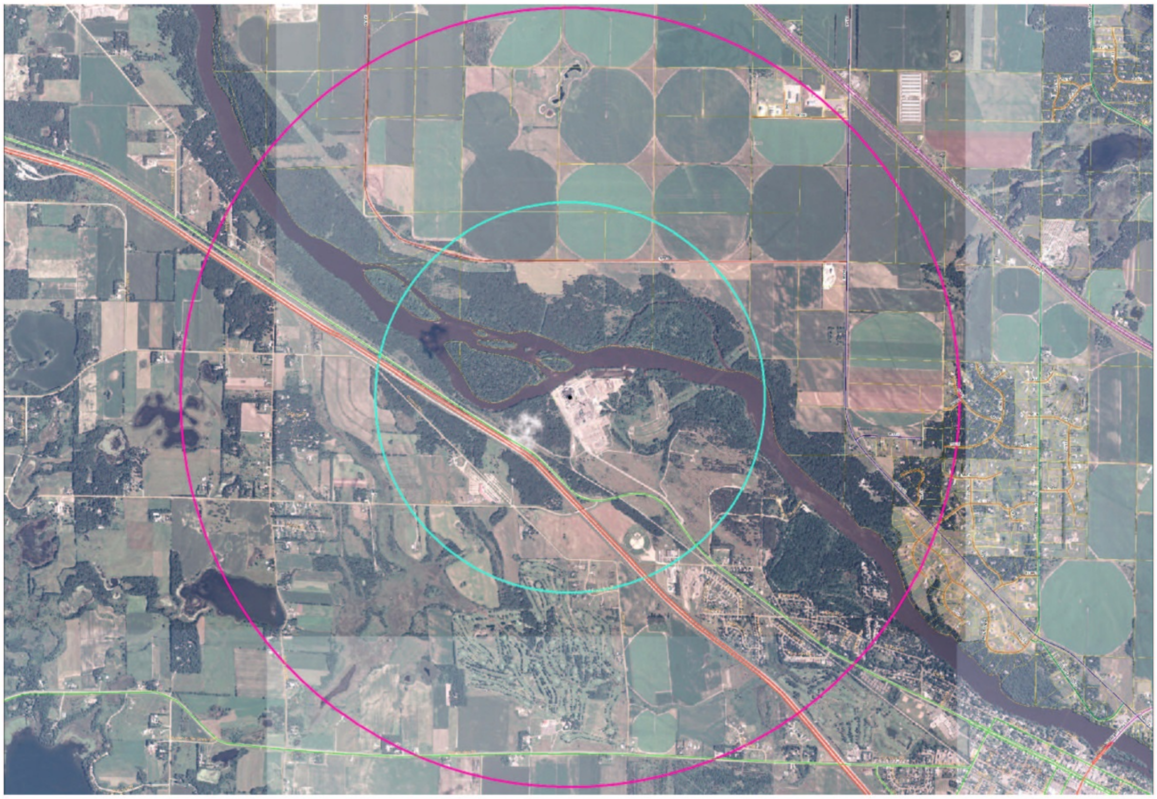
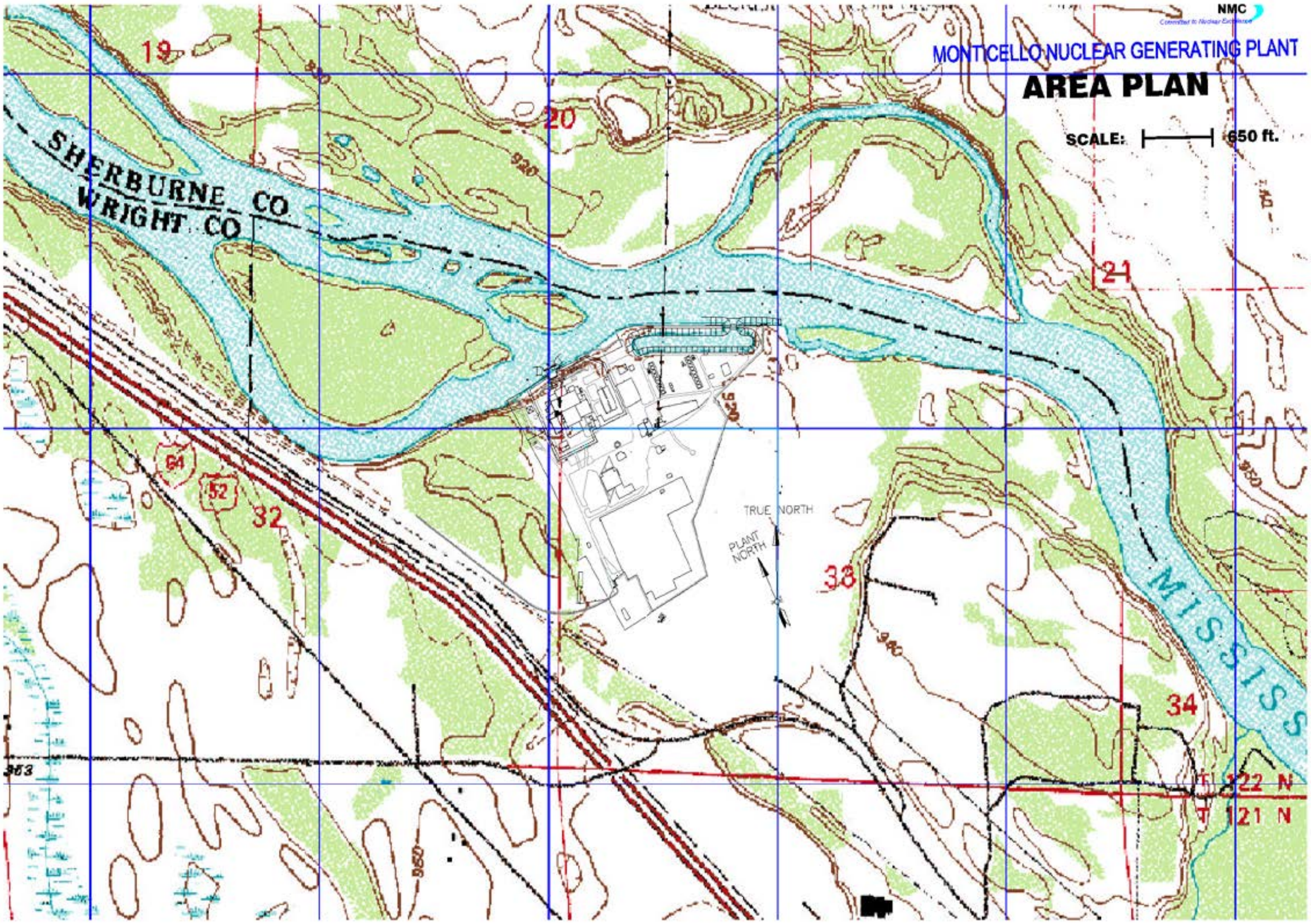
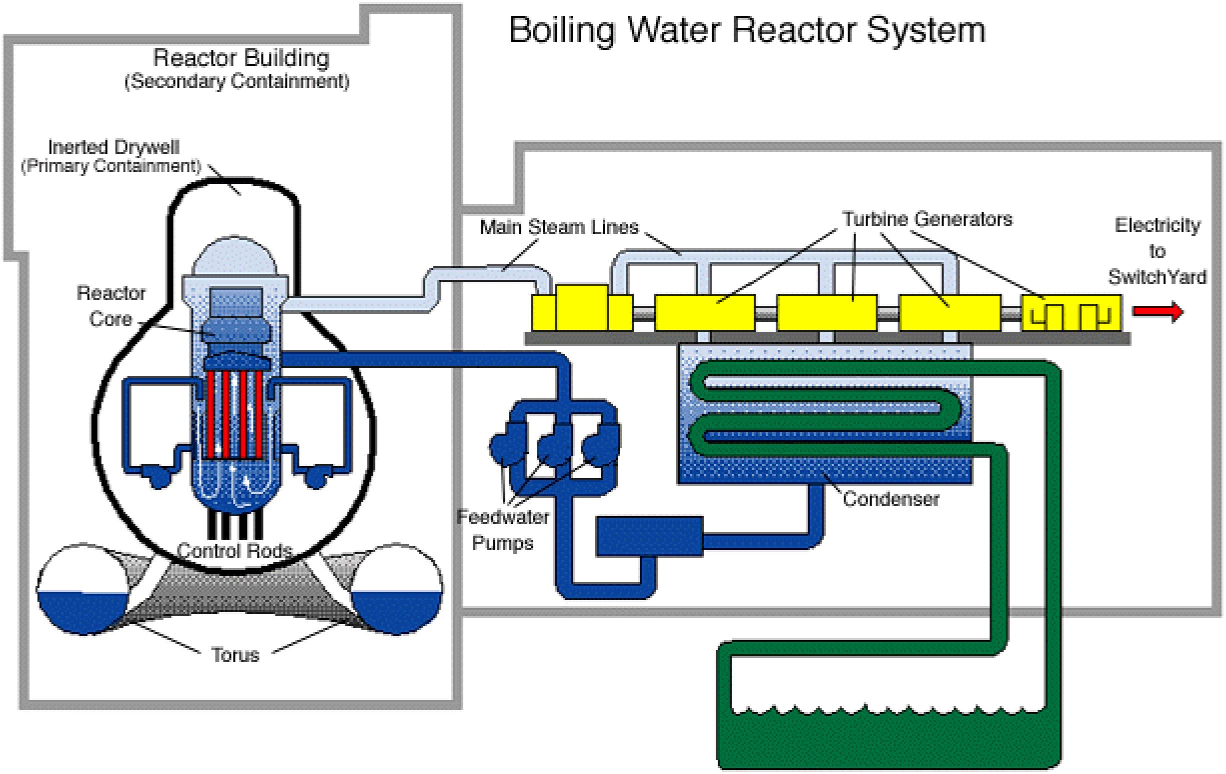


