Application for Permit to Appropriate Water within the State of South Dakota

Prepared for

Big Stone unit I and Big Stone II Co-Owners

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Big Stone Generating Plant
Grant County, South Dakota

Table of Contents

List of Tables

List of Figures

List of Attachments

1 Introduction

Otter Tail Corporation, doing business as Otter Tail Power Company, is filing this application for a Permit to Appropriate Water within the State of South Dakota in accordance with the applicable portions of South Dakota Code of Law (SDCL) Chapter 46-2A-2 and the Administrative Rules of South Dakota (ARSD) Section 74:02:01. This Application proposes a permitted 10,000 acre-ft annual appropriation of water from the Veblen Aquifer to provide cooling and process makeup water for an existing electric generating facility in Grant County, South Dakota, Big Stone unit I, the existing Northern Lights Ethanol Plant, and a proposed new electric generating facility, to be called Big Stone II, that will be constructed immediately adjacent to the existing unit. The Big Stone facility location is shown on Figure 1. Figure 2 is a site plan.

Big Stone unit I is a nominal 450 MW (net) coal-fired electric generating facility which began commercial operation in 1975 and is currently operated by Otter Tail Power Company. Big Stone unit I is co-owned by Northwestern Corporation dba NorthWestern Energy, Montana-Dakota Utilities Co., a Division of MDU Resources Group, Inc., and Otter Tail Power Company. Big Stone II will be a nominal 630 MW (net) coal-fired electric generating facility. Big Stone II, also to be operated by Otter Tail Power Company, will have the following Co-Owners:

- Central Minnesota Municipal Power Agency (CMMPA)
- Great River Energy (GRE)
- Heartland Consumers Power District (HCPD)
- Montana-Dakota Utilities Co., a Division of MDU Resources Group, Inc. (MDU)
- Otter Tail Corporation dba Otter Tail Power Company (OTP)
- Southern Minnesota Municipal Power Agency (SMMPA)
- Western Minnesota Municipal Power Agency (WMMPA)

The information provided in this Application represents the best knowledge and judgment of the Big Stone unit I and Big Stone II co-owners.

The increase in production that will result from the combined Big Stone unit I and Big Stone II electric generating facilities requires a significant increase in water usage, primarily for cooling purposes.

This additional appropriation is needed to adequately supply the Big Stone unit I and Big Stone II with water during periods of extended drought. Other users of water from the Veblen Aquifer will not be adversely affected by this appropriation, as the aquifer has adequate capacity as demonstrated in this Application.

This document is organized into six sections including this introductory section. Section 2 summarizes the Big Stone Plant permitting and water appropriation history to provide context for this current permit application. Section 3 outlines the specifics of this appropriation permit application including a description of the proposed groundwater withdrawal system, discussion of anticipated system operation and results of modeling of the frequency and magnitude of groundwater withdrawals. Section 4 provides background on the Veblen Aquifer and summarizes the results of a groundwater supply evaluation completed in 2006 and 2007 to provide additional information on the aquifer in the vicinity of the Big Stone plant. The existing users of the Veblen Aquifer and the modeling of impacts to the aquifer and existing users from the proposed appropriation are discussed in Section 5. Section 6 is a list of references and Section 7 contains the completed South Dakota Department of Environment and Natural Resources forms for a permit to appropriate water.

2 Permit and Appropriation History

No previous request for groundwater appropriations has been made related to the operation of the Big Stone Plant. Big Stone plant water rights and appropriations have been limited to surface water sources, specifically Big Stone Lake. This section summarizes the history of those surface water appropriation permits.

2.1 Water Rights and Permits

2.1.1 Water Permit No. 1768-3

Water Permit No. 1768-3 was originally issued to Northwestern Public Service Company, Montana-Dakota Utilities Co. and Otter Tail Power Company for withdrawal and storage of water from Big Stone Lake for Industrial Use with priority date of September 14, 1970. The permit authorized appropriation of up to 7,000 acre-ft of water from Big Stone Lake annually, subject to the following withdrawal restrictions:

- Maximum diversion rate of 100 cubic feet per second (cfs) when the lake water surface elevation is above Elevation 967 feet[1];
- Maximum diversion rate of 10 cfs, or its daily acre-ft equivalent (19.83 acre-ft per day) when the lake water surface elevation is between Elevation 967 feet and Elevation 965 feet, during the period October to April, inclusive.
- No diversion is allowed when the lake water surface elevation is at or below Elevation 967 during the period May to September, inclusive, without permission of the South Dakota-Minnesota Boundary Waters Commission (pursuant to SDCL 46-29-12).

2.1.2 Water Right No. 1983-3

The Big Stone Plant applied for Water Right No. 1983-3 in 1973 to address a discrepancy between the South Dakota water permit for the Big Stone plant and a permit the co-owners had received from the State of Minnesota for the same water appropriation. The Minnesota permit had a provision to allow withdrawals up to 460 acre-ft in any seven day period during the period October through April when the lake water level is above Elevation 966 feet. This volume corresponds to a withdrawal rate of 35 cfs, 25 cfs greater than was allowed under South Dakota Water Permit No. 1768-3.

[1] All elevations referenced in this document and the previous permit documents are referenced to project datum, which is 2.3 feet higher than the 1929 mean sea level datum.

Water Right No. 1983-3 was licensed for the Big Stone Plant in 1982 and authorized water withdrawals from Big Stone Lake with diversions between 10 and 110 cfs. The authorization incorporated the same diversion restrictions contained in Water Permit No. 1768-3, with the addition of the 35 cfs rate provision when the lake water level is between Elevation 966 feet and Elevation 967 feet.

2.1.3 Water Permit No. 6253-3

Current Water Permit No. 6253-3 was issued on May 2, 2001 to authorize the storage of an additional 1,000 acre-ft of water by increasing the storage capacity authorized by Water Right 1983-3. The permit authorized an increased withdrawal of up to 8,000 acre-ft per year in order to reflect actual storage capacity of the Big Stone plant's five water ponds. The permit also authorized the additional industrial use of the appropriated water for service of the adjacent Northern Lights Ethanol Plant.

No change in the previous diversion rate restrictions were authorized by the new permit. The permit's diversion rates are summarized in Table 1.

Table 1 Current Water Permit Allowable Diversion Rates

Time Period	Lake Elevation (Feet)	Diversion Rate
May-September	>967	110 cfs
May-September	<= 967	No Diversion Without Permission of SD and MN Boundary Water Commission
October-April	<965	No Diversion Without Permission of SD Water Management Board
October-April	>=965 and <=966	Restricted to 10 cfs or Daily Acre-feet Equivalent
October-April	>966 and <967	35 cfs or Daily Acre-feet Equivalent Not Exceeding 460 Acre-feet any Consecutive 7 Day Period
October-April	>= 967	110 cfs

2.1.4 Water Permit No. 6678-3

On March 16, 2006 Otter Tail Power made application for an additional appropriation of up to 10,000 acre-feet per year from Big Stone Lake. Approval of the application was made by the South Dakota Water Management Board on July 12, 2006 with Water Permit No. 6678-3 approved on August 23, 2006.

The diversion restrictions from Big Stone Lake under this permit are identical to the restrictions in Permit No. 6253-3 and shown in Table 1 above. Permit No. 6678-3 also authorizes an increase in storage capacity of holding ponds at the Big Stone facility to hold an additional 10,170 acre feet of water for a total of 18,170 acre feet of water storage capacity. The permit also authorizes the additional industrial use of the appropriated water for service of the adjacent Northern Lights Ethanol Plant.

2.2 Emergency Allocations

Emergency allocation requests were made for the Big Stone Plant on four occasions due to drought conditions and impending shortfall in makeup water. Those requests and the actual emergency withdrawals that were made are summarized in Table 2.

Table 2 Historical Emergency Allocations

Year of Request	Requested Volume	Request Granted by State of South Dakota?	Actual Withdrawal/Withdrawal Date
1976	1,000 acre-ft	Yes	492 acre-ft/October 1976 508 acre-ft/February 1977
1977	2,500 acre-ft	Yes	No withdrawal made
1988	500 acre-ft	Yes	500 acre-ft/Fall 1988
1989	3,700 acre-ft	Yes	No withdrawal made

3 Requested Water Appropriation

3.1 Appropriation Volume

Otter Tail Power Company, on behalf of all the Big Stone unit I and Big Stone II owners, is requesting a permit to appropriate up to 10,000 acre-ft of water annually from the Veblen Aquifer. This appropriation, along with existing authorized surface water withdrawals up to 18,000 acre-feet annually (Permit No. 6253-3 and Permit No. 6678-3), is to provide cooling and process makeup water for an existing electric generating facility in Grant County, South Dakota, Big Stone unit I, and a proposed new electric generating facility, to be called Big Stone II, to be constructed immediately adjacent to the existing unit. The appropriated water will also serve an additional industrial use, the adjacent Northern Lights Ethanol Plant.

The anticipated surface water makeup requirement for operation of the combined Big Stone unit I and Big Stone II, assuming typical precipitation and evaporation rates and expected plant operation, is approximately 13,000 acre-ft per year. The proposed water use for the combined Big Stone facility is illustrated in Figure 3.

3.2 Groundwater Withdrawal System

3.2.1 System Layout

The groundwater withdrawal system will consist of two wells constructed on property currently owned or under option to purchase by the Big Stone II Co-owners. The locations for the two on-site wells are shown on Figure 4. These wells were constructed as part of the groundwater supply evaluation discussed in Section 4.2. The required water volume is not available from on-site wells, so additional wells will be installed off the plant property. This Application is for, in addition to the two existing on-site wells, up to 12 additional off-site wells that may be necessary to obtain the desired water appropriation. Eighteen potential quarter-quarter sections (40 acre parcels) have been identified for placing those additional wells, as shown on Figure 4. The precise location of the off-site wells yet to be constructed may vary within the 40 acre parcels identified based on site-specific conditions.

3.2.2 Well Design

All wells installed for this appropriation will be constructed in accordance with South Dakota Well Code. Each well will be designed so that it can produce the maximum rate that the aquifer can yield at that location. Specific aquifer characteristics will determine the exact amount that each well will actually be able to deliver. The water bearing unit into which the wells will be constructed starts at roughly 20 to 100 feet below ground surface and extends to roughly 150 to 250 feet below ground surface. Anticipated static water levels are roughly 15 to 100 feet below ground surface. Anticipated pumping water levels are 40 feet or more below ground surface, again depending on site-specific aquifer characteristics.

Two production wells, PW1-2 and PW1-4, have already constructed. The water-bearing sand at well PW1-2 extends from 89 to 178 feet depth below ground surface. Static water level is 75 feet below ground surface. The pilot hole was overdrilled using an 18 ¾-inch bit using mud rotary drilling to a depth of 179 feet. A 10-inch diameter stainless steel screen was installed from 178 to 143 feet depth. The screen has varying slot size openings to match the aquifer grain size observed at various depths and is gravel packed. The well is cased with a 12-inch diameter carbon steel casing and pressure grouted using neat cement from ground surface to 105 feet below ground surface. The well was developed by jetting until water ran clear and was free of sand.

The water-bearing sand at well PW1-4 extends from 121 to 185 feet depth below ground surface. Static water level is 117 feet below ground surface. The pilot hole was overdrilled using an 18 ¾-inch bit using mud rotary drilling to a depth of 186 feet. A 10-inch diameter stainless steel screen was installed from 186 to 140 feet depth. The screen has varying slot size openings to match the aquifer grain size observed at various depths and is gravel packed. The well is cased with a 12-inch diameter carbon steel casing and pressure grouted using neat cement from ground surface to 126 feet below ground surface. The well was developed by jetting until water ran clear and was free of sand.