Figure 8-6:
Area Topographical Map



In a boiling water reactor, such as the Monticello Plant, a nuclear reaction in the reactor core generates heat, which boils water to produce steam inside the reactor vessel, which in turn is directed to turbine generators to produce electrical power (Figure 8-7). The steam is cooled in a condenser and returned to the reactor vessel to be boiled again. The cooling water is force-circulated by electrically powered feedwater pumps. Emergency cooling water is supplied by other pumps, which can be powered by onsite diesel generators or auxiliary steam from the reactor vessel.

Figure 8-7



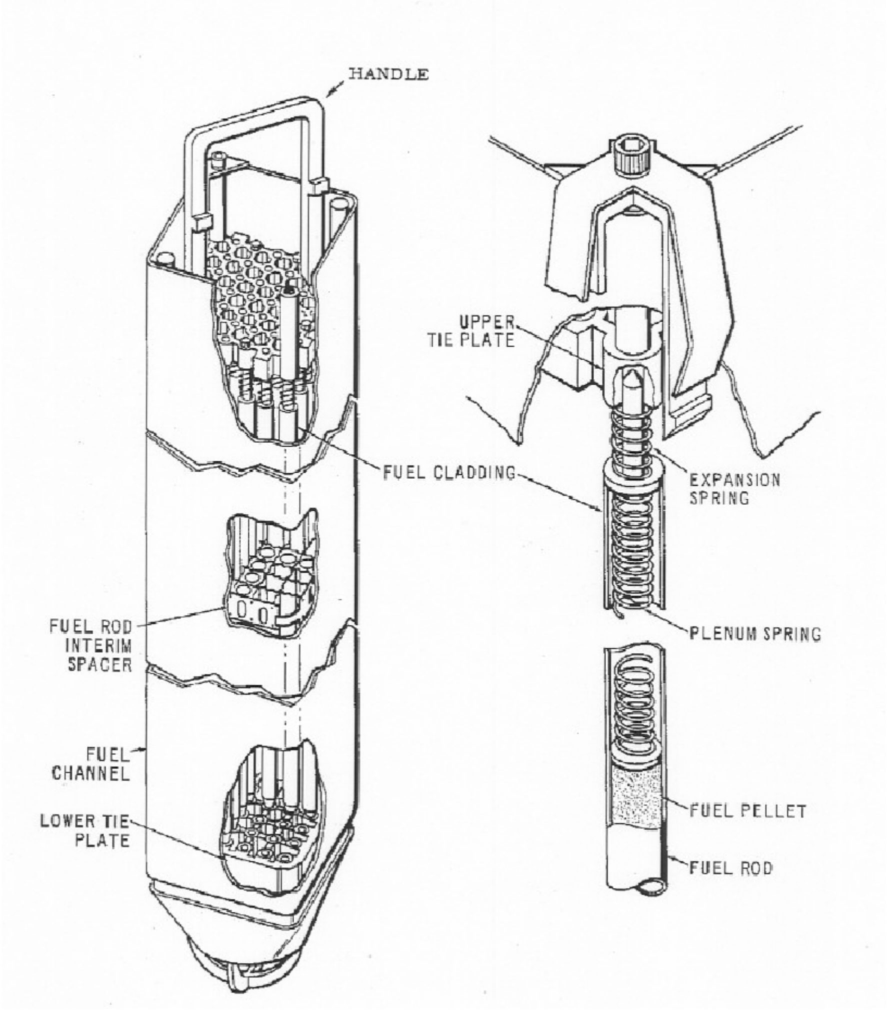
The Plant has an excellent operating history throughout its 50 years of operation. Both the Monticello and Prairie Island plants have maintained high levels of safety performance, achieving top marks on the industry's rigorous safety evaluations. In fact, our nuclear fleet was recognized as one of the highest performing fleets in the country according to our nuclear industry peer group.

8.3 FUEL CHARACTERISTICS

Each fuel assembly is 5.28 by 5.28 inches wide and up to 172 inches long. Figure 8-8 shows a representation of a typical fuel assembly used at the Plant.

Figure 8-8

Fuel Assembly **Fuel Rod**



Individual fuel rods within the assembly consist of high-density ceramic uranium dioxide fuel pellets, each about the size of a thimble, stacked in a tube made of a special alloy of steel called Zircaloy. The air in the filled tube is evacuated, helium (an inert gas) is backfilled, and the fuel rod is sealed by welding Zircaloy plugs in each end.

Each fuel assembly consists of standard fuel rods, part length fuel rods and water rods. Standard rods contain the nuclear fuel, and part length rods are fuel rods that extend to an intermediate point in the assembly. Water rods are hollow Zircaloy tubes with several holes located at each end to facilitate water flow through the assembly.

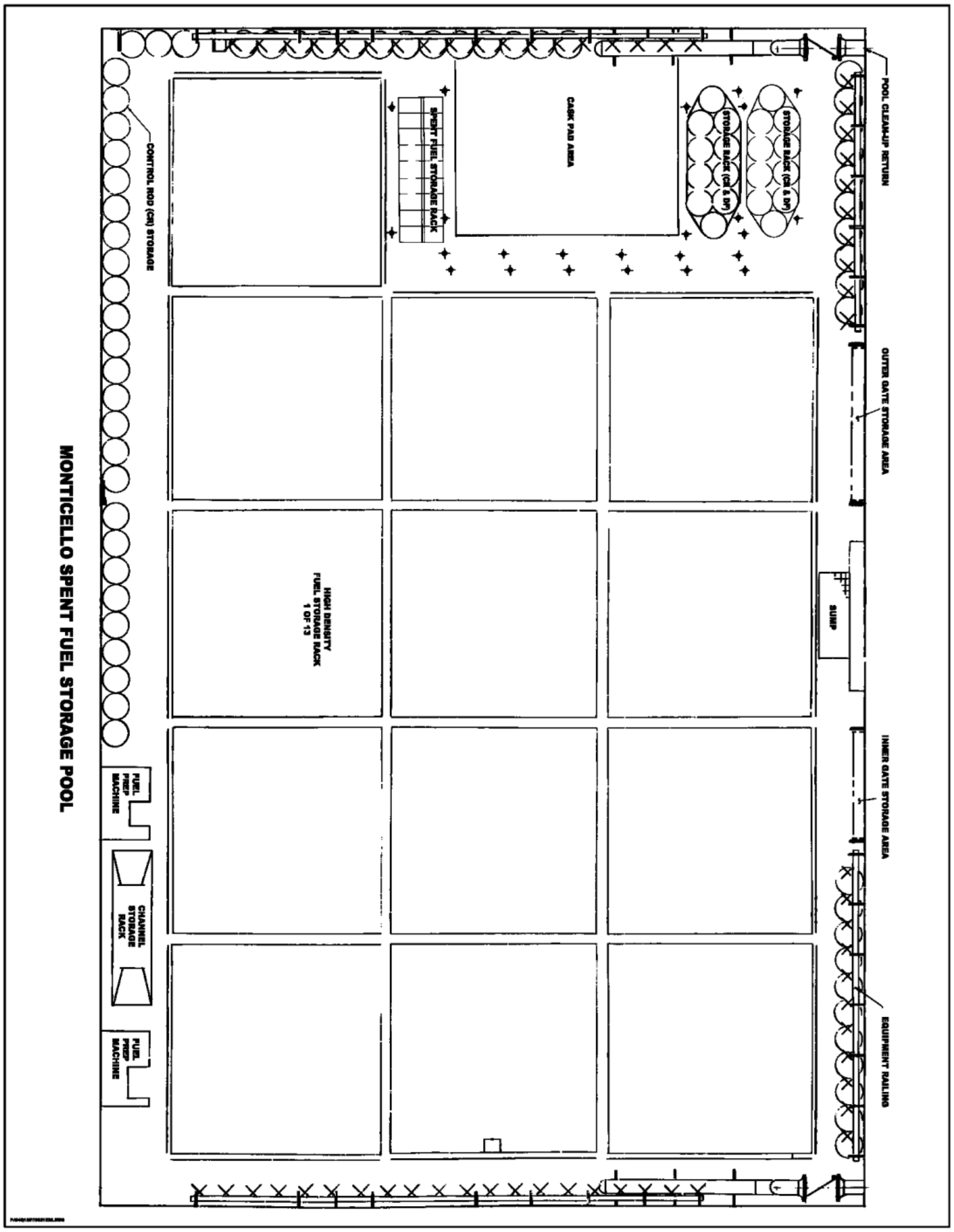
Fuel assemblies also contain spacers, springs and other components. A Zircaloy channel encloses the fuel bundle. The channel provides guidance and a bearing surface for the control rod, permits control of coolant flow, and provides mechanical support and protection during fuel handling operations. The Plant's reactor core is composed of 484 fuel assemblies, arranged in 121 cells. Each cell contains 4 fuel bundles, or assemblies, and a control blade.

Approximately every two years, the Plant is shut down to refuel the reactor. Between refueling outages, the Plant typically operates at full output around the clock, although at times the power level is "flexed" to lower levels to accommodate intermittent grid resources, such as wind powered turbines. During each refueling operation, approximately one-third of the fuel assemblies (currently 160), in the reactor are replaced with new assemblies. Thus, each nuclear fuel assembly provides heat constantly over about a six-year period before its output declines to the point it is no longer useful. These spent nuclear fuel assemblies are then removed from the reactor and stored in the Plant in the spent fuel pool.

8.4 SPENT FUEL POOL

The spent fuel pool provides storage for spent fuel assemblies. The pool is located on the refueling floor in the reactor building. It is filled with storage racks that hold the spent fuel assemblies and other irradiated reactor components. The depth of water in the pool is 37 feet, 9 inches. Figure 8-9 shows the spent fuel pool. The spent fuel pool is equipped with redundant cooling systems to remove heat that continues to be generated by the assemblies. The filtering portion of the system maintains pool water chemistry and removes suspended particles. The water above the spent fuel also provides radiation shielding. The spent fuel pool also provides an area for cask loading operations. Space is set aside so that a container can be lowered into the pool and assemblies transferred to it for dry storage or transport.

Figure 8-9



The NRC operating license allows for storage of up to 2,237 spent fuel assemblies in the current spent fuel storage rack configuration. Eight of the licensed storage spaces are not available because they did not meet quality control specifications when they were manufactured. This leaves 2,229 storage spaces available for use in the pool at the Plant. Twenty of those spaces hold used reactor control rod blades. Thus, there are 2,209 spaces available for spent nuclear fuel storage.

8.5 SPENT FUEL INVENTORY AND PRODUCTION ESTIMATE

As of June 1, 2021, 3,940 spent fuel assemblies have been discharged from the Plant's reactor. 1,052 spent fuel assemblies currently reside in the spent fuel pool and 1,830 spent fuel assemblies are stored in the ISFSI. In the mid 1980's, 1,058 spent fuel assemblies were shipped to a General Electric storage pool in Morris, Illinois.

The Plant maintains the ability to remove all the fuel from the reactor as part of good operating practice. This is referred to as full core offload capability. Maintaining full core offload capability is not necessary for safe plant operation, but provides flexibility in maintaining the reactor and associated systems. It is retained for economic reasons and operational flexibility. The existing pool has sufficient storage capacity to allow full core offload until the end of the Plant's current operating license in 2030.

Assuming approval to continue operation through 2040, Xcel Energy estimates that approximately 800 additional spent fuel assemblies would be discharged from the Plant's reactor, compared to ceasing operation of the Plant in 2030.[1] Table 8-1 provides an estimate of how many spent fuel assemblies will be discharged from the Plant's reactor over time.

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[1] Absent an extension of the operating license beyond 2030, the 2029 outage would only discharge 120 assemblies. With life extension, 160 assemblies would be discharged. Those additional 40 assemblies, together with the 2031 through 2039 discharged assemblies, total the 800 number referenced above.