Additional wells will be of similar construction to PW1-2 and PW1-4. Each well design will be modified as needed based on site specific data gathered during drilling. Final screen length, diameter, slot size, and gravel pack will be based on formation samples taken from the well during drilling. Similarly, future wells will be developed by jetting, surging, or other methods appropriate for removing sands and conditioning the aquifer in the vicinity of the well screen. The wells will then be test pumped to determine well characteristics and to size a pump. Wells will be finished at the surface with a pitless adaptor and the site will be graded to drain away from the well. Appropriate access will be provided along with electrical supply and well control features.

3.2.3 Pipeline Design

A pipeline will be constructed to convey water from the wells to the power plant. The pipeline will be located along existing public right of ways or other easements that already exist to the extent possible. Easements will be procured for the pipeline as needed. The pipeline route will be laid out to avoid to the extent possible all wetlands or other valuable environmental features. When this is not possible impacts will be mitigated as required by the regulating authority. Access to the pipeline will be considered during design and to the extent possible all portions of the pipeline will be readily accessible from public roads.

The pipeline will be constructed of either HDPE or PVC materials depending on availability and price. It will be buried approximately 7 ½ feet deep to prevent the line from freezing. The pipeline will be designed with appropriate thrust restraint and areas of poor soils will be avoided, corrected or taken into account in the pipeline design to ensure pipeline integrity.

The pipeline will vary in diameter depending on the number of wells connected to it at any given point. Well flow rates are anticipated to vary from as little as 200 gpm to as much as 2,000 gpm or more, therefore the pipe from the individual wells to the main pipeline is expected be 8 to 10 inches in diameter. The pipe size will increase in diameter as each well is added to the main pipeline. Diameters will increase based on matching flow velocities in the pipe to the extent practical. The maximum flow to be carried by the pipeline is 6,200-gpm. At this point the pipeline will be nominally 20 to 30 inches in diameter.

The pipeline will include various appurtenances to allow for reliable operation and maintenance. Pipeline tracer wires will be buried along with the pipe to allow for easier future location of the main. Valves will be included along the pipe line to allow each well to be isolated from the main line and at various points along the main pipeline to allow for pipeline maintenance. Check valves will be installed near each well to prevent back flow into the wells. Well flushing hydrants will be located at each well to allow for well maintenance. Air/vacuum valves will be installed at high points along the entire route to prevent air binding and control undesirable conditions from damaging the pipe. If needed, pressure relief valves and other devices will be included at key points to protect the main from surges. If needed, blow off valves will be installed at low points along the route to allow for the main to be emptied in the future. Pipeline cleanouts will be installed at regular intervals to facilitate maintenance.

3.2.4 Land Ownership

The proposed groundwater withdrawal system will be located on property that includes parcels currently owned by OTP, under option for purchase by OTP, and owned by others. Property owned or under option by OTP is indicated on Figure 4 as the "Property Boundary". OTP will be negotiating options and easements prior to the groundwater withdrawal system is constructed and tested.

3.3 Withdrawal Operations

The groundwater appropriation will be used to supplement the water withdrawn from Big Stone Lake under Permit No. 6253-3 and Permit No. 6678-3. Under typical plant operation, it is anticipated that surface water from Big Stone Lake would be the primary source of makeup water for the plant. Big Stone Lake water contains lower concentrations of minerals than the available groundwater, so is a preferred water source. Water from Big Stone Lake would be used to meet the immediate water needs of the plant and to keep the cooling pond (which will also serve as a makeup water storage pond) at near maximum capacity. During periods when withdrawals from Big Stone Lake are restricted by permit or other operational constraints, makeup water would be withdrawn from the cooling pond. The groundwater withdrawal system would be operated when those two sources could not meet plant water needs and to "top off" the cooling pond when that source has been drawn down and water is not available from Big Stone Lake. The groundwater withdrawn would enter the combined Big Stone Plant water management system by being piped to the plant for treatment prior to discharge to the cooling pond.

The current proposed water management plan differs slightly from the plan outlined in the application for Permit 6678-3. The water management plan previously included a 450-acre makeup water storage pond to provide a source of water to the plant when withdrawal from Big Stone Lake was restricted. Because of environmental and economic considerations, the makeup water storage pond has been eliminated from the proposed water management system.

The current plan to use groundwater for water makeup needs when Big Stone Lake appropriations are not available. During periods of extended drought it is possible that the groundwater withdrawal system could provide the majority of the plant water needs. With the working storage volume in the plant cooling pond of approximately 3,500 acre-feet and the proposed maximum annual groundwater appropriation of 10,000 acre-feet, both Big Stone units could be operated at full output for about a year without any appropriation of water from Big Stone Lake.

3.4 Expected Groundwater Withdrawals

During extreme and extended drought conditions is possible that the plant will appropriate as much as 6,200 gpm of groundwater continuously, up to the requested maximum annual groundwater appropriation volume of 10,000 acre-feet. However, the typical operating scheme contemplates using groundwater to supplement the primary source of makeup water for the plant, surface water from Big Stone Lake (see Section 3.3).

3.4.1 Water Use Model

To assess the likely frequency and duration of groundwater appropriations under the typical operating scheme, a simulation model developed by Barr Engineering was used. The model is a modified version of the spreadsheet model used to simulate the availability of water from Big Stone Lake and assess the effects of appropriations from Big Stone Lake on the lake water levels and Minnesota River flows as part of the appropriation permitting process for Permit No. 6678-3. The model was revised to allow for the simulation of a groundwater source in addition to the Big Stone Lake and plant storage ponds to meet the plant water needs.

The model input parameters include:

- The plant annual consumptive water need (13,000 acre-feet),
- The available live storage in the plant ponds (3,500 acre-feet), and
- The order of appropriations (from Big Stone Lake first, then ponds and finally groundwater to meet plant needs; withdraw from Big Stone Lake first, then groundwater to keep pond storage full).

Additionally, the model simulates the diversion restrictions based on Big Stone Lake water levels included in the appropriation permit conditions (No. 6253-3 and Permit No. 6678-3). The model is an Excel spreadsheet that calculates a water budget on quarter-monthly (weekly) time steps and simulates the operation of the Big Stone dam and the Big Stone water storage ponds. The model uses historical data to simulate future water budget allocations, specifically:

- Big Stone Lake Dam's operating plan
- Big Stone Power Plant's historical water appropriations
- Big Stone Power Plant's existing water storage capacity
- Historical Big Stone Lake levels
- Historical Minnesota River levels and flows

- Historical Whetstone River levels and flows
- Historical climatological data

The model evaluates the availability of water during the past 70 years, and compares it to the future needs of the power plant. Historic precipitation data were used to simulate net additions to the system from rain and snow.