Table 8-1:
Monticello Spent Fuel Assemblies

Year	Number of Additional Spent Fuel Assemblies Discharged During Refueling	Number of Spent Fuel Assemblies Stored at GE-Morris	Number of Spent Fuel Assemblies Stored at Monticello	Total Number of Spent Fuel Assemblies Produced at Monticello
2020		1058	2722	3780
2021	160	1058	2882	3940
2022		1058		
2023	160	1058	3042	4100
2024		1058		
2025	160	1058	3202	4260
2026		1058		
2027	160	1058	3362	4420
2028		1058		
2029	160	1058	3522	4580
2030		1058		
2031	160	1058	3682	4740
2032		1058		
2033	160	1058	3842	4900
2034		1058		
2035	160	1058	4002	5060
2036		1058		
2037	160	1058	4162	5220
2038		1058		
2039	120	1058	4282	5340
2040		1058		

8.6 EXISTING ISFSI FACILITY

The current ISFSI consists of a lighted area, approximately 460 feet long and 200 feet wide, roughly 3-1/2 acres in size, located adjacent to the reactor and turbine building. The tallest structures are the light poles that are approximately 40 feet tall. Two fences surround the facility with a monitored, clear zone between. Within the storage area, spent fuel is currently stored in 30 canisters in modular concrete vaults, placed on a reinforced concrete support pad. Concrete approach pads surround the support pad to accommodate vault placement and spent fuel canister transfer traffic. The site and storage vaults are monitored with cameras, other security devices, and temperature sensors. An access road connects the ISFSI to the rest of plant.

The storage facility can accommodate another thirty-six vaults of the existing design on a second support pad without having to change the security perimeter. The extra space can be used for the existing technology or a different welded canister system, depending on which is selected.

The location of the storage facility on the Plant site is shown in Figure 8-10. A plan view drawing showing major components of the facility is shown in Figure 8-11. An aerial view of the ISFSI is shown in Figure 8-12.

Figure 8-10:
Storage Site Location

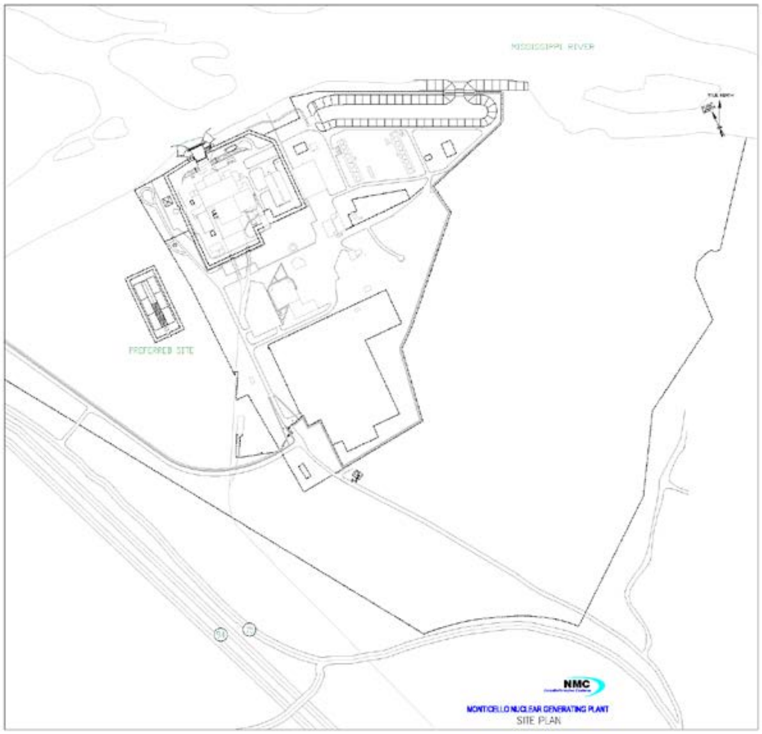


Figure 8-11:
Plan View Dry Spent Fuel Storage Facility

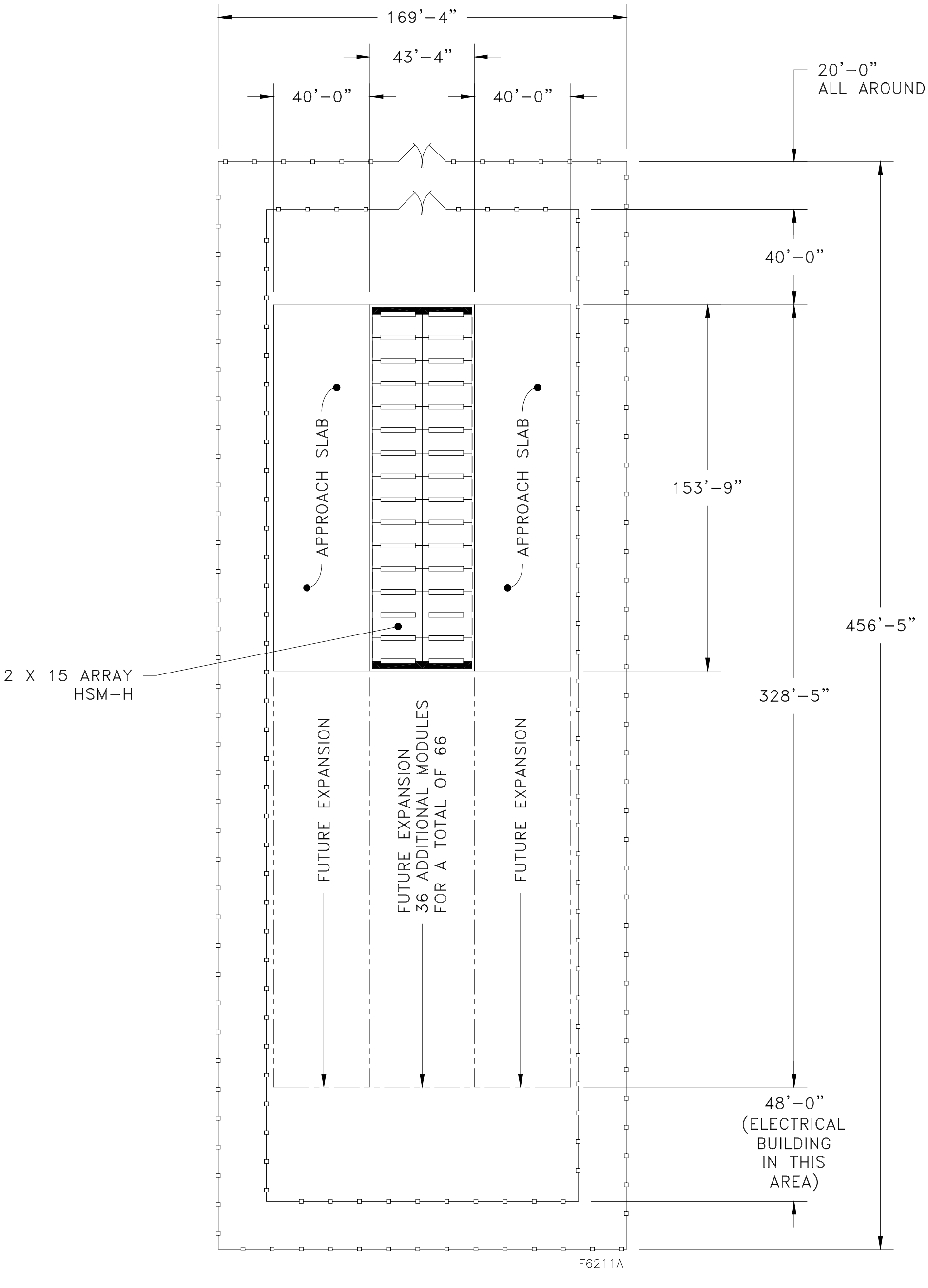


Figure 8-12:
Aerial Photo Showing the Dry Spent Fuel Storage Facility

8.7 NUMBER OF STORAGE CONTAINERS

Xcel Energy proposes to use a welded canister type storage system for the additional storage capacity at the Plant's ISFSI. This is the type of system currently in use at the ISFSI. In this type of system, the spent fuel assemblies are loaded into a metal canister with welded lids that provide a leak-tight confinement of the spent fuel. The interior of the canisters is dried of any water and filled with the inert gas helium. These canisters are then placed in a concrete overpack, either vertical (Figure 8-13) or horizontal (Figure 8-14) which then provide further radiation shielding to workers and members of the public and also protection from external hazards. There are currently several welded canister designs licensed by the NRC. These various designs have the capacity to store between 56 to 68 fuel assemblies similar to those used at the Plant. Based on the technology eventually selected, this would result in the need for between 12 to 15 additional storage modules.

Figure 8-13:
Vertical Canister Storage System

Figure 8-14:
Horizontal Canister Storage System

When the Plant shuts down and ceases operation, the inventory of assemblies in the reactor and pool must be removed to facilitate decommissioning. At the end of its current license in 2030, 40 containers would be required to store all of the fuel assemblies in the reactor and pool, assuming a 61-fuel assembly capacity cask.

8.8 DUAL PURPOSE CANISTER SYSTEM DESCRIPTION

Regardless of the specific vendor and system chosen, Xcel Energy proposes to use a dual-purpose sealed canister system licensed for both the storage of spent fuel under

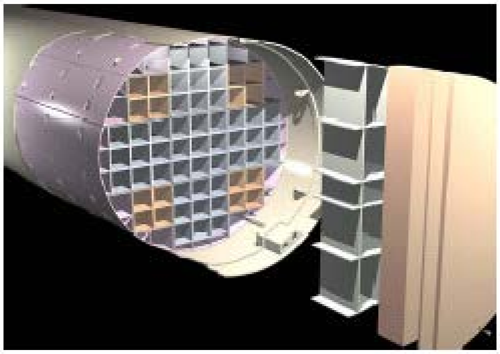
10 CFR Part 72 and transport under 10 CFR Part 71. The NUHOMS 61BT Dry Fuel Storage System currently in use is such a system.

Canister-based systems such as the NUHOMS 61BT Dry Fuel Storage System share similar components and operational sequences. These systems consist of the following primary components:

- Sealed metal canister – a steel container used to store between 56 and 68 sixty-one Monticello type fuel assemblies.
- Concrete Storage Module – a concrete vault used to protect and shield the metal canister, either horizontally or vertically.
- Transfer Cask – an intermediate steel cask used to handle and move the canister from the spent fuel pool to the concrete storage module.
- Lifting Yoke – a steel lifting device that interfaces with the crane to lift the transfer cask into and out of the spent fuel pool.
- Transfer vehicle – typically a multi-wheel trailer or vehicle used to safely support and move either the transfer cask (horizontal system) or the final concrete cask/steel canister from the reactor building to ISFSI.
- Ancillary Devices – auxiliary equipment used to dry, weld, backfill and seal the steel canisters for storage.
- Transportation Cask – a steel overpack cask used to ship the spent fuel canister from the Monticello Plant.

8.8.1 Welded Canister

In a canister-based system, confinement is accomplished in a steel canister with welded lids. While some details differ between the various designs, all are similar in terms of their overall design and construction.



As an example, below we describe some of the dimensions and characteristics of some NUHOMS canisters.

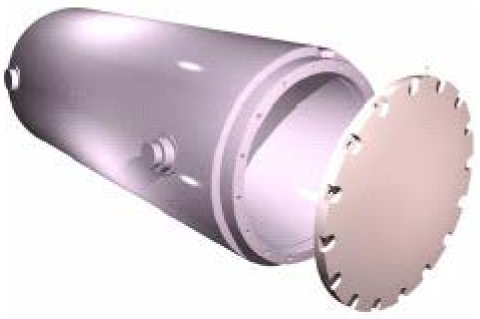
The canister consists of an outer shell, internal basket, radiation shield plug, and lid. The NUHOMS shell is a half-inch thick steel cylinder with an outside diameter of 67 inches and length of 196 inches. It has a base and lid thickness of approximately 7.5 and 9 inches respectively, which leaves a cavity length of 179.5 inches. The Plant's fuel assemblies have a length of up to 172 inches long. The lid is secured to the shell with a double weld closure to ensure no leakage of radioactive gases or gas used to backfill the canister. The shell, lid, and basket are constructed of stainless steel to provide a corrosion-resistant environment for the spent fuel. The lid incorporates a 7-inch thick carbon steel plug to provide radiological shielding for workers during closure operations.