3.4.2 Modeled Groundwater Appropriations

The model output includes an estimate of annual lake water and groundwater appropriation volumes over a seventy year plant operating period, given past climatic conditions (those conditions that occurred between 1930 and 2000). The modeled annual appropriations are shown in Figure 5.

The modeled annual groundwater appropriation required to operate both Big Stone unit I and Big Stone II ranged from 0 (4 out of 70 modeled years) to 10,000 acre-feet (3 out of 70 modeled years) Over the 70-year model period, the average groundwater appropriation was about 3,700 acre-feet.

Another model output is the available pond storage, shown in Figure 6. Because of the proposed operating scheme described above, two or more consecutive model time steps (quarter-month) with no water in pond storage indicates that there is insufficient water available from the three sources, Big Stone Lake, the storage pond and groundwater to run both units at full capacity. This situation occurs twice in the model, a 5-1/2 month period with 1934 conditions and a three month period with 1935 conditions.

3.4.3 Effect of Proposed Allocations on Big Stone Lake Levels and Minnesota River Flows

The model described above was used to evaluate the impact of the proposed water appropriation scheme on the water levels in Big Stone Lake and on the Minnesota River flows downstream of the lake.

Model results indicate that slightly lower lake levels at Big Stone Lake are expected on rare occasions as a result of increased power plant withdrawals. Study results indicate that if plant water withdrawals were increased to an average of 13,000 afy with a pond system storage volume of 3,500 af at the plant site and use of groundwater as simulated above and illustrated in Figure 6, the worst effect is that the lake would be about 10 inches lower in 2 non-consecutive weeks out of a 70-year model period. On average, over the 70-year model period, the lake elevation would only be decreased by an average of about 1-3/4 inches. This compares with a worst effect of the lake being about 12 inches lower in 3 non-consecutive weeks out of a 70-year model period and the lake elevation averaging 2-1/2 inches lower under the operating scheme described in the June 21, 2006 water appropriation permit application. That scheme utilized additional pond storage as a means to address extended drought periods rather than the use of groundwater wells, as currently contemplated. A comparison of the modeled lake level impacts under the two operating schemes is presented in Figure 7.

The predicted flow reductions in the Minnesota River related to the withdrawal of water from Big Stone Lake were also obtained from the modeling. Reduction during low flow periods (flows <80 cfs) are the primary concern for potential downstream impacts. The modeled effect on Minnesota River flows of the two operating schemes are summarized in Figure 8. While the reduction in low flows are only marginally improved with the operating scheme using groundwater for during drought periods, in either modeled case, the impacts on Minnesota River low flows is limited to less than 2 percent of the 2800 low-flow weeks modeled. This is because surface water appropriation permit diversion restrictions limit most lake appropriations to periods when Minnesota River flows are relatively high (e.g. spring runoff periods).

4 Review of Water Source-Veblen Aquifer

The proposed source the groundwater supply for the Big Stone Plant is the Veblen Aquifer. Other area aquifers were examined and the Veblen Aquifer was chosen for development primarily because of its proximity to the plant. It also does not appear to be as heavily used as other aquifers in the region. A review of potential groundwater sources completed by Barr Engineering Co. in 2002 is summarized in a memorandum provided in Attachment A. This section describes the Veblen Aquifer and discusses the potential impacts to the aquifer and other users from the proposed appropriation.

4.1 Published Information Summary

The Veblen aquifer is located in eastern Grant County and likely underlies the Big Stone plant, as shown on Figure 9. It is defined as a glacial outwash deposit composed of coarse sand and gravel. The aquifer was originally thought to be one continuous aquifer extending from the northeast corner of Marshall County across Roberts County and into Codington and Grant counties; however, more recent data has indicated that the Veblen aquifer in Grant County is different from the Veblen aquifer located in Roberts and Marshall Counties (USGS, 2001). The aquifer found in southeastern Roberts County was found to be very thin and discontinuous. For this reason the Veblen is not assumed to be present in southeastern Roberts County (USGS, 2001). However, the Fairmount aquifer could be a part of the Veblen aquifer which would increase the overall extent of the Veblen aquifer as discussed by Pro Gold, LLC.

For most locations in Grant County, the Veblen aquifer is generally an artesian aquifer. Near Milbank it is up to 150 feet thick, but this thick section of aquifer is relatively limited in area. Near Big Stone City, the thickness range is about 20 to 30 feet. The top of the aquifer is found at anywhere from 50 to 100 feet below ground surface near Big Stone City. Recharge is by infiltrating precipitation where overlying glacial till layers are thin, such as along its western extent and southwest of Big Stone City along the western boundary where the aquifer is at land surface (Hansen, 1990).

Municipal wells include Milbank – there are also domestic and stock-water wells. Wells located in the Veblen aquifer within a 10-mile radius of the Big Stone plant are shown on the Figure 10. These wells range in capacity from 100 gpm to 1000 gpm. Dewatering from granite quarries east of

Milbank removes some water from this aquifer. The total withdrawal from the Veblen aquifer is not known.

4.1.1 Water Quantity

The estimated areal extent of the Veblen Aquifer is approximately 260 square miles, and the estimated storage is approximately 700,000 acre-feet (Pro-Gold, LCC, 1995). Water level and storage fluctuations are caused by seasonal changes in recharge and discharge. Values of recharge are difficult to estimate for this area but the upper bounds must certainly be below average annual precipitation. For most of the area, a value of 1.0 inches per year is a reasonable assumption for recharge value. Along the aquifer periphery, Hansen (1990) suggests that the Veblen Aquifer is at or near ground surface and may receive recharge from direct precipitation. In these areas, a recharge value of 2.9 inches/year is a reasonable assumption.