8.8.2 Storage Module

The NUHOMS Horizontal Storage Module provides a protected storage location for the welded canisters. The storage module is made of reinforced concrete and is designed to provide radiological shielding, protection from environmental conditions, structural integrity, and heat removal. In the NUHOMS system, the welded canister is transferred from the transfer cask to the storage module at the ISFSI.

Vertical systems use a cylindrical concrete overpack to provide the same function as the NUHOMS Horizontal Storage Module. An annular gap provides for heat removal via natural convection of air around the canister. Vertical systems transfer the canister from the transfer cask to the concrete overpack in the plant and then move the final canister/overpack to the ISFSI using a heavy haul transporter.

8.8.3 Transfer Cask



The transfer cask is used to lift and handle the canister during spent fuel loading, closure, and transfer operations. The empty canister is placed inside of the transfer cask. The transfer cask is lifted using trunnions on either end of the cask. The cask also provides radiological shielding to protect plant personnel until the canister is loaded into the storage module.

8.8.4 Lifting Yoke

The lifting yoke assembly provides the interface between the plant crane and the transfer cask and is used to maneuver the cask within the Reactor Building. A lifting pin connects the crane hook to the lifting yoke. It is designed to be compatible with the reactor building crane hook. The lifting yoke engages the outer shoulder of the transfer cask lifting trunnions.

8.8.5 Transfer Trailer/Transfer Vehicle

The NUHOMS horizontal system uses an unpowered trailer to transport the transfer cask between the reactor building and ISFSI. The trailer is used to bring the empty transfer cask into the reactor building where the transfer cask is lifted off and up to the pool for loading and again when the loaded transfer cask is placed on the trailer for transfer to the ISFSI. The transfer trailer is also used to move the transportation cask within the Monticello Plant site.

Vertical systems typically use a towed or self powered cask transport vehicle to move the final cask configuration. A picture of a self-powered version is shown below.

8.8.6 Vacuum Drying System

The Vacuum Drying System removes all the moisture out of the canister after it is removed from the spent fuel pool. It performs blow down (bulk water removal), vacuum drying, and helium backfilling operations after fuel loading and prior to final closure.

8.8.7 Welding

The inner and outer canister lids are secured by multi-layers of welds to ensure canister integrity. The closure welding of the canister employs the high purity process, multi-layer welding, using an automated welding machine.

Closure welds are subjected to non-destructive examination to ensure high quality welds.

After welding, the canister is leak tested to meet the standards of a "leak tight" container. Leak testing of the closure takes advantage of the helium environment within the canister and draws a vacuum on the top closure welds.

8.8.8 Transportation Cask

Transportation casks are licensed under 10 CFR Part 71 for transport of the canister from the Plant. The canister is placed inside the transportation cask. The cask utilizes a bolted closure system.

Impact limiters mounted on either end of the transportation cask provide impact protection to meet accidental impact requirements of 10 CFR Part 71. The impact limiters absorb energy during an impact event.

8.9 OPERATIONS

This section provides a description of the fuel loading operations for transferring spent fuel from the pool to the ISFSI using the current NUHOMS design, as well as the operational sequence for off-loading canisters from the storage module at the ISFSI and transporting them off-site.

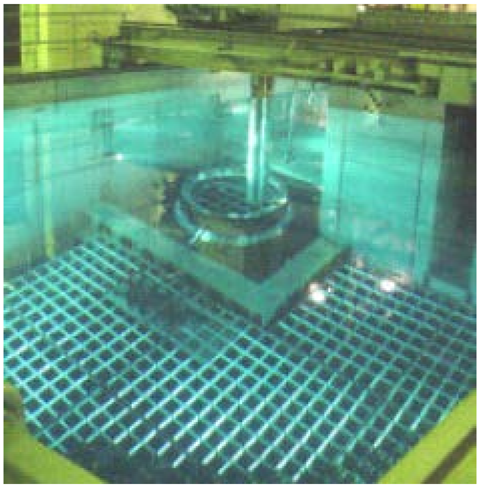
If a vertical storage design is used, the operations are nearly identical with the exception of the movement of the welded canister from the transfer cask to the concrete overpack. With a vertical system, the canister would be transferred to the concrete overpack inside the Monticello reactor building. The canister/concrete overpack would then be moved to the ISFSI for storage using a specially designed heavy haul vehicle as shown above.

8.9.1 Canister Loading

Canister loading includes physically placing the fuel assemblies into the canister, decontamination, draining, drying, and seal-welding, and includes the following sequence of events:

1. Stage the transfer cask and canister inside the truck bay door of the plant.
2. Lift the empty canister by its lifting lugs and place it vertically in the transfer cask.
3. Install the pneumatic seal between the cask and the canister and fill the canister with water.
4. Engage the lifting yoke with the cask upper trunnions.
5. Lift the transfer cask and canister up to the fuel pool.

6. Lower cask into the pool.
7. Load the spent fuel assemblies into the canister.



8. Install the canister shield plug underwater.
9. Lift the cask out of the pool water.
10. Drain water as required before the welding operation.
11. Wash down the exposed portions of the transfer cask.
12. Move to cask decontamination area.