4.1.2 Water Quality

4.1.2.1 Available Water Quality Information Sources

Four publicly available reports were reviewed to estimate the raw water quality that would be expected from the Veblen aquifer. The contents of those reports are summarized below.

Water Resources of Codington and Grant Counties, South Dakota, Hansen, 1990

This report discusses both surface water and groundwater in Codington and Grant Counties. Specifically, it describes the Veblen Aquifer, including geology, recharge and discharge, water level, depth below surface, and water quality. Analytical results for nine samples are presented in Table 6 of the report. The table in the report lists number of samples, mean, minimum and maximum concentration for a number of constituents.

Ground-Water Investigation for Big Stone City, South Dakota, Green and Gilbertson, 1987

This investigation was conducted to identify alternative groundwater supplies for Big Stone City, the nearest city to the project site. The report names the Veblen Aquifer as an option for alternative water supply to the City. Analytical results for six water samples are presented in Table 1 of the report. The table in the report lists number of samples, range, and average (mean) concentration for a number of constituents.

Investigation of Ground Water Resources in Portions of Roberts County, South Dakota, Gilbertson, 1996

This report summarizes the groundwater resources in Roberts County, the county just north of the project site. Veblen Aquifer water quality data is included in this report. Sample analytical results are shown in Appendix C of the report. Only samples taken in 1993 (5 samples) are used to estimate the water quality for the proposed project, because the water quality in this area has declined over the years and the most recent samples would provide a more accurate estimate of the current water quality. Using these sample results, Barr determined the mean, minimum and maximum concentration for a number of constituents.

Water Resources of the Lake Traverse Reservation, South and North Dakota, and Roberts County, South Dakota, Thompson, 2001

This report summarizes both the surface water and groundwater in Roberts County, and the Lake Traverse Indian Reservation. The area covered by this report is the farthest away from the project site. Extensive water quality analysis was completed on samples taken from the Veblen Aquifer. Sample results are shown in Table 13 of the report. The report Table 13 lists number of samples, which varies from 1 to 71 (depending on the constituent), mean, median, maximum and minimum concentration.

4.1.2.2 Expected Veblen Aquifer Water Quality

Table 3 summarizes the calculated mean, maximum and minimum concentration for various constituents from the various reports. Four columns of data are presented in this table. Presumably, the “Mean - Grant County” sampling results from these reports would most closely match the actual makeup water quality.

The “Mean - Grant County” column was determined by a weighted average of the results of the reports by Hansen and Green and Gilbertson, based on number of samples. For instance, if the Hansen report had 9 samples and the Green and Gilbertson report had 6 samples, the mean would be determined by multiplying the value from Hansen by 9 and the value from Green and Gilbertson by 6. This value would then be divided by the total number of samples, or 15. These reports covered the area closest to the project site.

Table 3 Veblen Aquifer Water Quality—Mean, Maximum and Minimum Sampling

Constituant	Unit	Mean - Grant County[1]	Mean - All Samples[2]	All Samples Minimum	All Samples Maximum
Specific Conductance	umhos/cm	1600	1730	575	9500
PH	Standard Units	--[3]	7.20	6	8.2
Carbon Dioxide, Dissolved	mg/L	--	45.1	2.3	88
Hardness, Total	mg/L	860	691	31	4700
Dissolved Solids (TDS)	mg/L	1653	1383	328	6450
Dissolved Calcium	mg/L	262	180	7.2	1000
Dissolved Magnesium	mg/L	89	67	3.1	535
Dissolved Sodium	mg/L	57	107	6.3	745
Dissolved Potasium	mg/L	10	11	2	39
Bicarbonate	mg/L	420	384	6	650
Alkalinity	mg/L	--	329	88	650
Dissolved Sulfate	mg/L	641	571	31	2700
Dissolved Chloride	mg/L	22	98	ND[4]	2600
Dissolved Fluoride	mg/L	0.76	0.35	0.1	2.79
Dissolved Silica	mg/L	--	16.6	2.6	31
Nitrate	mg/L	<0.04	2.55	ND	70
Phosphorus	mg/L	--	0.044	0.011	0.09
Aluminum	ug/L	--	--	<10	30
Arsenic	ug/L	--	4.67	1	13
Barium	ug/L	--	7.69	ND	100
Boron	ug/L	--	7.25	40	4700
Dissolved Cadmium	ug/L	--	6.5	6.5	6.5
Chromium	ug/L	--	<4	<4	4
Cobalt	ug/L	--	--	<2	20
Copper	ug/L	--	--	<2	10
Dissolved Iron	ug/L	2600	1573	0	18000
Dissolved Lead	ug/L	--	11.3	1.6	21
Lithium	ug/L	--	137	20	270
Dissolved Manganese	ug/L	420	626	0.04	1720
Dissolved Mercury	ug/L	--	<0.2	<0.2	<0.2
Molybdenum	ug/L	--	--	<4	18
Nickel	ug/L	--	<4	<4	6
Selenium	ug/L	--	--	ND	3
Silver	ug/L	--	--	<1	3
Strontium	ug/L	--	1005	190	2700
Vanadium	ug/L	--	>4	>4	>4
Zinc	ug/L	--	353	10	1700

[1] Grant County Mean is the weighted mean from the following reports: Hanson, Donald S., 1990, Water Resources of Codington and Grand Counties, South Dakota; and Green, Susan and Jay P. Gilbertson, 1987, Ground-Water Investigation for Big Stone City, South Dakota

[2] All Samples Mean is the weighted mean from all water quality reports reviewed.

[3] --, no data collected

[4] ND, not detected

The “Mean – All Samples” column was determined by averaging the results of all four reports with water quality data for the Veblen Aquifer. Again, determining the mean was based on number of samples, and the same principle was used to determine an overall mean. The area covered by these water samples covers a larger geographic area, and water quality results may vary depending on distance from the project site.

All four reports listed their minimum and maximum result. The “All Samples Minimum” column was determined by taking the lowest sampling result from the four reports. Likewise, the “All Samples Maximum” column was determined by taking the highest sampling result from all four reports. These values are shown to represent a possible range in the water quality in the area.

4.2 Project Groundwater Supply Evaluation

An investigation has been completed in late 2006 and early 2007 to aid in the hydrogeologic characterization of the Veblen aquifer in the vicinity of the Big Stone Plant Site. The objectives of the investigation were to:

- Identify locations for placement of production wells;
- Collect aquifer data for input into a groundwater model; and
- Collect groundwater quality data was to assist with the evaluation and design of water treatment requirements.

The investigation is summarized below. The groundwater supply evaluation scope, methodology and results are described in detail in Attachment B.

4.2.1 Pilot Borings

4.2.1.1 Phase 1

Pilot boreholes were completed in December 2006 at the five locations on the Big Stone Plant site shown on Figure 11. Two-inch diameter pilot holes were placed to Cretaceous bedrock using the rotosonic drilling method. The rotosonic drilling method allowed for collection of continuous intact core samples and logging of the soil stratigraphy. Phase 1 pilot borehole logs are included in Attachment B.

Evaluation of the five pilot borings completed during the Phase 1 investigation indicated that Locations 1-2 and 1-4 would be expected to provide pumping rates that warranted installation of production wells. The pilot boring logs at locations 1-1, 1-3 and 1-5 indicated that the aquifer at those locations was not likely to provide sufficient yields for production wells.

4.2.1.2 Phase 2

Phase 2 investigation work, consisting of seven additional pilot borings placed using rotosonic drilling methods, was completed in February 2007 in an area to the south and west of the plant site (see Figure 11). Locations 2-1 and 2-6 are proposed as sites for future installation of production wells.

4.2.1.3 Phase 3

Seven pilot borings were placed using rotosonic drilling methods in March 2007 in an area to the south and west of the plant site (see Figure 11). Locations 3-1, 3-5 and 3-9 are proposed as sites for future installation of production wells.. Locations 3-6 and 3-7 were unaccessible for placement of pilot borings in March 2007 and are planned for completion in late April 2007, in conjunction with the Phase 4 activities.

4.2.1.4 Phase 4

Twelve pilot borings placed using rotosonic drilling methods are proposed for Phase 4 in late April and May 2007 in the area to the south and west of the plant site (see Figure 11). Pilot borings at Locations 3-6 and 3-7 will also be placed during this time.

4.2.2 Well Installation

Production Wells PW1-2 and PW 1-4 were installed using mud rotary drilling methods in January 2007. Two-inch diameter wells were installed, also using mud rotary drilling methods, about 400 feet away from wells PW1-2 and PW1-4 and screened at about the same depth of the production wells to serve as observation wells during pumping tests. Well construction logs for the production wells and observation wells are included in Attachment B.

4.2.3 Aquifer Pumping Tests

A pumping test was conducted at pumping well 1-2 from January 26, 2007 to January 30, 2007. A pumping test was conducted at pumping well 1-4 from February 27, 2007 to March 7, 2007.

The initial aquifer (pumping) test was chosen for PW1-2 because location 1-2 is believed to be representative of the Veblen aquifer to the south and west of the plant site and would provide aquifer data that could be used for modeling of the aquifer. Evaluation of the boring and well logs at location 4 indicated that that location is not likely representative of the Veblen aquifer to the south and west of the plant site, so that location was chosen for the second pumping test and its results used for assessment of production yields at that specific location. The pumping test results are presented in Attachment B.

4.2.4 Water Quality Analyses

After well completion and during test pumping of Wells PW1-2 and PW1-4, water samples were collected at the discharge end of the pump. At each 6-hour interval temperature, dissolved oxygen, pH and specific conductance were measured and recorded in the field. Three groundwater samples were collected at 12-hour intervals for laboratory analysis, with the first sample collected 60 hours after the pump test start time, and the last sample collected immediately prior to shutting off the pump. Results of the field testing and laboratory analysis are provided in Attachment B.

4.2.5 Future Well Installation

The wells PW1-2 and PW1-4 already constructed; the proposed future well locations, 2-1, 2-6 and 3-1, 3-5 and 3-9; in addition to the specific locations to be determined during the Phase 4 drilling, are expected to provide the desired sustainable pumping yield—6,200 gpm or 10,000 acre-feet per year. Production well installation and testing will eventually be conducted at the proposed well locations, but that work is not yet scheduled. The procedures for installation of the production wells and aquifer testing at the additional locations will be the similar to those used for Wells PW1-2 and PW1-4.

5.1 Existing Users

Existing uses of water from the Veblen aquifer, based on SDDENR appropriations permit records, include irrigation, industrial, commercial and municipal uses. Grant County Water Rights and appropriation permits for water from the Veblen aquifer are listed in Table 4. The number of domestic wells drawing water from the Veblen aquifer is unknown, because those appropriations are not issued permits by the State of South Dakota. The area surrounding the plant that is not served by Big Stone City is served by the Grant-Roberts Rural Water System. Figure 12 shows the rural water system in the vicinity of the Big Stone Plant.