13. Lift the automatic weld machine (AWM) and install it over the inner top cover plate. Lift AWM and inner top cover together and install them over the canister. (The inner top cover plate and welder can be lifted and installed separately).
14. Perform inner top cover weld.

15. Connect the vacuum drying system to the vent and siphon ports.
16. Remove bulk water from the canister using pressurized air.
17. Perform vacuum drying and helium backfilling.
18. Install and seal weld the vent and siphon port covers.
19. Mount the AWM and outer cover plates on the canister.
20. Weld the canister outer top cover plate.
21. Bolt the cask lid.
22. Lift the transfer cask and move it to the loading bay.

8.9.2 Transport to the ISFSI

Canister transfer operations include: 1) transferring the loaded cask to the on-site transport trailer, 2) transporting the cask/canister to the ISFSI, and 3) inserting the canister into the storage module. The operations include:

23. Set the lower trunnions of the transfer cask into the support skid on the trailer.
24. Rotate the transfer cask to a horizontal orientation.
25. Use the on-site trailer to transfer the cask and canister to the ISFSI.
26. At the ISFSI, back the trailer and align the cask with the storage module.
27. Remove the hydraulic arm access cover, the cask lid and the storage module door.
28. Use the hydraulic arm to insert the canister into the storage module.
29. Install the storage module door.

The loading cycle time for each container placed in the ISFSI is expected to be five days based on typical operating experience.

8.9.3 Removal for Offsite Shipment

The storage system does not require lifting of the loaded canister during transfer to and from the storage module. The transportation cask can be backed up to the storage module and the canister transferred from the storage module. The steps are as follows:

1. Align the transportation cask with the storage module.
2. Remove the storage module's door.
3. Connect the hydraulic arm to the canister and withdraw the canister from the module into the transportation cask.
4. Install the transportation cask covers and seals.
5. Perform an assembly verification leak test on the transportation cask per ANSI N14.5, Table A-1, 8.5.5.
6. Lift the transportation cask from the trailer and place on a rail car.
7. Install the cask impact limiters.
8. Perform a radiological survey for transportation.
9. Move the cask and canister to the rail spur.

8.10 STORAGE PROPOSAL

Xcel Energy proposes to increase the capacity of the spent fuel storage at the Plant by loading additional welded canister modules and placing them within the existing facility. The existing facility was constructed with sufficient space to add the necessary additional storage modules. In order to support Plant operation beyond the current licensed life of 2030, additional canisters would need to be loaded in the 2028 timeframe. As noted earlier, there are several existing designs currently licensed by the NRC, and the Company has not yet selected the specific technology for this increased capacity. Instead, we are requesting that the Commission approve the Company's request for a CN for additional storage sufficient to support an additional

10 years of plant operation using a welded canister system, without specifying a particular vendor or cask technology. The Company then would select a specific vendor at a later date using a competitive bidding process that will assess all applicable designs and obtain the optimal technology at the best price for our customers.

8.11 LIFE OF THE STORAGE FACILITY

The economic life of the ISFSI and storage system (the period over which the investment in the facility will be depreciated) will be based on a judgment about how long it will remain in service. The length of time of operation of the ISFSI depends on how long the Plant will operate and the availability of off-site storage or a permanent repository.

The NRC's general license for the storage of spent fuel in each cask fabricated under a Certificate of Compliance terminates 20 years after the date that the particular cask is first used by the general licensee to store spent fuel, unless the cask's Certificate of Compliance is renewed, in which case the general license terminates 20 years after the cask's Certificate of Compliance renewal date. In order to renew a license, a demonstration must be made that the facility can continue to operate within the specifications of the storage license. No maintenance is required on the canisters or storage modules themselves. Section 5.1.3.5 of the Safety Analysis Report states, "NUHOMS is a totally passive system and therefore does not require maintenance. However, to ensure that ventilation airflow is not interrupted, the [module] is periodically inspected to insure that no debris is in the airflow inlet or outlet openings."

Physically, the facility can be operated indefinitely. The materials used in the storage system (canisters and storage modules), principally stainless steel and reinforced concrete, are sturdy and long-lived. The system requires no active support systems to ensure performance other than simple temperature monitors that are readily replaceable. Should it be necessary, a canister can be transferred to a new storage module. The supporting infrastructure (intrusion detection, cameras, lights, weed mitigation and access roadways) will be maintained as needed.

8.12 ISFSI DESIGN, CONSTRUCTION, COST AND SCHEDULE INFORMATION

The ISFSI facility was designed and constructed under the project that loaded the first 30 modules to support Plant operation until 2030. The facility footprint was sized to allow additional storage capability without changing the overall dimensions of the ISFSI. The soil under the area where additional storage could be added was removed and replaced with engineered soil that can support the weight of an additional pad and storage modules. A new concrete pad will need to be constructed to support the additional casks. Depending on the technology selected, either new horizontal storage modules will be placed on the new pad or loaded vertical concrete storage casks will be added.

The existing horizontal storage modules were fabricated offsite and assembled at the Plant. Vertical concrete casks are typically fabricated onsite due to the difficulty in transporting from an offsite facility. The steel canisters are fabricated in a specialized shop and shipper to the Plant for loading.

To support this operation beyond 2030, the storage canister system must be ordered and fabrication should begin in 2026. The loading campaign would begin in 2028 and take approximately four months to complete.

The estimated installed cost of the additional storage at the ISFSI in 2020 dollars is $72 million. The estimate includes the following major component costs:

Regulatory Processes	$ 2.5 M
Engineering, design, and construction	$ 9.6 M
Canisters/storage modules/loading	$60.0 M
Total	**$72.1 M**