Table 4 Grant County Veblen Aquifer Water Rights and Appropriation Permits

Permit No.	First Name	Last Name	Use	Permitted CFS	Licensed CFS	Priority Date
1939-3	KATHLEEN A	TRAPP	IRR	1.24	1.00	04/13/72
2759-3		LIEBE IRRIGATION	IRR	3.30	2.23	06/09/76
2808-3	DUANE	TRAPP	IRR	2.20	2.00	06/29/76
2994-3	ANTHONY G	FOLK	IRR	2.00	1.39	09/09/76
3234-3	MICHAEL D	JOHNSON	IRR	2.20	2.00	11/08/76
3412-3	FRANCIS	VAN LITH	IRR	2.00	1.33	12/10/76
3627-3	JAMES/TERESA	GRORUD	IRR	2.20	1.94	02/07/77
3723-3		ROCKY MEADOWS INC	IRR	2.00	1.11	02/14/77
3954-3	ROGER	MC CULLOUGH	IRR	0.00	2.11	05/05/77
4048-3	TOWN OF	TWIN BROOKS	MUN	0.30	0.07	01/01/34
4050-3	CITY OF	BIG STONE CITY	MUN	3.30	3.30	07/05/77
4084A-3	RICHARD	WILL	IRR	0.00	1.00	06/20/77
4502-3		ROCKY GARDENS	IRR	0.57	0.17	03/10/80
4735-3	MICHAEL D	JOHNSON	IRR	1.14	1.00	04/02/81
4856-3	MICHAEL D	JOHNSON	IRR	1.00	1.00	01/08/82
5469-3	MICHAEL	JOHNSON	IRR	0.00	2.00	04/29/76
548-3	CITY OF	MILBANK	MUN	2.10	2.10	01/01/24
5525-3		MIELITZ BROS	IRR	2.00	1.78	03/07/91
5918-3		VICTORY FARMS	COM	0.37	0.33	03/19/96
6161-3		LOU'S GREENHOUSE	COM	0.04	0.04	12/28/99
6171-3		COLD SPRING GRANITE CO	IND	0.11	0.11	01/18/00
6230-3		MILBANK COMM. FOUNDATION	COM	1.02	0.00	09/20/00
6358-3	MICHAEL & NANCY	JOHNSON	COM	0.12	0.00	08/06/02
6636-3		WESTERN CONSOLIDATED COOP	COM	0.02	0.00	07/06/05

Yearly irrigation records are collected by the State. While farmers are licensed to draw 2.0 acre-feet per year, records indicate that actual water used is only 2%-20% of this, depending on yearly precipitation. Records on actual water usage for the municipal, industrial and commercial users are not available.

5.2 Effect on Other Users

Groundwater modeling of the Veblen Aquifer in Grant County, South Dakota was completed to assess the potential impacts to other groundwater users from the proposed use this aquifer as a water supply for the Big Stone Power Plant. The groundwater modeling uses published information on the Veblen Aquifer as well as site-specific information obtained from the groundwater supply evaluation completed in 2006 and 2007 as described above. The details of the modeling methodology, results and conclusions presented in the Groundwater Evaluation Report included as Attachment B, are summarized below.

5.2.1 Groundwater Model

A numerical groundwater flow model was developed for the aquifer system in northeastern Grant County for the purpose of predicting the effects of pumping a groundwater supply for the proposed Big Stone II plant for a period of one year. The primary focus of the model is to predict drawdown, which can be used to evaluate the effects of pumping on existing groundwater users (i.e. wells) and surface waters. The U.S. Geological Survey's code MODFLOW was used for the groundwater flow modeling (McDonald and Harbaugh, 1988; Harbaugh and McDonald, 1996).

Two transient simulations of one-year in length were performed, each representing a slightly different set of pumping wells. Two different configurations were used because the results of the Phase 4 pilot borings are not yet available (these will be completed in April 2006). For the simulations, it was assumed that some of these Phase 4 pilot boring locations would be found to not be suitable for production wells.

The first configuration assumes seven wells will be capable of producing the requisite 6,200 gpm. The second configuration assumes that 14 wells will be needed to produce 6,200 gpm. These two configurations represent the minimum and maximum number of wells – the actual number of wells will likely be some number between 7 and 14. Additional field investigations should be able to verify this range and identify the actual number of wells.

5.2.2 Groundwater Modeling Results and Conclusions

The maximum drawdown is predicted to be between 35 feet (14 well configuration) and 40 feet (7 well configuration) below existing static water level at the end of one year of pumping. Within the well-field area, the drawdown is predicted to be approximately 15 to 35 feet. The 5-foot drawdown is predicted to extend 3 miles (7 well configuration) to 4 miles (14 well configurations) from the approximate center of the well field. The aquifer system is confined and recovery of groundwater levels will be approximately the inverse of pumping – i.e. water-levels will rebound quickly and then slowly approach pre-pumping conditions after approximately a year.

The field investigations and the groundwater-flow modeling indicate that the aquifer system should be capable of yielding 6,200 gpm for at least 1 year of pumping without significant regional drawdown. The connect of the aquifer to the surface (and therefore, to streams, such as the Whetstone River) was found to be negligible. The total number of wells required to produce 6,200 gpm will likely be in the range of 7 to 14.

6 References

Hansen, D.S., 1990. Water resources of Codington and Grant Counties, South Dakota, USGS Water-Resources Investigation Report 89-4147.

Pro-Gold, LLC, 1995. Water Permit Application and SDDENR Report.

USGS, 2001. Water Resources of Lake Traverse Reservation, South and North Dakota, and Roberts County, South Dakota, Water-Resources Investigations Report 01-4219.

McDonald, M.G., and A.W. Harbaugh, 1988. A Modular Three-Dimensional Finite-Difference Groundwater Flow Model, U.S. Geological Survey Techniques of Water Resource Investigations, TWRI 6-A1, 575 p.

7 Application Forms

SD EForm - 1585 V1
FORM 2: Application for uses other than irrigation
(type or print)

Mail to: Water Rights Program, Joe Foss Building, 523 E. Capitol, Pierre, SD 57501-3181, (605) 773-3352	(office use only) No. ______ Hydrologic Unit ______ Basin ______ Newspaper ______

Application For Permit To Appropriate Water Within The State Of South Dakota

Check use(s) of water:

- [ ] Municipal
- [ ] Rural Water System
- [ ] Domestic (over 18 gpm)
- [ ] Suburban Housing
- [ ] Commercial
- [x] Industrial
- [ ] Recreational
- [ ] Fish & Wildlife
- [ ] Other ______
- [ ] Institutional
- [ ] Geothermal Heat

Type of Application: (check one)

- [x] **New**
- [ ] **Vested Right** (Use predates Mar 2, 1955)
- [ ] **Future Use Reservation**
- [ ] **Place to Beneficial Use Water Reserved by Future Use Permit No.** ______
- [ ] **Amendment/Correction to Permit No.** ______

Description of amendment/correction: (i.e. change diversion point(s), add diversion point(s), change use, etc.)

1. Name of Applicant Otter Tail Corporation dba Otter Tail Power Co.**** Phone (218) 739-8407
(check one) [ ] Owner [ ] Tenant/lessee
Mailing Address Environmental Services, PO Box 496 Fergus Falls State MN 56538-0496
(Street, RR, or Box and City) (Zip Code)

2. Amount of water claimed ______ *CFS or ______ **GPM 10,000.00 ***AF
(*Cubic Feet per Second) (**Gallons per Minute) (***Acre Feet - storage capacity of dam/dugout or annual use if applicable)

3. Source of water supply Veblen Aquifer

4. Location of point of diversion (example - 3 wells in SW1/4 NE1/4 section 12-T104N-R53W) County Grant
See attached list and report Figure 4.

5. County or counties where water will be used Grant

6. Annual period during which water is to be used All year

7. Give a description of the project. When available include any preliminary engineering report or other reports or information that will help explain the project. (Attach sheet if more space is needed)
See attached report. ****The project will have the following Co-Owners: Central Minnesota Municipal Power Agency, Great River Energy, Heartland Consumers Power District, Montana-Dakota Utilities Co., Inc., Otter Tail Power Company, Southern Minnesota Municipal Power Agency, Western Minnesota Municipal Power Agency.

STATE OF SOUTH DAKOTA)
SS
County of Grant)

Attachments: Attach Form 2A if diversion is from a well or dugout, or if storage of water is proposed. Attach map and any other technical information. (see instructions)

I, Mark Rolfes, the applicant, certify that I have read this application, have examined the attached map and that the matters stated are true and that I intend, and am able to complete the necessary construction.

Applicant's signature [signature]

Subscribed and sworn to before me this 27th day of March 2007

[signature: Virginia Hoxtell]
Notary Public signature
My commission expires 11-2-12

4-2000

Form 2A **Supplemental Information**
(Complete applicable portions only)

(type or print in ink)

1. Well Information - Proposed Construction

a) Drill Hole Diameter 12-20 in. Depth 150-250 ft

b) Casing Type Steel Diameter 10-18 in. Thickness 0.375 in.

c) Screen Type SS Cont. Slot Diameter 10-18 in. Thickness n/a

d) Gravel Pack sized for #40 slt Length of Gravel Pack 30-100 ft.

e) Depth to Top of Water Bearing Material 40-130 ft.

f) Depth to Water (ground surface to water level) 10-120 ft.

g) Distance to nearest existing domestic well:

On applicants property see report On property owned by others see report

2. Wastewater Disposal System Information

a) Type of System (i.e. septic tank, drain field) ______

b) System Capacity (gallons) ______ Year Constructed ______

c) Connected to the City of ______ Sanitary System

3. Dugout Information

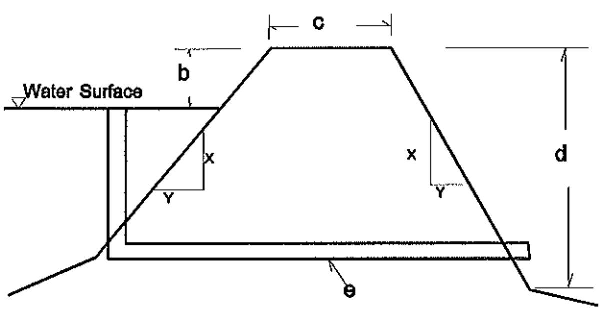
a) Surface Dimensions ______ Depth ______

b) Depth to water (ground surface to water level) ______

4. Water Storage Dams

If the proposed water use system contains one or more storage dams, please furnish the information requested below for each dam. The locations of the dams need to be shown on the map submitted with the application.

a) If a private engineering firm or government agency was involved in the design of this dam, please give their name and address:



b) Freeboard ______

c) Crest Width ______

Crest Length ______

d) Height ______

e) Primary Outlet Capacity ______

If pipe, diameter ______

f) Secondary Spillway Capacity ______

Spillway Width ______

g) X & Y Slope ______

Upstream ______

Downstream ______

h) Surface Area of Impoundment ______

i) Storage ______ Acre Feet

j) Drainage Area Above Dam ______ Acres

Points of Diversion

Site ID	Site Description
1-4	NE 1/4, NE 1/4, S. 7 of R. 46 W, T. 121 N
1-2	SE 1/4, SW 1/4, S. 15 of R. 47 W, T. 121 N
2-1	NW 1/4, SW 1/4, S. 15 of R. 47 W, T. 121 N
2-6	SE 1/4, NE 1/4, S. 19 of R. 47 W, T. 121 N
3-1	SW 1/4, NW 1/4, S. 28 of R. 47 W, T. 121 N
3-5	SE 1/4, SE 1/4, S. 19 of R. 47 W, T. 121 N
3-9	SE 1/4, NW 1/4. S. 20 of R. 47 W, T. 121 N
3-6	SE 1/4, NE 1/4, S. 20 of R. 47 W, T. 121 N
3-7	SW 1/4, NE 1/4, S. 20 of R. 47 W, T. 121 N
4-1	SE 1/4, NE 1/4, S. 28 of R. 47 W, T. 121 N
4-2	SE 1/4, SE 1/4, S. 28 of R. 47 W, T. 121 N
4-3	SW 1/4, SW 1/4, S. 28 of R. 47 W, T. 121 N
4-4	NW 1/4, NE 1/4, S. 32 of R. 47 W, T. 121 N
4-5	NE 1/4, NW 1/4, S. 32 of R. 47 W, T. 121 N
4-6	NW 1/4, NW 1/4, S. 32 of R. 47 W, T. 121 N
4-7	SW 1/4, SW 1/4, S. 29 of R. 47 W, T. 121 N
4-8	NW 1/4, NW 1/4, S. 32 of R. 47 W, T. 121 N
4-9	SW 1/4, NW 1/4, S. 32 of R. 47 W, T. 121 N
4-10	NW 1/4, SW 1/4, S. 32 of R. 47 W, T. 121 N
4-11	SW 1/4, SW 1/4, S. 32 of R 47 W, T. 121 N
4-12	NE 1/4, SW 1/4, S. 20 of R. 47 W, T. 121 N